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CASE STUDIES IN THE APPLICATION OF AIR QUALITY MODELING IN ENVIRONMENTAL DECISION MAKING

Summary and Recommendations

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ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

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Summary and Recommendations

by

Catherine G. Miller
John F. Kennedy School of Government
Harvard University
Cambridge, Massachusetts 02138

Grant No. R805558-01

Project Officer

Kenneth Demerjian
Meteorology and Assessment Division
Environmental Sciences Research Laboratory
Research Triangle Park, North Carolina 27711

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DISCLAIMER

ABSTRACT

Eleven case studies of the application of air quality models were undertaken in order to examine the problems encountered when trying to use these models in making environmental policy decisions. The case studies of air pollution control decisions describe the decision process, the models used, the critiques of the models, and the participation by outside interest groups in the decisions process. The studies include two cases of federal decisions, seven state decisions, one local decision, and a review of the evolution of modeling requirements in the Clean Air legislation. The time covered is from 1970 to the present and includes several cases for which a final decision has not yet been made.

The results of this investigation show that indeed the well-known technical and political constraints exist but that unresolved policy issues, the management of the decision process and conflicting institutional and organizational interests also cause problems. Recommendations are made on how to improve the technical planning and management of the decision process so that the air quality models can become a better policy tool within the state-of-the-art, political and organizational constraints.

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CONTENTS

TABLES

ACKNOWLEDGEMENTS

The cases were prepared under the supervision of the author and Professor Laurence E. Lynn, Jr., of the Kennedy School of Government. Primary responsibility for the research and writing of the cases should be credited as follows:

"Air Quality Modeling in Clean Air Legislation" by Catherine G. Miller and Evie Verderber
"The MATEP Power Plant" by Christopher Allen and Evie Verderber
"Pittston-Eastport" by Christopher Allen
"The Anaconda Copper Smelter Case" by Christopher Allen
"The Maryland SIP: An Exemption for the Westvaco Corporation" by Evie Verderber
"Massachusetts' Sulfur Regulations" by Deborah Wishner
"Ohio's State Implementation Plan" by Christopher Allen
"Connecticut's Transportation Control Plan" by Deborah Wishner
"Revision of the National Ambient Air Quality Standard for Ozone" by Catherine G. Miller
"Balancing on a Tightrope: How the U.S. Environmental Protection Agency Set New Source Performance Standards for New Coal-Fired Power Plants" by Elizabeth H. Haskell

Additional support for this last case study was received from the U.S. Public Health Service.

CASE STUDIES

This report briefly describes the case studies. For those interested in a more detailed description, the case studies are available on an individual basis from the

Technical Information Manager, MD-59
Environmental Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Titles of the individual case studies are listed below.

AIR QUALITY MODELING IN CLEAN AIR LEGISLATION

THE MATEP POWER PLANT

PITTSTON-EASTPORT

THE ANACONDA COPPER SMELTER CASE

THE MARYLAND SIP: AN EXEMPTION FOR THE WESTVACO CORPORATION

MASSACHUSETTS' SULFUR REGULATIONS

OHIO'S STATE IMPLEMENTATION PLANS

CONNECTICUT'S TRANSPORTATION CONTROL PLAN

AIR QUALITY MODELING AND THE 1978 SAN FRANCISCO BAY AIR QUALITY MAINTENANCE PLAN

REVISION OF THE NATIONAL AMBIENT AIR QUALITY STANDARD FOR OZONE

BALANCING ON A TIGHTROPE: HOW THE U.S. ENVIRONMENTAL PROTECTION AGENCY SET NEW SOURCE PERFORMANCE STANDARDS FOR NEW COAL-FIRED PLANT PLANTS

SECTION I

INTRODUCTION

The U.S. Environmental Protection Agency as well as many academic and other private institutions have developed a large repertoire of air quality models, models which predict the impact of emissions on the quality, or pollutant concentration levels, of the ambient air. The Clean Air Act Amendments now require the application of these models when making decisions about controlling air pollution. However, the cry is often heard that the models are not used. This study grew out of the concern that many modelers as well as potential users of models are dissatisfied: the modelers because they are not listened to and the users because they do not hear much that they want to listen to. Also users may apply the models in ways other than those intended by the modelers.

To look at this conflict between the modelers and decision makers (users), cases of specific applications of air quality models have been studied. The focus of the case studies is the decision making process, i.e. how policies and decisions are formed within the federal and state environmental agencies and what role the air quality models played within that process. Questions such as

- how were the models chosen,
- how did the industry models differ from the government agency models,
- what technical information was actually presented to the decision maker,
- what interest groups intervened in the process, and
- what policy or non-technical controversies arose and how were they resolved

are examined in order to develop a basis for understanding the role of the models, reasons for their success or failure and the critical attributes necessary for their use in a given context.

THE CASE STUDIES

The eleven case studies completed for this research project were picked to illustrate different levels of decision making (national to local), different institutional domains (administrative, judicial, and legislative) as well as the various EPA programs which require air quality modeling analyses. Table 1 lists the case studies and indicates which elements each contains. It should be noted that the case studies are intended to illustrate the various roles that air quality models have been called upon to serve but do not represent a scientific sample of all such cases.

A brief introduction to each case study follows in order to acquaint the reader with the range of situations presented in the eleven case studies.

Clean Air Legislation

This case study outlines the history of the federal Clean Air legislation and why several provisions of the 1977 amendments include modeling requirements. Some of these provisions are the focus of controversy in subsequent case studies and this history is intended to provide a context for these debates. It also points out the legislator's role in legitimizing the use of these models without actually having applied the models or made decisions requiring the use of the models.

MATEP

In 1972, Harvard University applied to the state of Massachusetts for a permit to construct cogeneration facilities as part of a power plant (the MATEP power plant) to be built near downtown Boston. The modeling analysis showed that the facilities, which included diesel engines to generate both steam heat and electricity, could meet the applicable national ambient standards. However, public concern centered on the short-term NO_2 levels which would be generated by the operation of the diesels and for which the federal EPA had not yet set a standard. Thus, without a standard the state had to review evidence on the health impacts of NO_2 in making its decision.

Pittston

In 1973, the Pittston Company applied for permission to build an oil refinery in Eastport, Maine. Eastport is a rural community on the northeast coast of Maine near the Canadian border. It is also near a national wildlife refuge and an international park, thus making the application subject to the prevention of significant deterioration (PSD) provisions of the Clean Air Act. The increment under contention in this case was the 24-hour sulfur dioxide PSD standard. Air quality modeling was done by both the company and the state to determine what plant design would meet this standard.

Anaconda

In order to meet the national ambient air quality standards set by the Clean Air Act Amendments of 1971, the Anaconda copper smelter located in Anaconda, Montana, was required to install pollution control equipment. This case study describes the extensive modeling done by EPA in order to reach agreement with the company and the state on an SO_2 emission rate for the smelter.

TABLE 1

PROGRAM CHARACTERISTICS OF THE CASE STUDIES

Case	EPA Program	Major Pollutant	Level of Government	Institution	Time Frame
Clean Air Legislation	Legislation	All	Congress	Legislative	1955 to 1977
MATEP	New source permit (urban)	NO_x	State	Administrative & Judicial	1972 to 1980
Pittston	New source permit (PSD, rural)	SO_2	Regional Office and Congress	Administrative	1973 to 1978
Anaconda	Existing source compliance (rural)	SO_2	State and Regional Office	Administrative	1972 to 1979
Westvaco	Existing source compliance (rural)	SO_2	Regional Office and Congress	Administrative	1974 to 1979
Massachusetts' Sulfur Regulations	Existing source compliance (urban)	SO_2	State and Regional Office	Legislative & Administrative	1975 to 1977
Ohio SIP	Plan and existing source compliance	SO_2	State and Regional Office	Administrative & Judicial	1975 to 1980
Connecticut TCP	Plan	O_x	State and Regional Office	Administrative	1973 to 1979
San Francisco AQMP	Plan	O_x	Local agency of State	Administrative	1970 to 1979
Ozone standard	Ambient standard revision	O_x	Federal EPA	Administrative	1976 to 1979
NSPS	New source regulation	SO_2	Federal EPA	Administrative	1977 to 1979

Westvaco

Maryland's State Implementation Plan (SIP) requires either the installation of a sulfur emissions control system on coal burning facilities or that only coal with a sulfur content of less than 1% weight be burned. In 1974, Maryland issued a notice of violation to the Westvaco Company for its operations at their pulp mill located on the Maryland/West Virginia border. Westvaco appealed the order to revoke its operating permit claiming that no SO_2 ambient air quality standards had been violated using the higher content sulfur coal. To substantiate this claim they submitted monitoring and modeling evidence to the EPA regional office.

Massachusetts' Sulfur Regulations

Massachusetts had regulations for limiting the percentage content of sulfur in fuel used in fuel-burning facilities in their state. For the Boston metropolitan area, commencing October 1, 1971, oil-burning facilities were restricted to 0.5% sulfur oil. In response to the 1973 constrictions in Middle East oil, the Massachusetts' legislature passed Chapter 494, which required the state environmental agency to relax its sulfur-in-fuel regulation making it no stricter than necessary to meet the national ambient air quality standards. To determine a new regulation on sulfur content in fuel, air quality modeling was done by the state, by the EPA regional office, and by the electrical utilities.

Ohio SIP

In 1972, the state of Ohio submitted a State Implementation Plan to EPA without agreeing on that portion of the plan wich would control SO_2. Three years later, with Ohio still unable to complete its SIP, EPA proposed one for them. The EPA plan prescribed procedures for setting emission limits for several large power plants near Lake Erie. When the utilities appealed EPA's use of the rollback model, EPA's plan was rejected by the courts. This case chronicles the subsequent modeling analyses done by EPA and the utilities in an attempt to set emission limits for two of the Lake Erie plants.

Connecticut TCP

The state of Connecticut, in preparing its State Implementation Plan, needed a Transportation Control Plan (TCP) for the control of oxidants. This case centers around the problem of transport: Connecticut wanted to base its plan on the fact that the oxidant problem within its boundaries was caused in part by pollutants emitted in New York and New Jersey and, hence, should be controlled by them. EPA's policy did not at that time allow for consideration of transport and their approved models did not take this factor into account. Thus, the state attempted to develop its own model to use in preparing a TCP.

San Francisco AQMP

The San Francisco Bay area, like Connecticut, needed a Transportation

Control Plan for controlling oxidants, as part of an Air Quality Maintenance Plan (AQMP) required by the 1977 Clean Air Act Amendments. This AQMP was also to be integrated into an Environmental Management Plan which would coordinate governmental planning in the areas of air pollution, water pollution, water supply and solid waste. This larger plan, to be done for the San Francisco Bay area, was a first attempt by any state or region to integrate these areas of concern. The exercise involved extensive air quality model development as well as coordination of governmental, scientific, industry and environmental groups.

Ozone Standard

In 1971, national ambient air quality standards were set by EPA for six pollutants. The first of these standards to be revised (eight years later) was the standard for ozone. The technical information developed for this decision included a criteria document, presenting evidence on the health and welfare effects of ozone but also containing a chapter describing the types of air quality models available to predict ambient ozone levels. For the standard revision decision, air quality models were used in preparing a cost and economic impact report which estimated the costs, nationwide, of achieving alternative levels of an ozone ambient air quality standard.

NSPS

In 1977, EPA announced that it would revise its New Source Performance Standards (NSPS) for coal-fired power plants, which were first set in 1971. This case study describes the economic modeling and other technical analyses produced for the revision and how technical questions, which arose during the decision process, were resolved. Although no model integrating environmental, economic and energy considerations was available at the time, this case illustrates the broad range of topics EPA faced and how an air quality model and other methods of analysis in the appropriate format could have been used and can be used for similar decisions in the future.

THE OBJECTIVE

The case studies are chronologies of what happened and what (if any) decisions were made. They outline specifically the modeling analyses undertaken and the results presented, who criticized them and what the criticisms were, and the modeler's response. Each case study, through interviews with persons who participated in the analyses and reviews of the public documents produced, describes the technical information available to the decision maker.

In making environmental policy decisions, EPA and the states require a sound scientific basis. Scientific research, including air quality models, has become increasingly important as well as more sophisticated and more widely used. However, as a useful input to the decision making process, the research has in many cases not met expectations. Critics often point out that the state-of-the-art of environmental research has not yet developed to the point where it can supply information in the detail and accuracy required to solve policy problems. Gaps certainly do exist in the available information; though, the reasons for these gaps and the constricted flow of information between researchers and decision makers can also be traced to the different professional and organizational settings within which researchers and decision makers work. Thus, the case studies also describe the decision process, what role the models played within this political context and how the modelers, given their professional and organizational orientation, did or did not repond to the policy dimensions of the problem.

The studies focus on the problems that arise in using research tools as policy tools. The policy maker must deal with poor information, uncertainty about future events, imperfect legal and administrative structures, and pressures exerted by various interest groups. The researcher is also confronted by uncertainties, budget gamesmanship, political agendas, and the reluctance to drop projects no longer strictly relevant to the policy problem. Indeed, "the problem" may be constantly changing as the policy mandate changes or as research leads to more mature formulations of appropriate solutions. Thus, the objective of these studies is to improve the quality of the research information while recognizing the existence and influence of these other problems, and to look at why the modeling--even modeling specifically done for policy purposes--does not necessarily or automatically conform to the decision maker's needs.

THE APPROACH

In this summary report I draw conclusions from the case studies but do not try to chronicle the events of each one. As framework for analyzing the case studies, Section II of this summary describes the uses of technical information commonly made in the public political arena. Section III then summarizes each case study, describes the uses of the models as they are found in the individual case studies and what elements of the political, professional, organizational and institutional environment of both the modeler and the decision maker seem to have shaped the uses and the decision. Section IV of this summary report draws conclusions about the common technical and managerial problems that arose during the decision making process, how the problems were resolved, or why they have as yet eluded resolution. Section V gives recommendations, based on the experiences outlined in the case studies, on how these technical and managerial problems might be alleviated or, at a minimum, better controlled.

One further qualification should be noted. In examining and analyzing these case studies, it is not my purpose to say what the decision should be. Making a normative judgment would be distracting to the arguments on how the decision (as opposed to what decision) was made and how to improve the presentation of the technical information.

SECTION II

USES OF MODELS IN A POLICY FRAMEWORK

Environmental decision making is a complex process involving experience, political insight and political pressures, as well as technical information. The complexity of the decision process and the intrinsic uncertainties of the scientific data base combine to make this study of model usage a wide-ranging one. One manifestation of this complexity is the term the "use of models" which can take on several meanings depending in part on the motives and organizational constraints operating on the decision maker. Likewise, the motives and constraints on the modeler developing the technical information may determine what information is available to the decision maker. Thus, this study of air quality models involves differentiating the uses policymakers have for the kind of technical information provided by air quality models and what elements of both the policy and research setting restrict or promote a certain type of use.

Models within a policy framework can be divided into four categories:*

-- models used for problem solving

-- models used for conceptualization

-- basic research leading to application

-- models used for political advantage or to advance self-interest.

The case studies examine these different types of uses of models for a particular decision. This section lays the groundwork for the analysis of the studies by outlining, in theoretical terms, the various types of uses and what motivational and organizational influences may determine how the model is applied or what problems result from the attempts to employ the models. The motivational factors include the background and professional interests of both the researcher and the decision maker. The organizational factors include both organizational interests within EPA and the various institutional interests of other governmental and non-governmental agencies and private and public lobbying groups in the larger political arena.

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*These categories overlap with those outlined by Weiss (1978) for social science research. Similar uses are described by Greenberger et al. (1976) and Brewer (1978).

MODELS USED FOR PROBLEM SOLVING

The primary use of research by a decision maker is for problem solving: the application of technical information to the problem at hand for the purpose of delineating the consequences of possible solutions in order to decide which solution is the most acceptable. Various motivational and organizational factors create problems in the use of models for this purpose.

Perhaps the specific information needed by the decision maker is not available. For instance, as chemically reactive pollutants are transported in the atmosphere downwind they are transformed into other substances. The models currently available are limited to a range of about 50 kilometers and cannot satisfactorily treat chemical transformation or removal processes.

Another example of this problem is transportation control planning. Models are available which indicate the reduction in vehicle miles travelled necessary for a given set of air quality standards. However, a publicly elected official is not always able to institute programs to reduce car travel locally and may prefer to depend on national emission standards or higher fuel prices. Thus, the decision maker only has control over certain variables. As an administrator for an environmental agency rather than a transportation agency, he or she cannot design highway projects to reduce vehicle miles travelled. Thus, what the modeler thinks is important may not be what the decision maker can control or change, and, as a result, the models are not relevant to the decision maker's needs.

This situation is exacerbated by institutional and organizational arrangements. The model developer may work in a different institution than the decision maker, for instance a consulting firm or a university. As such, it may be logistically difficult to arrange meetings to discuss the work. Also, the objectives of their institutions may differ. The university's department or particular discipline may have more influence in shaping the modeler's research agenda than the government agency. Research done within the government agency may be more directly responsive to the policymaker's problem.

Another aspect of the institutional structure is the source of funding. If the research is funded at the federal level, the needs at the state or local level may not be clearly understood by the federal employees funding the research. If the states are not able to make their needs clear and are not able to fund it themselves, then the necessary technical information may not be available to them.

Organizational arrangments can also aggravate the lack of common interests between researcher and policymaker. The policy problem may require a combination of information which crosses academic disciplines. If the organizational structure is such that researchers in each separate discipline report to separate administrators, then it may be necessary to create a team which crosses organizational lines. Issues of budget and personnel hours devoted to the team as opposed to the original discipline-oriented jobs must be managed, and a clear definition of needed results must be spelled out.

In other situations, appropriate models may be available but the decision maker does not employ them. Several difficulties might arise in the course of the decision making process to cause this problem. The model results may not be available on a timely basis, the necessary input to run the model may not be available, or the user may not know how to use the model's conclusions.

Another problem faced by a policymaker is that an issue may arise in a political context and be perceived as a crisis. Fish in mountain lakes have been dying. The newspapers call it acid rain. The information fueling the crisis may be based on relatively few cases and the cause not really known. The decision maker is faced with an aroused public and time is not sufficient to design a survey, gather data and perform a careful analysis.* Instead the decision maker searches for solutions and chooses the first that is "feasible" or "realistic." This may not be the best choice, but it serves the purpose of defusing the crisis. Problems are dealt with in a piecemeal or fragmented manner. This incremental approach,** which results in marginal adjustments to the system, minimizes uncertainty and the amount of information needed; it, therefore, also minimizes the need for research.***

In other cases the research may be prolonged as the modeler strives for accuracy by refining the research methodology. However, the policymaker, unable to directly control many variables of the process, may need perspective more than complete accuracy of the numbers. On the other side, the policymaker responding to crises may find it difficult to engage in long range planning which would have allowed the research to have started earlier and provide results on a timely basis.

Institutional and organizational arrangements can cause further delay. If research is not done in-house, procedures to procure and monitor grants or contracts can be time consuming. If separate parts of the problem are done by different organizational entities (e.g., modeling by one laboratory and monitoring to collect data by another laboratory), delays can result through the need to communicate up through the hierarchy and back down again.

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*Downs (1972) describes a cycle of how environmental crises come and go.

**Lindblom (1959 and 1965) was one of the earliest expositors of the notion of incrementalism, opposing the view of a rational decision maker carefully reviewing all options. Others in this tradition include Simon (1959) and Cyert and March (1963).

***Several authors have noted that the striking feature of the Clean Air Act of 1970 is that it was not incremental (Ingram, 1978 and Jones, 1975) and that this may have been due to the changed and increased role of the public interest groups.

Even if the research itself is relevant and timely, a frequent problem is the lack of input data for the particular situation. Large, complicated models often require detailed data which is only available on a case-by-case basis.* This can be expensive and beyond the resources of the potential user.** It might also be the case that the model requires the data to be in a different form than the form in which the data was originally collected and the available resources are not sufficient to change the data.***

This mismatch of input data can arise from the dissimilarities in interests and goals of the researcher and the policymaker. The researcher may be primarily concerned with furthering the field of research being studied. The question of what type of data, what form, or if this is the minimum amount of data that one can get away with and still solve the problem may come second to the question of whether the theory is sound and the research as accurate as possible. The policymaker with limited resources may be willing to trade off accuracy for the chance to use the research.

An organizational structure separating the research and data collecting efforts may create a communication problem which would tend to increase the need for advanced planning. Within the federal EPA the routine data gathering functions are carried out by an organizational group separate from the group developing the models. Indeed, much meteorological data is compiled by other federal agencies. Special efforts at communication must be initiated to either develop air quality models that conform to the available data or, conversely, to develop a suitable data base for the models.

In some situations, research may be available which could provide relevant information at reasonable cost, but the research is still not used because the policymaker's education and experience may not have included the form and techniques of scientific research. For example, the background of the policymaker may be such that he or she is not experienced in using quantitative information and the model results may not be summarized in a fashion readily understandable.****

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*Pack and Pack (1977) and EPA (1974) show this is especially true for environmental models.

**Some investigators (Greenberger _et al_. (1976) for land-use models and Roberts and Farrell (1978) for air quality models) have concluded that some models may be beyond the capacity of the data in the sense that even a more accurate model will not increase the accuracy of the results because the input data is of such low quality.

***Brewer (1978) discusses how this is a problem for demographic data for example.

****Ackerman _et al_. (1975) show how this led to a politically based decision even after a large modeling effort by the Delaware River Basin Commission.

The modeler and the user, often coming from different academic backgrounds, each have their own vocabularies, which can further complicate the process. For example, in modeling the current form of the ambient air quality standards, the standards are written into law as concentration levels not to be exceeded more than once a year. Using past monitoring records this is a simple determination and in the interests of protecting human health seems suitably cautious. However, the many uncertainties in modeling make such predictions unreliable. From a modeler's point of view a probabilistic approach would be more appropriate, but such an approach is not easily understood by a non-statistician.

Another problem for the decision maker may be the lack of documentation.* Even if the policymaker is experienced in using quantitative information, without documentation detailing the assumptions and limitations of the model, he or she may find it hard to determine whether the particular model is applicable. Thus, the policymaker could use the model in the wrong situation, or neglect to use an appropriate model.

The lack of validation has similar causes and effects. Sometimes a model is not validated because it is a costly and time consuming process. Also, models, as a representation of a system, can never be validated in the sense of being fully supported by objective truth. Testing a model involves looking for errors, trying to invalidate it. Thus, the process has no uniform procedure or well-defined end. It is not surprising then that a modeler may be more interested in starting a new study on a different aspect of the problem than in doing numerous applications of one model with no guarantee of success. This is especially true for models requiring large amounts of input data.

On the other hand, when the modeler does explain in detail the assumptions and limitations of the model, the report of the model results may be rewritten and summarized a number of times before it finally reaches the decision maker, who is removed organizationally from the modeler. The final report may alter the qualifications or leave them out altogether so that the decision maker is unaware of the limitations and may end up using the results incorrectly.

MODELS USED FOR CONCEPTUALIZATION

The use of research may not only be a consequence of the policymaker's search for appropriate technical information in a pending decision. A more general use is for conceptualization: planning for what issues are likely

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*Fromm et al. (1974) assess the extent of this problem for the U.S. government's domestic programs. They find that for many models a report on how it was developed exists so the modeler thinks the documentation is adequate, but lacking a detailed user's manual the potential user finds it inadequate.

to come up next or developing a strategy to deal with issues.*

The use of research for conceptualization is not as direct an application as for specific problem solving. However, this type of use may be easier to undertake because the application is less specific. Thus, the state-of-the-art is not so constraining and accuracy is not an overriding concern. General trends may be sufficient, or new input data may not be needed if a previous application was similar to the foreseeable future problems on the planning agenda.

The obstacles to research utilization created by the institutional structure may not be as serious in this case. If the need for technical information is not too specific, then research done for academic purposes may be useful to the government decision maker concerned with planning strategies on how to analyze a situation or deal with a category of problems.

While availability of information may be less of a problem in this use of research, the problems of organization and its resulting communications barriers remain. Organizational divisions may hinder the creation of relevant research as well as its communication to the decision maker through the reinforcement of traditional discipline-oriented research and the separation within the hierarchy of modeler and user.

The problem of documentation also arises. If the decision maker is unaware of research results, no matter how applicable, they will not be used.

BASIC RESEARCH LEADING TO APPLICATION

Basic research to expand the state-of-the-art may naturally lead to practical applications and new policies. Examples of this type of use generally come from the physical sciences: biochemical research often results in new drug uses unforeseen at the outset of the research; the development of the transistor led to the portable radio and space satellites.

As a regulatory agency, EPA is primarily concerned with operational programs for abating pollution. It focuses on the use of applied research which in turn depends on basic research. The U.S. Congress is reluctant to fund basic research for a regulatory agency which is responsible for getting on with abating pollution.** Thus, the overall goal of EPA would tend to limit the push for basic research.

A consequence of this reluctance is that the basic research to support

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*Gordon and Gordon (1972) discuss how it may be more difficult to use mathematical models for this type of planning than for problem solving or implementation.

**See U.S. Congress (1979) and National Academy of Sciences (1977) for the continuing debate on this subject.

the applied research may not exist, or may not in practice be applicable to policy issues. The lack of basic research may also result from the obstacles to communication caused by the divergence of professional interests between researchers and policymakers, as well as their organizational separation, as has been described above.

MODELS USED FOR POLITICAL ADVANTAGE OR TO ADVANCE SELF-INTEREST

Decisions made in a political context require consideration of political and social issues as well as technical information.* The tendency for the modeler, following the scientific tradition, is to push for accuracy and, failing that, to present research results with appropriate qualifications and caveats. The reluctance to come to firm conclusions for policy purposes leaves that task up to the policymaker who can then use the research in justifying a decision made for political reasons, if the research does not specifically say it is not applicable to the situation. The lack of documentation can make such uses easier.

Uncertainty in the scientific data base can likewise be exploited by advocates in the political process through the institutional structure. The decisions of the environmental agencies in the U.S. are subject to a review process involving the public, whereby evidence, including technical information, is presented by persons representing various interest groups. The lack of conclusive evidence allows the interest groups to be selective in the evidence they present. If access to this review process is institutionally determined--e.g., industrial lobbyists with more resources have greater access--then the information available to the decision maker will also be selective.

Organizational arrangements could also result in the use of models not strictly relevant to the decision. If the modeler is organizationally separated from the decision maker, the usual practice is to communicate the result of the models through a written summary. At each level of the hierarchy it may be necessary to further summarize. In the process the qualifications may be disregarded and partial findings taken uncritically at face value or misrepresented.

With these considerations in mind we now turn to the case studies and examine the uses of air quality modeling research by EPA and state and local environmental decision makers.

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*Greenberger _et al._ (1976) describe how these uses can build further support for the wider use of models for problem solving.

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SECTION III

THE CASE STUDIES AND THEIR USES OF MODELS

In the general description of the possible uses a decision maker might have for models, I have decribed what motivational and organizational factors might influence what the actual uses are in any given situation. In order to investigate how these factors currently affect the use of air quality models by decision makers in governmental agencies responsible for environmental affairs, eleven case studies have been conducted. This section of the report describes the uses of the models in reference to the framework of Section II.

The federal Clean Air Act provides for the establishment of ambient air quality standards in order to protect public health. These are national standards to be attained in all areas of the country. After the standards have been determined by the federal EPA, each state must draw up a State Implementation Plan (SIP) describing how it will control emissions from pollution sources within its boundaries in order to meet these ambient standards. For stationary sources the mechanism used is a permit (for new sources) or a compliance schedule (for existing sources). For mobile sources, such as automobiles, the Clean Air Act has mandated national emissions standards. Thus, the states' methods to reduce pollution caused by mobile sources include transportation control planning to reduce the number of cars or to change how and where they are operated and enforcement of the federal standards through inspection and maintenance programs or anti-tampering laws.

Within this legal context and division of administrative responsibilities the case studies illustrate the different types of decisions that must be made. The first case study describes the history of the clean air legislation, passed by the U.S. Congress over the last twenty-five years, from the point of view of how air quality modeling came to be included in its provisions and how its standard setting strategy influences how the models are subsequently used. The next two case studies describe the process whereby permits are issued for new stationary sources (one a co-generation power plant, the other an oil refinery). The next four cases involve regulating existing stationary sources (a copper smelter, a pulp mill, and two power plants). The next two describe efforts by state agencies to prepare implementation plans for controlling pollution from mobile and stationary sources. The last two cases review the process by which the federal EPA has recently revised two of its regulations: one an ambient air quality standard and the other an emissions standard for new stationary sources.

This section focuses on how the results of the application of air quality models were used in the decision process described by each case study. Table 2 summarizes the models that were used, the decision that was made, and the problems that were encountered for each case, as a reference for the discussion to follow.

CLEAN AIR LEGISLATION

The Congress first passed legislation concerning air pollution in 1955. This law restricted federal agencies to conducting research to aid state programs. Over the next fifteen years, Congress prodded the states to take action but it was not until 1971 that the federal EPA was required to, among other things, set national uniform ambient air quality standards while the states were required to develop programs to meet them.

The first federal legislation, however, viewed air pollution as a local phenomenon, best dealt with by local and state governments. Thus, the federal government was restricted to conducting research into the health effects of air pollutants and to providing grant monies to assist the local and state agencies. Out of this research grew the idea that the federal government would develop "criteria," or the scientific description of the health effects that can occur at various pollutant concentration levels in the ambient air. The criteria would then be used as guidelines by the states in setting ambient air quality standards. These ambient standards (concentration levels in the atmosphere not to be exceeded) were in turn to be met by establishing emission standards for each pollutant source in the geographic region for which the ambient standards applied.

This division of federal/state responsibility did not last long. The automobile industry, a national industry, did not like the prospect of having to meet fifty different state emissions standards. Also, there was a growing recognition that the problem did not respect state boundaries but that a source could have interstate impacts. But the factor that may have been the most important in changing the pattern of responsibility was the almost total lack of progress by the states and industry in developing programs and technology to control air pollution. Thus, the focus of legislative debate shifted to how far the federal role should be expanded and how much the economic feasibility of controls ought to be considered in setting health-related standards.

In 1970, the legislators looked at the singular lack of progress, jockeyed for popular support in the upcoming national elections, took note of the widespread public demonstrations on Earth Day in April 1970 and the vigorous lobbying by industry against any mandated controls. They concluded that if they waited until the technology was available and control was economically feasible, it would never happen. Instead, they agreed to set into law the desirable controls based on health rather than available technology. This type of technology-forcing legislation, i.e., requiring technical fixes which the experts do not necessarily agree are available, has permeated the clean air legislation since.

TABLE 2

MODELING CHARACTERISTICS OF THE CASE STUDIES

Case	Pollutant	Model/Modeler	Decision	Modeling Problem	Policy Problem
Clean Air Legislation	All	None	--	--	--
MATEP	NO_x	PSDM*/Permittee Short 1/Permittee PTMAX/State CRSTER/Permittee	Proposal to restrict operation of diesels under review.	Needed and obtained on-site data.	No federal standard for NO_x (short-term).
Pittston	SO_2	PTMTP (Larsen)/ EPA and permittee CRSTER/EPA PAL/EPA	Air permit granted (8/18/78). Water permit denied (decision appealed).	Meteorological data, coastal validation, fumigation (solved).	PSD and growth Acid rain
Anaconda	SO_2	VALLEY/EPA	Compliance schedule to reach emission limitation of model by 1988. Refinery closed down 10/80.	Complex terrain needed different disperson coefficients (obtained).	--
Westvaco	SO_2	PSDM*/permittee Cramer's model*/ EPA	Set up monitoring program.	Monitor siting, meteorological data, fumigation. Converting annual to short-term concentrations.	Impacts on inaccessible land. Monitoring on private property.

*Non-EPA Model

TABLE 2, continued

Case	Pollutant	Model/Modeler	Decision	Modeling Problem	Policy Problem
Massachusetts' Sulfur Regulations	SO_2	AQDM(Larsen)/State SCIM*/EPA PSDM*/permittee	Regulated % of sulfur in fuel, varies by source, subject to no monitored violations.	Lack of resources and data. Convert annual to short-term Not agree on alternatives to be modeled.	Tall stacks Intermittent controls
Ohio SIP	SO_2	Rollback/State RAM/State RAMR/permittee	Emissions limits based on permittee's model, subject to further modeling tests.	Monitor siting, downwash, fumigation.	Tall stacks Transport
Connecticut TCP	O_x	Rollback/State CONNAIR*/State EKMA/State	SIP revision proposal sent to EPA (7/79).	Lack of theory to treat reactive pollutants and transport.	Transport Federal EPA prefers uniform modeling from states
San Francisco AQMP	O_x	Rollback/State LIRAQ*/State	Integrated plan under review at EPA.	--	--
Ozone Standard	O_x	Appendix J/EPA EKMA/EPA Rollback/EPA	Relaxed ambient standard based on health effects.	Need flexibility in applying various models.	--
NSPS	SO_2	Energy and emissions models. No air quality models.	Variable emissions controls promulgated.	Uncertainties in assumptions.	--

*Non-EPA model.

This standard setting strategy depended, in part, on having air quality models to predict the relationship between emissions and ambient air quality. The federal EPA's research and technical assistance programs included, in addition to the health research, an air quality model development program. The models are developed by EPA but not in general used by the central EPA offices. Instead they are used by the states and EPA regional offices in setting emission standards. These agencies depend on the model documentation and communications with the geographically-removed central EPA offices when applications of the models or their review are necessary.

In several of the case studies we will see that this occasions delay (Ohio SIP) and misunderstandings (Westvaco). But such organizational confusion is not unique to the air quality modeling program as much of EPA's legislation contains this dichotomy between the federal policymaker and the state as operations manager.

It was not until 1977 that the clean air legislation required the use of air quality models in specific situations. Such models had been used extensively before this, but in the 1977 Amendments three new provisions explicitly called for their use for the first time. The three sections are for policies relating to prevention of significant deterioration (PSD), visibility protection, and nonattainment.

The prevention of significant deterioration policy came about as a result of litigation. It established increments in ambient pollutant concentrations that cannot be exceeded even if the region's air quality is cleaner than the ambient air standards. The nonattainment policy allows for an offset program, a program whereby new sources can locate in an area that has not yet attained the ambient standards only if the additional pollution can be "offset" by reductions from existing pollution sources. The new concern for impairment of visibility is restricted to those areas of the country which already have the cleanest air. The legislation directs EPA to develop a definition for visibility protection, rather than defining standards in the law.

In each of these provisions air quality models are mentioned as a tool for making policy and enforcement decisions under the law. However, our investigation of how the models came to be included in the legislation did not find any situation in which air quality models were analyzed for what information they could provide regarding accuracy and range of predictions. Instead, the legislators considered the strategy of the clean air legislation and concluded that the standard setting strategy depended on having air quality models to predict the relationship between emissions and air quality.

The starkest example is the visibility protection provisions. These were introduced through concern for two pending power plant projects to be located in the southwest. The environmentalists felt that even if the plants did not violate the PSD increments, they would visibly degrade the clean air of the area. The resulting legislation called for development of modeling techniques to predict visibility impairment without being able to define or characterize what visibility impairment means.

As far as the PSD provisions were concerned, they follow the usual form of a standard not to be violated. It was recognized that the more stringent standards required more accurate prediction techniques. However, the air quality modeling technique was seen as the best, indeed the only, available alternative for assessing new sources since no new sources can be licensed or built without a prediction of what its effects will be.

In the case of nonattainment the air quality models had been used by EPA and the states in some instances, but it appeared that in developing the offset policy only "best available control technology" requirements were being applied. The models address the additional question of whether the new source ought to be located at that particular site at all. Without them, the decision is made on economic grounds alone. Thus, the modeling requirement was added because the legislators felt EPA tended to ignore the siting problem in its offset regulations.

Thus, where standards are specified in the law and models exist to predict the impact of sources in relation to the standard, the ability of the models to make such provisions with the degree of accuracy required was discussed but generally ignored, because no alternatives were proposed. The general agreement was that models should be only one policymaking tool and that they could only be accurate to within a factor of two or more. However, little attention was given to what other tools might be available or needed. Attention was focused primarily on the political questions of how to strike the balance between protection of health and economic feasibility rather than how the legislation might be implemented. To the extent that there was evidence that EPA might be tempted too far to the economic side (nonattainment), the modeling requirement was inserted to focus efforts on the standards.

The technology-forcing philosophy of the act and its standard-setting strategy reinforced the tendency not to investigate too deeply whether models to suit the new programs were available. If the health-based standards require a given level of control, then technology to achieve that level will have to be developed. Similarly if the strategy of standards implies the use of modeling (not if the models are available), then models will be required.

Thus, the 1977 Clean Air Act Amendments were indeed amendments, changes to portions of the legislation in response to perceived implementation problems and lack of progress toward the goals of the act. They were not changes in the basic goals or strategy as established in 1970. The modeling requirements were added to focus attention on the health-based standards as the primary goal.

MATEP

The second case study examines the review of an application for a permit for a new stationary source in an urban area. Using the cogeneration concept, the source is a power plant using diesel engines to generate both steam heat and electricity. The controversial pollutant in this case was nitrogen oxides and, specifically, short-term concentrations of NO_2.

The applicant, Harvard University, proposed building the MATEP plant near downtown Boston, Massachusetts. They submitted an environmental impact report (EIR) to the state in 1975, although planning for the complex of medical institutions which would use the steam heat and electricity had begun as early as 1968. At that time, Harvard had bought nearby housing, which was to be torn down to make room to build the enlarged hospital facilities. After several design changes to the proposed plant were made in order to reduce pollutant emissions, the EIR was approved in 1977. However, before they could build and operate the plant, Harvard needed an air quality permit from the state's Department of Environmental Quality and Engineering (DEQE). This case centers on this permit decision by DEQE.

Cogeneration facilities offer several advantages over traditional power plants. The most significant is efficiency: by utilizing waste heat in nearby buildings a cogeneration plant is 30% more efficient than a normal fossil fuel plant. An ideal cogeneration site is therefore located in a cluster of large buildings. This often means an urban site. Already burdened with poor air quality, urban areas are difficult places to build power plants. The highest degree of emissions control is necessary but can still be insufficient, as when high background (existing) concentrations themselves violate a standard. MATEP's close proximity to a medical services complex calls for an extra degree of caution in designing and licensing the plant. The needs of the community would be a prime consideration in successfully designing this cogeneration facility.

MATEP got off to a good start. As designed, the plant would emit less SO_2 and TSP (total suspended particulates) and would make less noise than the plant it replaced. MATEP would provide an additional environmental benefit by reducing the local utility's load by 73,000 kilowatts, perhaps postponing construction of another power plant.

With the existing plant rapidly becoming obsolete, Harvard was anxious to begin construction as soon as possible. Also, at this time cogeneration was being praised as a forward looking, efficient source of power and, for Massachusetts, a source which might provide an alternative to nuclear power. This, combined with the fact that the proposal appeared to meet all applicable environmental standards, led Harvard to request permission to start construction even before the application for a permit had been submitted. DEQE approved this request on a limited basis. In addition to starting construction, Harvard made another decision, before getting the necessary permits, which proved irreversible. Harvard purchased six custom-made diesel engines for MATEP in 1975, almost two years before the possibility of an NO_2 problem was raised. Later, the state unofficially asked Harvard to look for alternatives to the diesels that would reduce NO_x levels. But any substitutions at this point would be more costly. Thus, Harvard, unwilling to change course after making such a commitment to diesels, instead challenged claims of adverse health effects.

The beginning of construction and the application for an air quality permit turned out to be the spur to community groups to coordinate and focus their opposition. Prior to 1977, several disparate groups had been battling Harvard's expansion into their neighborhood, Mission Hill. Although this opposition had been largely neutralized by an agreement to relocate the MATEP plant to a site where additional housing did not have to be torn down and to supply free steam heat to a nearby low-income housing project, there was a legacy of bad feelings surrounding the institutional complex which had slowly displaced residential property throughout the 1960's. With the start of construction, as concrete evidence of Harvard's intentions were seen, additional neighborhoods close to the plant but not immediately adjacent also became concerned. Brookline, the center of the most active of this new opposition, was a more affluent neighborhood and could provide professionals with the skills to interpret and critique the technical evidence being supplied in support of the proposed plant. The combination of these two interest groups (the Brookline people formed a coalition, called NO-MATEP, with the Mission Hill groups) proved stronger than the separate, individual groups because of their complementary areas of expertise. Brookline supplied lawyers and scientists while Mission Hill had experience in organizing community interests, participating in public hearings and knowledge of Harvard's previous expansion projects. As the name implies, their goal by this time was to stop the plant rather than search for alternative sites or design configurations. Their tactics did focus, however, on the scientific evidence and environmental standards as well as legal maneuvers to delay the construction and influence the decision.

Up to this time (during the EIR review) the environmental issues focused on the existing federal ambient standards, which were easily met once the project was redesigned to exclude an incineration facility. Many comments during the review criticized the assumptions and the input data used for the modeling analysis done for the EIR. To counter these criticisms, Harvard instituted monitoring at various sites near the plant and expanded their analysis to consider the downwash question, for example. This proved to be convincing to the DEQE who proposed to approve the plant subject to an NO_x emissions rate for the diesels.

However, Harvard's problems were just beginning. The exclusive focus on existing ambient standards and cost efficiency resulted from the federal air pollution legislation, which required EPA to set national ambient standards, leaving the state to enforce them and industry to try to meet them in the most cost efficient manner. This scheme, however, is not designed to uncover potential problems not yet regulated by EPA, and it was precisely such problems that the community groups opposing MATEP focused on as their previous arguments based on the existing standards were dismissed.

Public concern soon centered on the short-term NO_2 levels which would be generated by the operation of the diesels. Because EPA had not yet set a short-term standard for NO_2, the state was forced to consider evidence of health effects caused by NO_2 and establish its own standard. The state had initially been inclined to issue the permit, but the NO_2 controversy prompted it to solicit more information. Resolution of the NO_2 question was dependent on two issues: the definition of a reasonable short-term

NO_2 standard and the magnitude of short-term NO_2 concentrations MATEP would cause. Thus, the state was interested in the opinion of health experts on what concentration levels caused health effects, and it required the applicant to do more detailed modeling in an effort to refine the estimates of the emissions impact.

The health experts varied considerably in their opinions. The applicant found experts who proposed a high concentration level, while the citizens' groups found other experts who suggested caution and a low level. The state solicited opinions from a panel of experts of their own choosing. Though not ideal from a scientific perspective because the experts were not chosen in a scientifically random or systematic way, from the point of view of the alternative (choices of the applicant and the citizens' groups) it was considered an improvement and the only feasible approach given the time and resource constraints.

The evolution of the modeling analysis seems to reflect the history of the process--the development or expansion of the issues as forced by third-party interests. The new model analysis was more complex but it still relied on the assumption that all NO_x emissions from the plant would be in the form of NO_2 (all NO_x would be converted to NO_2 in the atmosphere). This was a conservative assumption because in cases where there are not high levels of ozone in the atmosphere to form a chemical reaction with NO (the primary constituent of NO_x emissions) less NO_2 will be formed and, therefore, a standard will be more easily met. Less than full conversion does not appreciably affect attainment of long-term (annual average) NO_2 standards. Thus, an analysis of conversion of NO to NO_2 had not been necessary as long as there was no short-term standard. Indeed, as long as the hourly standard being proposed was around 480 $\mu g/m^3$, the modeling analysis ignored the question of the ozone limitation because it showed the plant could meet such a standard even if all of the NO_x emissions were converted to NO_2. However, as lower standards began to be considered, Harvard brought up the question of conversion. None of the air quality models used could deal with reactive pollutants, such as NO_x, so that additional analysis was added onto the original model estimates. Criticisms of this approach and the data concerning actual ozone levels were, naturally, presented. But the major tactic of the opposition was to focus on the fact of conversion. Because 100% conversion could take place given enough ambient ozone, they maintained that the most conservative, "worst case" assumption was in fact 100% conversion. Thus, the question of how best to account for the reactive nature of NO_x was not systematically addressed because of the nature of the process in which single point (worst case) standards are the goal.

The effect of such standards and the available models can also be seen in the relative lack of discussion of the diesel emission rate. Although the federal EPA sets emission rates for many kinds of sources (new source performance standards), they have not yet done so for stationary diesel engines. Thus, the state was once again called upon to set a standard. In this case, once an ambient standard had been set they could work backwards, using the modeling analysis to determine what emission rate would be necessary to enable the plant to meet the standard. The models required data input of average monthly or annual emission rates to predict the short-term (hourly) ambient concentration levels. Thus, the question of the impact of the high variability of emissions at start-up or on a short-term basis was ignored by the model and, it turned out, also by the parties in the dispute.

The new model analysis was more complex but, when the modelers were asked what the level of accuracy was, they could say only that they were accurate to within a factor of two. The result was that because the one-hour health effects threshold or standard and the ambient air quality model results were both estimated to be within the same range, the policymaker did not have a clear picture as to which way the decision should go. The lack of a federal standard seems to have pushed the decision makers into examining more closely the accuracy and uncertainties of the model results. The close proximity of the public interest groups to the decision maker also helped to keep the controversy alive. The public comments seemed to have been effective in raising questions about aspects of the model assumptions which might otherwise have gone unnoticed by the government analysts who were reviewing the applicant's modeling results.

The role of the citizens' groups or public interest lobbies points out another use that was made of models in the MATEP case. Several citizens have stated that they oppose the construction of any power plant in an urban area and they specifically oppose the expansion of a large institution like Harvard University into their residential neighborhood. Thus, all information that can be used against the applicant, and only such information, is presented. Of course, the applicant also presents only such information as is advantageous to his position. But that is the purpose of the public hearings, to hear both sides of the issue.

For the decision maker who is not familiar with the details of the modeling, however, it becomes a question of how to choose among the experts. Numerous lengthy hearings have been held on the matter to ascertain how the experts arrived at their conclusions. The decision shifted several times over this period as new issues were raised.

To summarize, the models in this case were used to redesign the project to meet applicable standards. Neither the applicant nor the state environmental agency looked beyond what the models could tell them or beyond the strict requirements of the legislation until third-party interests forced them to do so. However, the public interest groups were not motivated either by a search for the best alternative. They were concerned with stopping the institution behind the project, who they felt had ignored their concerns in other areas for many years, and used the environmental arguments as tactics in this battle. The resulting controversy stimulated the decision maker to consider just what the assumptions and model's methodology and accuracy implied. The uncertainties revealed in the process helped shape the final decision which requires monitoring of the plant's impact. When (if) the monitoring results exceed a certain level (230 $\mu g/m^3$), the diesels will have to be shut down and electricity purchased from the local utility.

PITTSTON

The third case involves the application by the Pittston Company for permission to build an oil refinery in Eastport, Maine. Eastport is a rural community on the northeast coast of Maine near the Canadian border. It is also near a national wildlife refuge and an international park and the project is subject to the prevention of significant deterioration (PSD) provisions of the Clean Air Act. These provisions establish increments in air quality which cannot be exceeded by any combination of new projects in such areas. The increment under contention in this case was the 24-hour sulfur dioxide standard of 5 $\mu g/m^3$.

Pittston had first sought approval from the state of Maine in 1973. However, state regulations at that time did not cover air pollution programs. Thus, EPA was the government agency responsible for reviewing the air quality impacts of the proposed oil refinery. The Pittston Company submitted a draft environmental impact statement (EIS) to EPA in 1976 and formally applied for a PSD permit in the spring of 1977. EPA's initial review of the application was positive. But, when the Clean Air Act Amendments were passed in the summer of 1977 designating nearby national parklands as Class I areas, areas to be protected against significant deterioration of the air, Senator Muskie of Maine, as Commissioner of the park and as EPA's prime supporter in Congress, objected to the proposed refinery. The regional office then undertook its own analysis of the project and announced it could not approve it based on this analysis.

Over the next year, in response to both EPA's and several public interest groups' analyses, Pittston redesigned the project and was able to win EPA's approval for an air permit in August 1978. Pittston, however, has been denied a wastewater discharge permit by EPA so that it is not expected to begin construction in the near future. This case study is concerned with the air quality models that Pittston used to redesign the project and that EPA used to review and approve the air permit.

EPA has made several air quality models available to the states or an applicant by means of a computer program. The Pittston Company used one of EPA's models to show that the oil refinery's emissions would cause increased 24-hour SO_2 concentrations at the park of 4.3 $\mu g/m^3$ which is within the incremental limit of 5.0 $\mu g/m^3$.

The organizational unit within EPA responsible for evaluating the application and approving or denying the permit was its regional office located in Boston, Massachusetts. The regional office conducted its own modeling analysis using different models and came up with numbers two to three times as large as Pittston's numbers, which, therefore, indicated violations of the standard. During the next several months negotiations were held with the applicant. They centered on how the available models should be modified for the unusual site (coastal) characteristics, the assumptions concerning proper methods for deriving 24-hour concentration levels, and what constituted reasonable worst-case meteorology.

Two problems of significance to this study arose during the review of the permit application and remained unresolved. The first problem was that the meteorologic data used for the analysis came from a site over 100 kilometers away. Later, data from a site about 25 kilometers away was also used. The unique meteorology of the coastal site generated much debate on just how representative this data was. Although under the 1977 Amendments to the Clean Air Act, EPA can require an applicant to collect meteorological data, no attempt was made to require on-site monitoring in this case. The amendments were passed in the middle of the permit review and the EPA Region I office decided to "grandfather" the project and follow the regulations under which the application had been originally submittted before the new legislation was passed. Although the particular standard in question was not changed by the 1977 amendments, several procedural matters and some control requirements were, and they would require more time and resources from both Pittston and the EPA regional office. The decision to "grandfather" the project precipitated a law suit from several public interest groups as well as leaving open the question of the suitability of the meteorologic data.

The second unresolved problem concerned the results of a validation study for the model used in the analysis. The one coastal site studied showed that the model underpredicted, and this was pointed out in the public comments to the EPA regional office. EPA's response was that underprediction had not been found in other studies. However, this evaded the question because other validation studies of coastal sites had not been done. Several other modeling issues were also discussed, such as fumigation analysis and a 24-hour scaling factor. These issues, however, were resolved by calling on recognized experts within EPA who were able to agree on one technique.

After their review of the draft EIS and Pittston's permit application, EPA proposed to disapprove the project based on their modeling analysis. The company responded by making major design changes in the project in an effort to reduce the impact of emissions to within the allowable limits. For example, they eliminated an anchorage site for tanker traffic and lowered the sulfur content of the fuel oil. Thus, the models were used as a design tool to trade off economic efficiency and environmental impact.

However, certain emission parameters were also changed, including the number of stacks and exit velocity from the stack. In this case the project was designed around the model. Without changing the total amount of the pollutants, the models' specificity was exploited. The models determine ambient pollutant concentrations by relating them to emission rates and not total emissions. The models were not designed to answer the question of build-up of airborne pollutants in other media, such as water or land, or long-term effects. Thus, both the applicant and the decision maker ignored these questions because they did not have the means to address them.

The sequence of events which led up to the final approval of the permit implies another use of the models. The decision maker, the EPA regional office, was also a member of a governmental task force assembled to coordinate the task of siting oil refineries in New England. Thus, one objective of the EPA regional office was to help in finding a suitable site for an oil refinery. Sites other than the proposed site in Eastport, Maine, were discussed in the environmental impact statement but were rejected on economic grounds. Negotiations were then conducted between the agency and the applicant in an effort to design the project so that it would conform to the environmental constraints. Thus, it was politically advantageous and in the interest of EPA to approve this permit. The way was made easier because of the way the models are constructed and used. The model results are presented as single point estimates to be matched against a single standard value. Worst case meteorology is used and no sensitivity analysis was done to account for the possibility of underprediction. Moreover, the documentation and guidelines for choosing assumptions are ambiguous. The EPA regional office was able to pick one end of the suggested range for the wind speed, for example, without further justification other than "it appeared in the guidelines."

It was the job of the scientists in the EPA regional office to run the models, justify the assumptions, and respond to public comments. Discussions with the regional administrator, the ultimate decision maker, seem to have been limited to the legal question of when, not whether, the permit should be issued. Apparently they did not discuss the questions of how accurate the model results were or what environmental impacts may not have been measured. Although the allowable PSD increments at issue here appear to be of the same type as the other standards EPA administers, they are easier to violate and demand more precise measurement. Because the decision maker was not familiar enough with the air quality models to make this distinction, he had to rely on the analysts. Yet the analysts did not raise this issue because they did not have other methods to draw on.

To summarize the findings in this case study, the models were appropriately used to redesign the project to reduce the impacts on air quality. They may have been used inappropriately if long-term and other impacts, such as acid rain, are considered, because the models are not equipped to deal with such problems. The analysis also may have been used to justify a decision taken on other grounds. This was facilitated by the lack of familiarity by the decision maker with the models, the tendency within EPA to emphasize worst case analysis, and the lack of validation studies and documentation. The end result of these tendencies is one point estimate compared with the standard level without reference to accuracy or other uncertainties.

The role of the public in this case was somewhat circumscribed. The main opponents were the local citizenry, who lived in or near Eastport and were fishermen who felt their livelihood was threatened by the oil tanker traffic, and federal government officials concerned with the air quality impacts of the project on nearby federal park lands. Thus in this case, as opposed to the MATEP case, the citizens' groups opposing the permit were located in northern Maine and in Washington, D.C., while the decision maker and applicant were negotiating in Boston. This caused delays in obtaining information so that often the public comments were no longer relevant by the time they reached Boston. It was also frustrating for the public interest groups because they could not participate in the negotiations and the changes in the project design and modeling analyses would take them by surprise. They were constantly put in the position of requesting time extensions for the public comment periods so that they could receive the new materials and do their own critique.

EPA was under some time pressure to come to a decision on the permit application because it was grandfathered under the 1977 Clean Air Act Amendments, and this exemption from the new regulations could not be extended indefinitely. Thus, EPA was reluctant to grant the public comment extensions except when requested by Senator Muskie.

The public interest groups did submit critiques of the modeling analysis and in one instance were able to get a change in the project design (elimination of an anchorage site). However, many of their issues, such as the lack of suitable meteorologic data and validation studies for determining appropriate input parameters, were not resolved. Indeed, EPA technical documents recognized the problems but no policy discussions on the issues seem to have been held. The reasons for this appear to be the pressure to make a decision under the new amendments and the desirability of the site for purely economic reasons, as well as the lack of analytic tools to handle the questions and the geographical separation of the public interest groups from the EPA regional office.

The relative importance of this factor can be seen in comparison to the MATEP case. In both the Pittston and the MATEP cases the public asked questions which involved additional analysis on the part of EPA (or the state) and which did not appear on the agenda until the public interest groups raised them. However, the proximity of the interest groups to the decision making agency in the MATEP case seems to have been part of the reason for a greater and more detailed response from the state to the environmentalists' concerns.

ANACONDA

The Anaconda copper smelter is located in Anaconda, Montana. The smelter and the adjoining copper mine are virtually the only source of employment for this area of Montana and the only source of SO_2, as well. The operations provide close to 12% of the domestic U.S. copper production. Montana established state air quality standards in 1967. It was not until 1971 with the establishment of federal standards that the company agreed to install control devices to reduce emissions. Their proposal was to meet the 90% reduction as required by the state by 1973.

Before an agreement could be reached, however, events at the federal level caused Anaconda to retract its proposal and claim that such stringent controls could not be required. The federal Office of Management and Budget (OMB) had recommended that EPA delete the requirement for emissions limitations from their SIP guidelines to the states and that economic impacts be considered in choosing control measures. EPA revised its guidelines to reflect the OMB recommendations. Anaconda subsequently petitioned the state to revise its SIP regulation, requiring 90% reduction in SO_2 emissions, citing the new SIP guidelines from EPA.

Within the state government there was disagreement on what the SIP regulations ought to be. The State Board of Health continued to push for the 90% removal requirement, but the governor did not support it. Without the governor's approval, EPA was forced to propose its own SO_2 regulations for Montana. The EPA proposal for the Anaconda smelter turned out to be based on faulty and very limited data--one 24-hour sample from a monitor which was found to be malfunctioning and uncalibrated. Anaconda went to court over several issues concerning EPA's proposal. Regarding the data base the court reprimanded EPA for using what it felt to be an arbitrary figure which EPA intended not as defendable, in fact, but as bait for discussion in subsequent public hearings.

The court's opinion that EPA had done an inadequate job in proposing a standard originally seems to have been the incentive needed for EPA to commit vast resources to modeling this particular copper smelter. EPA had learned that, while they may be given the benefit of the doubt on technical issues, the court would not stand for no effort to compile a technical basis for its decisions. Also, non-ferrous copper smelters were singled out in the Clean Air Act as sources particularly difficult to control and, hence, potentially able to receive exemptions from complying with standards. EPA had developed the "Valley" model for this particular situation and wanted to prove its worth.

Thus, EPA began to collect data near the smelter and develop a model for analyzing the impact of copper smelters located in mountainous terrain. EPA was faced with developing regulations for several such copper smelters so the model was not just for this one unique situation. What was unique was the use of helicopters to monitor actual impacts for validating the model for the Anaconda plant. These were supplied by the EPA Las Vegas laboratory, which was relatively close by and whose mission included working to upgrade EPA's monitoring program, so that the Anaconda project fit with its responsibilities as well.

Throughout this modeling effort, EPA proposed specific emissions limitations based on the modeling results. The company would then criticize the model and make its own proposal which was in turn generally supported by the state. The state was reluctant to take action against such a large employer in its state. Indeed, at one point the company threatened to close the plant if EPA's proposal went into effect. Again, EPA's response was to do its own analysis. In this case it hired a consultant who concluded that, while economic impacts would be significant, it was unlikely that the smelter would close. Thus, EPA continued to upgrade its technical analysis as its response during the decision process.

By January 1980, all parties had agreed to a compliance schedule for the Anaconda copper smelter which would mean an emission limitation of 142 tons per day (down from current emissions of 170 TPD) by 1988. At the final hour an EPA agency policy (that smelters would be subject to a 6-hour standard as well as a 24-hour standard) was arbitrarily applied and raised objections from the company. But on further reflection a compromise was reached and the emissions limitation based on the model analysis stood.

The case of the Anaconda copper smelter in Montana is an example of EPA spending an unusual amount of resources to conduct and defend its own modeling effort. The company criticized the modeling as it progressed but did not do its own modeling. However, the company did install, over the years, pollution control equipment which resulted in a total of almost 80% reduced emissions. Also, the final decision by EPA was based directly on its modeling analysis, after it was revised to reflect the company's comments and validated by extensive and expensive monitoring data.

The agreement, however, seems to be due to a change in the attitude of both the governor of Montana and the company as much as it was due to the extensive monitoring and validation efforts of the EPA Las Vegas laboratory. Early in 1978, the Atlantic Richfield Company bought the Anaconda Company. Their willingness to make this investment took into account the pollution control problems, and they were willing to negotiate with EPA where Anaconda had not been. Also, the outcome of the state elections was such that the governor and the State Board of Health were in accord for the first time in this process so the state was willing to participate in the negotiations.

The dependence of the eventual outcome upon the willingness of the separate parties to view the agreement as in their self-interest becomes clear in the events subsequent to the approval of the compliance schedule. In October 1980, Atlantic Richfield announced the closing of the smelting operations. Their decision, which led directly to the loss of jobs by two-thirds of the inhabitants of the town of Anaconda, followed a nationwide strike of copper workers. Striking workers settled and went back to their jobs at all but the Anaconda smelter. Also at this time, Montana promulgated stricter air quality standards. The company chose to cite the environmental and health and safety regulations as the cause of the plant closing. The company has obtained a seven-year, multimilion dollar contract with Japan to smelt the copper mined in Anaconda.

WESTVACO

Maryland's SIP requires all plants either to burn 1% sulfur-in-content fuel or to install emission control equipment. Since 1975, the Westvaco company has sought an exemption to these requirements for one of its pulp mills claiming it could burn up to 2.7% sulfur fuel without violating ambient air quality standards. In 1974, Westvaco had bought several nearby coal mines but would not be able to use this coal in their mill if they were required to burn 1% sulfur fuel. Over the years, they submitted monitoring data and an air quality analysis in an effort to gain approval of their exemption request.

The state of Maryland approved Westvaco's request. The company is a large employer throughout the state, and state officials cited the energy and employment problems and the competitive disadvantage for them in not exempting Westvaco as part of their concern in this matter. The EPA regional office, however, did not support approval of the exemption. Their review of the company's air quality analysis convinced them that violations of SO_2 standards would occur unless the lower sulfur coal was burned (or other controls applied).

In 1976, Westvaco completed construction of a smokestack 600 feet high. Under the existing legislation, this was legal and could be done without EPA's approval. It was not until the 1977 Amendments to the Clean Air Act that taller smokestacks had to be justified, as preventing a downwash problem, so that they would not be used to export the pollution problem downwind.

Also in 1976, Westvaco installed SO_2 monitors in an effort to show that no violations occurred when the higher sulfur coal was burned. The land where violations of the standards were expected to occur (to the south and southwest) belonged to Westvaco. Westvaco chose not to monitor there, and the federal EPA had not issued a policy for monitoring on private land. Throughout this time they were reviewing the issue but had come to no decision. Instead, Westvaco sited two monitors to the north and one to the east at the bottom of the valley (600 feet below the top of the stack). Safe in the knowledge that the monitors were not likely to record the highest concentrations, Westvaco claimed that the monitoring evidence showed no violations of SO_2 standards. If there were no violations monitored, they reasoned, there was no barrier to granting the exemption. The EPA regional office continued to point out that the monitors were not sited so as to detect violations, but it turned out to be a battle of words. EPA was unable to persuade Westvaco to change their monitors, and it lacked the resources to do its own monitoring.

Another controversy concerned the area where EPA suspected that violations would occur (to the south of the mill). Westvaco claimed that this area was inaccessible and uninhabited so that standards to protect <u>public</u> health should not apply there. Even after EPA discovered a secondary road and several homes there, the company did not drop its claim in its subsequent pleas to Congress.

A third claim by Westvaco was also not strictly according to the facts. Westvaco claimed that low sulfur coal was not available locally. However, the Sierra Club, in opposing the exemption request, showed that low sulfur coal was available but it would cost more and it was not part of the coal resources owned by Westvaco.

The EPA's regional office response was not without problems, however. Because they lack the resources to do modeling for each permit application, their policy is to do no modeling of their own but, rather, to criticize the applicant's modeling in an effort to get changes in the assumptions or input which they think will more closely approximate "worst case" concentrations. For almost two years (November 1975 to August 1977) EPA outlined its objections to Westvaco's model. The major problem with the modeling analysis was the complex or hilly terrain surrounding the plant. There was not a model available which would readily deal with this problem so that the criticism dealt with how Westvaco had altered the available models. EPA criticized the fumigation and trapping analysis, the lack of on-site meteorological monitoring, the assumption of no SO_2 background levels, the terrain reflection factor and the sector averaging assumptions. These last two assumptions, for example, are used to model the impact of elevated terrain on the vertical and horizontal dispersion of the plume and had a significant impact on the model results. Westvaco's numbers for these factors produced results one-fourth as large as results using EPA's suggested numbers for the same factors.

The example of the terrain reflection factor (where Westvaco modelers assumed total absorption and EPA assumed total reflectivity) is similar to the disagreement over how to treat individual sources at the plant. Westvaco modelers suggested averaging the sources and EPA said common modeling practice treated separate plumes as additive (pointing out that Westvaco's approach would tend to cause each additional source to decrease rather than increase the total impact of the plant). Both of these examples show the opposite extremes chosen by each side. Throughout the three-year modeling process they were unable to reach a compromise on these and most of the other areas of contention. This result seems to have been due, in part, to EPA's approach of stating in the most technical of terms how it should have been done but not providing any financial incentive for Westvaco to comply, not providing model results for comparison with Westvaco's analysis, and not addressing the broader issues of employment and energy that Westvaco and the state raised.

Thus, Westvaco was unwilling to change either its modeling or its monitors. In the face of this intransigence, EPA proposed to disapprove the exemption request.

Westvaco's response was to appeal to Congress for support. Several senators and representatives from the region held positions on various committees which oversaw EPA's budget. It was to these congressmen that Westvaco appealed. Westvaco emphasized the fact that no violations had been monitored, that its models predicted no violations, and that EPA had produced no modeling analysis of its own to show violations. The company also stated its concern that EPA's disapproval of its exemption request would have adverse consequences for the employment and energy situation of the region. The congressmen, in turn, wrote EPA expressing their concern that EPA was not giving due attention to the Westvaco request.

The culmination of these exchanges of letters was a meeting set up by Senator Randolph where Westvaco consultants came prepared to fully defend their model but EPA appeared unprepared, having misunderstood the purpose of the meeting. EPA had assumed that a congressman was interested in the policy issues rather than the technical issues, and did not have technical presentations ready.

There generally seems to have been little communication between the parties except on the narrow issues of the Westvaco model. However, after the meeting the EPA did hire a consultant to do some modeling and did begin to respond to the range of technical issues raised by the congressmen as well as by Westvaco. But the agency was still circumscribed by its plans for proceeding with the SIP revision process. This is exemplified by its response to the suggestion of a joint industry-EPA study of models. EPA refused on the basis that its modeling had already been "objective." It did not see any need for, perhaps, establishing a legitimacy to the process in the political arena beyond the legal procedural requirements.

In the end, the EPA model was used to help site a new monitoring network which Westvaco is required to run during a three-year variance which will allow them to burn higher sulfur fuel. Already it appears that the new monitors do indeed show violations, as EPA has contended. But the more appropriate monitoring network was established more than four years after monitoring was first begun. The delay seems to have been in part due to the lack of an EPA policy on monitoring but also due to EPA's conception of how such decision processes ought to be managed. EPA expected the Westvaco modelers to respond to its criticisms and continued to review only the narrow issue of modeling even after the controversy had been taken to Congress and expanded to include other issues such as employment. EPA, supported by the courts, had taken the position that the Clean Air Act requires a polluter to prove his case on his own time, i.e., that emissions must be reduced to comply with SIP provisions during the time an exemption is sought. However, EPA did not enforce this policy in the case of Westvaco and, after the issue was appealed to Congress, its decision was to allow the burning of higher sulfur coal during the three-year monitoring program. Thus, Westvaco had no incentives to change its modeling or monitoring until after EPA did its own analyses that pointed out the faulty monitor siting and required changes in Westvaco's monitoring network as a condition of continued operation of the plant.

MASSACHUSETTS' SULFUR REGULATIONS

In 1970, the state of Massachusetts set an ambient SO_2 standard and developed regulations for meeting this standard; the regulations included a restriction on the sulfur content in fuel that could be burned in the Boston area. The restriction to 1% sulfur fuel at first and then to 0.5% sulfur fuel was based on technology (the fact that such fuel was available even if more costly) rather than any link to ambient air quality. It was not until the energy crisis (with rising fuel prices) that the public, and the Massachusetts legislature, required a technical justification based on the impacts on ambient air quality for these regulations.

By 1973 a few modeling efforts had been undertaken. The rollback model was used by the state to justify its 0.5% limitation. A study by the Harvard School of Public Health (whose project director would later be hired by the utilities to perform modeling analyses) predicted that the regulation could be relaxed to 1% without violating the state ambient standards. The regulations were indeed relaxed in response to the technical analysis and widespread public support in the face of rising fuel prices.

This relaxation did not, however, solve the problem. In 1974, the Massachusetts legislature passed a law that required the state standards to be no stricter than the federal standards and for the standards to be met in the most cost effective manner. In response, several interested parties initiated modeling analyses. Each party (utilities, the state, and

EPA) formulated the question to be answered by the model from their own perspective. The utilities wanted to be able to burn higher sulfur fuel as often as possible and proposed fuel switching plans. The state asked what percentage sulfur fuel would be sufficient to assure that the national standards were met; they wanted to change the content but not the form of the existing regulations. EPA was concerned with enforcement of any fuel switching plans so tended to favor permanent limitations but also was concerned with the possibility of future growth so that just meeting the standard was not enough. Thus, although each interest used an air quality model to predict ambient air quality, their different perspectives led to different conclusions.

All of the models that were used were, however, an improvement over the previous technical analysis. For instance, the state developed an improved emissions inventory (still based on fuel usage rather than actual emissions) which allowed for more accurate geographical distribution of emissions. Also models which calculated the varying impact of certain meteorological parameters such as different wind directions and speeds and stability classes were used. Questions remained, however, about the techniques used to estimate 24-hour concentrations from either hourly or annual averages.

In all, four modeling studies were done: one by the state, two by the utility interests and one by the EPA regional office. In theory, numerous analyses of one problem might give the decision maker (in this case, the state, but with EPA's approval) a good range of data with which to work. However, in practice, there was very little effort made to coordinate, relate or compare the various modeling efforts and the consequence was that the state felt free to base its decision solely on its own model analysis and its own perspective on the problem.

None of the parties felt that it was its responsibility to contrast or compare the analyses. EPA criticized the state's modeling assumptions and data but did not reach an agreement on what should be done. In its own analysis, a different model was used but, further, EPA's consultant did not analyze the alternative actually chosen by the state. Instead, EPA continued to push its model as superior for answering its own particular questions. The result was that the state made a decision based on its model and EPA was forced to agree since no violations were being monitored and experience supported the state's stand.

EPA had maintained that the state's analysis was not accurate enough to regulate large point sources and plan for future growth. But the state's situation was that a deadline for the regulation had been set, it did not have additional resources to do more modeling, no standards violations were predicted by its models or had been observed, and the legislation had clearly mandated less restrictive emissions limitations. Thus, the state proposed as a trial to implement its alternative for one year to see if violations occurred. In this light, the EPA regional office agreed that the state's modeling was better than could be expected under the circumstances.

It should be noted that in the end much of the resistance to the fuel regulations (as opposed to the modeling) came from the EPA's headquarters office rather than the regional office located in Boston. Several elements of the state legislation which precipitated the fuel regulation review appeared to be inconsistent with national policy. These included the mention of taller stacks and fuel switching as possible solutions. From a national perspective tall stacks can only be justified in cases of a downwash problem. The state's modeling did not include stack extensions but this had to be explicitly clarified in the discussions. EPA also objects to "intermittent control systems," such as fuel switching based on meteorological conditions, because of the enforcement problems involved. The utilities had requested such a system but the state was proposing permanent limitations. Where a plant's emissions impact was predicted to be near the standard these sources were required to maintain monitoring systems and a short-term supply of low sulfur fuel in case the models had underpredicted. Thus, the state was able to meet EPA's objections when the discussions were focused on the policy and implementation implications.

Generally, EPA objects to regulations that carry the presumption that they may have to be tightened. Rather they work for regulations that are conservative and may have to be relaxed in the future. The court upholds this view of the SIP process. This view is based on the cost and time required to reach compliance when capital expenditures for control equipment are required. However, in this case, over the years it was shown that plants could readily change the type of fuel they used. Indeed, the utilities proposed compliance through fuel switching. Thus, a trial period to test the model's predictions without requiring the higher expenditures on low sulfur fuel may be a good solution given the relatively quick response possible to regulation changes. It was satisfactory from the state's perspective because it felt that its monitoring network would indicate compliance or, if not, that stricter regulations could be promulgated. EPA tended to resist this view, since, from a national perspective, a conservative (stricter) approach was necessary for those states reluctant to enforce Clean Air laws.

OHIO'S STATE IMPLEMENTATION PLAN

Ohio was the last large industrial state to propose a State Implementation Plan. However, it could not agree on what SO_2 control plan to include so EPA formulated one instead. The EPA Region V office first proposed a plan based on the linear rollback technique. As a result of public hearings where extensive criticisms of the plan were voiced, EPA replaced its analysis with one using an air quality dispersion model called RAM.

The state had taken from 1972 to 1975 to propose an incomplete SIP. EPA's SO_2 plan based on RAM was promulgated in 1976. It contained specific emissions limitations for Ohio's power plants. The utilities took EPA to court questioning EPA's procedure in setting emissions limits (replacing linear rollback with RAM without additional public hearings) as well as the capability of the RAM model itself. The state joined the utilities' suit, questioning EPA's authority to impose a plan on the state. EPA corrected the procedural problems, and the court upheld EPA's authority and decisionmaking based on the RAM model. Through the court suits, however, the state and the utilities had gained considerable time. The court ruled in favor of EPA in February 1978, six years after the legislative deadline.

But the court's ruling did not guarantee action. The utilities responded with requests for specific revisions for their plants. This case study looks at the actions taken by the Cleveland Electric Illuminating Company (CEI) for its plants near Lake Erie.

At the time CEI had joined the court suit against EPA's use of RAM, it had also set up a monitoring network around its plants and began its own modeling study. These actions by CEI effectively set the stage for the ensuing dialogue between EPA and CEI over the requested SIP revision, a dialogue which was to last for almost three years.

EPA did not take any steps to influence CEI's modeling efforts until after the court upheld the SIP. At that time they documented their criticisms of the monitoring network and CEI's use of the rural version of the RAM model. EPA asked for corrections from CEI and the discussion came to dwell exclusively on model assumptions and accuracy and the comparison of EPA's application versus CEI's.

EPA had problems with much of the company's modeling analysis. The rural RAM underpredicted at several of the monitoring locations; neither the analysis nor the monitors were arranged so as to show maximum impacts; their fumigation analysis only addressed one of the stacks; their monitoring network lacked spatial distribution; and the company's analysis depended on building taller stacks to avoid downwash but defended this action with an old study based on different operating characteristics.

The EPA Regional Office could only ask for better modeling and threaten CEI with disapproval of its SIP revision request. This narrow sphere of responsibility caused two problems: (1) EPA was unable to resolve the question of whether CEI could build additional height onto its stacks in lieu of reducing emissions and (2) EPA's threat became a hollow one when a statement by the federal Council on Wage and Price Stability (CWPS) effectively eliminated all solutions except the non-compliance one. In the end, the EPA Regional Office was left only a defense on technical grounds of a model they admitted did not cover some important issues (downwash and fumigation) and had no means to require the company to provide better monitoring data. Also, while CEI's model underpredicted, EPA's model (urban) RAM overpredicted in some cases. But requests by EPA for CEI to use a better model fell on deaf ears.

The company, of course, acted in its own self-interest. It sited its monitors so that the model would come up with the "right" answers; it selectively used data from an old study purporting to show a downwash problem so as to justify the building of taller stacks; it went on to build the taller stacks in the face of EPA's indecision on a policy for this issue; it failed to do a fumigation study, preferring to claim it did not present a problem though without data to back the claim; and it continued to submit data only from the original monitors. All this served as delaying tactics while the Ohio utility industry sought help from Congress and the White House.

The Section 125 amendment to the Clean Air Act in August 1977 and the CWPS statement in March 1979 provided that assistance.

Section 125 of the Clean Air Act (first proposed by the Senator from Ohio) allowed the President to restrict a power plant to using only locally available fuels if this was necessary to prevent local economic disruption or unemployment due to a switch in fuel use in order to comply with a SIP requirement. The CEI plants are the largest users of high sulfur Ohio coal. CEI threatened to switch to out-of-state lower sulfur coal if forced to comply with EPA's SO_2 plan. The governor of Ohio asked that Section 125 be invoked. EPA proposed to do just that. This would leave CEI with three options: (1) mix high and low sulfur coal (more costly than just high sulfur coal), (2) install costly "scrubbers" to clean the stack emission, or (3) not comply with EPA's SO_2 emissions limitations.

At this point the President stepped in, through his Council on Wage and Price Stability. CWPS issued a statement saying that the economic disruption would not be as severe as EPA had indicated but that scrubbers, by raising electricity costs, would cause unemployment. The statement concluded by saying that economic considerations would likely delay compliance with the SIP. CWPS, thus, chose the non-compliance option.

The debate returned to the modeling analysis. EPA again requested better monitoring and modeling and CEI responded with more data from its original monitors. The final decision, breaking this stalemate, was apparently made by the EPA headquarters' office. In May 1979, CEI was informed that, while neither EPA's nor CEI's data seemed to be sufficient for a modeling analysis, "status quo" emissions rates were being proposed because of the severe economic hardships involved. This decision did, however, require expanded monitoring and testing around the plants to improve the analysis and possibly provide for restricted emissions in the future.

This case points out the consequences of the narrow perspective of the EPA modelers. Their job appeared to them to be to produce the best model analysis that they could, including critiquing the industry models. This narrow focus on the models as the issue hid the true issues. For instance, the issue of long-range transport of pollutants and acid rain from the taller stacks was never really addressed. Only the question of whether EPA wanted to impose a case-by-case demonstration of downwash or whether this represented an "undesirable burden" on existing sources. The question of what impact the taller stacks of the CEI plants had on out-of-state areas downwind of the plants was not of concern to the state and utility officials and, also, could not be answered by the available models. EPA headquarters in the face of the uncertainty and opposition could not decide on a "tall stacks" policy, and the company was free to build them although the final decision did include provisions for further analysis of this problem.

A second example of an unaddressed issue is the full range of economic consequences. The models do not deal with costs, and the Clean Air legislation only allows cost-effective considerations in what controls to impose, not on whether to impose controls. However, the final decision stated that economic considerations were paramount in this case. The difficulty is, then, that no strict analysis based on economic impacts was done. Numerous statements about costs were made in public hearings, for instance, but no official decision or technical document compared the costs of the various options and whether the costs of an option other than non-compliance might be acceptable. Thus, EPA, seemingly restricted to analyzing air quality and not cost impacts, eventually made the decision to delay compliance based on economic grounds which were not fully analyzed.

A third issue not appropriately addressed was the monitoring and collection of input data. The lack of attention at the very beginning when the company set up its monitors lost for EPA the ability to collect appropriate input data. Also, by limiting their actions to criticisms and requests for changes, EPA did not provide any incentives for the company to do a better analysis. Instead, the company's response was to lobby the state, Congress, and the White House for support. The EPA Regional Office is restricted in what it can do, of course, and did try to get EPA headquarters to issue a tall stacks policy but it was essentially alone in its opposition to CEI. The active opposition by the state, Congress, and the White House as well as the passive attitude of EPA headquarters undermined the work of the Regional Office. They were supported by the court and the EPA Office of Research and Development. However, the court can only act when asked and ORD only spoke to the incomplete modeling analysis. Thus, the question of tall stacks, long-range transport and acid rain was not addressed because the discussion of issues was never expanded beyond the narrow local impacts that the available models addressed while the spectre of economic hardship (without technical analysis of the issue) won the day.

CONNECTICUT'S TRANSPORTATION CONTROL PLAN

The state of Connecticut had to develop a plan for controlling pollution sources within its borders so that the national ambient air standards would be met. The particular portion of the plan that this case investigates is the transportation control plan (TCP) aimed at meeting the ozone standard.

When work on the implementation plan first began in Connecticut, EPA required the use of a technique called Appendix J, a modified form of rollback. The graph to be used by the states was based on data from such cities as Los Angeles. Thus, Appendix J was criticized as being inapplicable to other cities not included in the graph. The method for generating the graph which would be specific to a particular city required five years of data on ambient pollutant concentrations. Such data was not available in most cases. Thus, many states pressured EPA to allow them to use the linear rollback method. The only other alternative was complex photochemical dispersion models which required even more input data.

Apart from the problems of data Connecticut also was beginning to discover the problem of transport, the flux of ozone and ozone producing pollutants into their state from other, upwind states such as New York, New Jersey and even midwestern states. Neither rollback or Appendix J, nor EPA policy, recognized the transport factor. They treated all pollution as having been produced, and therefore subject to control, locally. The result was modeling analyses requiring 90 percent control of all sources. A number considered by Connecticut as impossible and, because of transport, unnecessary to achieve.

Thus, Connecticut decided to develop its own model to take the pollutant transport problem into account. This model consisted of a fixed grid system with an extensive inventory of source emissions superimposed on it, with assumptions made about how the sources mixed and were dispersed within each grid. It estimated the effects of transport and reduced emission reduction requirements accordingly. Connecticut's model also attempted to portray the non-linear relationship between ozone and ozone precursors (hydrocarbons and nitrogen oxides which react in the presence of sunlight in the atmosphere to produce ozone and other oxidants). The linear rollback and Appendix J methods assumed an essentially linear relationship and, as a consequence, required higher emissions reductions than a model based on a non-linear relationship would.

The state environmental agency ran into opposition from several quarters. Although the state transportation agency had cooperated in the development of the state model and supplied traffic control data, when the model results showed that large areas of the state would have tight restrictions on what highways could be built, the agency quickly changed its position. It criticized the model and emphasized that transport, rather than in-state mobile sources, was the problem. The state legislature joined the transportation agency in opposing the plan based on the model. The legislators and the governor did not speak to the technical merits of the model but opposed any plan requiring controls as long as EPA ignored the transport problem. Their attitude was that they would be willing to implement controls if the other states in the region were also required to, but they would not do it alone and clean up someone else's pollution. When concessions were made, environmental lobbying groups concerned with public health and environmental impacts also began to oppose the model results. Thus, the state environmental agency was opposed on all sides within the state for primarily policy reasons even though this was camouflaged by technical criticisms leveled at the model.

When they turned to EPA for support, however, they found it lacking there as well. The initial federal approach to the ozone problem had not taken transport into account. Thus, while they were studying the transport issue, the policy had not been changed. States, in order to meet the national standards, still had to base their reduction estimates on existing ambient air quality regardless of its jurisdictional source. Also, since the job of evaluating state plans would be considerably harder if each state developed its own model, all states were required to use Appendix J. Thus, besides criticizing the theory and assumptions of the state's model, fundamentally EPA wanted all states to use a uniform data base and methodology to make their review easier.

The primary problem facing the state agency, then, was to get the federal EPA to recognize the transport problem. This fact, combined with the opposition within the state to the model's results, led to the state's model being abandoned. To remove one obstacle, the state confined its search for a new model to those acceptable to EPA. However, both Appendix J and linear rollback were still unacceptable to the state, and the photochemical dispersion models required money and data resources that were not available. By this time, however, EPA had developed the model called EKMA.

The difficulties with the available methodologies for determining the requisite reduction in the precursors to ozone had led EPA to develop this new model. Their objective was to develop a technique for modeling the relationship between the precursors to ozone and ozone itself which would take into account nitrogen oxides as well as hydrocarbons, would be based on the physical and chemical nature of the pollutants, and would necessitate only a limited amount of input data. The result of this effort was the EKMA model, an approach based on smog chamber data and using isopleths to determine the necessary reduction. Although this model still did not treat the transport problem, the state decided to use EKMA because it was a methodology acceptable to EPA.

Thus, the state's environmental agency submitted another transportation control plan to EPA, this one based on the EKMA model. However, the number of opponents to the actions required by the plan did not appreciably change. The plan set up a transportation plan review program whereby projects would, in theory, have to be certified as consistent with the air quality plan based on the model. In practice, because of the criticisms that could be leveled at the model, the criteria for consistency became any improvement in air quality (rather than a sufficient improvement to meet the standards). The state transportation agency and the legislature continued to approve projects in this manner while the environmental agency felt powerless to oppose them because of the lack of support from EPA.

In this case, the EPA Region I office had been supporting the state's efforts to gain recognition of the transport problem. A regional conference of northeastern states had been held to obtain agreement that (1) transport was a problem and (2) until models were developed as a predictive tool, reasonable available control technology (RACT) would be required. Unfortunately, the EPA headquarters' office did not endorse such a policy until a year later and the national legislation did not recognize such interim measures until two years later. Meanwhile, EPA had been threatening sanctions against the state if it did not come up with a workable and enforcable transportation control plan. However, since they never carried out their threat, the state legislature felt free to ignore them. The legislature was concerned with not doing anything "prematurely," before other states in the region.

A cycle in the planning process developed. The state environmental agency would fund a model application effort. Both the state transportation agency and EPA would find fault with the model. The transportation agency would suggest another study and lacking support for the environmental agency's modeling efforts or a believable threat of sanctions from EPA, the state legislature would agree to further study. Unless forced to implement a plan the governor and the legislature saw no reason for doing so. This is the situation as it stands today. Most of the old issues remain unresolved while new ones, also not handled well by existing models, continue to arise.

The case points out the problem in communication and divergence of goals that exists in our federal-state system. The problem that the state was attempting to model was different than the problem as defined by the federal EPA. Much time and effort was spent in developing a model specific to the state's definition of the problem. In the end they had to abandon it because it did not meet the criteria of EPA.

EPA, on the other hand, views the process as linear, in one direction. They develop the models, then the states use them. Because they are familiar with the models and all states are treated the same, EPA's job is made easier by not having to assess each state's model as well as their plan. However, it does mean that they resist learning from the states and are slow to perceive and consider new issues.

THE SAN FRANCISCO AIR QUALITY MAINTENANCE PLAN

The San Francisco Bay region has had a governmental agency concerned with air pollution control since 1955. In 1961 the Association of Bay Area Governments (ABAG) was formed to act as a coordinating institution for all of the region's governmental programs, not just environmental ones. This history of regional and joint perspective is perhaps longer than in any other state and provided an important tradition of cooperation as a basis for developing an air quality control plan.

However, the severity of the oxidant problem, the widespread dependence on the automobile in California and the political unacceptability of transportation control measures beyond automobile emissions standards tempted the state to let EPA develop a plan since they could not develop a politically acceptable one that would meet the national oxidant standard. But EPA's plan, promulgated in 1973, contained the same politically unacceptable strategies and was based on linear rollback, which the state felt was technically indefensible. Thus, the responsibility for developing a transportation control plan was back in the state's hands, or, for the particular case of the San Francisco region, in the hands of the various regional government agencies and ABAG. The issues were how to solve the modeling problem and, more importantly, how to gain legitimacy for the plan in the political sphere.

In addition to the EPA's transportation control plan, another incident established the seriousness of the problem and the need for an acceptable solution. During this same period under the New Source Review program, the local air pollution control agency had proven its resolve to enforce its regulations by denying a permit to Dow Chemical Company. Dow wanted to build a large facility which would create new jobs and tax revenues but was denied a permit because of the increase in air pollutants the facility would cause.

Thus, the stage was set for a conflict between environmental quality and the regional economy. The willingness of the environmental agencies to impose stringent control requirements put industry and other governmental agencies on notice that the threats were real (as opposed to the case of Connecticut's Transportation Control Plan where none of EPA's threats were carried out). But the environmental agencies had also learned that they would have to come up with a politically acceptable plan--that federal actions would not bail them out.

Also during this time, the federal EPA had decided that the San Francisco region was an appropriate area to experiment in integrated planning. In 1975, ABAG was awarded a federal grant to compile an integrated air quality, water quality and solid waste management plan. Thus, the presumption that the type of planning was experimental plus the additional funding helped lay the foundation for a more sophisticated and elaborate air quality modeling exercise than was undertaken in most other states. As we saw in the Connecticut Transportation Control Plan, the Appendix J model and, later, the EKMA model were the models which EPA approved for use by states for analysis of the oxidant problem; EPA suggested these models particularly in cases where the modeling resources were limited. Connecticut attempted to develop its own model but its methodology was not significantly more advanced to overcome EPA's reluctance to review different or new models. In the San Francisco case, however, funds were available and a photochemical air quality dispersion model, called LIRAQ, was developed. It utilized advanced methodology in analyzing both transport and chemical reactivity. Also, it was evaluated by various technical modeling experts and EPA approved the use of LIRAQ for the San Francisco plan.

Other factors also led to the choice and approval of this particular photochemical air quality dispersion model. For one, ABAG was lucky; in the San Francisco region the Lawrence Livermore Laboratory had been trying to interest the Bay Area Air Pollution Control District (BAAPCD) in the idea of developing an air quality model specific to the region and useable by the agency. Their entrepreneurial efforts included raising the necessary funds from outside sources. They had received a grant from the National Science Foundation in 1970 and had an operational model for the San Francisco region by 1975. The conditions of the grant included specific tasks to be performed by the local environmental agency, the Bay Area Air Pollution Control District. Thus, the modelers at Lawrence Livermore Laboratories, interested in advancing their own professional field, were able to aid BAAPCD by recognizing early the need for a better model than linear rollback and by gathering the necessary resources. By having to get sponsorship from BAAPCD the modelers were aware from the beginning who would use the model and what this meant for how the model should be developed. Also, by the time the model was operational the BAAPCD staff was familiar with how to run it on their own in-house computer.

Throughout the planning process other models were compared to the LIRAQ model, the model developed by the Lawrence Livermore Laboratory. The long time over which LIRAQ had been developed and verified specifically for the San Francisco Bay region combined with its relative sophistication when compared with other oxidant models and its familiarity to the users helped it remain the model of choice. These evaluations by technical experts in the modeling field also played a central role in establishing the model's political legitimacy within the planning process as a whole. The early discussion and support of recognized experts helped to resolve technical questions before they became political questions.

Once the sponsoring government agency and the modeling experts were identified the experience and history of how public policy was formed in the San Francisco Bay region came into play. The failure of the previous transportation control planning by EPA, an outsider, pointed out the folly of not using the successful structure of joint effort and responsibility provided by ABAG. This early recognition of the need to provide for political acceptability of the technical methodology led to extensive use of joint task forces. The elements of this structure, important to the success of the planning effort, include:

--the formation of task forces at both the managerial and technical staff level;

--the broad representation of interests on the task forces; and

--the formal imposition of responsibility for a successful solution on the task force rather than on one particular agency.

The primary aim of the planning process with regard to the technical data was public acceptability. This was accomplished by creating an open planning process which allowed all relevant interests to debate the technical issues from the beginning. ABAG formed an Environmental Management Task Force (EMTF) to coordinate the development of the overall plan. Each pollution area (air, water, water supply and solid waste) had its own staff and committees, but parallel work schedules, tasks and the technical baseline data were rigidly enforced so that the final plan would indeed be an integrated plan. Private citizen and industry participation was encouraged throughout the process. A set time for citizen comments was reserved at the beginning of each EMTF meeting. Also, representatives of the various interest groups were members of the technical and advisory committees which reported to the EMTF. Regional and local governmental agencies were also not forgotten. The Metropolitan Transportation Committee and the state Department of Transportation (CalTrans) sent staff representatives to the Joint Technical Staff and Modeling subcommittees. These committees also included modelers from the regional, local, state and federal environmental agencies as well as private counsulting firms who were supported by private businesses. In this way the concensus of the technical committees was broadly based and subject to public scrutiny. In the end the process provided a defensible data base--a modeling analysis which most participants felt was as good a job as was possible within state-of-the-art and resource constraints.

The formation of task forces at the managerial level had the effect of putting the responsibility for a successful plan on the individual members of the task force rather than on one particular agency. Thus, the members worked toward a plan which each could sell to his or her own agency. This, in effect, aligned their self-interest with developing a successful plan to replace the apparent alternative, EPA's plan. Inclusion of industry and environmental representatives from the beginning had the same effect. These interest groups could not criticize without also participating in finding a solution. This can be contrasted to the case of the Ohio SIP where utilities claimed in court that the RAM model was inadequate but, when asked for something better, claimed proprietary interests forbade them from providing that information. In this case, criticisms from both industry and the environmentalists were raised and considered early in the process while there was still time to respond. This helped create confidence in the defensibility and, hence, acceptability of the plan.

The last factor, responsibility of the task force rather than one agency, points to a creative solution to a frequent problem. For example, in the state of Connecticut, the Department of Transportation was able to defeat the modeling efforts of the environmental agency because its only responsibility in the transportation control planning effort was to criticize. Given their mission of building and maintaining highways, their response was to resist efforts which would delay or reduce these activities. In California, however, the Department of Transportation, based on its traffic control experience, was assigned a major role in the development of the transportation control data and membership on the technical committees. Thus, they could not just sit back and criticize; they had to come up with solutions acceptable to their agency as well as to the environmental agency. If they chose not to participate, they lost the opportunity to influence the outcome because the process was set up to function on the recommendations of the joint committees rather than having to wait for separate action from each agency. Also, because the question at this stage was a limited, technical one (which of the available models is best?) and not a policy one (which of the alternative model outcomes is best?), the criticisms had to be based on technical factors not policy preferences. Indeed, there was resistance, but the transportation agencies could not stop the process and did participate by providing certain baseline data.

The stated goals of this joint regional planning process were

--to improve air and water quality by the greatest possible amount,

--to reach compliance with federal and state standards at the earliest possible date, and

--to be implementable.

Thus, the reality of the politically unacceptable transportation control plan of EPA and the non-attainment of the oxidant standard in the Bay Area shaped the plan developed by the task force. The task force members recognized that certain limitations, including possible non-compliance with current standards, existed.

Before actually assessing alternative plans according to the above goals, however, the objective was to settle the technical questions. Thus, part of the task of establishing political legitimacy was to attain technical credibility. To do this it was necessary to gain a concensus among the technical experts that the best job possible, given the state-of-the-art, was being done. Again, individuals were not allowed to criticize without offering solutions that the task forces could accept. Also, recognized experts from independent institutions (tied neither to government nor to industry) were asked to pass judgment on the quality of the job being done.

These actions served to focus the early stages of the process on the questions of a strategy for picking a model, explicit justification for the choice, technical problems, such as input data, and what outputs would serve the needs of the particular user. The consequence was that later in the process the politically debated issues were the political issues, such as land use controls, rather than the technical ones which had been debated by the experts before the modeling results were known. Indeed, by recognizing that issues would be politically debated the presentation of the model results was divided into long and short term policies, thereby relegating those policies that could not be implemented to the long term and preventing them from bringing down the whole plan.

The resulting plan eliminated completely highly unacceptable strategies no matter how effective they might be in reaching the standards. For example, land use controls were left to the jurisdiction of local agencies. The so-called long term policies were policies that for some reason, including their controversial nature, could not be implemented in the near future. At the same time, they were not completely rejected; it was recognized that long term policies needed more debate at the political level. This approach was meant to allow for future flexibility. The agencies were not locked into a plan without recourse if appropriate changes were needed.

The final plan, recognizing these limitations, requests a five-year extension to 1987 for the attainment of the federal oxidant standard. Thus, it attempts to improve air quality while taking into account the political and economic realities. EPA, in its initial review of the plan, has in turn questioned this political assessment by calling for further justification for the absence of certain transportation control measures.

Thus, in the face of EPA's transportation control plan for California the stage was set for action by the regional governmental agency. This case parallels the case of Connecticut's transportation control plan but ABAG succeeded in developing a model and technical basis for a plan where Connecticut's attempt to develop a workable plan largely failed. The elements that seem to be different for the San Francisco Bay Area agencies include

--a history of air pollution control always ahead of and leading the rest of the nation;

--a recognized team of experts, outside the agency, willing to help raise funds and undertake the work to expand the state-of-the-art; and

--a governmental structure and tradition organized toward cooperation and communication as tools necessary to lend legitimacy and credence to public policies.

The process is not finished; EPA has not approved the plan and the air quality standards have not all been attained. Also, the process was not perfect. The data base is still of poor quality in several areas. The question of whether or not a model (rather than which model) was not addressed. The transportation control measures incorporated into the plan are limited. However, a plan tolerated by the various interests involved was completed and no one agency or group was allowed a veto. This is in contrast to both the situation in Connecticut with its transportation control plan and the situation in California previously when the state was unable to come up with a plan and EPA had promulgated a totally unacceptable plan.

OZONE STANDARD REVISION

In April 1971, EPA set national ambient air quality standards for six pollutants. In 1976, it began the process of revising these standards. The first such standard to be reviewed was the one for ozone. Because the Clean Air legislation requires a standard based on health effects, EPA publishes a criteria document which describes the available health effects studies. By tradition, this document for the ozone standard revision also contained the available scientific information on the control and formation of ozone and a review of the air quality models.

The 1971 regulations establishing the ozone standard included the requirement that the Appendix J model be used to show future compliance with the standard. As we saw in the Connecticut TCP case, the states complained about Appendix J and the EKMA model was developed in response. The revision of the ozone standard provided the opportunity to change the regulations regarding the use of models. The change was accomplished without controversy. No one objected to replacing a method, which had been shown to be in error, by the most flexible of approaches.

The process followed in revising the criteria document (both the health effects and modeling chapters) included the compilation of studies by means of a conference of recognized experts as well as external review of drafts of the document. In general this review was highly controversial with regard to the health effects data but almost non-controversial with regard to the models. The reasons for this difference lie primarily in the fact that the relevant decision, the level of the primary standard, was based exclusively on the health effects data. The models were to be used much later, in implementing the standard decision. The process for reviewing the scientific information was an open one, with various experts called upon to comment or various groups (National Academy of Sciences, American Petroleum Institute, EPA Task Force) submitting their evaluations of the various models. In this way, a concensus developed that, while air quality simulation models might be better predictors in a given situation, their actual use was severely limited by their large data and resource requirements.

The office within EPA responsible for the criteria document was the Office of Research and Development (ORD). The office responsible for the recommendation on a standard level and for overseeing the use of models in the implementation of the standard decision was the Office of Air Quality

Planning and Standards (OAQPS). These two offices had formed a joint task force to develop a new model when the states were complaining about linear rollback and Appendix J. The result of this cooperative effort was EKMA. The criteria document, while reviewing the strengths and weaknesses of all the types of models, concluded that EKMA was the model of choice when data and resources were limited and not available for using with air quality simulation models. OAQPS reflected this conclusion in revising the regulations concerning model use. They recognized the limitations of the available models and maintained maximum flexibility by no longer specifying a particular methodology.

OAQPS also used the recommended EKMA model when it came time for them to prepare the cost and economic impact report. The cost and economic impact report was another document produced for the standard revision decision. However, unlike the criteria document, this report was an administrative requirement of the President and not a requirement of the Clean Air Act. Indeed, the Clean Air Act, as interpreted by EPA, prohibits the consideration of anything but the health effects data. The cost data was instead intended to be an educational tool to let the public know the costs of the legislative requirements.

It was the job of OAQPS to produce this report and, over time, their choice of models changed. The first version of the cost report was an analysis of a sample of eight cities. The EKMA model, which is most suitable to high density, urban areas, was used in the initial drafts of the report. When the analysis was expanded to include all large cities, the input parameter which made the model results specific to each city, the HC/NO_x ratio, was not changed. A sensitivity analysis was done which showed that the results were not sensitive to this parameter.

However, as the report began to be reviewed by others within and outside EPA, the models and their applications were changed. First, linear rollback was introduced as another estimate in a range of estimates. This was justified because city specific data was not available and nationwide reduction estimates do not require a high degree of accuracy. These estimates were considerably lower than those using the EKMA model.

Even though the cost estimates were not to be used in making the standard revision decision they became controversial as the total magnitude of the costs became known. They ranged up to an annual cost of $12 billion. Thus, although technical reasons were cited in the report for the choice of models, the persons involved in the writing of the reports also cited the pressure within EPA to make sure the costs were as low as possible. The initial choice of EKMA seems to have been one of "what model am I familiar with" and "what model is the latest new technique" rather than a complete search for what was most appropriate. Indeed, the operations office (OAQPS) did not consult with the developers of the model in the research office about their choice of models. As pressure mounted to keep the cost estimates low, linear rollback was introduced. In the final version and in presentations to the EPA Administrator only the linear rollback figures were cited, because it was felt that listing different ranges and estimates from the various models was too confusing. While the choice of model may have been correct for the problem as defined by EPA, the choice was simplified by political considerations.

In this case, we once again see the attempt to conduct an open decision process. The decision process in this case concerned what kind of regulation would be promulgated concerning the use of models by states in planning for attainment of the oxidant standard. A joint task force was successful in identifying the problem as one of data and resource limitations. As long as the discussion remained on the scientific or technical level of evaluating model methodologies within the structure of a joint task force, the cooperative effort was successful. The task force participants had a common professional background (in meteorology) and a circumscribed problem area.

After the review panels for the criteria document were concluded, EPA returned to its separate organizational method of operation. ORD completed the criteria document and OAQPS began work on its recommendation for a standard level and its cost report. Without the structure of a joint task force the use of the models (in estimating costs) was left entirely to OAQPS without any review by ORD, the developer of the other models. Each organization had returned to their own separate interests--ORD in advancing the scientific foundations for the tecnical analysis and OAQPS in implementing the regulations. The result was an emphasis on the details of the cost assumptions by the economist in charge of the cost report and relatively little evaluation of which air quality model might be the most appropriate.

Even though the process was a relatively open one with experts able to recognize their influence on the final decision, the non-controversial nature of the decision to change the ozone modeling requirements was also due to

--the fact that the models did not provide information germane to the immediate decision but would only be relevant in later decisions,

--other information (on health effects) was highly controversial, and

--the proposed regulation on model use was much more flexible than the one it replaced.

NEW SOURCE PERFORMANCE STANDARDS

The technology-forcing strategy of the Clean Air Act occasions quite a bit of debate and controversy within EPA and often results in varying interpretations of the law. The case study of the new source performance standards for coal-fired power plants describes the process followed by EPA to develop a regulation for new coal-fired power plants based on controversial technology and for which EPA spent an unusual amount of resources for technical analysis.

In 1971, the original new source performance standard (NSPS) for coal-fired power plants had been set in the form of a ceiling, an emissions limitation of 1.2 lbs. of SO_2 per million Btu of heat input. No percentage reduction of potential emissions was specified. As required by the 1970 Clean Air Act, this standard was based on an engineering judgment of what constituted the best technological control system and no analysis of cost or emissions impacts was done. The consequence of setting the standard in this way was that the utility companies shifted to the use of low sulfur coal whenever the costs of transporting the coal were less than the cost to install the available control technology, flue gas desulfurization systems also called wet scrubbers. These wet scrubber systems were considered expensive and unreliable and also produced considerable wet sludge as a waste by-product. The alternative, low sulfur coal, is mainly found in the western part of the United States. However, the utilities, especially those in the Middle West, found it cheaper to transport this coal from the West than to buy and operate scrubbers. The result was a decline in demand for the higher sulfur coal of Appalachia and the Middle West and a rise in unemployment in these coal mining regions.

By 1976 the experience with the few scrubbers that had been installed had led environmentalists to conclude that the technology was capable of 90% removal of SO_2, at least when burning low sulfur coals on which scrubbers were more reliable. This led the Sierra Club to petition EPA to revise the NSPS on the grounds that scrubbers were now a proven technology and, therefore, the performance standard should be upgraded to reflect this new technology. In January 1977, EPA announced it would review the 1971 standard and studies were begun.

However, the environmentalists did not stop there. During this time, amendments to the Clean Air Act and a National Energy Plan were being debated in Congress. Thus, an unusual political alliance developed. Both environmental and high sulfur coal interests began to push for an amendment (Section 111) which would require a NSPS to include a percentage reduction figure as well as an emissions ceiling. A percentage reduction figure would not permit low sulfur coal to be burned without some controls and would, thus, eliminate some of its advantages and encourage more use of high sulfur coal. For the environmentalists, a uniform standard of 90% reduction of potential SO_2 emissions, regardless of the sulfur content of the coal, would reflect the best technology available and would require emissions reductions even in the West. They saw this as an aid in preventing visibility degradation in the West. The utilities were opposed to any amendment, however, because of the costs and sludge disposal problems as well as what they still considered to be the unreliability of scrubber systems. The new Carter Administration and the Department of Energy (DOE) saw the use of scrubbers as a way to increase the use of coal, the linchpin of their proposed National Energy Plan, in an environmentally sound way.

The House passed the amended Section 111, but the Senate did not. Senator Muskie considered it economic protectionist legislation rather than clean air legislation. The compromise enacted into law retained the amended Section 111, with its requirement of "the degree of emissions limitation and the percentage reduction achievable through the application of the best technological [control] system . . . taking into consideration the cost . . .

and any non-air quality health and environmental impact and energy requirements," but included confusing language in the accompanying Conference Report. The utilities were successful in lobbying for a paragraph in the Conference Report which said that EPA could "set a range of pollution reduction that reflects varying fuel characteristics," while the environmentalists and high sulfur coal interests obtained a warning that "any departure from the uniform national percentage reduction requirement . . . must be accompanied by a finding that such a departure does not undermine the basic purposes . . . of the Act, such as maximizing the use of locally available fuels." This uncertainty about congressional intent was later to plague EPA in its review of the standard, but the actual language of the Act as well as the initial support of the White House and DOE led EPA to make the presumption that the same, or uniform, percentage reduction would be required of low as well as high sulfur coal unless costs or other impacts were unreasonable. This presumption of the EPA staff was fortified by the fact that the EPA Assistant Administrator who would be making the new standard recommendation had previously headed the air quality project of the Natural Resources Defense Council, a group active in lobbying for the Section 111 amendment. Thus, the question posed by the EPA staff was what percentage of SO_2 could reasonably be reduced from high sulfur coal.

The initial technical analyses examined the associated cost and energy impacts of alternative uniform percentage reduction figures and emission ceilings. It actually began as a small effort based on the type of economic studies EPA had used in the past--cost and energy impacts and emissions based on a single model plant plus extrapolation to a nationwide basis. It was initiated by the program office responsible for developing the regulation, the Office of Air Quality Planning and Standards (OAQPS). The analysis showed small differences in costs with relatively large differences in emissions levels for various alternatives and supported the initial EPA assumption that a uniform percentage reduction or full scrubbing (scrubbers on all plants regardless of what type of sulfur-content-in-coal was used) would be required.

In December 1977, EPA went public with the results of its technical analysis and indicated that they were considering a stringent standard of 90% reduction. This draft NSPS was presented by the staff of OAQPS at a public hearing. Their strategy was to start with the toughest defensible standard with the realization that a more moderate final standard would probably be negotiated. Indeed, the draft standard did elicit debate from groups both within and without EPA. As these other groups joined in the decision process, both the preconceptions and the technical analysis radically changed.

Within EPA, the Office of Planning and Evaluation (OPE) was concerned with cost effectiveness of the standard (whether different controls on different coals might be justified considering the cost of controls in light of resultant reduction in emissions) while it felt OAQPS was only looking at the cost affordability (whether the industry could afford the cost of controls). The Office of Research and Development (ORD) was also concerned with the 90% reduction figure but it emphasized that 90% might not be technologically feasible.

Outside EPA, opposition seems to have been stimulated by the public release of the draft NSPS. The utility industry began to lobby actively in Congress, the White House and the Department of Energy. With a concrete proposal they were able to tie specific costs of the full scrubbing alternative to constituents (consumers of electricity) who would have to bear them. DOE responded to this pressure; the Deputy Secretary and the Assistant Secretary for the Environment were both to publicly state that full scrubbing may be unreliable and unacceptable. The opponents to EPA's draft NSPS were proposing a variable rather than uniform standard, a standard that would reflect varying fuel characteristics and would not require scrubbing on the lowest sulfur coals.

As the debate intensified, OAQPS realized it would have to conduct further technical analyses in order to resolve intra-agency disputes. OPE objected to the model* OAQPS was using and had funded a different modeling analysis. In this case OAQPS and OPE reached an agreement to form a joint task force for developing the technical analysis. The joint staff agreed to use the OPE model because it was more detailed, and, being in a later stage of development, seemed more "consistent and persuasive." Also, it was a model that DOE had previously sponsored. Thus, the joint task force was expanded to include DOE staff members. With the establishment of this task force both the head of EPA and of DOE directed their staffs to secure agreement on the modeling assumptions and modeling techniques, thus committing their agencies to resolving their differences on technical, if not policy, issues. The major impetus for the commitment of these resources as well as the time of the top management of EPA to this decision was the recognition of the importance of this decision for EPA in the political arena. The debates on the Clean Air Act Amendments, the push for regulatory reforms from within the administration at this time, and their recent controversial decision on the ozone standard underscored the political vulnerability of EPA's regulations. Thus, EPA was determined to resolve as many of the technical issues as possible so that the debate would focus on the policy issues --whether costs or emissions are more important--rather than the technical issues--what will be the costs or the emissions.

This new modeling analysis was undertaken by DOE and EPA, but all interested parties were invited to debate the assumptions, suggest alternatives and inspect the results. The new analysis eventually convinced the EPA decision makers that their original presumption of a uniform standard was wrong if all environmental, economic, energy and political consequences were weighed. The new model found an overall smaller difference in costs between the full and variable scrubbing options than the original analysis. It also produced a counterintuitive result--that stricter emissions limitations would lead to more, rather than less, emissions. This result came from the assumption that an increase in construction costs (of scrubbers) would cause the owner of an old plant to keep it running longer (with higher

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*An emissions, energy and economic impact model, not an air quality model.

emissions) rather than building a new source subject to the higher costs of control.*

The final standard was a variable standard allowing from 70 to 90 percent reduction of SO_2. The actual figures were chosen to allow for a technology called dry scrubbing. The dry scrubbing option actually became the focus of attention relatively late in the process. It is a newer technology so that ORD, while having suggested that it could save utilities money, was not willing to attest to its reliability. But more importantly, as long as the Assistant Administrator for air programs, who was pushing the full scrubbing option, felt that the EPA Administrator still favored a tight rule and the legislative presumption of full scrubbing, he preferred not to suggest any variable scrubbing solution. Also, the industry was interested in a relaxed standard requiring no scrubbing for some coals so that a new option based on some scrubbing, even if less costly, did not interest them for a mandatory standard. However, when the technical analysis showed the large cost savings from a variable standard without large increases in emissions, the discussion turned to an analysis which included the possibility of allowing the dry scrubbing control option for low sulfur coals, which in turn established the 70% lower limit for the standard.

The strategy of pushing for agreement on technical issues also turned out to be of importance in concluding the decision process with, at least, a reduced level of controversy as compared with other recent environmental and health regulations. Even though the White House and several Senators continued to express their keen interest in the decision and the technical information, the briefings by EPA focused on the policy issues and were structured so that the President could reserve the decision for himself. President Carter left the decision to EPA after the opposition views had been aired.

EPA was sued by both the environmentalists and the industry over this decision. The environmentalists contended that the last few weeks of hectic meetings and model runs, conducted to meet a court ordered deadline, that produced the dry scrubbing option amounted to "ex parte," or off-the-record, communications with Congress and industry officials and that the decision was made on the basis of new information, not part of the public record. They still wanted a uniform scrubbing standard and were never reconciled to the counterintuitive results of the model. The industry suit contended that several provisions of the standard were too restrictive and were impossible to meet. But EPA officials were generally pleased with the outcome. They felt that large expenditures of time and resources had resulted in a technically defensible standard that did indeed balance environmental with energy and other considerations. They were not surprised by the law suits given the adversary tradition that has been set up by the clean air legislation and its various interest groups.

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*The environmentalists objected to this assumption. They maintained that political, financial and institutional constraints would alter this cost-minimizing behavior.

That this effort to produce a technical analysis was in large part successful can be attributed to several factors, including:

--a model of sufficient complexity for the situation was available and did not have to be developed,

--the model was flexible (some thirty-three alternatives were eventually analyzed) and produced the required output format,

--the model itself, its assumptions and how it worked were understandable to the decision makers, and

--EPA committed the level of resources and time needed to do a full analysis.

In the end, EPA was able to produce agreed upon numbers and a cooperative interagency process that focused on the policy issues and left the ultimate decision in the hands of EPA. Other factors than the model, of course, helped produce this outcome. They included:

--top EPA management involved early and actively in the process,

--interagency groups that attracted staff with similar perspectives and backgrounds,

--EPA's solicitation of public participation from the beginning of the process and their willingness to change their modeling analysis in response to public criticisms, and

--the willingness of the utility industry, as a regulated monopoly, to divulge information which other industries might regard as trade secrets.

Thus, the development of this regulation contained all the potentially controversial elements--opposing political interest groups, technical uncertainties and organizational conflicts--of the other case studies. However, the fortuitous existence of a relatively complex model, closely approximating the situation, as well as the conscious management of the process so as to defuse the opposition, at least on technical grouds, helped it to work well. Clearly, in almost any EPA decision and especially in an important one like this not every element of controversy can be avoided. In this case EPA reduced the controversy even if they could not avoid it altogether.

The major technical qeustion that was not addressed was that of the benefits of pollution reduction. A first step in such an analysis would be an air quality model to relate emissions to ambient air quality. EPA has not in general tried to conduct benefits analysis for its decisions in the past. New interpretations and new legislative language may change this in the future and air quality models may be called upon to fit into and be compatible with the larger analysis. Thus, this case study has been included in this report both to indicate how technical analysis can be used in the EPA decision process in general and to show what expanded uses might be made of air quality models if they were available in the correct format in the future.

SUMMARY

The case studies conducted for this report cover a variety of programs (standard setting, implementation planning and implementation for both new and existing sources) that EPA has jurisdiction over and which require some form of technical or modeling analysis. Although the cases vary by geographical and political extent, these attempts to apply models and use the results in solving the political as well as the technical problem reveal some common threads that delay and confuse the decision process. The difficulties arise from the model formulations but also from the process as laid down in the legislation and as managed by EPA, its regional offices and the states. Section II of this report outlined four possible types of uses of models: for problem solving, for conceptualization, applying basic research, and for political advantage or self-interest. We have seen examples of all of these in the case studies, and they provide the basis for identifying common difficulties linking the case studies.

Uses for Problem Solving

Air quality models provide the data which applicants for a permit to build a new project can and do use to design their project so that it will meet environmental constraints. Environmental agencies use such data to plan for new pollution sources and for assessing compliance with standards of existing sources. However, the models are far from perfect. The major obstacles to the use of air quality models for problem solving will be discussed in the next section of this report but, briefly, they include technical problems such as:

--a lack of theory and validation for complex topographic situations,

--a lack of input data (monitoring), and

--time and resource constraints.

Furthermore, there are managerial problems, such as:

--a lack of federal policy directives,

--the mismanagement of model critiques, and

--conflicting or narrow institutional and organizational perspectives,

which stem from not so much the technical problems of modeling but from the legislative framework and the adversary structure for decision making that it creates.

Political Uses of Models

One example of the interaction of the political and technical frameworks is the use of models or technical information by the interest groups. The legislation has set up an adversary system of public hearings, administrative hearings and court appeals. Such a system encourages the selective use of technical information which in turn is bolstered by the uncertainties and numerous assumptions of the models. By far the greatest use of the models by environmental and industry groups in these cases was in opposing or defending the projects, often for non-environmental reasons, rather than in seeking to resolve or even define the problem as a broad one of how to balance the conflicting interests. Essentially the adversary system of opposing sides sets up a narrow, limited sphere of concern--whether the project meets certain standards and not whether this project at this time and place meets the broad public interest.

However, in some cases the environmental agencies were able to use the advocacy system of public hearings to advantage. Several times key issues regarding the accuracy and appropriateness of the models were initially brought up through the public hearing process. In a society of limited resources this may be a fairly good way of making sure such issues are raised. EPA or the state agencies cannot have the resources or the time to investigate every aspect. The San Francisco AQMP shows how this system can be used to advantage. A problem with this approach is that it tends to occur late in the process so that the EPA modelers are put in the position of justifying their conclusions. Although, as we saw in the NSPS case, when the issues are raised in the early stages of the process, it is possible for EPA to respond and correct the analysis. This problem may be exacerbated if the distribution of resources or availability of information is unequal. In the Pittston case the citizen advocates were at a disadvantage on both counts. In the MATEP case the citizen groups had better access to the information. In general, both the industry groups and the environmental groups were predictable in their criticisms and responses, but the environmentalists, in some cases, lacked the resources to play a significant role while there was always clear industry opposition to controls.

Interest groups are not the only outside advocates in these case studies. The legislative (Congress) and the executive (governors and the White House) branches were also called upon to lend their influence. For instance, in the Westvaco case the company pleaded their case to several congressmen who in turn demanded technical justifications from EPA. Subsequent congressional inquiries led EPA to conduct its own technical analysis. In the case of the Ohio SIP, the statement by the Council on Wage and Price Stability foreclosed several options that EPA had been considering without referencing specific technical information. But it was clear to EPA that there was no appeal and another solution would have to be found. In the Connecticut TCP case the Governor and legislature agreed that when and if other states established strict control programs then and only then would Connecticut do so. This type of intervention by other governmental interests was possible both because air quality modeling is not an exact science and because generally the environmental decision process does not have a clear tradition establishing how the technical information should be evaluated (the

San Francisco AWMP and the NSPS cases being notable exceptions).

The state-of-the-art of air quality modeling and the management of the decision process also result in "self interest" uses by the decision maker. For instance, the lack of input data and the emphasis on conservative "worst case" analysis leads to the presentation of just one point estimate. No sensitivity analysis or allowance for uncertainty in the data or the methodology is presented to the decision maker. This is encouraged by the decision maker, who is usually not a scientist and therefore has difficulty assessing variable results. When only one number, which is below the standard level, is presented, the decision is obvious, and the decision maker does not have to question the accuracy or indeed the applicability of the model. These questions did come out in the MATEP case because no standard had been set. But even here, the short-term NO_2 effects were not seen as an issue until public comments raised them.

This points out a major influence on how models are chosen and used. Choices are made based on experience, but this experience is not that of validation and documentation. Instead, the experience is what was used last time. For the decision maker this means point estimates of concentration levels have become familiar. Whether the prevention of significant deterioration provisions are substantively different and demand a different approach or whether the problem should be expanded to include possible future growth on employment impacts is not asked. If no standard exists, the tendency is to avoid the issue. Indeed, even in the more successful example of the NSPS case the analysis began with the familiar but was expanded as the importance of and widespread interest in the regulation was recognized.

The modeler also has "self interest" uses for the models. For the modeler it is easier to apply a model previously used than to learn how to apply a new one. Also, if the decision maker is satisfied with point estimates, then the work of producing sensitivity analyses and educating the decision maker as to what they mean is not worth the effort. Connecticut also learned it is easier to use a model that is familiar to the federal EPA than to fight the modeling issue as well as the transport issue with both EPA and its own state agencies.

Uses for Conceptualization and the Use of Basic Research

As for the other two uses--conceptualization and the use of basic research--fewer examples were found. The accumulation of experience in trying to use Appendix J and linear rollback led to a search for a better method by both San Francisco and Connecticut. But policies on transport, on monitoring for permit applications or on the prevention of significant deterioration provision have not been developed yet, although models do exist which could provide useful information for policy purposes in these areas. Also, the available models are used but there is no strategy for how they ought to be used.

Basic research to develop better, more accurate models has concentrated on the photochemical dispersion models. But they require data and computer time beyond the resources of the state agencies, and therefore, are not often used. It was because this research was not responsive to the decision makers' needs for more timely and less expensive models that the EKMA model was developed. But generally the problems of data and computer resources remain.

With this background on how the air quality models were used during the decision process, I turn now to the difficulties (technical, managerial and political) in trying to use them and how the difficulties helped shape some of the political and "self interest" uses and hindered the use of the models for problem solving and conceptualization.

SECTION IV

CONCLUSIONS

The case studies describe what air quality models were applied in the given situation and what technical, managerial, and political problems were encountered in the attempted applications. Except for the bare skeleton of identifying the project or industry and sites affected and ensuring compliance with the public participation provisions of the law, these cases reveal no standard or organized procedures to affect decisions in the environmental area where air quality models are involved. Neither the responsibilities of the various governmental agencies nor realistic expectations of the interested parties are established at the outset, and they often are in flux throughout the decision making process. The details of the case studies show that

--the legislative and political framework,

--the limitations of the technical capability of the models and the input data, and

--the management of the generation and use of the technical information within this framework

together cause a narrow and sometimes contradictory definition of both the problem to be resolved and the solution proposed.

The legislation and EPA's interpretation of it have established air quality models as <u>the</u> tool of policy analysis. However, the models relate only emissions to ambient air quality. The models can be used to redesign a proposed project, assess compliance of existing sources and answer planning questions about future growth. They do not by themselves evaluate impacts other than air quality impacts or problems not directly related to existing standards. The reliance on the models tends to narrow the definition of the problem and the perspective of the decision maker.

The legislation also specifies a structure for the decision process. It requires EPA to conduct an "open process" of public hearings. They are meant to ensure that the decision maker has obtained all available technical information. In practice, the public participation process is modeled after the advocacy form of court proceedings, where opponents are identified and information (testimony) is strictly limited to what is in the interest of the speaker as an advocate for one side of the issue. The problem for environmental decision makers arises in the limited purpose of the public hearings and in EPA's management of the process. Generally, their purpose is to establish a record for the technical information without the further step of utilizing the technical experts to assess that information for its relevance to the decision. In this way a fundamentally political decision is structured as a technical decision. But the nature of the uncertainties of the models and the dependence on technical analysis that is narrower than the problem to be solved leads to delay and, frequently, no decision while the essentially uncertain analysis is debated as if the uncertainties could be resolved. The more successful cases show how structuring the problem to separate the technical facts and uncertainties from the political forum and using the technical analysis as an input, rather than the solution, to the policy problem helps alleviate (but not necessarily eliminate) some of the controversy and delay of the decision process.

The process as conducted in these case studies also is, by and large, a one way process. The federal EPA has the resources to develop the models, which are then made available to the states. Thus, seldom does a state search for other options. Or, when it does, much effort has to be made to convince EPA that the state developed model is acceptable. Moreover, EPA is organizationally structured so that the research office (ORD) is separate from the office (OAQPS) which helps the states in their model applications. This separation of the model development and use activities both within the EPA and between it and the states hinders communication of the states' experiences. Officially the federal EPA provides technical assistance to the states. Only a few administrators have realized that the states' experiences may also be useful to the federal EPA. Thus, the process itself and the experience of the states in using the models has had little impact within EPA on broader issues of strategy and policy.

The overall result is a separation of modeler and decision maker during the time the technical information is generated. The most obvious symptom of the problems such a separation produces is seen in the contrast between the questions posed and answered by the modeler and the policy questions encountered in the given situation. As Table 3 shows, in a majority of cases the appropriate question from the point of view of policymaking was not asked or answered by the modelers. The process is designed so as to require air quality models to assess a health-based standard. The consequence of this strategy has been an application of the models, chosen for their familiarity with relatively few resources expended for validation and documentation, and model results presented as point estimates based on "worst case" assumptions with little focus on educating the decision maker with regard to the remaining technical uncertainties and impacts not assessed by the models.

As discussed above, the reasons for this dichotomy between what the modeler saw as the problem to be solved and the question that the decision maker needed answered are based in the structure and management of the decision process as well as the technical capabilities of the models. The analysis of the case studies in this section of the report shows in detail how these technical, political and managerial factors produced the problems encountered in the case studies. For purposes of organization and clarity four areas have been identified for discussion:

TABLE 3

DICHOTOMY BETWEEN MODELER'S QUESTION AND POLICY QUESTION

Case	Question Answered by Modeler	Policy Question
Clean Air Legislation	None	How do air pollution control programs affect other environmental, economic and energy programs; are there policy tools (in addition to or instead of models) appropriate to the problem?
MATEP	What are the resulting concentration levels in the ambient air?	What should the standard be?
Pittston	How can the project be redesigned so that this site can be used; when can the permit be issued?	Which site is best; should the permit be issued?
Anaconda	(Same as policy question)	What emissions limitations are needed to meet the standard?
Westvaco	What violations do existing monitors show?	What violations are expected; are monitors sited to show them?
Massachusetts' Sulfur Regulations	Plan for existing conditions	Plan for growth
Ohio SIP	What violations do existing monitors show?	How do the plants impact downwind areas; are monitors sited to show violations?
Connecticut TCP	Which model should be applied; what are model results?	What control strategy is best (including non-model alternatives)?
San Francisco AQMP	(Same as policy question)	What is best strategy that can be implemented?
Ozone Standard	(Same as policy question)	What is best strategy for developing the planning data base; what are the costs of alternative standards?
NSPS	What are costs and emissions impact?	What are costs and emissions impact; what are benefits of controls?

--technical and political constraints,

--unresolved policy issues,

--management by EPA of the decision process, and

--conflicting institutional and organizational interests.

It will be emphasized, however, that the problem is a complex one with the factors interacting to produce the confusion, delay and controversy found in the case studies. No one factor stands out as the dominant cause or easy target for reform. Solutions appear to be as complex as the problem.

TECHNICAL AND POLITICAL CONSTRAINTS

The first part of this discussion describes technical problems which face the modeler and shape what questions he or she can answer. It is pointed out, however, that the technical limitations do not necessarily determine what questions the modeler actually chooses to answer. Likewise, a decision maker faces limitations in legal or administrative authority which determine what problems appear on the political agenda but, as the cases show, are not the sole determinants of what solutions are applied. Instead, other factors (managerial and organizational) that are under the control of the decision maker and the modeler significantly affect the decision process. They are discussed separately and will be the focus of the recommendations in the final section of this report.

Technical Problems

The major technical problems encountered in the case studies are

--state-of-the-art,
--lack of input data,
--lack of sensitivity analysis, and
--form of the output of the model.

Each case study gives specific details on the models and what particular assumptions were criticized so that this summary report will discuss some problems common to the cases and draw conclusions from the successful cases.

State-of-the-Art--

A major problem in all the case studies is a lack of theory for handling different topographic situations (complex terrain, coastal areas, fumigation, downwash), choosing values for specific meteorological parameters (wind speed, sector averaging) and reactive pollutants (their formation and transport in the ambient air). Lacking a definitive theory the modeler is forced to make assumptions and EPA has published guidelines for choosing the assumptions and input parameters for their models. However, there is great latitude in the choices and, as we saw in the Massachusetts' Sulfur Regulations and Ohio SIP cases, even the same model in the hands of different modelers will produce different results.

Compounding this problem is the lack of verification studies. Many more resources have been spent developing new models than in verifying old ones. The case studies point out that rarely is there sufficient data to even apply the model much less to verify it with an independent set of data. Usually the data is supplied by the applicant, hardly an independent data source. The Anaconda and the San Francisco AQMP cases are the notable exceptions. In these cases much larger amounts of time and resources were spent by EPA and the San Francisco governmental agency to verify the models for the topographic and meteorological characteristics of the particular situation. In general, however, the users (EPA or the state agency who is making the decision) do not have available such resoruces nor is it seen as their responsibility. Their job is to assess the model results not develop the model itself.

Lack of Input Data--

Another critical problem in almost every case was the lack of input data for the meteorological and topographic parameters needed to apply and validate the model for the specific site. As the Anaconda, San Francisco AQMP, and NSPS cases show, more time and resources help considerably in solving this problem. However, time and resources may not be the binding constraints. Table 1 shows the time span the decisions covered. Only three cases took less than four years and all local or regional cases (except Pittston) used on-site monitoring for part of the necessary data. The major problem was that the monitoring was not, in general, of the type or location needed to answer the questions of the decision maker.

EPA's policy, in light of the state-of-the-art and uncertainties of the modeling analysis and the fact that the legislation calls for no violations of a health-based standard, is to require a "worst case" analysis rather than a statistically likely prediction. Thus, accurate monitoring and input data is essential. However, when the permit applicants must spend the resources to supply this data, they will do so only when it is in their interest. In the MATEP case the applicant supplemented the available data with new monitoring sites because EPA threatened to base their decision on data from a "hot" spot, a site not representative of the sites impacted by the proposed power plant. Since additional data was neither advantageous nor required in the Pittston, Westvaco and Ohio SIP cases, no new, more appropriate input data was collected and the problem remained. In the Anaconda case, EPA had to collect the necessary data. In the other cases, however, EPA did not monitor and, instead, requested better monitoring sites from the applicants, with a singular lack of response. That this was a major problem can be seen by the number of decisions which were contingent on further monitoring taking place (MATEP, Westvaco, Massachusetts' Sulfur Regulations, and Ohio's SIP).

Lack of Sensitivity Analysis--

Another problem, the lack of sensitivity analysis, exacerbates the input data problem. In only a few cases did the modelers carry out a sensitivity analysis in order to determine just how accurate their input data needed to be or which assumptions significantly influenced the outcome. For example, in applying the EKMA model in the ozone standard revision case sensitivity analysis showed that a city-specific ratio, one of the input data items lacking for many cities, did not have a significant effect on the decision on how much hydrocarbons should be controlled nationwide. Only if the decision maker was interested in a particular city, rather than an average for the nation as a whole, was such a high degree of accuracy required. Thus, the accuracy available from EKMA, as shown by the sensitivity analysis, was sufficient since the particular decision concerned a national standard and the standard was based on the health data rather than the cost data. Also, in reaching agreement on the technical analysis in the NSPS case the Department of Energy insisted on sensitivity analyses and dropped some of their opposition based on the results.

However, in most of the case studies such an analysis was not done. Instead, the modelers used the available input data but did not test what the inaccuracies in the data implied. The emphasis on conservative "worst case" analysis is one cause of this problem. The models are used to produce one point estimate. The decision maker can then ask: is that estimate above or below the standard. This appears to have taken into account the uncertainties of the data. However, the variabilities in the models are quite large so all that it really does is hide the inaccuracies. The Pittston case is an example of this problem. The oil refinery project was designed so that modeling analysis showed an impact of 4.9 μ/m^3 when the standard was 5.0 μ/m^3. As different models were applied, the refinery characteristics were redesigned so that the impact always remained just below 5.0 μ/m^3. However, as one public interest group representative pointed out, if just one parameter (the wind speed) was not accurate the results could have reasonably been as high as 10 μ/m^3. Relying on one case, said by the company to be the worst case but clearly not considered by everyone to be the worst case, without doing sensitivity analysis to show the range of possible results leaves the analysis open to wide and extensive debate. The purpose of sensitivity analysis is to detail which values of the assumptions or input parameters may significantly alter the results. But, for the policy decision process, a second important result of sensitivity analysis is to show which assumptions are not as important, and therefore, do not need extended debate. It should be noted that sensitivity analysis rightly comes after the model has been evaluated and verified and is not a substitute for those procedures, which, as discussed above, have also been lacking.

Form of Output of Model--

A fourth technical problem encountered in the case studies is a lack of appropriate form for the model's output. While not a widespread problem in the sense that the models do predict pollutant concentrations in appropriate averaging times at various geographical locations, the models do not always serve to answer the decision maker's broader questions. For example, the question of the impact of the decision on employment and energy was often raised. The models are not meant to answer such questions but neither are they designed so that their output could then be used in further analysis of these other issues. One exception was the ozone standard revision case where the organization applying the air quality models was primarily responsible for the employment and energy questions, rather than the air quality question, so that they did do the full analysis. The San Francisco AQMP case gives another example; again the responsible agency was not limited to environmental policy questions but was required to look at the broader problem.

A second manifestation of the lack of an appropriate form for the models' output can be seen by contrasting the San Francisco AQMP case with the Connecticut TCP case. The use of the LIRAQ model in conjunction with employment models provided the decision makers with the flexibility they needed to produce a politically acceptable plan. The modelers provided an analysis of various strategies and, when the policymakers decided to reject them on the basis of their land-use implications, the modelers were able to provide an analysis of other strategies whose land-use implications were acceptable. In contrast, Connecticut's Administrator, if he had accepted the model results, would have rejected over half of the proposed construction projects. Clearly, the situation in Connecticut could have been such that, no matter what strategy was chosen, over half of the projects would be stopped. But this is not certain since the modelers could only produce one analysis. Their model was not flexible enough to analyze different strategies within the time frame needed. This caused the rejection of the model and the Administrator was left without a strategy for assessing proposed projects.

Probably the major factor causing this problem is the professional backgrounds of the modelers. As meteorologists, they do not know how to model the economy or are not familiar with energy or employment models so that they could make air quality models compatible with them. However, the problem also stems from the narrow interests of the environmental agencies and, sometimes, departments within the agencies. The Connecticut TCP case gives the example of two agencies, with two separate missions (environmental protection and transportation), which could not come to a compromise because they were never required to expand their analysis beyond what would be the impacts on their own programs. The San Francisco AQMP case shows how reorganizing the job responsibilities into joint task forces where, instead of competing solutions, the agencies are responsible for coming up with one joint solution, led to an acceptable plan. The NSPS case also used the task force method to advantage in this way.

Social and Political Constraints

Just as the modeler faces limitations due to the state-of-the-art of modeling, the decision maker faces social and political constraints within which he or she must make decisions. For instance, visibility was not a concern in federal air pollution programs until the 1977 Clean Air Act Amendments were passed, while emissions of hydrocarbons and carbon monoxide from automobiles have been regulated by some states since 1960. Thus, while in the future the laws may change, for the present they set certain bounds on the range of problems and solutions available to the decision maker. Funding and time constraints affect the decision maker as well as the modeler; even if the technical information exists, it may be too time consuming to collect.

Examples of the social and political constraints encountered in the case studies are discussed in this section. However, it should be noted that "politics" may not be as binding as is usually believed. A common excuse for why models were not determinant is that the politics of the situation caused the model results to be ignored. But an examination of the case studies shows that there are often other reasons, such as the organizational structure or the management of the decision process, which fueled the controversies.

Energy and Employment Impacts--

As an example, we turn to the problem of energy and employment impacts. Energy was a pervasive theme in two cases where the outcome was different. The state legislature called for a revision of the Massachusetts' sulfur regulations because of the rising price of oil. Originally, the regulations concerning sulfur content in fuel had been set without an analysis by air quality modeling. They were relaxed in the same manner under the emergency legislation. Several modeling analyses were done to support (and refute) the regulations after the fact and the relaxation was upheld. In contrast, the MATEP cogeneration power plant was aimed at conserving energy, but the debate remained centered on air quality and neighborhood land-use issues.

A similar diversity of outcomes can be seen in the different treatment of the issue of employment in the Westvaco and the Anaconda cases. In the Anaconda case, when the company raised the spectre of lost jobs, EPA hired a consultant to investigate and the issue did not delay the decision. In the Westvaco case, the issue remained controversial after the company raised it because EPA did no study of the problem. In this case, the EPA regional office did very little technical analysis of any kind, including the "jobs" questions, while in the Anaconda case massive resources had been allocated to the air quality modeling, and the contract to study employment impacts was not a large additional item of analysis.

Intervention of Other Interested Parties--

The problems of energy and employment can be foreseen and, if necessary, studied. The problem of intervention by other political interests is not so easily dealt with, however. In several cases a party not apparently connected with the decision intervened with significant consequences. For example, the Council on Wage and Price Stability issued a statement undermining EPA's position on Section 125 and its application to the Ohio SIP. Also, the Office of Management and Budget required revisions to EPA's SIP regulations so that the Anaconda company withdrew their proposal to reduce emissions by 90% and instead insisted that reasonable available control technology was all that was required. It took EPA (and a change of governors and company ownership) over seven years to again approach the 90% reduction level.

The Anaconda case also points out how the individuals who are directly involved in reaching the decision can play a decisive role. A new governor and the new owner of the mine were more amenable to reaching an agreement and the permit decision proceeded without further delay. In contrast, the Connecticut Transportation Control Plan seems to have proceeded slowly or been delayed because a new governor needed time to test the political waters.

Summary

These technical and political problems are not new. EPA has a monitoring program; it has underway a validation program; more time and resources for technical analysis of all kinds is always sought; and outside political issues and interests are always there. However, what I have tried to point out by the examples cited in this section is that in several ways, these technical problems are not caused by the state-of-the-art or by resource and political constraints alone. Instead, policy, managerial and organizational elements add to the problems and extend the controversies in many cases. It is these factors which are now discussed and which the recommendations of this report will focus on because, even if the technical problems are solved, the controversies will not end and, even without solving the technical problems, the decision process can be improved and better technical analysis done if the motivational and organizational structure is changed.

POLICY, MANAGERIAL AND ORGANIZATIONAL PROBLEMS

The examples of the political constraints have been cited to illustrate the various influences, outside the technical sphere of air quality modeling, that have an impact on the decision making agency in a manner similar to the technical problems' impact on the modeling analysis. The examples of these technical and political constraints also serve to show that their impact on the decision and the decision making process varies from case to case. Now, however, I turn to a discussion of other factors that also serve as constraints and significantly influence the decision making process but can be more directly controlled by EPA or the decision making agency. For convenience these factors are divided into three categories:

--policies of the federal EPA,
--management of the decision process, and
--institutional and organizational interests.

But they do overlap and actions taken to correct one problem may have consequences in the other areas.

Policies of the Federal EPA

The decisions requiring the application of air quality models are, for the most part, taken by the individual state or (if the state lacks a SIP) the EPA regional office. The major role of the federal EPA is to set national policies within which the regional and local decisions are made. In a majority of our cases the lack of EPA policy on a particular issue led to considerable controversy and delay (see Table 2).

The missing policies encompassed both political and technical areas. Three political issues raised in our case studies and addressed in the 1977

Clean Air Act Amendments, but not yet resolved by EPA are:

- --transport (ozone, tall stacks and acid rain),
- --NO_x short-term standard, and
- --prevention of significant deterioration (PSD) and growth.

A more technical issue for which EPA has not established guidelines and which added to the controversy in several of our case studies is that of monitoring,

- --in what instances can EPA require an applicant for a permit to set up a monitoring network on private property, and
- --should monitoring be done in areas inaccessible to humans.

A third area

- --what happens when national and regional policies conflict (as in the case of the use of scrubbers or low-sulfur coal),

illuminates how federal policies do impact on regional and local decisions and, to a limited extent, why the federal EPA may be reluctant to establish such policies.

Political Issues--

The transport issue arose in several cases. For a state trying to devise a State Implementation Plan the EPA policy of ignoring that the problem exists leads to the need for extensive controls to counterbalance the pollution arriving from an upwind state. Connecticut was unwilling to impose what they saw as extra controls. The EPA regional office and other states in the Northeast agreed and together devised an alternative policy. But this was rejected by the federal EPA as not consistent with national policy and Connecticut's TCP was stalemated.

A more satisfactory solution was reached in the San Francisco AQMP case. Their modeling considered the problem of the formation of ozone from upwind sources. They were able to do this because the geographical area covered by the plan did not cross state boundaries and because they had the resources to employ a sophisticated photochemical dispersion model (LIRAQ) to make their case.

The lack of a policy on transport also translates into specific consequences when permit applications are considered. In the case of the Ohio power plants, the company proceeded to build taller stacks without the EPA regional office being able to require them to substantiate the need for them and before any permit was issued. The company felt free to do so in the face of EPA's confusion on the issue.

EPA has not yet promulgated a short-term standard for NO_2. The lack of such a standard in the MATEP case forced the state into doing an analysis of health effects studies, duplicating analysis that the federal EPA has been and is now conducting. It also put the state into a position of potential conflict; if the federal standard turns out to be less strict than the one established by the state for MATEP--a state law requires that all state standards be no more stringent than the federal ones--the standard for MATEP will have to be relaxed.

The third political issue, PSD and growth, arose in the Pittston case. Officially EPA ignores the problem of how and if additional pollution sources, beyond the one under consideration, should influence the decision at hand. The result is an application of the usual air quality models to one source without recognizing that PSD increments, being small, may require more accuracy than if the standard was a national ambient air quality standard and without requiring an investigation of the impact of potential future sources.

Technical Issue of Monitoring--

The more technical issue of monitoring also shapes the information available to decision makers. The Clean Air Act Amendments of 1977 allow EPA to require monitoring on private land but EPA has been reluctant to impose this requirement and has no guidelines for when it should be imposed. Two of our cases demonstrate the problem caused when monitoring is not required: Westvaco and the Ohio SIP. In each case the company set up monitors where the EPA regional office's analysis indicated violations were not likely to occur but did not locate monitors where violations were expected to occur. Subsequently, the companies tried to focus the debate on the fact that their monitors were not located so as to detect violations. In the absence of a federal policy the companies successfully delayed for many years, installing monitors which conceivably would have shown the need for them to install addition control equipment.

Appropriate monitoring was conducted in two permit decision cases: MATEP and Anaconda. In these cases, however, EPA did the monitoring and the burden of proof that the monitoring was wrong was on the applicant instead.

National versus Regional Policies--

National policy which can be applied to all local situations is not easy to develop. The Ohio SIP case highlights this problem. The effect of the NSPS for coal-fired power plants is to have new plants install scrubbers and use high-sulfur coal so that low-sulfur coal can be saved for existing plants. However, in Ohio the existing plants prefer to use the high-sulfur coal because it is locally available.

Another example is the Connecticut TCP case where the state was joined by the EPA Region I office in sponsoring a conference on the transport issue and in pressing for a resolution satisfactory to the nineteen states of the north and east which sent representatives. Transport was one of the major problems in this area of the country and had been delaying completion of Connecticut's TCP. The regional solution was to apply reasonable available control techniques (RACT) until more accurate and sophisticated modeling was available to pinpoint the contribution of specific sources. From a national point of view, however, such a solution would imply RACT was sufficient for a host of other states not experiencing the transport problem and these states would want to revise their SIPs to require fewer controls. Therefore, EPA headquarters stood firm in demanding the use of the available oxidant air quality models.

There are always exceptions to policies whose consequences have to be dealt with. However, as we will see in the next section, a lack of clear and consistent policy, combined with a weak management process, leads to long time delays without an efficient development of information.

Management of the Decision Process

Most of our case studies involved long delays and unresolved controversies. As we saw in Table 3, this often resulted from the modeler's having asked and answered the wrong question. Part of the reason for why this happened can be traced to the management of the decision process. Three problems in particular are found in the case studies as contributing to this problem:

--no systematic effort at choosing the most appropriate model was made or, at a minimum, was made clear to the public;

--no effort was made to establish the legitimacy of the decision process; and

--EPA's method of criticizing others' model applications was ineffective.

Choice of Model--

The earliest technique for estimating the degree of control of emissions needed to meet air quality standards was the linear rollback model. This technique, as an adequate policy tool, pleased almost no one and in all of our case studies other models were used. However, as Table 4 shows, the choice of these other models was not subject to an exhaustive search for the best model for the particular topographic and meteorological situation. Even when appropriate constraints such as cost, data availability and user needs are added to the list of criteria for choosing a model we still see that in only a few cases were the models chosen for these reasons.

Instead, the models were chosen because that was what the modeler was familiar with or because it was the latest developed model. In some cases, models were rejected and others applied because the policymakers did not like the results of the model. Also, in several instances a consultant was chosen, often also for reasons of familiarity, who then applied the particular model that had been developed by that consulting firm. The state or regional office, then, relied on the consultant's model without evaluating it against alternative models.

This procedure can be contrasted with the procedure followed by the Association of Bay Area Governments (ABAG) in its choice of the LIRAQ model for developing the San Francisco Bay Area's Air Quality Maintenance Plan.

TABLE 4

CRITERIA USED IN CHOOSING AN AIR QUALITY MODEL

	Evaluated Alternatives	State of the Art	Cost Constraint	Data Constraint	User Audience Needs	Determined by Results	Familiarity with Model	Latest Model	Consultant's own Model
MATEP		X					X	X	
Pittston							X	X	X
Anaconda		X							
Westvaco									X
Massachusetts' Sulfur Regulations		X	X	X					X
Ohio SIP								X	
Connecticut TCP	X		X	X	X	X			
San Francisco AQMP	X	X			X				
Ozone Standard						X		X	

ABAG had been faced with a plan, developed by EPA utilizing linear rollback, which was totally unacceptable in its implications for land use and transportation restrictions. In this political climate and under the initiative of the Lawrence Livermore Laboratory, LIRAQ was developed. The first phase of the new plan development consisted of drawing up criteria to which the model had to conform. These criteria included:

--technical acceptability,
--reasonable cost,
--user-oriented, and
--consistency with other models to be used.

The government agency was willing to participate in the coordination of the development of a data base and the state-of-the-art in order to assure conformance with these criteria. However, ABAG did not stop there. Throughout the modeling process they were careful to evaluate alternative models and maintain open avenues for public criticism of the model. The combination of these actions ensured public acceptability of the results and, thus, increased the chances that the plan could be implemented.

Legitimacy--

The ABAG process was managed from the point of view of establishing legitimacy for the process. They realized that technical defensibility of the model was not enough; they knew they had the best model given the particular circumstances, but they also knew that they had to prove it was the best to the public. They did this by involving interested parties on all sides of the issue from the beginning. This strategy was also followed in the NSPS case and, clearly, it involves extensive meetings, time and resources.

However, other case studies show that a less open process generates controversy over models (rather than over policy) and delay. EPA is required to hold meetings for soliciting public comments and consider them in its decisions. The problem with the process as followed in the other case studies is that the public hearings are not held until quite late in the process and the modelers are put in the position of justifying their already-reached conclusions rather than changing their analysis in response to appropriate criticisms. Thus, the process as managed by EPA is an "open process" in the sense that public hearings are held. However, it is not open in the sense of encouraging all interested parties to bear some responsibility for assessing the technical data and the possible solutions.

Involving environmental, business and other government agency representatives from the beginning gives these outside interests a stake in the outcome. For example, ABAG included the California Department of Transportation as a participant and made the transportation representative responsible for explaining and obtaining his department's concurrence as the work proceeded. In the NSPS case, EPA formed a joint task force which included potential opponents from other government agencies. In Connecticut, however, the state's Department of Transportation remained a critic rather than a participant and in the end helped sabotage the state's model by withdrawing its support. Also, if environmentalists and industrialists are members of the working groups, it is harder for them to raise unimportant issues as if they were important without participating in their resolution. For instance, the Westvaco company insisted that no violations had been monitored without admitting that the monitors were not sited so as to reveal violations. Or, in the Ohio SIP case the companies assailed the assumptions of EPA's models without admitting that the state-of-the-art allowed for no better analysis.

Role of Criticism--

The method by which the state or EPA regional offices managed the process of criticism in making permit decisions also had pitfalls. Generally, the company applied for the permit by submitting modeling analyses which EPA or the state would then criticize. By this point in the process, though, the company had already set up any monitoring they were going to do and chosen the model (or consulting firm to do the modeling). Thus, their response to EPA criticisms would be minimal, perhaps including more recent monitoring data but rarely changing their assumptions, model, or monitoring network.

This method of criticism, insistence on doing it EPA's way of "worst case" analysis, maximizes the adversarial positions of the two parties and does not appear to be an effective way of improving the modeling analysis, based on the evidence of the case studies. The exchange of letters and lack of progress, for instance, lasted over five years in the Westvaco case and is a fairly accurate description of the actions of industry in the Massachusetts' Sulfur Regulations and Ohio SIP cases. In the cases of MATEP and Pittston, EPA asked for and received more refined modeling but not better input data.

When the modeling analysis is being conducted strictly within government agencies (e.g., in the San Francisco AQMP, Connecticut TCP, and the NSPS cases), critiques of the models seem to have more effect. In San Francisco and for the NSPS, criticisms were actively solicited and responses made; Connecticut adopted EPA's model, dropping their own, at EPA's insistence. However, counter examples also exist. Massachusetts ignored EPA's analysis of their sulfur regulations because the EPA model did not analyze their preferred strategy. Also, in the ozone standard revision case EPA ignored CEQ's criticisms unless they happened to coincide with their own preference. The deciding factor in these last three examples seems to be whether the critic held the authority to enforce his preference. In the Connecticut case EPA did; in the others the critic did not. For industry permits, EPA, in theory, has the authority; but our case studies show they are reluctant to apply it because such action leads to court and further delays.

Institutional and Organizational Interests

Each case study involves many actors who operate within the context of their own interests and experience. As we saw above, the modelers often answered questions of their own devising rather than questions relevant to the decision maker's need (see Table 3). The information they produced was shaped by what they were able to provide but also by what was of scientific interest to them. Similarly, if we look at the various institutions involved (EPA headquarters, EPA regional offices, state agencies, public and private interest groups), we also see divergent interests shaping the debate.

EPA Headquarters versus EPA Regional Offices--

The federal EPA's major responsibility in air pollution control is to set the national ambient air quality standards and other general policies called for in the Clean Air legislation. Examples are performance standards for new sources, regulations on what a State Implementation Plan should include, transport or tall stacks policy and other areas where actions impact beyond state boundaries or there is a desire for all those affected to be treated the same. The state is then expected to apply these policies for their particular circumstances. When states have been delegated this authority, the regional EPA office acts as the agent for EPA headquarters by overseeing compliance with national policies (e.g., MATEP and the Massachusetts' Sulfur Regulations cases). However, when the state does not yet have an approved plan for issuing permits or when it chooses not to act,then the EPA regional office will act in its stead (e.g., Pittston and the Ohio SIP cases). In this way the regional office's interests are shaped by regional concerns which sometimes brings it into conflict with EPA headquarters' offices.

This conflict between national and regional perspectives shapes the actions of the various organizational levels within EPA. One example is the Massachusetts' Sulfur Regulations case. The Massachusetts law requiring the regulation revision mentioned the use of tall stacks as one technique for ensuring compliance with ambient standards. While EPA does not yet have a specific guideline for when tall stacks are appropriate, they wanted to express their disapproval of the state's proposed policy. The EPA regional office, however, having had experience with such situations where EPA lacked specific policies and knowing that the likely consequence was delay and controversy, rather than a resolution of the issue, instead urged a speedy resolution of the specific regulation issues as proposed (i.e., limitations on sulfur content in fuel) and not the more hypothetical issues of the law.

In areas not concerned with deciding general policies, however, EPA headquarters supported the regional offices (and states). For example, in the Ohio SIP case industry tried an end-run around the Region V office by asking for a review by the EPA headquarters office located in Research Triangle Park of the modeling done by the regional office. The reply was that the modeling was adequate under the circumstances. In several other cases the regional modelers requested and obtained assistance from headquarters on particular modeling problems (e.g., Pittston on the fumigation issue and Anaconda on validation monitoring).

It should also be pointed out that within one agency there will be organizational units with divergent interests as well. The ozone standard revision case illustrates how different organizational interests will lead its members to view the same information differently. The Office of Research and Development (ORD), charged with the development of air quality models, presented the various alternative techniques in the criteria document. However, the choice of a model for obtaining cost estimates was left to the Office of Air Quality Planning and Standards. In this case the initial choice of the EKMA model seems to have been one of "what model am I familiar with" rather than a complete search for what was most appropriate, the assumption behind the modeling chapter in ORD's criteria document.

EPA versus the States--

The case studies describe to one extent or another the interaction between EPA (headquarters and regional offices) and the states, and it is at this level that regional versus national perspectives come into sharpest focus. In the Anaconda and Ohio SIP cases, for instance, the states refused to act because they were not willing to risk having the companies close down or cut back in employment in their state in preference for a state with less strict emission standards. Thus, EPA had to conduct the modeling analyses and make the decisions. Connecticut's governor and legislature also refused to pass a strict transportation control plan unless and until other states had such programs.

Of course, not all the states are the same. In the Westvaco case, Maryland was pushing for strict emission standards while West Virginia was considering relaxing its standards. But generally there is a regression towards the mean; the states are indeed applying more uniform standards. The Massachusetts' sulfur regulation changes illustrate this. The state environmental agency was charged with relaxing its regulation of the sulfur content in fuel so that it was no stricter than was necessary to meet the national ambient standard. EPA actually encouraged such action by Connecticut's environmental agency when they would settle only for one of their own models. They rejected the model developed by the state at least in part on the grounds that the SIPs had to be uniform in their technical bases and this included consistency in data base and model. Such uniformity, it was said, made EPA's review job easier.

EPA versus Other Government Agencies--

Just as states do not present a united front, neither do all government agencies. For instance, the U.S. Departments of the Interior and Commerce opposed EPA's permit allowing Pittston to build an oil refinery in northern Maine. Their concern was with endangered species as well as air quality. (Indeed, within EPA the same project that received an air permit was denied a water permit.) Another, more predictable opponent of EPA decisions is the Department of Transportation (DOT). In the Connecticut TCP case, the state DOT supported the development of the analysis but continuously and effectively opposed the results when they called for reducing highway construction projects. In other words, DOT was opposing policies whose effect would be to reduce its own programs.

In the San Francisco AQMP case the environmental program managers foresaw this problem and took steps to neutralize CalTrans' opposition by including the transportation agency on the governmental task force responsible for coming up with a solution. Thus, CalTrans was not allowed to get away with simply criticizing. They also had to make constructive suggestions and participate in finding a solution acceptable to their agency as well as to the environmental agency. Clearly, the resulting plan was not all EPA could have wished for, but when compared to the almost total lack of a plan in Connecticut, it is a more satisfactory solution. In a similar manner EPA foresaw opposition from the Department of Energy and others in the administration to their proposed NSPS for coal-fired power plants. In this case, in addition to joint task forces, they scheduled many meetings to inform the potential opponents about the analysis in order to raise and resolve the technical issues.

Business Interests--

Industry is the most obvious adversary of EPA in the process of making the type of environmental decisions found in these case studies. Generally, the interest of the company applying for a permit or who will have to comply with the state's or EPA's regulations is to minimize production costs and this can usually be directly translated into minimizing expenditures on pollution control equipment.* Several consequences arise from this divergence of interests.

First, while the company is required to submit evidence of air quality impacts of its proposed project, once it has picked an air quality model, assumptions and the monitoring data, the tendency is to stick with it, defend it if necessary, but not to respond to EPA's criticisms by either changing the model or the monitoring. The advantage in this tactic is that, at a minimum, it results in delay, especially if the matter ends up in court; and delay means delay in incurring the costs of installing pollution control equipment. We can see the importance of the capital cost factor by contrasting the cases involving large construction projects with their long delays and frequent court cases with the case of the Massachusetts' Sulfur Regulations. While this was a case of relaxing standards, the utility industry was lobbying for an even greater relaxation. However, there was not, in the end, a court case or protracted delay in part because the costs involved the cost of fuel not capital expenditures. These operating costs could be passed on directly to the customer and no large fixed costs would be forfeited if later the regulation was again changed. For similar reasons, the utility in the Ohio SIP case delayed and went to court as often as possible because they would not be able to pass on the costs of installing the pollution control equipment directly to the customers.

A second consequence of the adversarial system is that EPA loses from the beginning any ability it has to obtain information that the company may not want to supply. Industry's use of the courts and delay led in several cases to the inability of EPA to obtain adequate monitoring data. In both the Westvaco case and the Ohio SIP case the company had sited monitors at the beginning of the process and refused to change them when EPA showed that

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*In the water pollution area production processes can often be changed to reduce toxic effluents and at the same time save money. But this has not often been done in the air pollution area.

they were located at the wrong sites if maximum concentrations were to be recorded. Of course, EPA can do its own monitoring, as in the Anaconda case, but this is expensive, and, without a policy allowing them access to private property, difficult if the company wishes to oppose them.

The third result of business interests in the adversarial system of environmental decision making is the inclusion in the debate of issues broader than just environmental issues to which EPA is not prepared to respond. For instance, the concerns of energy and employment impacts were often raised in the case studies. The problem is that, while these are legitimate public policy issues, they may or may not be important concerns in a specific situation. However, in the adversarial system of environmental decision making, business can raise the question without any attempt to resolve it. If EPA is unprepared with answers, the issue may remain controversial without anyone knowing if it is important or not. The Westvaco case is perhaps the clearest example of the problems that occur when EPA is unprepared to respond to all the issues. In this case EPA did not do modeling of their own until fairly late in the process so that they were not able to defend their assertion that violations would occur. Further, the company raised the spectre of jobs and plant closings and had many individual workers testify on the hardships this would cause. In many instances, EPA has found the threat of plant closings to be just that, only a threat, but no independent information on this issue was presented in this case and the controversy remained.

The case of the Anaconda copper smelter shows how EPA can counter these business interests. In this case they conducted their own monitoring and modeling and hired a consulting firm to investigate the employment issue. However, a fortuitous circumstance may also have helped in the resolution of this case. The smelter was sold to another company, Atlantic Richfield, in the middle of the negotiations. Atlantic Richfield, then, knew of the environmental problems and presumably factored in the costs of pollution control when they agreed to buy the company.

Environmental Interest Groups--

One other organization also has an interest in the type of decisions we are looking at in these case studies: the public interest groups of environmentalists. However, in terms of resources for supplying information they are the odd man out. Generally, these groups do not have access to the resources and expertise necessary to do their own modeling, although in several cases they did do technical critiques of the modeling done by EPA and the industry.

The problem is that their role is restricted to public hearings where they voice criticisms and present evidence. Over time their positions become predictable and tend to be discounted as a presentation of just one side of the issue, just like business when it raises an issue but does not offer a solution or an explanation of its significance. Also, the environmentalists will raise the hard issues, for example, the short-term NO_x impacts in the MATEP case or why did Connecticut not sue EPA in court over the transport issue, when the analysts or modelers had not raised them because they did not have the answers.

A factor that often exacerbates this adversarial relationship between EPA and the environmentalists is the fact that the public hearings usually come late in the decision process. This means that the technical analysis has been done and the modelers would rather defend what they have than change it.

The San Francisco AQMP case shows the advantages of changing the process so as to encourage public participation as early in the process as possible. By having representatives from the environmental groups on the original task forces assigned to conduct the technical analyses the environmentalists could ask their hard questions early with a chance that answers could be found. They also became allies with a stake in helping to find a solution rather than remaining a critical spectator. In this way, the final debate was focused on the policy issues by obtaining the agreement of all interests on the technical issues in the earlier task force meetings.

SUMMARY

These case studies have investigated technical, political, policy, managerial and organizational aspects of the use of air quality models by EPA and the states. The technical problems which arose in these cases included:

--lack of verification studies, especially for complex topographic situations;

--lack of input data, especially if industry supplied the data;

--lack of sensitivity analysis due in large part to EPA's "worst case" requirements; and

--output formats that do not take into account the larger picture of how air pollution fits into the energy and employment problems.

The political issues which appeared were:

--the analyses tend to ignore the larger issues because air quality models do not address them, and

--other interested parties intervene to try to influence EPA's decisions.

The policy problem centered on:

--a lack of directives because the focus was on the technical rather than the policy implications.

Several aspects of the management of the decision process led to:

--an isolation of the modeling analysis in the early stages of the process, and

--a lack of legitimacy or credibility for the analysis.

The investigation of the institutional and organizational activities in the cases points out that:

--institutions and organizations have separate and conflicting interests in the impacts of decisions, which tend to fuel the controversies rather than resolve them.

Clearly, not all of these factors will be under the control of the decision maker or the modeler. The recommendations in the next section focus on those that can be controlled or changed (mainly the technical and managerial ones). They recognize and try to work within the others as limitations or constraints on the decision process.

SECTION V

RECOMMENDATIONS

There is no easy methodology or approach to using an air quality model in an environmental control decision. The decision based on the models, given the state-of-the-art of the modeling, will continue to be controversial. However, several steps can be taken to make the available information more useful to the decision maker.

The first three recommendations recognize several of the technical problems that the EPA Office of Research and Development (ORD) could address alone. The other recommendations focus on managerial problems. These recommendations require ORD to act in concert with other organizations within EPA and the states. Thus, they will require additional planning and cooperation across organizational and institutional lines which recognizes the conflicting interests involved.

TECHNICAL RECOMMENDATIONS

Several unresolved technical issues (e.g., downwash, fumigation, reactive pollutants, transport) result from the state-of-the-art of air quality modeling. EPA's research programs are designed to discover and investigate this type of problem and it is not my purpose here nor was it the primary purpose of the project to indicate the priorities of the research agenda. Instead, the recommendations of this section focus on technical planning and analysis that can be done within the existing state-of-the-art.

1. Plan and require monitoring.

The lack of monitoring and input data created problems in many of the case studies. Often the decision was to require a better monitoring network, but this decision was made after a delay of several years and controversial court cases. In most of the cases it was possible to define a better monitoring network. Thus, an analysis of what monitoring would be appropriate should be done or required by EPA as a first step in the decision process.

2. Detail guidelines for sensitivity analysis and output format when developing a model.

In order to focus the modeler's attention on the policy issues that the decision maker will have to face when using a model one requirement for documentation of the model ought to be how a sensitivity analysis should be done and what different forms the output can take, depending on the policy question asked. The inclusion of such topics in model development rather than in model application will make sensitivity analysis easier and the model output more flexible but, more importantly, it will force the modeler to develop a model which is more likely to be relevant to the policy (as opposed to research) setting.

3. Focus verification studies on actual needs.

EPA's programs to verify the models should be based on what applications and models have in the past shown to be problems. A systematic attempt to discover these problems could be made through a questionnaire to the states and other model users each year during the budgeting cycle. It is important to ask the user, not the modeler, what problems the models are and will be called upon to address.

MANAGERIAL RECOMMENDATIONS

Technical issues generally comprised only a small portion of the problems which arose in the case studies. The management of the decision process also caused delay and controversy. The recommendations of this section focus on the managerial aspects in an effort to increase the interaction and communication between the modelers, the users and the other interested parties. The purpose of the changes recommended here is to focus the decision on the policy issues rather than on technicalities which cannot be resolved and to reduce the time delays in an effort to increase the credibility of the technical analysis and establish the legitimacy of the decision process based on the models.

It should be noted that neither these recommendations nor the project as a whole considers changes in the legislation. The legislative framework is taken as a given and the managerial changes focus on improvements in the development and use of technical information by EPA that can take place within the existing law.

4. Include all interested parties from the beginning.

Non-governmental interest groups as well as non-EPA government agencies should be included in the process from the beginning. This could take the form of early fact-finding public hearings or it could include the formation of task forces. This recommendation appears to require resources and time which may not seem to be available. However, the case studies show that decisions take years and, more importantly, that it is costly and time consuming to have an issue raised late in the process when the issue could and should have been dealt with earlier.

Several of the managerial recommendations suggest the formation of a task force or other cooperative group which crosses organizational and institutional lines. In assessing the need for and appropriate form of such a task force, attention should be given to the assignment of responsibilities for the development of a solution that can be endorsed by the organizations represented in the group. Without commitments to the solution, even if the solution is limited, say, to certain technical issues, such task forces would be little more than another layer of meetings and incentive to delay rather than a serious attempt to assess the importance of issues and negotiate and balance interests.

5. Establish criteria and boundaries for the technical analysis for each decision.

Criteria, such as what the broad issues are, what is the range of policy options, if and how modeling will be done, and how the data will be used, should be established before choosing which model, which data or which assumptions to use. The current legislation, by mentioning air quality models as a technical analysis tool, presumes they should and ought to be used in a variety of situations. This in turn has tended to narrow the range of issues considered and the options for technical analysis investigated.

If such questions as how the energy and employment issues will be analyzed and whether monitoring rather than modeling is more appropriate for the particular situation are addressed before any technical results are presented, it is more likely that the decision will not founder on state-of-the-art questions but instead can be focused on the policy issues.

6. Establish agreement on state-of-the-art and assumptions before the technical results are presented.

Early in the process the discussion should focus on what is the appropriate model given the available resources. In this way it is harder to choose a model because of its results rather than because it is appropriate for the particular situation. How to negotiate such agreements will have to come through practice as there are very few examples of such attempts, much less successful outcomes. Several methods could be tried in various situations, including:

- --joint task forces,
- --industry application requiring approval of model(s) before analysis is undertaken, or
- --independent scientific review body to set criteria.

Which method is chosen may depend on the size and expected impacts of the project, the willingness of the parties to negotiate or, indeed, the incentives for the parties to cooperate.

7. Establish joint industry/EPA modeling studies.

Presently, a firm applying for an air quality permit will conduct a modeling study as part of its application. EPA (or the state) then criticizes the modeling analysis and sometimes conducts its own. In the spirit of recommendations #4, #5, and #6, consideration should be given to undertaking a joint modeling study for the decision, rather than separate ones. Other interests should also be included but the major resources would be from industry and EPA. The idea is to force agreement early on the technical assumptions. Clearly, agreement will not always be possible but disagreements would be investigated and their impacts detailed for the decision maker without going to court.

8. Explain decision and alternatives considered in detail.

As decisions are made throughout the process, the alternatives considered should be explained in detail. Presently, the modeling analysis is usually described, in more or less detail, but the alternatives such as other models, other data or other issues, are not. To establish legitimacy for the process and to counter the technical and political debate the basis for the decision has to be made public. This also, of course, encourages the broader consideration of alternatives in the decision.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT Eleven case studies of the application of air quality models were undertaken in order to examine the problems encountered when trying to use these models in making environmental policy decisions. The case studies of air pollution control decisions describe the decision process, the models used, the critiques of the models, and the participation by outside interest groups in the decision process. The studies include two cases of federal decisions, seven state decisions, one local decision, and a review of the evolution of modeling requirements in the Clean Air legislation. The time covered is from 1970 to the present and includes several cases for which a final decision has not yet been made.

The results of this investigation show that indeed the well-known technical and political constraints exist but that unresolved policy issues, the management of the decision process and conflicting institutional and organizational interests also cause problems. Recommendations are made on how to improve the technical planning and management of the decision process so that the air quality models can become a better policy tool within the state-of-the-art, political and organizational constraints.

17. KEY WORDS AND DOCUMENT ANALYSIS

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