Economic Incentive Approaches to Air Pollution Control

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TABLE OF CONTENTS

PAGE

PAGE

EXECUTIVE SUMMARY

Traditional command-and-control approaches to air pollution regulation typically require companies to use specified pollution control technologies or require classes of emissions sources to meet performance standards. Such approaches ration each source's use of the air as a receiver for pollutants in order to meet National Ambient Air Quality Standards (NAAQS) or other air quality goals.

These approaches provide little flexibility to companies in determining the degree to or the way in which pollution control requirements are met. They provide no economic incentive to companies to install controls quickly or to go beyond regulatory requirements. They provide little incentive to innovation which could decrease long term pollution control costs or make more effective control possible. These characteristics probably result in a regulatory program that costs more and in the long run may do less to protect the environment than might otherwise be possible.

Economic incentives can overcome some of the limitations of traditional regulatory approaches by providing the flexibility that is missing with command-and-control approaches and giving sources incentives to use that flexibility. Because polluters have greater knowledge about their own control costs, plans for development and possibilities for technological advance than government officials, they can use this knowledge to respond to pollution control requirements in a cost-effective way.

This report responds to the requirement in Section 405(g) of the Clean Air Act (CAA), as Amended, for a general report to Congress on economic incentive approaches to air pollution control. Section 405 of the CAA directs EPA and the Council of Economic Advisors (CEA) to identify, study and assess economic measures which could:

- o strengthen the effectiveness of existing regulatory requirements by encouraging compliance;
- o provide incentives to abate pollution to a greater degree than is required by existing regulations; and

o serve as a primary means to control air pollution problems that are not addressed by existing regulations.

A report to Congress analyzing the use of economic incentives to control stationary source NO_x emissions was completed in early 1981 in accord with Section 405(f) of the Clean Air Act Amendments.

This Executive Summary discusses the implications of any desirable changes to existing legislation, and then presents the major analytic conclusions reached by EPA and CEA.

Legislative Implications

Analytic Conclusions[1]

- REPLACEMENT OF THE IN-PLACE REGULATORY SYSTEM WITH STAND-ALONE EMISSIONS CHARGES OR MARKETABLE PERMITS IS NOT NECESSARY. ALL SIGNIFICANT BENEFITS OF ECONOMIC INCENTIVES CAN BE ATTAINED THROUGH CAREFUL SELECTION AND DESIGN OF CHARGE OR TRADING APPROACHES WHICH SUPPLEMENT THE CURRENT REGULATORY SYSTEM. The current regulatory system has accomplished a great deal, and it would be disruptive and confusing to replace this system. If the full potential of supplemental charges and "controlled trading" programs (the buying and selling of obligations to reduce emissions or of credits for abatement which was not required) could be achieved, no significant incremental benefits would be available from use of stand-alone charges or a "pure" system of marketable permits. However, stand-alone charges and permits would offer a fresh start that may be important to achieving the potential benefits of economic approaches in certain unregulated areas.

- WITH ITS OFFSET, BUBBLE, AND EMISSIONS BANKING POLICIES, EPA HAS MADE SIGNIFICANT STRIDES TOWARDS INCORPORATING MARKET INCENTIVES IN ITS AIR PROGRAM. In each of these policies, polluters have incentives to seek out sources of low-cost emission reductions. The result will be a more cost-effective pollution abatement program. However, these policies have not yet been fully implemented by the states. One reason has been the cumbersome administrative procedures and certain restrictions associated with these policies. EPA has taken steps to streamline the process and to remove restrictions. EPA is continuing to explore additional improvements.

- NONCOMPLIANCE PENALTIES SIGNIFICANTLY STRENGTHEN THE EFFECTIVENESS OF CURRENT REGULATORY REQUIREMENTS BY ENCOURAGING COMPLIANCE. Noncompliance penalties are a special form of economic incentive intended to neutralize the economic benefits which would otherwise accrue to stationary sources that delay compliance with regulatory requirements. EPA has implemented these penalties, and EPA and CEA expect them to be highly effective.

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[1] Only the most significant analytic conclusions are reported here. A more complete set of conclusions is given in Chapter V.

o IT IS DIFFICULT TO DIRECTLY PURSUE ECONOMICALLY EFFICIENCT OUTCOMES. Economic efficiency requires that damages from emissions and control costs be equalized at the margin. In the absence of an ability to determine damages accurately, efficient outcomes cannot be identified. Thus the operational test of efficiency is that of cost-effectiveness, i.e., achieving an environmental objective at least cost. This is the standard of efficiency pursued by EPA in its consideration of incentive approaches. Any approach that is economically efficient will also be cost-effective.

o BOTH SUPPLEMENTAL CHARGES AND "CONTROLLED TRADING" CAN PROVIDE INCENTIVES TO ABATE POLLUTION TO A GREATER DEGREE THAN IS REQUIRED BY CURRENT STANDARDS. Supplemental charges imposed on some or all residual emissions can be as effective as stand-alone charges in providing a continuous incentive to sources to go beyond current standards and to find innovative ways to reduce control costs. Controlled trading provides identical incentives for each source and can lead to a reduction in total emissions as emission reduction credits are created for later use or sale.

o STAND-ALONE CHARGES AND UNRESTRICTED TRADING OF MARKETABLE PERMITS CAN BEST SERVE AS A PRIMARY MEANS TO CONTROL THOSE AIR POLLUTION PROBLEMS WHICH ARE NOT ADDRESSED OR DEALT WITH SUCCESSFULLY BY CURRENT REGULATIONS. Air pollution problems which are not being addressed by the current regulations should receive careful scrutiny as candidates for implementing emission charges or marketable permits. In these cases, economic incentives cannot disrupt an existing program, and may provide a better approach to as yet unsolved problems.

o IN GENERAL, A MARKETABLE PERMIT SYSTEM IS PREFERABLE TO A CHARGE SYSTEM FOR ATTAINING AND MAINTAINING AN AMBIENT STANDARD. We base this conclusion on the following findings of our comparative analysis of these two economic policies:

-- Under a charge system the quantity of pollutants emitted depends upon the response of sources to the costs imposed by a charge. Thus, under a charge system, administering agency has greater certainty in the short run that standards will be met than under a permit systems, unless charges are initially set very high.

-- To implement an efficient charge system to attain or maintain an ambient standard, the administrating agency must acquire information about sources' control costs. This is a difficult and expensive undertaking if costs are to be determined accurately. Under a permit system, the quantity of emissions is fixed by the quantity of permits issued, so the agency does not need detailed source-by-source cost data. Cost data would still useful to design permit systems that operate smoothly. These data will be revealed by sources as they buy and sell permits from one another.

-- A marketable permit system self-adjusts to inflation and growth. A charge system requires that the agency make periodic adjustments to these factors, adjustments which depend upon uncertain and perhaps expensive data. Furthermore, frequent changing of charge rates may undercut the credibility of a charge system.

-- A marketable permit system is administratively and legally similar to permit programs now operated under regulatory control programs. This means that it could be administered alongside of existing regulatory programs more easily than could a charge system, and would probably encounter less opposition from vested interests. A marketable permit system is also similar to the Offset and Bubble Policies currently in force.

o <u>CHARGE-BASED APPROACHES ARE MOST ATTRACTIVE WHERE TRADITIONAL APPROACHES WILL HAVE A DIFFICULT TIME MEETING AIR QUALITY STANDARDS ON A SCHEDULE, WHERE THERE IS A FAIRLY LONG LAG BETWEEN EMISSIONS AND SUBSEQUENT ENVIRONMENTAL EFFECTS, OR WHERE MAXIMUM FEASIBLE CONTROL EFFORT IS SOUGHT.</u> Where attainment of air quality goals on schedule is in doubt, or there is no grave concern over short-term damages during the period of necessary adjustments in charge rates, charges can provide a means to induce cost--effective control steps with very little information on hand. Where maximum feasible efforts are sought, charges can induce control efforts that would not have been feasible to identify in advance and efforts that could not have been induced through specific enforceable control obligations.

o THE USEFULNESS AND FEASIBILITY OF A MARKETABLE PERMIT APPROACH DEPENDS UPON WHETHER AN ALTERNATIVE CONTROLLED TRADING APPROACH COULD APPROXIMATE THE CHARACTERISTICS OF PERMITS. Marketable permits offer little incremental benefit, if controlled trading works well. This requires that restrictions on controlled trading be no more extensive than restriction on the sale and use of marketable permits, and that states have the authority and will to allocate control obligations in a manner that will assure attainment.

I

INTRODUCTION

Traditional "command-and-control" approaches to air pollution regulation typically require sources of emissions (plants, automobiles, etc.) to use pollution control technologies specified in the regulations, or require classes of emissions sources to meet performance standards. These approaches provide little flexibility to sources in determining the degree or the way in which pollution control requirements are met. While there may exist an incentive to minimize the cost of a given level of control, they provide no economic incentive to install controls quickly or to go beyond regulatory requirements. They provide little incentive to innovation which could decrease long-term pollution control costs or make more effective control possible. These characteristics result in a regulatory program that costs more, and does less to protect the environment, than might otherwise be possible.

Economic incentives can overcome some of the limitations of traditional regulatory approaches by providing the flexibility that is missing with command-and-control approaches and by letting the market reward companies which use that flexibility intelligently. EPA has already implemented some economic approaches and has studied or is considering several more. This report examines economic approaches that can improve the efficiency and effectiveness of the existing environmental program. In addition, existing provisions of the Clean Air Act (CAA) or of current EPA regulations and policies that reduce economic efficiency are noted.

This chapter briefly describes the existing environmental program for controlling air pollution. Chapter II introduces the economic approaches that are discussed in this report. Chapter III provides a discussion of the key considerations that are important for selecting and designing economic approaches. Chapter IV describes the economic approaches that EPA is now using or considering, and summarizes the results of studies of the feasibility of using economic approaches in other cases. The Appendix describes the studies in greater detail. Chapter V discusses EPA's conclusions regarding the use of economic approaches, and identifies the steps that are prohibited or inhibited by the current provisions of the Clean Air Act.

A. BACKGROUND

A.1 THE NEED FOR GOVERNMENT REGULATION

The need for environmental regulation arises because companies do not pay for the damages that result from the pollution they emit. Since in the absence of regulation the ability to pollute is "free," there is no incentive for companies to reduce emissions. Those companies that pay to reduce emissions are at a competitive disadvantage compared to companies that do not. Yet pollution causes damages to society in the form of health problems, damage to property, damage to the environment and reduced esthetic values. Society would be better off if polluters controlled their emissions, but in the absence of some form of regulation, few if any will do so.

Environmental regulations reduce the damages incurred by society by requiring polluters to reduce emissions. The costs of control are then reflected in the prices that emitters charge for their products, so that the consumers that benefit from the products indirectly pay for the controls.

A.2 STRATEGIES FOR ACHIEVING ENVIRONMENTAL GOALS

Ideally, decisions about the stringency of environmental regulations for each source should be based on the relationship of control costs to the value of the damages avoided by the additional control effort. This holds true regardless of whether the air quality goal is to achieve acceptable levels of health impacts, to provide for a margin of growth or to control degradation of air quality. Unfortunately, control strategies cannot be directly based on cost-benefit considerations because damages are usually very difficult to measure in physical terms, much less in economic terms, and are difficult to assign to particular sources.[1] As an illustration, Figure I-1 is a schematic of the steps (and variables) that must be taken into account in translating emissions into estimates of physical damages. Given the uncertainty associated with

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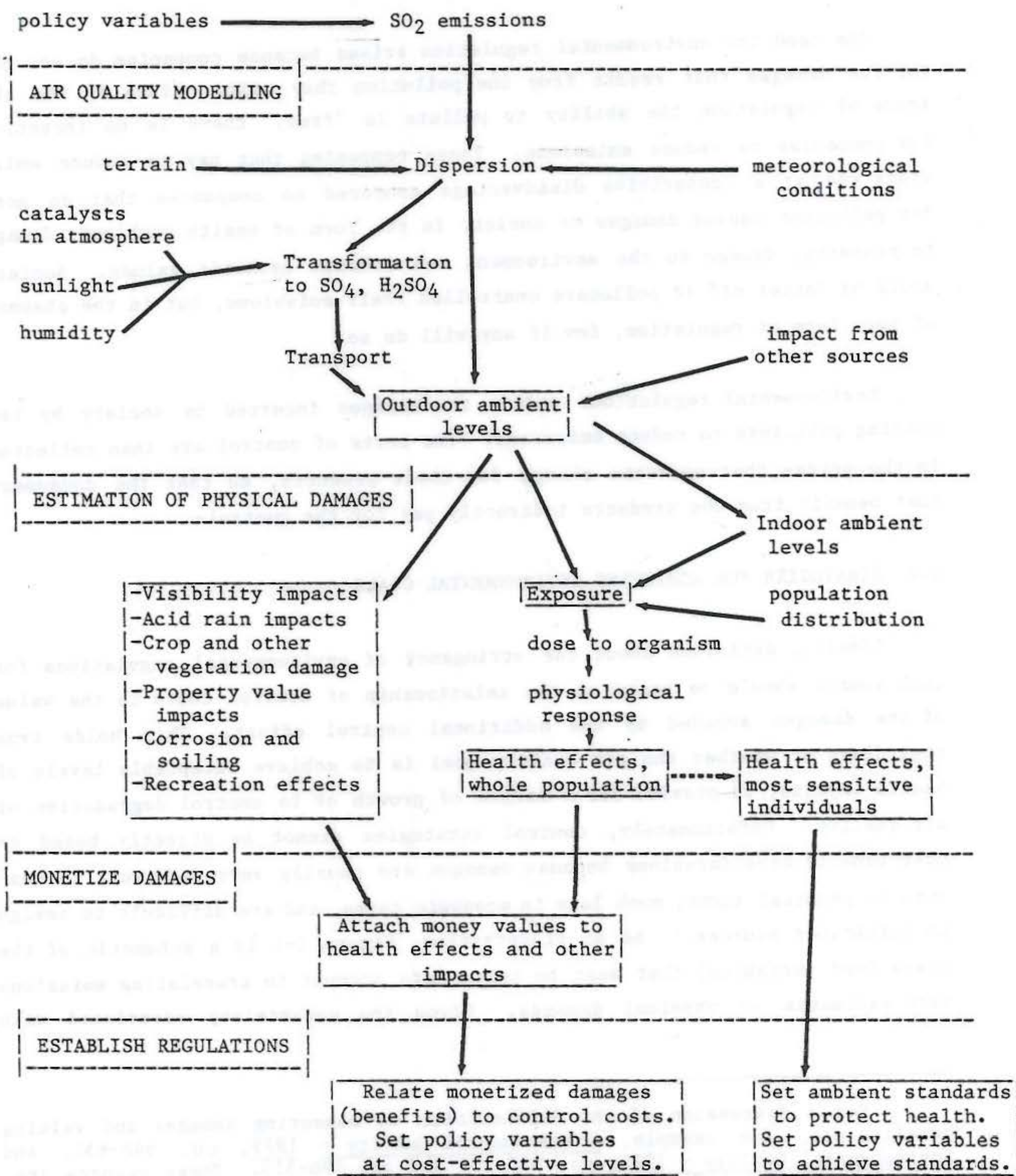
[1] For a discussion of the difficulties in measuring damages and valuing benefits see, for example, Environmental Quality - 1979, pp, 648-652, and Environmental Quality - 1975, pp. 338-347 and pp. 496-519. These reports are, respectively, the Tenth and Fifth Annual Reports of the Council on Environmental Quality.

Figure I-1

Schematic of Steps in Translating Emissions into Damages



benefits analysis, it is understandable that the Clean Air Act has not based protection of the environment and health on direct cost-benefit evaluations.

Regulatory strategies have been based on considerations that can be more readily identified and acted upon than cost-benefit considerations. The strategies that have been used to date to achieve air quality goals are based on achieving specified ambient air quality levels or reducing emissions to levels determined by technological considerations. This does not mean that these surrogate strategies can not be used to control pollution to socially desirable levels -- the levels that would have been required using cost-benefit analysis.[1] Rather, it means that Congress has made the judgment that these strategies were the most desirable at the time for achieving the levels of control that were deemed socially desirable. EPA's responsibility has been to implement these legislatively-mandated strategies in a manner that is consistent with legislative requirements and (where permitted) at lowest cost.

These ambient- and technology-based approaches are described briefly below.

Ambient-Based Strategies

Specification of target ambient concentrations can be used as a surrogate for a damages-related (cost-benefit) assessment of each source as a basis for regulation. There are a number of difficulties in using ambient-based strategies, but as illustrated in Figure I-1, such strategies involve fewer uncertainties than strategies based on source-by-source cost-benefit considerations. This is primarily because ambient-based strategies can be implemented without explictly monetizing the damages from emissions or assigning them to sources.

The pursuit of air quality goals through use of ambient standards is a difficult undertaking where modeling projections of ambient concentration levels are used as a basis for establishing control requirements. Accurate

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[1] For an excellent review of environmental benefits studies, see A. Myrick Freeman III, "The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates," prepared for the Council on Environmental Quality, December 1979. A summary of Freeman's study is contained on pp. 654-655 of CEQ's 1979 Annual Report.

prediction of the impact of individual plants on ambient concentrations requires complex modeling and substantial data. Moreover, air quality models currently available require substantial judgment because they are not yet well specified, they tend to oversimplify reality and, in most cases, the available data are not ideal. In addition, political problems may arise if later verification efforts by means of monitoring show controls were either too little or too much to attain the ambient targets.

Typically, ambient targets are set at levels that are considered to be "thresholds" that protect human health and welfare. Establishing thresholds is difficult because the applicable data are limited, inconclusive or ambiguous. Furthermore, for most regulated pollutants, a sharp line does not always exist that separates benign from adverse conditions: differences in health impacts may exist for different segments of the population, for short-term versus long-term exposure, and for different combinations of pollutants. Because of these difficulties and the implementation uncertainties discussed above, air quality standards are targeted at the most vulnerable segments of the population and are designed with a margin of safety.

Ambient concentrations cannot be used as a basis for regulation when the target levels cannot be accurately determined or where the social goals are not reflected in ambient targets. Target levels may not be accurately determined where available information indicates a health problem but is inadequate to identify a "safe" level, if it exists, or where available modeling is inadequate to link emissions to ambient concentrations, such as in the case of long-range transport problems like acid rain. Target levels cannot be used to represent some air quality goals such as slowing the degradation of air quality in areas where ambient "standards" are being met. In these cases, technology-based strategies can be used.

Technology-Based Strategies

In the absence of operative ambient concentration targets, technology is used to provide the basis for determining how far companies should go in reducing emissions.

The direct relationship of technology-based standards to primary environmental goals can be difficult to define or to quantify because technology-based strategies are generally used precisely in those cases where environmental goals are especially difficult to quantify. Nonetheless, just as ambient targets have an underlying rationale (i.e., health), technology-based standards also have underlying rationales. For example:

- As the economy expands and the population grows, it is inevitable that the potential for emissions from mobile and stationary sources will increase. In the face of an increasingly difficult pollution problem, it might be less costly and more effective in the long run to devise and follow decision rules that require the installation of "best controls" into the stock of capital, particularly where "best" pollution controls can be incorporated during initial construction. As older plants and mobile sources are retired and replaced, the overall pollution potential for a given level of economic activity will drop and the long run pollution problem could be less severe than it would be if new plants and mobile sources had not faced stringent emission reduction obligations. In fact, it is sometimes argued that the absence of requirements of pollution control technology on new sources could preclude the efficient installation of such equipment in the long run if new environmental evidence later indicates the need for more stringent controls.

- We have very uncertain knowledge about future growth patterns and about long-run damages to the environment, some of which may not be reversible. With our lack of knowledge, some overcontrol and added expense may be more advisable than accepting risks which cannot be reliably assessed. While more stringent ambient concentrations could provide a "hedge" or margin of safety for protecting the nation's health and welfare, this could involve unacceptable economic disruption. A technology-based approach can tie the amount of "hedge" acquired to the ability of new sources to incorporate stringent controls into their production planning process.

- In areas that are meeting ambient standards, the quality of the air will degrade as economic and population growth results in new sources of emissions. The degradation of air quality can be slowed or controlled by requiring new sources to meet some level of control even though it is not needed to attain ambient targets. In addition, such requirements can be used to ration the air resource between new sources over a longer time period -- otherwise there is a possibility that the first new sources will use up the margin for growth. In this manner, the ability of the air resource to accomodate growth will be prolonged, and the need to obtain more controls from existing plants to accomodate growth will be deferred.

Certainly congressional sympathy at the time the Clean Air Act was passed appeared to be with such arguments, as reflected in the technology-based requirements for new sources. Moreover, less information and studies regarding the use of economic incentive approaches were available for consideration at the time.

To determine whether technology-based requirements are "reasonable," a combination of criteria have been weighed by regulatory agencies, depending on the problem that is being addressed and statutory requirements. These criteria include technical feasibility, cost, energy impacts and the perceived seriousness of the pollution problem. Establishing technology-based standards can be difficult and time-consuming since there are many classes of sources and even within a class production facilities may be unique.

Mixed Strategies

Some strategies are based on a combination of ambient and technology considerations.

Mixed strategies are useful when ambient standards cannot be attained and another method for determining and limiting the control obligations of sources must be used. For example, as discussed later in this chapter, some areas have failed to attain ambient standards for some pollutants, and may not be able to attain the standards in the near term. How far should existing sources be required to go in further reducing their emissions? In this case, the Clean Air Act requires that existing sources be required to reduce emissions to the extent determined by available technology -- Reasonably Available Control Technology.

Mixed strategies are also useful when ambient standards cannot be attained with existing technology and the ambient targets are used as a basis to "force" the development of adequate technology. For example, as discussed later in this chapter, certain standards for mobile sources have been related to technology which is expected to be available and, in this manner, a clear target for industrial efforts to develop the needed technology is provided.

A.3 SELECTING APPROACHES FOR EXECUTING STRATEGIES

Ambient- and technology-based strategies or any other environmental strategy can be implemented by using command-and-control (i.e., typical regulatory) approaches, economic incentive approaches, or both. Selecting the approach to be used requires balancing the key attributes (or operating characteristics) of the different approaches. The key attributes are introduced below and discussed in general terms. Command-and-control approaches currently in use are discussed in terms of these attributes at the end of this Chapter and economic approaches are evaluated throughout the remainder of this report.

Economic Efficiency

Approaches are efficient if the cost of reducing emissions on the margin[1] is equal to the damages that would result if the emissions were less intensively controlled. Thus, it only makes sense to require that an additional ton of emissions be abated up to the point where the damage caused by that ton is greater than the cost to control that ton. An equivalent definition of efficiency is that point at which the difference between total benefits and total costs (B-C) is greatest.

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[1] "The margin" is the point where decisions are made about the last increment of control effort, and it is here that costs and benefits must be compared to make determinations about economic efficiency. This concept is explained more fully in Chapter II.

In most cases, damages from emissions cannot be measured or precisely calculated. However, even if damages are not explicitly known, every regulatory action involves an implicit assessment that the cost of the regulation does not exceed its social value. To the extent that social costs are known, some approaches may be better able to assure efficiency than others. In the absence of an ability to determine damages accurately, the operational economic goal is that of cost-effectiveness, i.e., achieving an environmental objective at least cost. Any approach that is economically efficient will also be cost-effective.

Cost-Effectiveness

Environmental approaches are cost-effective if they achieve environmental objectives at the least cost. That is, it is more cost-effective to achieve a reduction of 100 tons of emissions at a cost of $0.10 per pound than at a cost of $0.50 per pound. Similarly, approaches are cost-effective if, for a given cost, they are more effective in achieving environmental objectives. Thus, over a given time frame it is more cost-effective to pay $20,000 to achieve a reduction of 100 tons of emissions than to achieve a reduction of 20 tons of emissions.

Different approaches to environmental control may be cost-effective at different levels. For example, consider a plant that has five emission points, each of which is emitting ten tons of pollution per year, for a total of fifty tons. Some control approaches may be cost-effective for the individual emission points within the plant -- the five emission points may each be best controlled to two tons per year at a cost of $200,000 each. The result will be a total cost of one million dollars and total remaining emissions of ten tons per year. While this may be the least cost for controlling individual emissions points, it may not be the least cost approach for reducing the overall level of emissions for the entire plant to ten tons per year. Other approaches may be cost-effective on a plant-wide basis, so that the total cost for a plant to achieve a particular environmental goal is minimized. Thus, for example, it may be possible to control four of the emission points to one ton per year at a cost of $225,000 each and the remaining emission point to six tons per year at a cost of $50,000; the remaining emissions will still be ten tons per year, but the total cost will be $950,000. But even this plant-wide approach neglects opportunities to reduce total cost because it fails to include other plants in the universe of opportunities to reduce costs.

Thus, to be "truly" cost-effective, approaches must be evaluated for all sources and the overall environmental goal must be achieved at the least total cost. In the case of achieving target emission levels (or ambient targets), this will occur when the marginal cost of controlling the last increments of pollution (or ambient impacts) is the same for every regulated emission point -- one would never pay $0.50 per pound to control emissions at one emissions point when emissions could be further controlled at $0.10 per pound at another emissions point.

Effectiveness

Effectiveness refers to the ability of an approach to achieve the desired objectives. Approaches may differ in the extent to which objectives are attained, in the certainty (or reliability) of attaining objectives, and in timing. Environmental objectives include protecting health and welfare, protecting air quality by controlling degradation, encouraging the development of new or less expensive ways to reduce emissions, obtaining more emissions reductions than required by regulation, and reducing the states' ability to use less stringent environmental regulations as a means of attracting new industry.

Environmental objectives are not always apparant. They are often represented by the attainment of ambient standards or the installation of specified pollution control technology. However, the objectives that underlie these measures should be kept in mind when evaluating the effectiveness (and the cost-effectiveness) of different approaches -- the measure should not be mistaken for the objective itself. For example, a technology-based standard may be used simply because it is not possible to specify appropriate ambient levels. The underlying objective in this case is to achieve a specified emissions reduction, not to develop or install a particular technology. Thus, while one approach might be superior in achieving the development of technology to reduce emissions at a particular emission point, it might not be superior in achieving the underlying objective, i.e., achieving a given level of emission reduction.

The manner in which the environmental strategy is described can facilitate or hinder the evaluation of effectiveness. Environmental strategies can be correctly described in terms of either obligations to control or "entitlements"[1] to emit. Both of these descriptions will be correct in every case, but one will generally provide a clearer perspective. Consider a regulation that requires an emission reduction of 10 tons from a plant that is emitting 100 tons. One viewpoint is that the regulation creates an obligation to reduce emissions by 10 tons and that the control authority has allocated the requirement to control emissions. Another viewpoint is that the regulation creates an entitlement to emit 90 tons, and that the control authority has rationed the "emissions-absorbing capacity" of the atmosphere. The desirability of using one or the other perspective depends on the environmental objectives.

Feasibility

Approaches are administratively feasible to the degree their information and resource requirements can be met at acceptable levels of effort and cost. In some cases, approaches may not be feasible because the needed information is not available. In other cases, the cost of design, implementation and enforcement may exceed available resources.

Approaches must also be politically feasible. They must be capable of attracting sufficient support to secure passage of the legislation. Of course, even with political support, an approach must possess legislative feasibility. In broadest terms, this means it must be workable within the context of existing, functioning legislation.

Trade-offs between feasibility and other attributes (such as effectiveness and cost-effectiveness) are especially likely. For example, some approaches may be more effective for the same information and resources than other

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1 "Entitlement" is used throughout this report in the economist's sense of permission to emit certain levels of pollutants rather than in the specific legal sense of rights conferred on polluters. Because the government is able to reclaim entitlements under current practice, entitlements are "leased" by sources rather than owned.

approaches. In other cases, some approaches will require less information and resources but require a longer period of time to achieve the desired environmental objectives or impose higher control costs on sources.

Equity

Equity considerations would be straightforward if the regulations for each emitter could be based on the direct social cost of the damages that result from its emissions. In these cases, the responsibility for control and the cost of control would be apportioned in direct causal relationship to the social damages. But because damage cannot be precisely attributed to and quantified for each emitter in an air quality control region, this approach is unlikely to be feasible for determining equity.

When the regulations are not based on the damages that result from emissions, regulators must make additional decisions about who pays, how much they pay and when they pay to control emissions. All approaches that are not based on damages will raise the same equity issues, although some approaches deal with them more explicitly than do others.

Equity or fairness involves both (1) allocation or "income distribution" issues and (2) procedural neutrality or "equal treatment of equals." Assignment or alteration of control obligations always raises income distribution issues, but these are most recognizable when a new program is first established. Different approaches are possible, and they may lead to different conclusions. Common approaches are based on principles related to "equal treatment of equals," "benefits" and "ability to pay." "Equal treatment of equals" is a difficult principle to apply in practice, since there are always many inconsistent dimensions against which to judge equality of both sources and requirements. The principle is sometimes seen, particularly in the political arena, as satisfied if uniform requirements are imposed on all sources or all major sources. This shifts attention to the assumptions used for defining uniform requirements rather than on assembling groups of "equals." Under a "benefit principle" those who benefit from pollution control would pay the costs of control in proportion to benefits received; under a similarly founded but converse "damages principle" those who cause damage by polluting would pay in proportion to damages caused. Under an "ability to pay principle" costs of control would be borne in proportion to ability to pay. This criterion is frequently used in tax policy, but is less applicable when dealing with production decisions by economically motivated companies rather than with taxes on individuals. Companies will not have "abilities to pay" as much as economic reactions to changes in production cost. For example, "rich" companies may shut down heavily-regulated sources as uneconomic, or control costs may be passed through to consumers with low "ability to pay" but with no real option other than purchase of the product.

Other Considerations

Other considerations can be important when evaluating the relative merits of alternative approaches. These include adaptability in accomodating changing environmental problems, economic circumstances, and growth; and the creation of incentives to innovate and to control beyond regulatory requirements.

B. THE CURRENT APPROACH TO AIR POLLUTION REGULATION

The pollutants that are regulated under the Clean Air Act fall into one of three categories: criteria pollutants, hazardous air pollutants, or designated pollutants. Criteria pollutants are regulated by National Ambient Air Quality Standards (NAAQS) that are established by EPA at levels intended to protect the national health and welfare. Pollutants that are not regulated by NAAQS but that may cause an increase in mortality or serious illness are regulated by National Emission Standards for Hazardous Air Pollution (NESHAP). Pollutants that are not controlled under either NAAQS or NESHAP may be "designated" pollutants and regulated under Section 111(d) of the Clean Air Act.

The current approach to regulating these pollutants depends on the type of pollutant that is being controlled, on whether the regulated emittor is a new or existing source, and on the severity of the air pollution problem in the area affected by the regulated source. The following discussion briefly describes the approaches that are now used by EPA and the states[1] to regulate stationary and mobile sources.

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1 In general, states have chosen to use command-and-control approaches to meet air quality goals. However, the Clean Air Act does not specifically require the states to use a command-and-control approach to state regulation of existing sources.

B.1 REGULATION OF STATIONARY SOURCES

Existing Plants

The Clean Air Act directs EPA to establish National Ambient Air Quality Standards (NAAQS) at levels that protect the public health and welfare. States are required to prepare State Implementation Plans (SIPs) for attaining the NAAQS within the time frames specified in the Act. Typically, states meet these standards by imposing specific requirements on emissions points in existing plants to reduce their emissions. The states adopt these requirements as regulations that are the basis of the State Implementation Plans.

As long as the SIP demonstrates attainment by the statutory deadlines, the states exercise great discretion in the regulation of existing sources. The SIPs must demonstrate attainment for total suspended particulates, nitrogen oxide, and sulfur dioxide by 1982; and for ozone and carbon monoxide by 1987. However, if states cannot attain the ambient standards for these pollutants by the statutory deadlines, the Clean Air Act directs EPA to disapprove the SIP, impose a ban on construction of new sources and require the states to impose technology-based standards on sources in existing plants.[1] The standards for existing plants are called Reasonably Available Control Technology (RACT).

The current approach also includes the "bubble policy" which is explained in some detail in Chapter IV. Once the control requirements for a plant have been established by a state, the bubble policy encourages companies to propose alternative control requirements that achieve the same environmental goal for their plants (whether it is an ambient level or an amount of emissions reduction). In this manner, plant managers have the opportunity to achieve environmental requirements at the lowest possible cost -- thus achieving cost-effectiveness "within" plants. In addition, plant managers may propose alternative control requirements that lessen controls for their plants but that involve additional compensating controls at other plants -- thus achieving cost-effectiveness "among" plants.

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[1] For ozone and carbon monoxide, despite the 1987 attainment date, if the state cannot demonstrate attainment of standards by <u>1982</u>, the state is required to impose RACT-level technology on existing sources.

Existing plants may be required to meet NESHAP, which can be either emissions standards or, if emissions standards are not practicable, design standards. In addition, if Section 111(d) requirements are established for a category of new plants under NSPS (as discussed in the next section), states must establish requirements for the designated pollutant for existing plants in the same category. The states have substantial discretion in establishing Section 111(d) requirements.

New Plants and Modifications

Emissions points in new sources must always meet technology-based standards where these have been established regardless of the air quality in the area in which the new plant is sited. Each technology-based standard and its rationale is described below.

At a minimum, the Clean Air Act requires most types of emission points in new plants to meet emissions levels based on New Source Performance Standards (NSPS).[1] NSPS reduces the pollution problem in the future -- avoiding pollution problems can be easier than dealing with problems after they have already developed. This is accomplished by providing a means for the continued reduction of emissions in the long run; as older plants are retired, the remaining plants will be well controlled and the pollution problem will be less severe in the future than otherwise. The pollutants for which the NSPS are applicable are criteria pollutants and designated pollutants. The NSPS emissions levels are established nationally for different categories of sources (emission units) and are based upon consideration of the performance of adequately demonstrated technology, cost, energy requirements and non-air quality impacts.

To prevent the significant deterioration of air quality in those areas that are now meeting the NAAQS (PSD areas), sources in new plants may have to install control equipment based on Best Available Control Technology (BACT), which must be at least as stringent as NSPS. BACT provides a way to manage the deterioration of air quality, to ration the air resource and to provide a case-by-case mechanism for establishing control levels for new sources where

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1 NSPS have not been established for all source categories.

NSPS has not been defined. BACT is required for every pollutant that is regulated under the Clean Air Act and emission levels are determined on a case-by-case basis using the same considerations as for NSPS. NSPS and NESHAPS represent the minimum levels allowable for BACT.

In areas that have not attained the NAAQS ("nonattainment areas"), new plants must install technology based upon the Lowest Achievable Emissions Rate (LAER) for the pollutants that exceed the NAAQS. LAER minimizes the immediate impact of growth on the non-attainment problem as well as the long run impact of growth on the ability of areas to eventually come into or to maintain attainment. LAER is the most stringent requirement for new sources, though it coincides in many cases with the definition of NSPS or BACT. LAER is determined on a case-by-case basis for each affected sources, and must be either the lowest emission rate achieved in practice or the most stringent SIP requirement in the country for sources of the kind in question. In addition, unless there is a "growth margin" in an area due to stringent control of existing sources, new plants that locate in nonattainment areas must obtain offsetting reductions in emissions from existing sources in the area. These "offsets" compensate for the remaining increase in emissions that occur after the application of LAER.

New sources are also required to meet any applicable National Emissions Standards for Hazardous Air Pollutants (NESHAP).

B.2 REGULATION OF MOBILE SOURCES

New vehicles must meet emissions standards that are established separately for classes of vehicles (e.g., passenger cars, light-duty trucks, heavy-duty trucks). These standards are based on the use of technologies that are expected to be available when the new vehicles are manufactured. The standards are designed to ensure that all vehicles in a class will be able to meet the emissions standards based on the expected performance of the anticipated technology. Thus, the performance of heavier vehicles in a class will often limit the stringency of a standard, even though lighter vehicles may be expected to have better emissions performance. The standards are periodically reviewed to ensure that they are based upon the best technology that is expected to be available.

New passenger cars that do not meet the standards cannot be sold. As specified in Section 206(g)(3) of the Clean Air Act Amendments of 1977, a nonconformance penalty structure is to be established that permits the sale of trucks that cannot, for technological reasons, meet emission standards. This is described in Chapter IV and the Appendix.

The standards for new vehicle emissions performance must be met after expected deterioration in performance over 50,000 miles of operation. An extensive program of performance and durability testing is used to establish new vehicle performance levels and to estimate deterioration factors. Manufacturer-recommended maintenance is performed during durability testing.[1]

For 1981 and later model years, manufacturers are required to warrant to vehicle owners that emissions performance will be within the standards for 50,000 miles with normal maintenance. If a particular warranted vehicle does not perform as required when in use for reasons other than owner neglect or abuse,[2] manufacturers are required to pay for repairs (and for the diagnosis to identify the problem). Where failures for a model of vehicle are due to design, manufacturers may have to recall the model. Emission recalls usually will not involve major problems, since manufacturer efforts and EPA testing will identify major problems before a model is placed on the market.

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1 The in-use emissions performance of vehicles depends on initial design and, for pre-model year 1981 vehicles, on routine maintenance. The use of leaded fuels in vehicles equipped with catalytic control devices can also degrade emissions performance. Owners often have little incentive to bear the expense of voluntary testing or of any maintenance directed specifically at emissions control for pre-1981 model year vehicles, because there is usually no significant vehicle performance or fuel economy benefit from such maintenance. For new vehicles with computerized engine controls routine maintenance is not as important to emission performance, although periodic testing can detect systems which have stopped functioning. (GM systems are designed with a dashboard failure indicator.) Vehicles with nonfunctioning computer controls have higher emissions and lower fuel economy, but performance is not affected.

2 "Neglect or abuse" need not involve deliberate tampering with the control system. Failure to replace sparkplugs on schedule or to detect loose wires or electrical short circuits can constitute neglect, and mistuning by a home mechanic can constitute abuse. Diagnostic costs are relatively low with pre-model year 1981 vehicles, but may be high for computer-controlled vehicles.

States which have not demonstrated attainment for HC and CO are required, as part of a good faith effort to reach attainment, to take steps to establish a mandatory program for periodic vehicle emission inspection and maintenance I&M.[1] I&M programs may expose manufacturers to warranty claims in the future, but have no effect on EPA recall activities because no mechanism is in place to use inspection data to identify defective vehicles. The failure rate can be varied depending on what is needed to reach attainment. Mandatory I&M programs will typically fail 20 to 30 percent of tested vehicles: for pre-1981 model year vehicles, 20 to 30 percent of vehicles account for 75 percent of excess emissions, although higher percentages fail to meet standards by small amounts; for computer-controlled cars, 5 percent of all vehicles are expected to account for 75 percent of excess emissions.

C. ATTRIBUTES OF THE CURRENT APPROACH

The current approach is to implement ambient- and technology-based strategies using command-and-control methods. These methods generally specify the manner in which sources can meet environmental goals. Thus, for example, specific emission points within a plant are typically required to meet certain levels of performance. This section briefly evaluates the command-and-control aspects of the current approach in order to provide a context for considering economic approaches. The economic approaches that are already in use are covered in more detail later in this report.

C.1 STATIONARY SOURCES

Ambient Standards

o Economic Efficiency

The relative economic efficiency of ambient standards depends on whether they have been established at economically efficient levels and on whether control occurs in a cost-effective manner.

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[1] Recently, California became the first state to be penalized through loss of some federal highway and sewer grant funds for failing to institute a mandatory I&M program in air quality control regions which had not demonstrated attainment.

Information regarding the benefits and costs of ambient air quality standards are limited, but generally indicate that their benefits exceed the costs. For example, Freeman's[1] study for CEQ concluded that the total national benefits realized from reductions in air pollution since 1970 lie in the range of roughly $5 billion to $51 billion per year, with the "most reasonable estimate" of annual benefits of air quality improvement enjoyed in 1978 being $21.4 billion. Freeman views this estimate as quite conservative. This can be compared to the estimate of costs to the nation for air pollution control for 1978 contained in CEQ's 1979 Annual Report[2] of $16.6 billion. This does not mean that the standards are actually optimal -- optimality occurs where the difference between benefits and costs is maximized, not where benefits simply exceed costs. Moreover, it is unlikely that the national standards could be economically efficient everywhere, since the ambient targets are uniform nationally, while both the marginal damages from air pollution and the costs of control at the margin to attain the standards are likely to vary locally. Nevertheless, in the absence of the capability to conduct cost-benefit analysis that is adequate for the purpose of standard-setting, uniform ambient concentrations remain a practical, health-related substitute.

o Effectiveness

No ambient standards have as yet been met at all times in all areas of the country and deadlines for achieving standards have been repeatedly missed. Thus, the current approach of command-and-control regulation has not been fully effective in attaining ambient targets, and has not lived up to the theoretical capability of traditional regulation to control the timing of emission reductions. Nevertheless, substantial improvement has been made. From 1972-1978 ambient levels of particulates (smoke and dust) were reduced 10 percent, sulfur dioxide by 17 percent, carbon monoxide by 35 percent and lead by 26 percent. Ozone levels remained essentially stable over this period, with 1979 showing a 3 percent decrease from 1978 levels. Violations of ambient standards in 50 of the most polluted countries have remained constant or declined from 1974 to

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1 Op. cit., p. vi.

2 Op. cit., p. 666.

1977. Over the same period, the number of unhealthful and very unhealthy days in 25 major metropolitan areas declined by 15 and 32 percent, respectively,

Where additional controls are needed to attain standards, the command-and-control approach may not succeed in identifying sufficient reductions to achieve ambient standards because of the difficulty in identifying yet additional ways to control emissions. As discussed below, the feasibility of obtaining additional reductions through command-and-control alone is low. Moreover, command-and-control approaches do not provide any on-going incentive for companies to find new ways to continue to reduce emissions. Thus, command-and-control approaches are likely to be less effective in the future than they have been to date.

o Cost-Effectiveness

Since regulators have limited knowledge about the specifics of individual plants, the SIP requirements are not necessarily the least-cost ways of achieving the desired results. Moreover, even if the SIP requirements are cost-effective for individual plants, they would not result in the lowest overall cost unless regulators were able to optimize among all sources of emissions. Of course, implementation of the bubble policy has increased the cost-effectiveness of SIP requirements by allowing plant managers to optimize controls within and among plants. To the extent that trading markets develop as a result of the bubble policy and to the extent that trading takes place the overall cost of attaining and maintaining ambient standards to existing sources can be minimized.[1]

o Feasibility

Command-and-control regulations are typically easier to develop for the initial stages of control because initial control requirements are generally based on the application of well known control technologies for basic sources of emissions. As command-and-control regulations become increasingly stringent, regulators must know more of the specific characteristics of individual sources

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[1] As discussed later in this chapter, trading under the bubble policy is limited to existing plants.

of emissions and more about sophisticated control methods. In some cases, the needed control methods may not yet exist or be readily apparant to regulators, but could be readily developed or employed by industry if adequate incentives were available. Thus, where ambient standards have not been met and more stringent control requirements are needed, command-and-control approaches will be less feasible to use than before.

o Equity

A number of allocation decisions have been made by states and by Congress. To meet ambient-based standards, states have allocated control obligations (or entitlements to emit) among existing sources of emissions. The basis for the allocations have included technical feasibility, cost and economic impact. The cost for additional controls will be higher than in the past and it will be increasingly difficult for states to determine which sources should be obligated to control additional emissions (or conversely which sources should be entitled to emit more pollution than others). Control opportunities will increasingly be special cases, making "equal treatment of equals" ran even more difficult principle to apply than in the past.

Allocation decisions have been made that affect transfers of wealth between new and existing sources. In some cases (such as nonattainment areas) existing sources own all of the entitlements; new sources must purchase emission reductions (offsets) from existing sources. In other cases, states have created a margin for growth in their SIPs; in these cases, states have essentially required existing sources to generate emission reductions (offsets) which the state provides at no cost to new sources.

o Other Considerations

The current approach does not provide much incentive to innovate or to control emissions in excess of requirements. However, to the extent that the bubble policy is used by industry and as long as offsets are needed, some incentives will exist to develop new ways to meet SIP requirements.

Technology-based Standards

Technology-based standards have been primarily used to establish control levels for new mobile sources (discussed later in this section) and for new and modified stationary sources. The technology-based standards for stationary sources achieve several objectives: NSPS helps reduce the long-run pollution problem when the capital stock turns over; BACT rations the capacity of the air in PSD areas and is a backup to NSPS; and LAER allows growth in nonattainment areas while minimizing its environmental impact. Additional objectives of these requirements may be to "force" technology, to provide a hedge against uncertainty about achieving ambient standards, and about the level at which ambient standards should be set.

The attributes of these requirements is discussed below.

o Economic Efficiency

LAER typically represents the highest marginal costs of control in nonattainment areas. As in the case of existing stationary sources, it is not known how the cost of LAER compares to the marginal damages associated with current ambient levels. However, since LAER typically represents the highest marginal costs, it is the most likely requirement to be inefficient, if inefficiency occurs. There is some evidence that LAER is inefficient in at least some areas. Some air quality regions have come into attainment without paying the marginal costs associated with LAER. If the ambient standards in these areas are efficient, then the cost of LAER must be too high; conversely, if the cost of LAER is not too high, then areas that have attained ambient standards without paying the cost of LAER are undercontrolling, and the ambient standards would need to be made more stringent for these areas if economic efficiency is to be achieved. However, we do not know whether LAER is too stringent in some cases or whether some local ambient standards are too lax from the standpoint of economic efficiency. This result is not unexpected since the ambient standards are national instead of local -- it may well be that the ambient standards are as economically efficient as it is possible to be for a national standard.

The efficiency of NSPS and BACT is more difficult to assess because they seem to be intended to achieve several objectives that are not directly related to ambient standards. However, it is not likely that NSPS and BACT can be economically efficient. The primary reason is that there is a wide disparity in the marginal costs of control for these standards -- for example, the marginal cost of NSPS control of a pollutant can vary widely from one industry to the next. Thus, regardless of the objectives, since the marginal costs vary widely, it is not likely that the objectives are being attained in a cost-effective manner (unless the benefits to be achieved are related more to industries than to pollutants). Since cost-effectiveness is a prerequisite of efficiency, it is also not likely that the requirements are economically efficient.

However, even if the marginal costs for all NSPS and for all BACT standards are equalized, these requirements may still not be efficient. NSPS is largely oriented toward achieving future environmental benefits and BACT is largely oriented toward managing growth. Both either tend to delay the time when ambient concentrations in attainment areas begin to approach the ambient standards or tend to lower the cost of obtaining emission reductions in the future. If this is largely true, most of the benefits of NSPS and BACT are related to deferring the damages associated with nonattainment or to lowering the cost of achieving attainment. If the marginal costs currently experienced to achieve attainment are economically efficient, the value of deferring or avoiding nonattainment should be no greater than the costs incurred to achieve attainment now. Typically, the cost of NSPS and BACT is higher than the cost of SIP requirements where attainment has been achieved, but lower than the cost of LAER (where attainment has not been achieved). Whether or not NSPS and BACT are economically efficient depends on whether LAER is considered to be overcontrol or whether ambient standards in attainment areas are considered to be lax. It may well be that NSPS and BACT (and LAER) represent economically efficient levels of control effort, while some ambient concentrations are low because of political or practical constraints or because of the use of national instead of local ambient targets.

As indicated above, there are a number of uncertainties about the efficiency of technology-based standards. These uncertainties do not mean that the technology-based standards are necessarily inefficient. They do strongly indicate that it would be desirable to minimize the cost associated with achieving the reductions represented by these requirements.

o Effectiveness

These technology-based standards have in most cases led to the installation of control measures as required. In some cases, the standards have led to the use of technologies that were not previously in wide commercial use. However, when standards that are meant to be technology-forcing cannot be met (or when the consequences to industry of not meeting the standard are so severe that they lose credibility as enforcement tools), technology-forcing command-and-control approaches alone may not lead to compliance.

o Cost-Effectiveness

The cost-effectiveness of technology-based standards depends on the objectives. As discussed earlier, the cost-effectiveness calculation for a given approach would differ, for example, depending on whether the intent was to reduce emissions by a particular amount, to reduce emissions at particular plants, or to reduce emissions at particular plants at specified emission points using innovative or advanced technologies. Different approaches could achieve these objectives for different costs.

The Clean Air Act, as it is currently written, is interpreted to require the control of emission reductions at new sources, regardless of which of the underlying objectives is most important. Thus, trading against technology requirements to achieve the same amount of emissions reductions at other plants is not permitted. As discussed in later chapters, such trading could be used to achieve the same emission reductions at lower total cost while still achieving objectives such as reducing emissions as the capital stock turns over, rationing the capacity of the air resource, or achieving innovation (the innovation would occur in existing plants to a greater extent). If all of the objectives of technology-based standards can still be met if trading is allowed, then the existing approach for regulating new plants is not cost-effective.

o Feasibility

NSPS, BACT and LAER have been developed for a number of classes of plants and for a number of individual plants. While experience has shown that these standards can be developed, they are sometimes difficult to develop and the subject of controversy. The exact specification of these standards is important because, unlike existing plants that can use single or multi-plant bubbles, there is no flexibility for new sources in meeting the standards. In addition, the administrative cost of implementing some new source requirements may be higher than necessary because of the frequent similarity of NSPS, BACT, and LAER -- some of the of the elaborate case-by-case analysis (and delay) for BACT and LAER is, in restrospect, duplicative.

o Equity

New sources have been required to control emissions to levels determined by technological considerations. These requirements essentially ration the capacity of the atmosphere to absorb pollution. Thus, there has been a distribution of wealth between those who locate first and those who locate later.

There are also wealth distributions between new and existing sources. Wealth is transferred to existing sources because additional control requirements for existing sources may be deferred as a result of the steps taken to control new sources first (and more stringently). The rationale for this is that (1) new sources are likely to be more efficient in achieving pollution control requirements by virtue of their ability to incorporate such controls into production planning, and (2) existing sources were constructed at a time when they did not have to meet stringent control standards and it is, in a sense, unfair to penalize them to the same extent as new sources for requirements they could not have foreseen. In addition, to the extent that the standards are intended to force technology, new sources are obligated to contribute to the commercialization of technology. However, in some cases wealth is also transferred to new sources from existing sources where states have created a margin for growth in their SIPs; in these cases, states have essentially required existing sources to provide emission reductions (offsets) at no cost.

o Other Considerations

Command-and-control approaches can limit total emissions in the face of economic growth only by becoming increasingly stringent. While technology-based requirements can force use of new technologies that will permit more effective control, no other incentives to innovation are provided. In addition, where regulations are based on technology, innovation may be discouraged -- there may be a tendency to "freeze" technology at current levels.

C.2 MOBILE SOURCES

. Emission standards for mobile sources are technology-based, and intended to force the development of new technology and to help attain ambient standards. Thus, much of the previous discussion of ambient-based and technology-based strategies for stationary sources applies to mobile sources as well.

Technology-forcing mobile source standards are unlikely to be economically efficient since the same emissions performance is required of each vehicle in a class regardless of where it is used or of the costs of meeting standards. (It would be more efficient to vary control requirements according to the cost of control and the need for control in a given area.) Economic efficiency and cost-effectiveness are also limited by the use of vehicle classes and the lack of flexibility accorded manufacturers: attention is necessarily focused on solving the most difficult technical control problems rather than on reducing emissions at the least cost possible. In the past, these efforts resulted in some degradation of vehicle performance and fuel economy, and may have placed heavier domestic vehicles at a competitive disadvantage to lighter foreign vehicles. These technological tradeoffs have been eliminated as performance and fuel economy characteristics have been improved. However, control technology has now reached a point where increasingly stringent standards may not be as cost-effective as past mobile source measures, or as other control efforts.

Mobile source standards have been fairly effective in forcing the development of cleaner new vehicles, although some delays in compliance have had to be accepted. The existing program has been less effective in controlling the emissions of vehicles after they have been sold. Recall is expensive for manufacturers and must be used with discretion. Owners have little economic incentive to maintain controls in the absence of mandatory I&M or to respond to recall notices. Mandatory I&M is not popular with manufacturers (as it may lead to recalls and warranty claims), with states or with vehicle owners.

II

INTRODUCTION TO ECONOMIC APPROACHES

Economic approaches to air pollution control can be expected to be more economically efficient than command-and-control regulations because they can better exploit and adjust to differences in the costs of controls experienced by different companies. Economic approaches manage this primarily be placing greater decision-making power in the hands of companies, which have better access to information about relevant costs than do the regulators and which can act on this information. This is accomplished by creating an economic value for reducing emissions that allows companies to make economically efficient decisions about pollution control. This economic value is created when the government allows companies to trade entitlements to emit (or obligations to reduce emissions) or when the government places a charge on undesirable activities (such as "excess" emissions).

This report groups economic approaches to air pollution control into two classes: charge-based approaches and trading approaches. Charges induce emitters to make socially desirable decisions about controlling pollution by requiring them to pay a fee for emissions in excess of defined levels; these levels may or may not allow some emissions without charge. Trading opportunities induce emitters to meet environmental requirements in the most cost-effective manner by allowing them to buy or sell either entitlements to emit or requirements to make emission reductions. Thus, trading systems establish a market for such entitlements or emission reductions.

In many cases, either pricing or trading can be used to achieve a given goal, although often one approach will be more desirable than the other. Pricing approaches are a more radical departure from existing regulatory programs. However, in some cases economic incentives can be used as supplements to enhance command-and-control systems.

In this chapter, economic approaches are discussed in terms of the criteria identified in the introduction--effectiveness, economic efficiency, cost-effectiveness, feasibility, equity and other considerations such as adaptability to change and effects on innovation. (The order in which these attributes are addressed will vary as necessary to aid exposition.)

A. CHARGE-BASED APPROACHES

Charges can be used as the sole means of achieving environmental objectives or they can be used to supplement approaches that are already in use. These are discussed separately as stand-alone charges and supplementary charges.

A.1 STAND-ALONE CHARGES

Charges set a price on use of the air. The basic concept is that a charge is established for every unit (or every unit in excess of a specified limit) of pollution emitted, and sources have the choice of paying the cost of reducing pollution or paying a charge to emit it. Sources will pay to reduce pollution to the extent that it is cheaper than paying the charge, and can reduce emissions in any way they wish. At the margin--the last unit of pollution controlled--sources will pay up to the amount of the charge to reduce pollution. As a result, no source will pay more at the margin per unit of pollution reduction than any other source. In this way, charges lead to cost-effective controls within companies and among companies.

Conceptually, the charge should be based on the environmental damages caused by a source's emissions. In this way, no source will pay more for controlling emissions than it is worth to society to do so.

Charges can also be used as an alternative means to meet the same environmental objectives as to command-and-control regulations. The charge can be set at a level that is expected to induce companies to reduce enough emissions to achieve the goals that would have been attained by the traditional regulatory approach. Because traditional approaches usually do not set requirements on the basis of source-by-source marginal control costs, charges will result in lower total costs of emission controls than traditional regulation. Even if traditional regulation was sensitive to marginal control costs or charges were levied in a uniform fashion across categories of polluters, charges would result in lower costs because they leave technical decisions in the hands of those with the most information, and provide incentives to develop cheaper control methods.

The above considerations are discussed in greater detail below.

Cost-Effectiveness

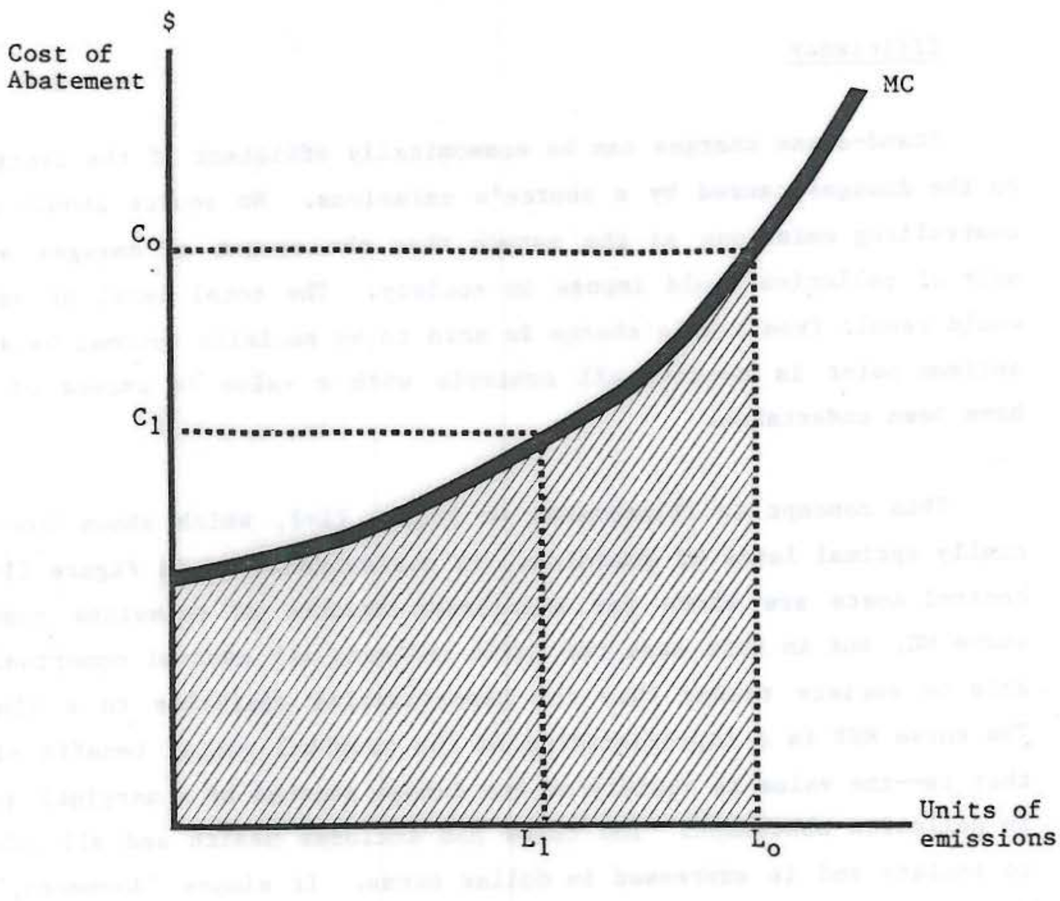
Figure II-1 illustrates the choice offered to a firm by stand-alone charges, and the process by which a firm's behavior will be determined. The curve MC shows the firm's marginal control costs--that is: its cost, at any given level of abatement, of a successive increment of abatement. It is assumed that marginal control costs increase as abatement efforts become more intense. The cost level labeled C_o on the scale measuring abatement cost shows the charge imposed on emissions. It is assumed that this charge is the same for each unit of pollution.

If the firm represented in the graph is faced with an emissions charge of C_o dollars per unit of emissions, the firm will have to decide whether to pay the charge or to "purchase" additional abatement by incurring the costs of additional reduction in emissions. If the firm was purchasing L_1 units of abatement prior to imposition of the charge, the charge the firm now faces is greater than the cost of further abatement, and continues to be so until point L_o. Therefore, the firm will continue to increase its abatement until its marginal cost of abatement equals the charge at L_o. The firm will pay the charge for its emissions that remain unabated at the abatement level L_o because the charge is lower than the marginal cost of abatement for those units of emissions. The firm's total control costs at the new emissions level are represented by the cross-hatched area under the marginal cost curve, MC.

There is an incentive for every emitter that is faced with an emissions charge to behave like the source in Figure II-1, reducing pollution to the extent that it is less expensive to install controls rather than pay the established charge. Because all sources base their behavior on the charge, no source will pay more per unit of pollution reduction at the margin than any other source.

This equalization of marginal costs is a desirable outcome, because it means that the pattern of control effort which results from a charge will be fully cost-effective. Those sources with relatively higher abatement costs will abate less; those with lower, more. Whatever the resulting level of control, the total overall cost of control will be the minimum possible for

Figure II-1.
Effects of a Charge on an Emitter



that level. Similarly, whatever the total expenditure on controls, the level of control achieved will be the maximum possible for expenditures of that magnitude. Thus, charges not only lead to cost-effectiveness within plants but also among plants. In this way, charge-based approaches also contribute to a better use of all of society's productive resources than is likely to be achieved with a command-and-control approach alone.

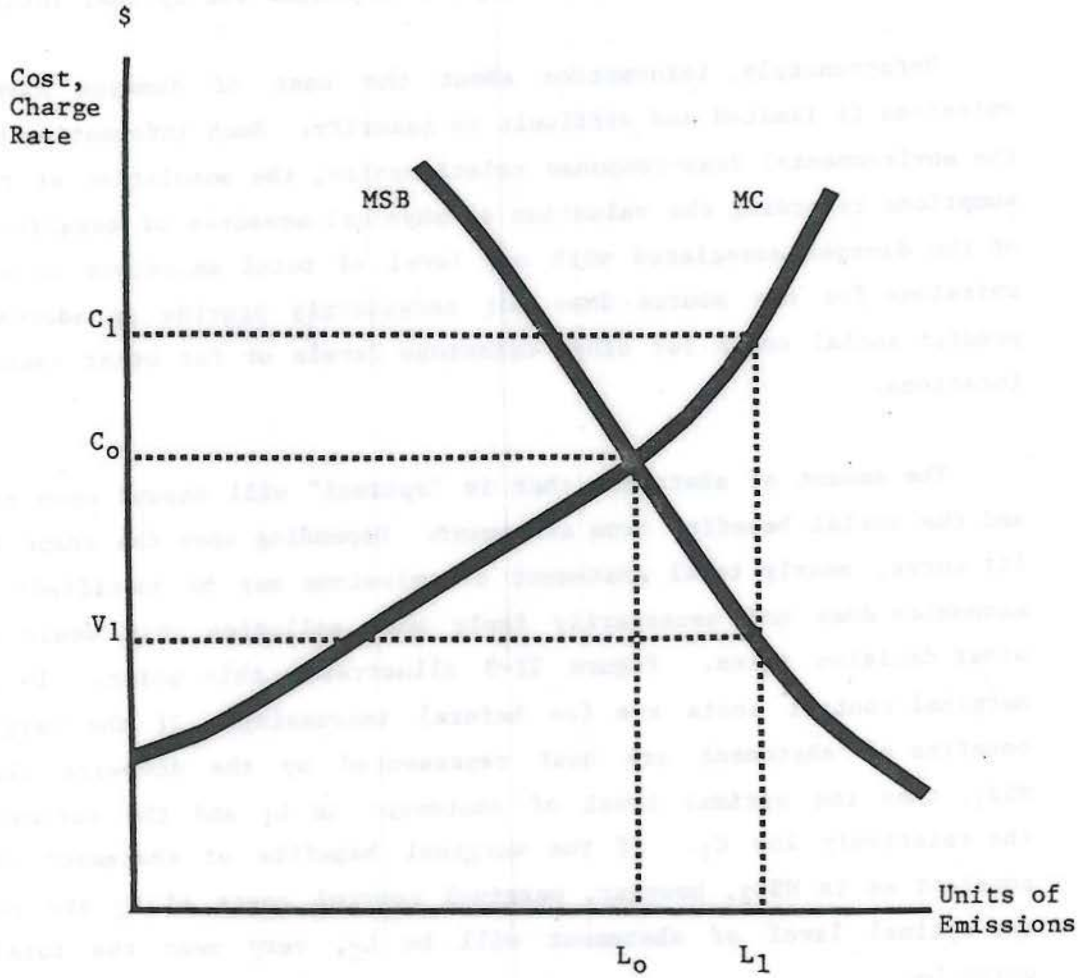
Efficiency

Stand-alone charges can be economically efficient if the charges are based on the damages caused by a source's emissions. No source should pay more for controlling emissions at the margin than the amount of damages an additional unit of pollution would impose on society. The total level of emissions that would result from such a charge is said to be socially optimal because when the optimum point is reached all controls with a value in excess of their costs have been undertaken.

This concept is illustrated in Figure II-2, which shows how L_o, the socially optimal level of emissions, is determined. As in Figure II-1, marginal control costs are shown for successive amounts of emissions removed by the curve MC, but in this case the curve reflects all control opportunities available to society rather than the opportunities available to a single source. The curve MSB is a representation of the marginal social benefit of abatement, that is--the value to society of the damage averted by a marginal unit increase in pollution abatement. The curve MSB includes health and all other benefits to society and is expressed in dollar terms. It slopes "downward," indicating that at low abatement levels (high emissions levels) the social value of a marginal increase in abatement is high; when abatement is already high, in contrast, the marginal social benefit from an additional unit of abatement is low. The optimal charge rate in Figure II-2 is C_o, since this is the only charge which will induce source behavior that will equalize the marginal costs of abatement to the marginal social benefit from abatement. A higher charge of C_1 would induce control that is more expensive than it is worth, as the L_1 units of abatement that would be purchased by society at a marginal cost equal to C_1 are valued at the margin at only V_1.

Figure II-2.

Setting the Charge Rate to Yield
A Socially Optimal Level of Emissions



Aggregate Abatement

Figure II-2 illustrates the quantity of information that is required to determine an optimal charge rate. In that illustration, information about the quantity-based relationships (the "shape of the curve") of both the social benefits from abatement and control costs would be needed. Only if marginal social benefits are equal for all units of emissions is knowledge of marginal social benefits from abatement adequate to define the optimal rate.

Unfortunately, information about the cost of damages associated with emissions is limited and difficult to quantify. Such information would include the environmental dose-response relationships, the population at risk, and assumptions regarding the valuation of physical measures of benefits. Knowledge of the damages associated with one level of total emissions or with marginal emissions for one source does not necessarily provide an adequate basis to predict social costs for other emissions levels or for other sources in other locations.

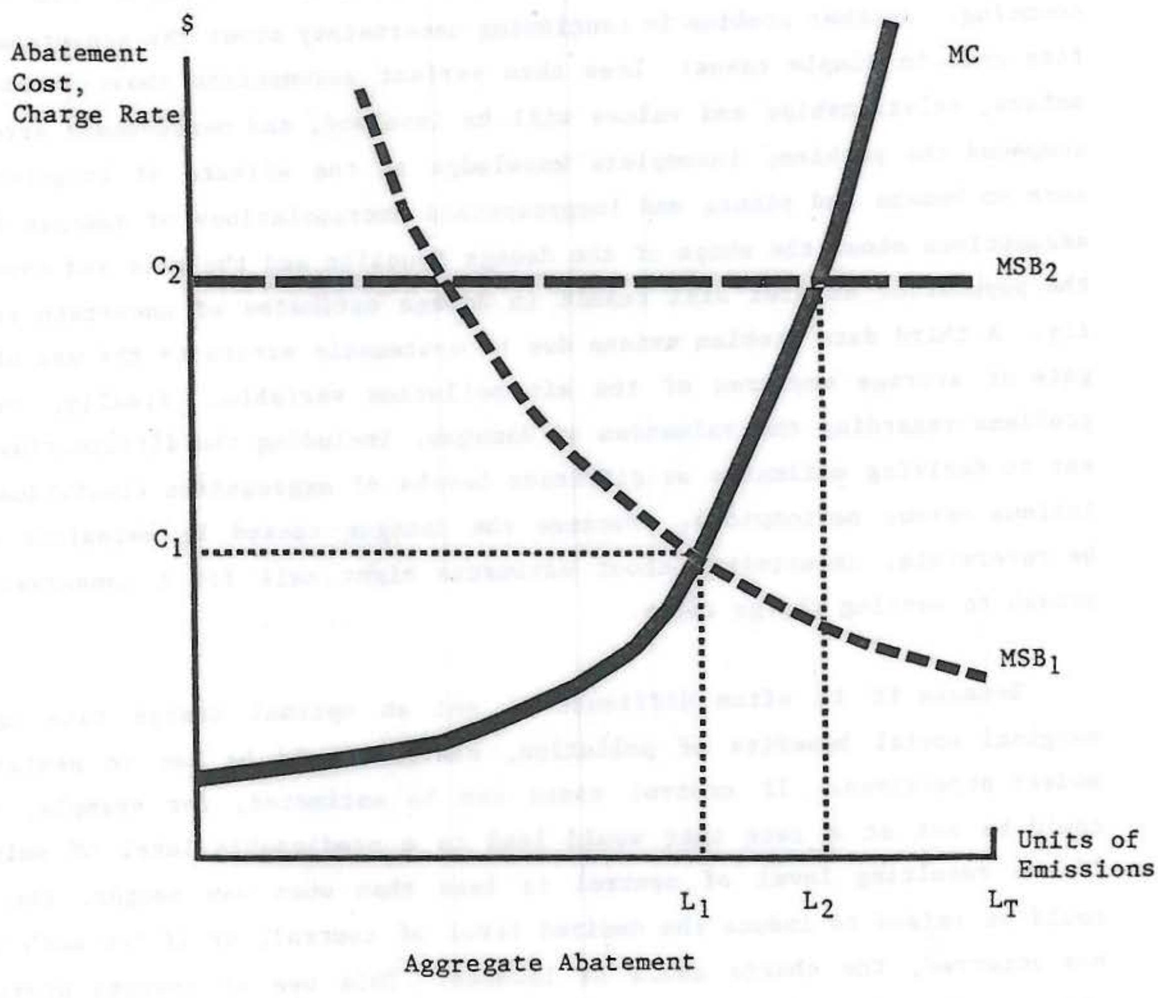
The amount of abatement that is "optimal" will depend upon control costs and the social benefits from abatement. Depending upon the shape of the benefit curve, nearly total abatement of emissions may be justified: the use of economics does not necessarily imply more pollution than would occur under other decision rules. Figure II-3 illustrates this point. In that figure marginal control costs are (as before) increasing. If the marginal social benefits of abatement are best represented by the downward sloping curve MSB_1, then the optimal level of abatement is L_1 and the optimal charge is the relatively low C_1. If the marginal benefits of abatement are high and constant as in MSB_2, however, marginal control costs of C_2 are justified and the optimal level of abatement will be L_2, very near the total abatement point L_T.

Feasibility

Setting charge rates at the point where marginal social benefits equal marginal control costs is only possible where the benefits are quantifiable. Unfortunately, generally they are not.

Figure II-3.

Dependence of "Optimal" Abatement on Shape of Benefits Curve



Data difficulties regarding estimation of benefits occur because emissions have overlapping effects and because effects change as emissions change. Different pollutants occurring together (or pollutants from more than one source) may both cause the same type of effect, but the benefits of controlling one source will depend on the controls imposed on other sources. Or there may be two kinds of effects (e.g., health, property values) arising from the same pollutant which must be estimated separately, thus creating a risk of double counting. Another problem is continuing uncertainty about the measurement benefits even in simple cases: Less than perfect assumptions about unknown parameters, relationships and values will be involved, and measurement errors will compound the problem; incomplete knowledge of the effects of long-term exposure on humans and plants and inappropriate extrapolations of damages based on assumptions about the shape of the damage function and the size and exposure of the population at risk will result in damage estimates of uncertain reliability. A third data problem arises due to systematic errors in the use of aggregate or average measures of the air pollution variable. Finally, there are problems regarding the valuation of damages, including the difficulties inherent in deriving estimates at different levels of aggregation (individual regulations versus nationwide). Because the damages caused by emissions may not be reversible, uncertainty about estimates might call for a conservative approach to setting charge rates.

Because it is often difficult to set an optimal charge rate based on marginal social benefits of pollution, charges could be set to achieve more modest objectives. If control costs can be estimated, for example, charges could be set at a rate that would lead to a predictable level of emissions. If the resulting level of control is less than what was sought, the charge could be raised to induce the desired level of control; or if too much control has occurred, the charge could be lowered. This use of charges provides an alternative means of achieving the objectives of traditional command-and-control regulation, but at a lower total cost of control and with less information.

Moreover, charges can be useful where control authorities are unable to use traditional approaches to secure needed progress toward attainment. If timing (the level of emissions in the short as well as the long run) is important, however, more information may be needed to ensure that the charge is initially set at an appropriate level. This is because the responses of polluters to a charge is difficult to predict in the short run without considerable information. In addition, some target ambient levels can only be achieved by controlling emissions from particular sources; this holds true for "local" pollutants such as particulates, nitrogen oxides and sulfur oxides, but is not the case with area pollutants such as hydrocarbons.[1] Achieving the target ambient levels for local pollutants requires a nonuniform charge system that will induce the targeted firms to reduce emissions by the targeted amounts. Developing nonuniform charge systems to induce particular behavior by sources at acceptable costs can be as difficult as establishing source-by-source command-and-control regulations.

In any of these applications, charges allow more control over the costs incurred by sources, while command-and-control regulations allow more control over level and timing of emission reductions. If more is known about acceptable control costs than about damages from emissions, charges may be the approach which makes best use of available information to reach a good outcome. This is especially true if control costs vary a great deal with the level of control, while marginal damages are relatively constant.

There are legal problems implementing charge systems under current legislation. Congress has been unwilling in the past to relinquish control over any area that is related to setting taxes or tax rates, and may be precluded by the courts from delegating the inherently legislative authority to establish and periodically change charge rates. However, if an agency was left with little discretion in determining charge rates according to the instructions set out by Congress, the courts might find that no delegation had occurred. Constitutional problems may also be raised by charge rates that differ from source to source if they are characterized as discriminatory taxes. But "discriminatory" rates (rates which vary to reflect ambient impacts) will be optimal for many pollutants.

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[1] While it is likely the spatial and temporal pattern of emissions and their chemical composition affect the pattern of ozone concentration, we do not have operational models to deal with the detailed photochemical processes. Thus, for some pollutants such as hydrocarbons it is <u>assumed</u> that emissions are an appropriate, proportional measure of ambient air quality impacts.

Effectiveness

As indicated in Figure II-1, it will be difficult to predict the effects of a charge in advance, unless all sources' marginal cost curves MC are known. Charge-based approaches do not guarantee that total emissions will be reduced to a particular level or that a particular ambient level will be attained, unless the system operates with exact knowledge of each firm's abatement costs. Therefore, the effects of charges on total emissions usually cannot be accurately predicted in advance. Initially, if the charge is set too low, industry's response will fall short of the goal; or the charge may be set too high, and industry may control more emissions than desired. Charges could be varied over time, but this could lead to a loss of credibility with the public. Charges will reduce emissions at the lowest cost if they are stable but the unpredictability of source responses to charges limits their effectiveness in meeting air quality goals where speed is important. In contrast, command-and-control approaches allow prediction of the level of emissions, but costs of achieving these goals are not controlled. Charges are more likely to be effective in practice where another system is not already in place, with the associated vested interests.

Where information or resources are limited, charges can be more effective than command-and-control regulations. Charges will eventually induce cost-effective controls regardless of the agency's ability to identify them in advance. In addition, charges can induce innovation because firms will have a continuing incentive to develop new ways to reduce emissions. Charges are also very credible tools for technology forcing because firms know with certainty that they will pay a charge if they fail to reduce emissions; charges hold no hope for polluters to avoid costs by delay or postponement of deadlines. Charges eliminate the incentive to delay control efforts that exists with command-and-control systems.

Equity

Stand-alone charges affect all covered sources in the same way; each is required to pay an equal amount per unit of regulated emissions which are not eliminated. Typically, charges will not result in the same pattern of control effort or the same costs to sources as traditional approaches. In particular, if companies prefer to pay some charges rather than reduce emissions to zero, charges will result in money transfers from industry to the government that will not occur with other approaches. To reduce these transfers, charges might be imposed only on emissions in excess of some threshold established for each source. (Thresholds might also be established to confine charges to a supplemental role. This use of charges is discussed in detail after the next subsection).

Other Considerations

The effects of charges will depend upon the level of the charge relative to control costs and on the number of sources that wish to emit. As inflation drives up control costs and growth drives up demand for use of the air as a receiver of emissions, charges need to be adjusted if they are to remain equally effective at controlling total emissions.[1] However, assuming statutory authority, charges can be increased at least as easily as more stringent command-and-control regulations can be instituted. In addition, charges provide a continuous incentive to sources to find new and less expensive ways to reduce emissions in order to avoid paying them. This may also create a need for adjustments in charge rates to avoid overcontrol.

A.2 CHARGES AS A SUPPLEMENT WHEN STANDARDS ARE SPECIFIED

Charges may be used as supplements to the current command-and-control approach to regulation, in order to combine some of the characteristics of each approach that have been identified in the previous chapter and the previous section. When used as an addition to established standards, charges can (1) provide added incentives to comply with requirements, (2) provide an incentive to exceed requirements, or (3) simultaneously provide a credible alternative to compliance and an incentive to develop new technology.

Charges can increase the effectiveness of command-and-control requirements by eliminating economic incentives to delay installation of controls. In this

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[1] If the environmental goal is to match control costs to damages rather than to limit total emissions and if damages per unit of emissions are rather constant, charge rates may not need to be adjusted.

context, such charges are similar in purpose to "noncompliance penalties," which are discussed in more detail in Chapter IV and are a feature of the current provisions of the Clean Air Act. These penalties are set separately for each noncomplying source at a level equal to the costs savings obtained by the source's failure to comply with regulatory requirements on schedule.

Supplemental charges can also be assessed for emissions remaining after command-and-control requirements are met. Such charges provide a continuing incentive to sources to find ways to reduce emissions further at lower cost.

Finally, sources could be allowed to pay a "nonconformance" fee as a temporary alternative to compliance. A program of this kind, by payment of a penalty charge, allows continued operation of sources faced with technically infeasible or high cost requirements, yet maintains incentives to come into compliance eventually. Supplemental fees of this kind can increase the effectiveness of technology-forcing standards by providing a credible enforcement alternative that induces eventual compliance. Congress, in the Clean Air Act Amendments of 1977, authorized a program of this kind in the mobile source area, where technological laggards may find it difficult to comply with heavy-duty truck standards on schedule.

Effectiveness and Feasibility

Supplemental charges used to provide incentives to comply with regulatory requirements can greatly increase the effectiveness of command-and-control requirements, by eliminating the economic benefits of delaying compliance. Charges set to provide a temporary alternative to compliance can also increase the effectiveness and feasibility of command-and-control systems by providing a credible alternative to immediate compliance. This alternative eliminates any prospect for regulatory tolerance of delays based on questions of technical feasibility or economic impact.

Supplemental charges used to provide an incentive for additional emissions reduction will be as effective as stand-alone charges of the same level, but involve fewer institutional risks. If supplemental charges were subjected to successful legal attack as an unconstitutional discriminatory tax or as based on an unconstitutional delegation of legislative authority, existing regulatory requirements would still be in place. Stand-alone charges involve no such backup.

Such supplementary charges are easier to set than stand-alone charges because primary reliance can be placed on the existing regulatory requirements to meet minimum standards. In addition, the availability of a workable "safety valve" in the event of unacceptable cost or technological infeasibility can allow control authorities to set technology-based standards with less information than would be required if these standards had to be enforced by themselves. These charges can be set in anticipation of particular expenditures by particuar firms, and can be adjusted retroactively to reflect actual cost experiences. Therefore, charges of this kind are feasible.

Efficiency

Supplemental charges which provide an alternative to compliance with regulatory requirements, or which are intended to force technology, may (where sufficient information is available) be set at a level which reflects the marginal social costs of emissions. Such charges will contribute to efficiency in the allocation of resources, since they prevent purchase of overly expensive increments of abatement.

Equity

Those supplemental charges that simply increase the effectiveness of existing regulatory requirements do not raise new equity issues. Moreover, the nonconformance and noncompliance type fees eliminate the "inequity" of some sources failing to comply while others do. However, supplemental charges will typically involve money transfers from industry to government, and charges which provide an alternative to compliance and set a ceiling on marginal control costs can affect the total costs incurred by some sources. To this extent charges will have a different, though not necessarily better or worse, equity impact than do command-and-control requirements.

Cost-Effectiveness

Supplemental charges which set a ceiling on marginal control costs should increase the cost-effectiveness of command-and-control requirements because they systematically eliminate the requirement to comply with control obligations that are more expensive than is considered justifiable. Marginal control costs will be equalized for sources with the highest costs, and total costs incurred by some individual companies will decrease even after money transfers to the government. Charges which force or encourage the development of new technology may also contribute to cost-effectiveness by lowering the overall cost of control in the long run.

Other Considerations

Like stand-alone charges, supplemental charges may have to be adjusted to reflect inflation technological change and levels of emissions. If imposed on emissions which are allowable under the established standards, they provide the same incentive to innovation as stand-alone charges. Section III contains an assessment of the factors that are important in choosing the appropriate economic approach.

B. TRADING APPROACHES

Trading can be used either as a primary means of achieving specified environmental goals in a cost-effective manner or as a means of enhancing the effectiveness, feasibility and cost-effectiveness of traditional regulation. This section describes the general features of trading approaches, discusses the operation of trading markets and then summarizes the attributes of trading approaches. The next chapter will discuss more detailed design considerations of trading programs and Chapter IV will describe already existing trading programs.

B.1 OVERVIEW OF TRADING APPROACHES

This section describes marketable permits, stationary source controlled trading and mobile source averaging. Marketable permits include a continuum of trading approaches that regulate the quantity of pollution that can be emitted.

In its "pure" form, marketable permits refer to a system that contains a minimum of government intervention and provides entitlements to emit prescribed amounts of pollution. The absence of restrictions and wide coverage of a "pure" system would encourage an active permit market. Stationary source controlled trading and mobile source averaging are variants of marketable permits which have been developed as supplementary approaches to traditional regulation. Trading under these more restrictive program is likely to be much less active.

Marketable Permits

Marketable permits are entitlements to emit specified amounts of pollutants in a period of time at a specified location or area. As in the case of command-and-control regulations, marketable permits "ration" the amount of pollution that control authorities are willing to allow. Companies may only emit the amounts specified in the permits they own. Permits may be bought where a seller is willing and may be sold by their owners. Companies will be willing to pay for permits an amount up to their cost of reducing their emissions. As with charge-based approaches, the resulting overall cost to companies will be minimized. The marketable permit approach is best applied to pollutants that occur within a definable geographical area. Under certain supply conditions entitlements will trade at a price equal to the rate that would be used under a charge-based approach. In this case, a marketable permit policy will result in control costs equivalent to those under charge-based approaches, with the added advantage that the level and timing of emission reduction is known with a certainty limited only by enforcement capabilities.

A key issue in designing a marketable permit system is the manner in which permits are to be allocated initially. Allocation options include auctions, distribution based on historical use, and distribution based on government discretion.[1] There are apparent, important competitive and wealth transfer implications for any marketable permit approach. Of course, the imposition of any regulatory approach has the same types of implications--they are simply more obvious for marketable permits.

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1 The Government has a long history of awarding valuable rights, e.g., the right to plant crops, the right to the use of water, the right to import or to buy low cost domestic crude oil, landing "slots" at airports, etc.

Controlled Trading

"Controlled trading" approaches have been developed and implemented as regulatory supplements to reduce the costs of complying with requirements under the existing regulatory framework. Trading can reduce the cost of command-and-control regulations by allowing companies to meet their control obligations in less expensive ways. This can be accomplished by allowing companies to use alternative control strategies for emissions sources within their plants as long as they achieve the same environmental goal (total emissions or ambient impacts), and are just as reliable and as enforceable as the original source-specific control requirements. EPA's "bubble" policy is already in use and allows such flexibility for existing plants to meet SIP requirements. The bubble policy also encourages multi-plant bubbles; plants can meet their control obligations by allocating emission reductions among all of the emissions sources in the plants. Thus, trading establishes a market for emissions reductions that allows companies to minimize their cost of control. It also creates incentives for the equalization of the marginal costs of control and can lead to cost-effectiveness within plants and among plants.

Trading may provide a means for new sources to locate in nonattainment areas while actually contributing toward progress in reducing emissions. A new source can purchase emission reductions or "offsets" from existing sources to compensate for the emissions it adds to the area. Alternatively, a government seeking to attract new industry could provide offsets by taking actions to generate emissions reductions itself or inducing other sources to do so with or without compensation. Such government-mediated transactions have been more common in the past than arms-length bargaining between firms: these transactions do not necessarily have the same optimality properties as trades between firms.

In principle, controlled trading could be expanded until a traditional approach with controlled trading would be more like a marketable permit system than a command-and-control approach. The practical aspects of a comparison between these approaches are examined more fully in Chapter III.

Averaging

Averaging for mobile sources offers benefits similar to that of the bubble policy for stationary sources. Under this approach, emissions standards for individual vehicles would be replaced with average standards applicable to a manufacturer's entire fleet or to broad classes of vehicles made by the manufacturer. Emissions of vehicles that are lower than the standards can be used to offset or compensate for emissions of vehicles that exceed the standard. This would allow manufacturers to control more emissions where costs are low or where sales volume is high, and to reduce controls elsewhere. If properly designed, overall emissions should be no higher than under the current approach, but the overall cost of control should be less.

B.2 OPERATION OF TRADING MARKETS

Market Transactions

Once entitlements or obligations to control have been allocated to sources, the resulting markets for entitlements or obligations operate in essentially the same way as any other market. The discussion in this section is cast in terms of entitlements, but is equally applicable if obligations to reduce emissions are traded.

Unless entitlements are auctioned, it is likely that sources will face different marginal costs in attempting to reduce emissions to levels consistent with the entitlements in hand. Most sources will, of course, use some of the entitlements they possess themselves. Some of these sources will be potential buyers of additional entitlements and some others will be potential sellers. Not all entitlements initially allocated will find their way into the market.

After permits are initially allocated, they may be bought and sold. An emitter will be willing to pay up to its marginal cost of reducing emissions for permits to pollute so as to avoid the cost of emissions reductions. An emitter will be willing to sell permits if it can do so for a price equal to or higher than its marginal cost of abatement. The price which "clears the market" by bringing supply and demand into balance is determined by both buyers and sellers. At higher prices there will be more willingness to supply entitlements, since more expensive control measures can be justified in order to free an entitlement for sale. However, there will be less interest in higher priced entitlements on the part of buyers. Conversely, at lower prices for entitlements there will be fewer entitlements offered for sale, since sources will use low value entitlements to cover their own emissions rather than to undertake more expensive control efforts, and there will be more interested buyers. At prices that will be determined by the market, these tendencies will balance each other. When this occurs, all sources incur the same costs for abatement at the margin. Abatement which could occur at a lower cost will have been undertaken to make entitlements available for sale, and abatement that is more expensive will be avoided through purchase of entitlements.

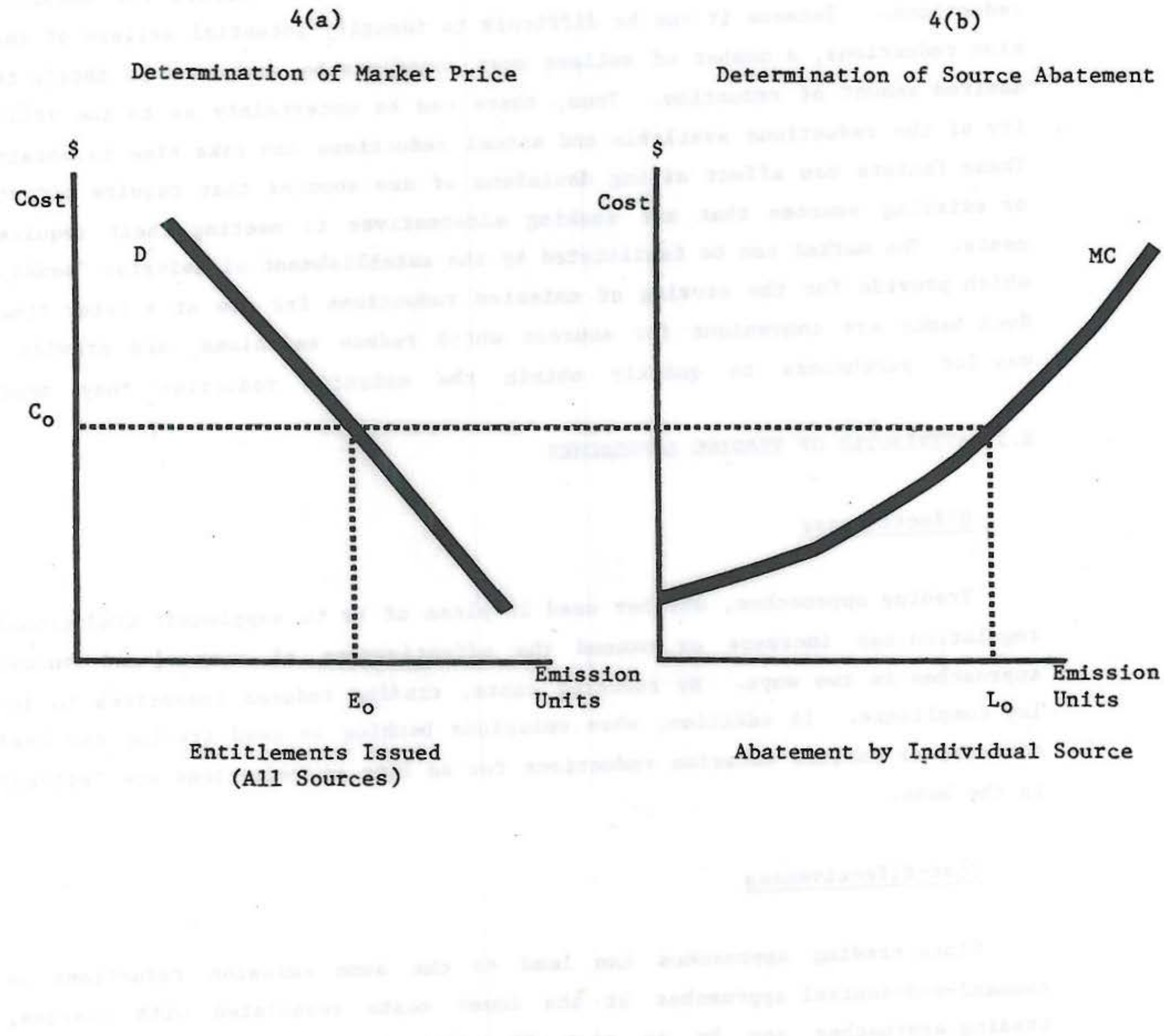
This process is set out in Figure II-4, which combines an illustration of the determination of a market-clearing price in 4(a) with an illustration of the effects of that price on the decision of one source in 4(b).

In 4(a), the market demand curve for entitlements D is the summation over all sources of the marginal costs of abatement; that is, the sum of the emissions reductions that would be undertaken by each firm for any given marginal cost. The supply of entitlements, E_o on the diagram, is fixed by the government. Thus, for any given total number of entitlements issued, the price at which they would be traded on the market is the marginal cost of attaining the abatement level corresponding to the entitlements issued, shown by C_o, the price at which supply and demand for entitlements are in balance. Although the amount of entitlements actually bought and sold in the market will depend upon individual sources' marginal cost curves and their original allocation of entitlements, total abatement undertaken will not. This will be determined by the quantity of entitlements originally allocated.

In 4(b), the role of the individual source in this market is illustrated. One source with marginal costs illustrated by the curve MC responds to the market-clearing entitlements price by reducing emissions by the amount k_o. This source may then become either a buyer or a seller of entitlements, depending on whether its allocation of entitlements is less than or greater than the emissions level remaining when the abatement is L_o. If more abatement is required, the source will purchase entitlements in lieu of undertaking control

Figure II-4.

The Market for Entitlements



at costs in excess of C_0. The crucial factor is that marginal control costs remain at C_0, for this source and for all sources.

Banking

Trading is most effective when there is an active market for emissions reductions. Because it can be difficult to identify potential sellers of emission reductions, a number of sellers must sometimes be contacted to obtain the desired amount of reduction. Thus, there can be uncertainty as to the validity of the reductions available and actual reductions can take time to obtain. These factors can affect siting decisions of new sources that require offsets or existing sources that are seeking alternatives to meeting their requirements. The market can be facilitated by the establishment of emission "banks," which provide for the storing of emission reductions for use at a later time. Such banks are convenient for sources which reduce emissions, and provide a way for purchasers to quickly obtain the emission reduction they need.

B.3 ATTRIBUTES OF TRADING APPROACHES

Effectiveness

Trading approaches, whether used in place of or to supplement traditional regulation can increase or exceed the effectiveness of command-and-control approaches in two ways. By reducing costs, trading reduces incentives to delay compliance. In addition, when emissions banking is used trading can lead to extra or earlier emission reductions for as long as reductions are "stored" in the bank.

Cost-Effectiveness

Since trading approaches can lead to the same emission reductions as command-and-control approaches at the lower costs associated with charges, trading approaches can be as cost-effective as charges and considerably more cost-effective than command-and-control approaches alone. Even if total emissions are identical so that there is an equality of marginal social benefits between approaches with and without trading, the total costs of control can be expected to be less with trading.

Economic Efficiency

In addition to being more cost-effective than command-and-control approaches, trading approaches will tend to be more economically efficient. Where marginal control costs exceeded marginal social benefits prior to trading, trading should increase economic efficiency by reducing expenditures for control. If trading approaches work well they will be as efficient as charge-based approaches for the same level of total control, because all sources will have the same marginal cost of control when the market for entitlements clears. This is an important consideration, because trading can be used regardless of the total quantity of entitlements initially allocated or the distribution of those entitlements among sources, and still lead to cost-effective control efforts. The conditions under which trading is likely to work well are examined in greater detail in Chapter III.

Feasibility

Trading approaches used in lieu of command-and-control regulation can be designed and implemented with the same information as the system they replace. Supplementary trading can be added to a command-and-control system with no new information, although, as discussed in the next chapter, attention must be given to ensuring that trading will not interfere with attaining the goals of the command-and-control regulations. Trading can provide information about control costs that might not be available otherwise.

Equity

The equity implications of trading approaches that replace traditional approaches are no different than those faced in command-and-control systems; new regulatory requirements mean that decisions must be made about who pays for controls and how much they pay. Marketable permits can be allocated in the same way as the requirements of traditional regulations are allocated. As discussed in the next chapter, entitlements can also be allocated in market-oriented ways, such as through auctions. Although equity and allocation issues are the same for command-and-control regulations, trading can give them added visibility because money will change hands as entitlements are traded.

Supplementary trading should not affect the equity decisions that were made when developing the command-and-control regulations that form the basis for trading. The initial allocation of entitlements will not be affected, and all sources in similar situations can be given similar opportunities to trade.

Other Considerations

Trading does not require the government to establish a price for entitlements or to adjust that price to reflect inflation or to offset the effects of economic growth. Prices will be set by supply and demand for entitlements in the market, will adjust automatically to reflect inflation and increased demand as a result of economic growth, and will also adjust as a result of technological improvements in production as well as control technologies. Consequently, the government need not, and indeed should not, directly intervene to affect market prices of entitlements.

Trading stimulates technological change because a market for entitlements gives all sources an incentive to find ways to reduce emissions further to make entitlements available for sale.

III

DESIGNING AND SELECTING SPECIFIC ECONOMIC APPROACHES

The general discussion of charges and trading in the Introduction and in the previous chapter provides a starting point for matching broad categories of economic approaches to goals. This chapter begin by drawing this material together to suggest in general terms when particular approaches might be appropriate. The chapter then identifies variations in the design (major variables or parameters) of charge-based and trading approaches, identifies the information required to use each variation, and discusses in detail the implications of particular design variations. No attempt is made here to characterize particular approaches or potential design variations as desirable or to identify what can and cannot be done under the current statute: these conclusions are contained in Chapter V.

A. CHOOSING AN ECONOMIC APPROACH

This section attempts to identify the most important factors in choosing an economic approach. Stand-alone charges set equal to marginal social costs (the economist's classic case) is briefly discussed first. The use of charges to pursue air quality or emission targets is then compared to the use of trading approaches to pursue the same goals.

Choices among economic approaches need not be completely constrained by the existence of a previous regulatory program, because some adaptation is possible. Controlled trading or supplemental charges can be used if a regulatory system already exists and is not to be replaced; marketable permits or stand-alone charges can be used where new control systems are needed. Therefore, some form of charge, either supplemental or stand-alone charges, can be used under all circumstances. Expansions of controlled trading and marketable permits also act as complements to one another, so one of these approaches can also be used in all situations.

A.1 CHARGES SET EQUAL TO MARGINAL SOCIAL COSTS

Where the marginal social benefits of emissions are known or are being implicitly estimated, no economic approach, and of course no other control mechanism, is more economically efficient than stand-alone charges, because this approach leads to optimal emissions at minimum total cost. Allocation and equity issues are avoided; each source is required to pay for its damages at the margin. Money transfers to the government make the hidden costs of pollution apparent to businesses and contribute to a better allocation of all of society's productive resources. Crude estimates of marginal social benefits are implicit in some current air pollution control programs, and more frequent and better estimates will become important as the stringency of controls and therefore control costs increase. The use of charges may therefore become more practicable in the future.

If marginal social benefits are not known, stand-alone charges can be used to pursue a target level of air quality or total emissions.

A.2 CHARGES AND TRADING TO PURSUE TARGETS

Either stand-alone charges or trading can be used when a target level of emissions or air quality is sought. The major difference between these approaches is that charges cannot directly control total emissions while trading approaches can. If this attribute of charges is unacceptable, trading should be preferred over charges. If it is acceptable, other considerations are important when comparing charges and trading.

Stand-alone charges are better able to reduce control costs than trading where markets for trading entitlements are very thin. However, charges are less appropriate than trading where ambient concentrations or emission reduction goals must be met because charges cannot directly and certainly control total emissions in the short run. The desired responses of polluters can, of course, be achieved in time as rates are adjusted up and down depending on associated emissions or air quality.

Charges are more likely to be seen as fair, and therefore should be more politically acceptable, where they can be set at uniform rates for all sources. This means that charges are most likely to be suited to pollutants for which emissions are assumed to be representative of ambient impacts and to pollutants the impacts of which are relatively insensitive to source location and other source characteristics. Seasonality or time-of-day characteristics must be carefully analyzed in considering particular pollutants as candidates for charges. Finally, charges are not well suited to situations where marginal control costs and emissions levels after controls are in place will be high. In this situation, the rates to induce appropriate responses are likely to be high, and transfers to the government for emissions which cannot be reduced will be large.

Trading can have important advantages over charges in certain circumstances, particularly where information is limited and costs are highly variable between sources. Trading approaches do not require information about control costs, because entitlements prices are set in the market. Trading approaches require less adjustment over time than charge-based approaches because they adjust automatically to changes in the supply of and demand for entitlements, to inflation, and to changes in control costs. Trading approaches are, therefore, superior where control technology is evolving or regional economic growth or decline is relatively rapid and air quality goals are stable.

The major limitation of trading approaches is that they can function well only where significant trade-off opportunities exist between sources and where the market for trades between firms is not too thin. Several factors can contribute to an active and broad-based market. More trading will occur if major continuous point sources with different control costs account for a large portion of emissions and if firms are in the process of making control decisions when the trading option is established. Such decisions are more likely if new sources are entering an area or environmental requirements are changing than if industrial activity is stable and adequate controls are in place.

Trading will be easier to implement if a large portion of emissions in an area are reasonably interchangeable, because under such circumstances impacts are not highly dependent on source characteristics and location. However, even if air quality impacts are highly variable and information is poor, trading approaches can still have an advantage over charge-based and command-and-control approaches. Trading allows and encourages sources to seek out cost-reducing opportunities and allows the agency to look at relative impacts for one pair of traders at a time. While charges also encourage cost reductions, neither charges nor command-and-control approaches can easily make use of such partial information on relative air quality impacts.

B. SPECIFIC CHARGE-BASED APPROACHES

Stand-alone charges, supplemental charges, and the use of proceeds from such charges, are discussed in turn below.

B.1 STAND-ALONE CHARGES

Stand-alone charges can differ (a) in the principle used to set rates; (b) as to how that rate is applied; and (c) as to which sources are affected.

Rate-Setting Principle

Stand-alone charges may be used to bring marginal control costs and damages into balance, to pursue ambient air quality goals or to induce use of particular control technology.

If the information were available, rates for stand-alone charges could (and ideally would) be set equal to the marginal social damages from emissions. The goal of this approach is to reach an equilibrium level of pollution abatement in which the charge rate, marginal social benefits from abatement and marginal control costs are equal. Any control approach (charges, command-and-control, or trading) can reach this goal if social costs at an equilibrium level of control can be estimated and marginal control costs are known. Charges are the simplest way to achieve this goal when information is available. Other approaches will usually pursue less ambitious goals.

Estimates of marginal social costs may involve impacts on air quality and the relationship of air quality to damages to structures, crops and individuals, or quantification of effects on aesthetic values. This information is more likely to exist where the marginal social costs of emissions are constant over a wide range or where a sharp change in marginal social costs occurs at some level of total emissions. Where marginal social costs vary gradually with the level of total emissions, information on control costs will also be needed to predict the equilibrium level of emissions which will result from a given charge.

To reach a specified emissions or air quality target with a charge system the control agency must know how particular sources will respond to different levels of charges. If the timing of control efforts is important, charge approaches will require at least as much information about sources as command-and-control approaches, and will require more unless the command-and-control approach was sensitive to control costs. This information is likely to be more expensive and difficult to collect where charges are imposed in a new area than where pre-existing requirements are being replaced. Where information on anticipated responses is not sufficient, more information may be accumulated through trial and error by varying charge rates, experimentally or according to an announced schedule. Experimental variations would take more time, and the uncertainty would make business planning difficult. Control cost curves would change after imposition of a regime of controls, making the determination of the necessary variation in charge rates more difficult. Such charges would also probably encounter considerable opposition in the political arena. Uncertainty can be reduced if control authorities find acceptable any total emissions outcome within the likely scope of a specified charge rate or schedule. Use of announced schedules of rate escalations is possible where it is acceptable to delay reaching environmental goals. Schedules provide a better basis for business planning, but complete predictability is not possible. Even if charges could be increased on an announced schedule until targets were attained, deviations from the schedule would then be needed to avoid over-control and to offset both the effects of inflation on costs and the effects of economic growth on total emissions.

Application of Rate

Rates under a stand-alone charge may be applied to emissions, to ambient impacts, to the performance or non performance of maintenance procedures which affect emissions, or to any other factor (such as production levels, raw material inputs, or source characteristics or locations) which is closely correlated with emissions or air quality impacts. Where charges are related to emissions, emissions rates or levels can be established through direct monitoring or by reference to design and operating parameters which affect emissions.

Where charges are keyed to ambient impacts, relative impacts on air quality could be predicted by air quality modelling and measured by monitors. If charges are used to control local pollutants, the rates per unit of emissions will typically vary from source to source.

Sources and Emissions Affected

Charges may be assessed against all emission sources of a pollutant or only against selected sources. Selective application could be based on the need for control by a particular source (e.g., for pollutants with local impacts), or on the costs of control by particular classes of sources (if environmental goals can be met by controlling only some sources). Use of any of these bases requires substantial information, although only more detailed cost information would be necessary in addition to the data that should be collected to design traditional approaches.

All emissions by a source may be subjected to charges, or charges may be confined to emissions in excess of some base level for each source. The use of a threshold before charges apply can be appropriate where the environmental goal is to encourage a known amount of further emissions reduction. It will be as difficult and costly to set thresholds for charges as it would be to set traditional regulatory requirements for each source. The necessary information about sources is more likely to be available where thresholds can be based on preexisting regulatory requirements which will typically already have categorized sources in a meaningful way.

Selective application of charges across source categories or continuing charges to emissions in excess of a base level can also reduce the money transfers from sources to the government.

B.2 SUPPLEMENTAL CHARGES

Supplemental charges that encourage controls beyond required levels have design considerations similar to stand-alone charges. Supplemental charges are likely to be useful whenever control relies primarily on source-specific standards either to induce compliance with regulatory requirements, to place a cap on marginal control costs or to provide credibility for technology-forcing standards. Each case is discussed below. In addition, the implication of combining supplemental charges with trading is discussed.

Supplemental Charges that Induce Compliance

Compliance-inducing charges can be highly effective solutions to the difficult problem of making it in the economic interest of sources to reduce emissions to a target level. Charges which are intended to induce compliance can be set at a uniform level, or be set separately for each source, and can be based on different economic criteria. While payments are not based on a measurement of emissions, EPA's existing noncompliance penalties for stationary sources induce compliance by assessing the source-specific savings from delaying compliance with regulatory requirements. Planned nonconformance penalties for heavy-duty trucks will use a uniform charge rate related to the marginal costs incurred by competitors to come into compliance with regulatory standards; the initial cost-based rate will escalate over time to provide stronger incentives to comply. The total amount of the penalty will of course also be greater when emissions exceed standards by greater degrees. Culpability and damages need not be assessed to set these economically-based fees, but control costs must be known. This is a comparatively straightforward process because fees can be adjusted after actual control costs have actually been incurred to come into compliance.

Supplemental Charges that Provide a "Safety Valve"

Supplemental charges could also be used to set a ceiling on marginal control costs incurred, by providing sources the option of paying a fee as a short- or long-run alternative to compliance. (While a regulatory variance procedure accomplishes the same purpose, a charge can be tailored to achieve a more efficient results.) A fee set to serve these functions would typically be uniform for all excess emissions. A supplemental charge should be set low enough so that at least a few sources would pay the fee for a short period of time. A fee set at this level would act as a "safety valve" in case control requirements prove to be infeasible or too expensive for some sources. This can be particularly important if control obligations are so costly or difficult to meet that some sources would otherwise unexpectedly shut down. Alternatively, the fee could be set at a lower level to ensure that environmental benefits and economic costs were balanced for most sources, by capping marginal control costs.

Supplemental fees set at a moderate level to provide a safety valve, and a stand-alone charge for emissions in excess of some baseline level, are in some respects equivalent approaches. Both seek to balance environmental objectives and costs by relating control effort to marginal control costs. However, the supplemental fees are merely an overlay to a set of regulatory requirements and trading opportunities that may be sufficient to attain air quality goals even with the safety valve in place, while the stand-alone charges provide no assurance that minimum environmental standards will be met at any particular time.

Combining Trading with Supplemental Charges

The existence or nonexistence of trading should be considered in using a supplemental fee. If controlled trading is not working well enough, some sources may have no practical ability to come into compliance when their own control costs are very high or control is not feasible. If trading is working well and emissions reduction credits are available for sale, the opportunity to purchase entitlements or "credits"[1] can serve as a safety valve for cost and feasibility pressures. If trading is permitted, the implications of a safety valve fee will depend on the level of the charge relative to the price of any credits available for sale. In the absence of a fee, credits will change hands at a price which reflects--and balances--supply and demand. If a safety valve charge is set at a price in excess of the market price for credits the safety valve becomes operationally irrelevant; sources will either control their emissions or purchase credits in the private market rather than pay the charge. (The charge may still serve to convince sources that the agency intends to stand by the requirements that it imposes.) If the charge is set below the market price for credits, it will provide added flexibility to sources. Less control will be undertaken and there will be substantial effects on

[1] Credits are salable entitlements to emit, which are created by reducing emissions below the levels required by applicable regulations.

trading. Less trading will occur than otherwise, as some sources pay the charge rather than purchase emission reduction credits. A new and lower market price for credits will be established to reflect this reduced demand for credits.

B.3 USE OF FEE PROCEEDS

The revenue generated by emissions charges could be returned to the U.S. Treasury, or be used to finance agency operations, to purchase emission reductions from sources, or to compensate those who are damaged by pollution.

In general, revenues from charges will decline as industry adjusts to the charge by reducing emissions. If revenues are to be made available to fund the operation or programs of the control agency (this would require statutory authority), there may be an incentive to prevent this decline, creating a conflict of interest. To avoid this, proceeds can be returned to the Treasury. This would be consistent with common fiscal policy practices, which typically separate spending decisions from revenue collection.

Government purchase of emission reductions using fee proceeds duplicates a trade in which one source pays another to generate an emissions reduction. But governmental willingness to trade purchase reductions (whatever the source of revenues) can disrupt private trade. If sources have responded to a charge by reducing emissions or if trading has resulted in establishment of a market-clearing price for credits, the government will not be able to secure any additional reductions at a price per unit equal to that implied by the fee or the market equilibrium price for credits. If the government is expected to offer higher prices for reductions than are available in the market, the private market for trades will inevitably be disrupted as potential sellers of credits withdraw to await government intervention.

Compensation payments attempt to replace a private transaction in which polluters pay victims to accept the consequences of pollution. If such transactions could in fact be arranged and were preferred by all parties, payment of compensation in lieu of further control would be more economically efficient. Use of fee proceeds to compensate those who are injured, or to mitigate the effects of pollution, could make higher levels of emissions politically tolerable. A program to compensate those harmed by pollution is currently operable in Japan.

As shown above, the use of fee proceeds to compensate those who are damaged by pollution or to purchase emission reductions puts the control agency in the position of attempting to replace private transactions. This is not a role the government necessarily should play, or is likely to play well. For example, compensation transactions are desirable if they occur as a result of private exchanges, because there are no forced sales of anyone's rights and because preferences are respected even if they are unusual. An attempt by government to duplicate such transactions would at best result in "fair" compensation, not in an outcome where all participants felt better off. Similarly, private trades of entitlements result in equal marginal control costs and cost-effective control. But if the government becomes involved, some sources would be required to pay the government a fee or reduce emissions, while others would be paid a fee by the government to reduce emissions. Moreover, the government would in some cases pay more for reductions that it was willing to see sources pay themselves. The government discouraged high cost control by providing the alternative of paying a fee. Some subsidy might well be in order where extremely high cost control was socially justified, but the use of a fee to generate revenues would be a clumsy and disruptive procedure.

C. SPECIFIC TRADING APPROACHES

C.1 REVIEW OF CONTROLLED TRADING AND MARKETABLE PERMITS

In this report, trading approaches have been formally divided into "controlled trading" and "marketable permit" groupings, but formal distinctions are probably less important than practical differences and potential similarities. In practice, trading approaches fall on a continuum where the importance of trading increases as restrictions on trading decrease. Either controlled trading or marketable permits could in principle be implemented at either end of this continuum. Formally, the approaches are distinguished by the manner in which the asset that is traded is created. With marketable permits, a central agency creates and distributes entitlements or "permits" to emit quantities of a pollutant. With controlled trading, sources create entitlements of "credits" by reducing emissions below levels set in baseline regulatory requirements.

Of course, this baseline can be specified in the same way that permit allocations were specified.

Because controlled trading assets are defined and measured by reference to a regulatory baseline, it is the baseline program rather than trading which will be central to the goal of environmental protection. Controlled trading is firmly rooted in a set of regulatory specifications which could stand without (and usually will have pre-dated) trading. As a practical matter this context usually means that controlled trading programs involve many restrictions. This may be less true with permits, but no history exists and theory suggests that restrictions would play identical roles under either approach.

The most familiar "controlled trading" approaches are EPA's existing offset trading program and bubble policy. These particular controlled trading approaches, which are still evolving, are discussed more fully in Chapter IV. As described earlier, an offset program allows new facilities to be constructed in nonattainment areas, provided emissions which remain after a new source has installed specified controls are offset by reductions in emissions from existing sources. The bubble policy allows existing plants in attainment areas to increase emissions at some sources to levels in excess of baseline SIP requirements, in return for reduced emissions at other sources.

In their "pure" form, marketable permits are envisioned as replacing command-and-control systems where the latter exist. Emissions covered by permits are allowed, and all emissions which exist must be so covered. Thus, marketable permits are usually viewed as a complete and distinct approach to the control of emissions rather than a means of reducing the costs incurred by sources in meeting a baseline set of command-and-control requirements. The pure form of marketable permits is most appropriate where no control program has been established or if it appears feasible to replace the existing control program.

When a command-and-control regulatory program is already in existence (or can be created) the usefulness of a marketable permit approach will depend in practice upon the extent to which an alternative controlled trading approach could effectively approximate the characteristics of permits. If states have the authority and will to allocate control obligations in a manner that will assure attainment, and restrictions on controlled trading are minimized, permits are not needed to control emissions or to allow additional control cost reductions. But operational differences between controlled trading and "pure" marketable permits or political ability to use particular characteristics in different contexts can affect the way in which these trading approaches are actually implemented. In some cases, permits may be the more attractive alternative simply because they offer the possibility of a clean slate when beginning the regulatory process or introducing trading opportunities. Finally, the need to explicitly allocate permits suggests that "pure" marketable permit approaches are better suited to situations where a major change in regulatory requirements or control technology is taking place than to stable control situations. A changing situation provides an occasion for a new initial allocation of entitlements and avoids the disruptive effects of imposing a new formal structure on a stable control situation.

C.2 VARIATIONS IN CONTROLLED TRADING AND PERMIT APPROACHES

Controlled trading and permit approaches have several design parameters. This section discusses five areas in which choices of characteristics are possible, and the implications of particular choices in each of these areas. In most cases choices of characteristics in each area can be made independently of choices in the other areas; thus a very large number of potential trading approaches exists.

The five areas discussed are (a) the existence and scope of a banking program; (b) agency involvement in market operations; (c) the determination of equivalent emissions; (d) restrictions on trading--which sources are allowed to and choose to trade, which emissions reductions are creditable, and how emissions reduction credits may be used; and (e) how emissions entitlements and assessments requiring additional emissions reductions are allocated. The implications of different characteristics in each of these areas will change as a trading approach evolves, so that designs which are appropriate when trading plays a limited role can become inappropriate as trading becomes more common.

Banking

"Banking" gives sources a right to sell or use[1] emission reduction credits or entitlements at a time most convenient to the source. In the absence of banking, trades must be contemporaneous, which presents a serious barrier to trading transactions, regardless of the other characteristics of a control system that included trading. Banking "rules" may set out the conditions under which a control agency can restrict the future use of banked credits. The issues involved in such actions by a control agency are discussed in a later subsection on the allocation of additional control obligations. This subsection discusses the useful consequences of banking that should be recognized when designing trading approaches. Chapter IV contains a more detailed description of EPA's existing banking activity.

If emission reductions must occur at the same time as the emissions increases which they offset, trading can be very difficult for both buyers and sellers. Without banking, would-be buyers of credits must locate sellers and may find the delays this could involve unacceptable from a planning or financial standpoint. Without banking, sellers must wait to generate credits at a time that is convenient for buyers rather than appropriate to their own operation and investment plans, or generate credits without complete information on how the agency will treat the credits in the future. Because it is risky to make financial commitments when other actors are not bound, credits will typically not be deliberately created in jurisdictions without banking in anticipation of sale or use, unless a buyer or an immediate use for the credits has been identified and the control agency has been sounded out. Even emission reductions which would be economically justified might be deferred until a simultaneous exchange can be worked out to make use of valuable reduction credits.

Banking eliminates this unnecessary timing restriction and reduces uncertainty by allowing the size, ownership and type of emission reductions to be certified when a reduction is undertaken, and allowing the credits to be held

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[1] Under the current banking proposals, use must be approved on a case-by-case basis.

for use or sale at a later time. This makes it possible for the trading system to induce creation of surplus reductions, and avoids three practical proglems with trading. First, investments in controls tend to be lumpy in size and constrained as to timing; banking allows firms to create surplus reductions when convenient (e.g., when some new equipment must be installed) for sale when possible.[1] Second, banking may be used as an occasion to focus market activity, by channeling reductions through a central institution; this can reduce the transactions costs involved in finding and negotiating with potential suppliers of emissions reduction credits. Finally, with banking, emission reduction credits may be readily available for sale, or a firm might be able to buy a future reduction or an option on a future reduction now. This reduces uncertainty about the costs of meeting environmental requirements and thereby facilitates business planning.

Market Involvement by the Control Agency

Some involvement by the air pollution control agency in trading transactions will usually be unavoidable, but the scope of involvement can vary widely and perhaps should vary depending on the maturity of the market. Initially, an agency might see a need to help establish a market or to help finance emission reductions. However, financing reductions will be less of a problem when the market value of credits is clear from experience, and mature markets will be able to sustain themselves with less agency involvement than new markets. Since agency involvement can hinder operation of a mature market, agencies should do no more than is clearly necessary.

The least amount of involvement that is likely to be feasible would be to do nothing more than certify entitlements for sale. The least centralized

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1 This coin has two sides. By eliminating timing restrictions, banking can permit the sale of credits which would otherwise have lapsed under applicable rules upon shutdown of an uneconomic or obsolete facility; in such cases flexibility prevents a net emissions decrease. But these cases may be rare. The timing of source shutdowns can be delayed to permit sale of the credits even in the absence of banking. By eliminating the incentive to delay shutdown in this more typical case, banking can lead to reductions in total emissions from earlier closures.

form of market operation would then allow free trading of certified entitlements between sources, perhaps with the assistance of private brokers. Because brokers could profit from arranging trades, they could provide valuable and specialized services that would help establish the controlled trading approach, and could assume the financial risks involved in purchasing an inventory of emissions reductions for future sale. The agency would still operate any banking system, and might set any necessary exchange ratios for trades between sources to protect air quality.

The smallest (and a likely effective) step an agency might take toward centralizing market functions would be to act as a clearinghouse for information about potential sellers and users of emission reduction credits. The next step would be to become directly involved in the initiation of private trades by encouraging sources to reduce emissions in order to generate entitlements for banking and by helping potential buyers and sellers locate one another.

In a fully centralized market an agency would establish itself or some other entity as the sole buyer of entitlements generated by emissions reductions and as the sole seller of entitlements to offset increased emissions. Numerous variations on this approach exist. Once acquired, credits or permits could be sold at a prespecified price, at a negotiated price in particular transactions, or at periodic auctions. Use of a centralized purchase approach could provide a means to guarantee a market to those that generate emissions reductions and help to establish a controlled trading approach quickly. However, attempts to encourage the market in this way would expose the control agency to culpability for financial risks which are not usually accepted by government agencies. Attempts to limit these risks could lead to purchase prices that were lower and sales prices that were higher than a market-clearing price. Some useful trades would not occur under these circumstances. In extreme cases, an agency might take and give credits rather then buying and selling them, either by imposing control requirements in excess of those needed for attainment or by confiscating credits when a source reduces emissions.

Establishing the Equivalence of Emissions

Trades of equal quantities of emissions from sources in different locations or with different characteristics can result in adverse effects on air quality. Where ambient concentrations represent the environmental goal an agency must ensure that emissions which are traded have equivalent air quality implications. In the simplest trades presented to an agency for approval the sources of emissions will be very similar (e.g., emissions from stacks of nearly similar height) and the overall ambient impacts of emissions from the trading sources will be the same as long as the overall emissions level does not increase. A unit for unit exchange of emissions of the same pollutant between such sources would be acceptable. More complicated cases make it more difficult for an agency to assure that air quality after a trade is equivalent to air quality prior to that trade. Air quality modelling is usually used to measure equivalence when sources have different impacts on air quality.

Equivalence questions can also arise because the relationship of control efforts to emissions is uncertain or because the relationship of emissions to ambient impacts is not well understood (i.e., available models work imperfectly). Differences in the timing of control efforts or in the reliability and enforceability of proposed control measures can also raise questions. Even if these questions were addressed adequately for baseline emission levels and control approaches, they must be addressed again when trades which will change these factors are proposed. In other cases, companies may propose emission reductions from previously unregulated sources of emissions that are not well understood or may propose use of technology that does not have an established record of control efficiency.

Most questions about equivalence can be addressed by requiring demonstrations of proposed approaches before trades are permitted or before a final exchange ratio is specified, or by building an air quality cushion into the trade by setting an exchange ratio that reduces total emissions.

Uncertainty regarding the government's judgments about equivalence can impede trading because sources will not be able to confidently assess the value of the commodity to be exchanged. Some sources may be discouraged from attempting trades if there is any need to reveal the existence of a control opportunity to the control agency before a trade has been worked out. To the extent that control agencies can reduce uncertainty and give source tools which can be used without agency assistance, trading will be facilitated.

Restrictions on Trading

Greater cost savings will be achieved with a trading approach if trading is maximized. Ideally every emissions reduction that would not otherwise occur should generate a tradeable credit, and reduction credits or permits could be used (once an equivalence ratio was established) to offset any emission increase. Restrictions (such as conditions or bans on the use of credits by new sources or by sources in nonattainment areas) may be used in some trading approaches, however, either as a result of historical development or as an indirect way to keep trading from interferring with regulatory strategies. The subsections below discuss restrictions on trades of reductions generated by particular sources and restrictions on use of reduction credits by particular sources. In general, alternatives to restrictions exist in the form of clearer specification of baseline obligations, or direct action to offset the consequences of trading.

- Restrictions on tradeable reductions

Existing regulatory programs contain significant restrictions on the use of emission reductions generated by certain sources; in some cases these restrictions are cast in terms of requirements that reductions be "real" and "permanent." In practice this often means that reductions which were relied upon in demonstrating attainment under the state SIP (usually from the shutdown of an existing source or from plans to impose more stringent controls on existing sources) could not be used to offset longer-lived emission increases. In other cases restrictions prevent trades of credits generated by emissions reductions which might be quickly replaced by emissions from a new entity or new facility which replaces the seller. For example, a company which owned a source with uncontrolled emissions might negate the effectiveness of its agreement to reduce emissions at that source through a sale of assets to a new company. Or gains from reductions achieved by shutdown of a facility for which there is undiminished market demand could be neutralized if an equivalent facility could be established to meet demand without the purchase of offsets.

Restrictions based on the concern that reductions be real and permanent have their base in uncertainty about the ownership of entitlements when a source shuts down. More generally, the issue involves definition and measurement of the entitlements implied by pretrading control obligations in a dynamic situation. If permissible emissions were well defined both as to quantity and time for all existing sources, and all new sources were required to secure entitlements to offset their emissions, restrictions on the sale of credits generated by nonobligated emission reductions could be avoided.

The ability of a control agency to eliminate restrictions on trades of certain credits is directly related to its ability to specify ownership of entitlements in likely future situations. This proved to be possible when the alternative was blocking economic growth in nonattainment areas. Although new obligations may need to be imposed on existing sources in these areas to demonstrate attainment, existing sources are able to sell credits as offsets to new sources when they reduce emissions below currently required levels.

Some restrictions on trades of particular emission reductions are simply based on applicable statutory provisions. For example, reductions to meet control obligations must now be achieved by using continuous rather than intermittent controls; this restriction has been extended to the use of intermittent controls to generate credits for sale. This contributes nothing to air quality if intermittent controls would result in real, permanent and enforceable emission reductions.

o Restrictions on the Use of Credits

Under the current statute, credits cannot be used to exceed technology-based requirements such as NSPS, LAER or BACT. Because these are stringent and high-cost control requirements, this restriction is a major barrier to realizing the full cost-reducing potential of controlled trading. The restriction has no effect on emissions in the short-run, since trading does not increase or decrease allowable emissions. Stringent statutory standards are instead apparently imposed on new sources in an attempt to preserve or slow the use of available air increments for economic growth and to assure continuing air quality improvement--regardless of ambient standards--as the capital stock turns over. These goals were described more fully in Chapter I.

However, trading by new sources need not be prohibited to ensure that these regulatory goals are achieved. Some restriction on offsetting actions will be needed in some situations, but these can be kept to a minimum.

Restrictions on the use of credits by new sources can better "preserve" air quality for future growth only if they make imposition of added requirements that may be desired at a later time more feasible. This is a doubtful proposition: at some cost, existing sources would be able to reduce emissions in the future, providing room for economic growth, and the new source which purchased entitlements could also install more controls later. It is sometimes argued requiring physical controls on the new source today will be easier because it would be more expensive to retrofit controls later; however, any potential savings is offset by the certain expense of denying sources an opportunity to install the most cost-effective controls today.

If future economic growth can be accommodated, there is less need to be concerned with emission reduction as the capital stock turns over. In any event, restricting use of the air resource by new sources will contribute to emission reductions as the capital stock turns over only if credits sold by existing sources and credits generated by shutdown of existing sources are treated inconsistently. If credits may be sold even when sources shut down it makes no difference when in a source's lifetime credits are sold. Similarly, if existing sources are only able to trade explicitly temporary entitlements to new sources and cannot sell credits when they shutdown, restrictions on the use of such temporary credits by new sources play no role in reducing emissions over time. In the first case, credits live on after the existing source regardless of the timing of any trades. In the second case, credits cease to exist after the source shuts down, regardless of any trades. It is only when credits which are sold become permanent and credits which are not sold are forfeited upon shutdown that any rationale for a restriction exists. And even in this case other means exist to meet targets for air quality improvements over time.

Allocation of Entitlements and Assessments of Additional Control Obligations

The allocation of entitlements and assessments imposes costs or confers benefits on particular segments of the population; thus the primary issues involved in the allocation are the distribution of wealth and income. If trading works well, allocation decisions will not adversely affect environmental goals, economic efficiency or cost-effectiveness. Trading can also increase the political acceptability of different approaches to the allocation of entitlements and additional control obligations, since trading allows sources to adapt to agency allocation decisions through trades before installing controls. The adaptive potential of trading means that the way in which entitlements are allocated is not as important as assigning all entitlements to some source and allowing trading to assure that all entitlements are properly valued. There are several approaches which can be used to allocate entitlements and to assess additional control obligations: initial allocation can be taken from the distribution of emissions as reflected in the baseline regulatory program if one exists, or it can be managed by relying on agency discretion, on rules, or on an auction. Discretionary, rule-based and auction allocation of entitlements are each discussed separately in the subsections immediately below. The fourth subsection discusses the use of discretionary and rule-based approaches to allocate additional control obligations ("assessments") subsequent to the initial allocation.

o Discretionary Allocation of Entitlements

Initial entitlements could be allocated by an air quality control agency in any manner it sees fit, either without charge or upon payment of a fixed price, and without conditions or with ancillary restrictions attached. An agency choosing discretionary allocation could adopt as its guiding principle equity or fairness, extrapolation of existing emissions based on a regulatory baseline, cost minimization, a matching of control obligations with the ability to pay for controls, or local or agency preferences for particular kinds of economic activity. These same concerns can play a role in discretionary allocation of additional control obligations. If allocation is based on any criteria other than cost minimization, trading will be extensive as sources adjust to control costs and trading will therefore play a major role in reducing total control costs. To the extent allocation is sensitive to relative control costs, the need for subsequent trades to minimize costs will be reduced. Direct discretionary allocation avoids the problem of large payments by sources to the government.

Discretionary allocation can encourage a focus on technical considerations or on the ability of a source to afford controls on its own facilities. These concerns are important where trading does not exist but should become less important when trading works well. Trading allows a source which cannot reduce its own emissions further, given current technology, to pay another source to generate reductions. Similarly, a source which cannot afford to install additional controls on its own facility may be able to afford lower cost controls elsewhere.

Discretionary allocation require information about particular sources to provide some basis for allocation decisions; thus, these decisions will be expensive to make and will reflect any biases or flaws in the data used. On the other hand, a discretionary approach can make use of all relevant and available information; if information is good, decisions can provide for fair allocations that will meet air quality goals with a minimum of economic disruption and at a low total control cost.

o Allocation of Entitlements by Pre-established Rules

Rule-based allocation of initial entitlements will typically condition receipt of an entitlement on some action by a source or potential source. The most common current rule is first-come, first-served allocation or allocation on demand, which simply requires a source to get in line to obtain permission for constructing a facility that meets certain conditions. This approach is used in PSD areas and is implicit in mobile source regulations. First-come, first-served allocation is simple, familiar and easily understood. It is perceived by some to be "fair", based on the notions that either everybody has an equal chance to be first in line or that those who want the resource most will make the effort to be first, and thus deserve the first chance. On the other hand, the first-come, first-served rule as now used in PSD areas involves inefficiencies that might be avoided by other rule-based approaches. In part this is because sources must simply install some controls and be first in line to receive entitlements and in part because assigned increments are not readily tradeable. Thus, there is no opportunity for other potential new sources to indicate that they place a higher value on available entitlements until after the source which is granted entitlements without charge is constructed. Only at that point can the source which holds the entitlements resell them, as an "existing" source. Finally, the first-come, first-served rule generally applies only to those sources which need but lack entitlements. Some sources may be exempted or may already have sufficient entitlements, so that incentives to reduce emissions in order to preserve air increments will not be everywhere the same.

Pre-established rules which could act as alternatives to first-come, first-served rules include rules which require other positive steps by sources to reduce emissions. For example, the offset policy now in force in nonattainment areas could be adapted to the needs of clean air areas by requiring new source purchase of partial offsets prior to siting in clean air areas. This would in effect gradually increase the price of the air as it became increasingly scarce. Designing such an approach to achieve the greatest possible benefits would be a complex task, and the approach would increase the costs to those who receive entitlements in the near term. It must also be pointed out that the markets for offset trades in PSD areas may be thin.

Rule-based allocation of assessments can also rely on a formula to guide allocation rather than on actions by sources. For example, the simplest formula would apportion equal percentage reduction requirements to all existing sources. However, a formula could be adjusted to reflect past control efforts or be used to impose obligations only on certain categories of sources (e.g., those that can afford additional controls).

Formulaic assessments in their simplest form (i.e., those based on equal percentage reduction or "rollbacks" by all sources) can provide an administratively low-cost and less controversial way to allocate additional control obligations; because no discretion is exercised, little information is required and there is no occasion for second-guessing agency decisions. The opportunity to use a fixed simple formula also makes it unnecessary to be concerned with the effects of trading on the ability of the agency to impose controls on particular sources. Simple formulaic assessments encourage trading and are most feasible where trading works well, because sources can then take technical capabilities and differences in control costs into account through trading before controls are actually installed. However, if trading does not work well, formulaic assessments will result in patterns of control effort that are not cost-effective, since no account is taken of polluters' marginal control costs. Cost-effectiveness will also be poor where emissions from different sources have different ambient impacts, since unnecessary control will be undertaken.

A formulaic approach may be difficult to impose in its simple form, especially on top of preexisting regulatory requirements. It may not be fair to disregard previous control efforts nor wise to rely on trading to overcome problems of technical feasibility nor politically acceptable to ignore ability to pay. Ideas about equity that focus on outcomes will clash with ideas which focus on changes. Where these concerns must be accommodated, the costs of allocating assessments will increase and agency decisions will be open to question. The importance of these concerns will vary. If existing control requirements are believed to be essentially fair, a uniform additional assessment may also be seen as fair. However, if some categories of sources have been required to do more than others, a formula will be less acceptable.

Once the limits of technological capability are reached, a formulaic approach places more reliance on trading. If trading exists only on paper, defending technically impossible requirements by invoking formulas and trading will be difficult. However, if trading is frequently used, sources will recognize that assessments are essentially assignments of financial liability. (This will be especially clear if a supplemental charge is used.) If sources which cannot afford additional control obligations are free to sell emissions reduction credits upon shutting down, less importance might be attached to financial feasibility;[1] but if credits from shutting down revert to the control agency (or if society is unwilling to face the prospect of reducing economic activity to reduce emissions), financial feasibility must be given

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[1] It will be important, however, to recognize the associated economic impacts from shutdown.

more attention. Therefore, it is important to consider characteristics which promote the success of trading if a formulaic allocation approach is used.

o Allocation of Entitlements by Auction

Allocation by auction can take many forms. Auction may involve separate and sequential sales of lots with the "high" bidder purchasing the lot being offered on the block.[1] This is a traditional "English" auction. In the less familiar "Dutch" auction, quantity orders are taken at successively lower prices until the market clears, with all units sold at the clearing price. This system has some attractive properties, which are explained below. Variations on and alternatives to these classic "English" and "Dutch" systems abound. Different approaches are likely to result in different costs to sources, in different allocations of entitlements, and in the generation of different amounts of information about control costs.

A slight variation of the Dutch-type auction can produce excellent information about control costs. In this variation, sealed bids specifying a price and a maximum quantity of entitlements would be submitted. The air quality agency would fill as many bids as it could, all at the price of the last bid it was able to fill. No bidder would bid more than entitlements were worth to him because control would be cheaper than permits, and none would bid less than the maximum amount entitlements are truly worth to them because the price paid would be set by the last bid filled; a bid which was higher than necessary to win would imply no excess costs to the bidder.

Because auctions bring market mechanisms to bear in determining the initial allocation of entitlements, they will result in an initial allocation which is closer to the minimum control cost allocation than other approaches. By bringing traders together at a single place and time, auctions can also help overcome problems with thin markets. "Thin" markets could also be strengthened by allowing potential new sources to bid for entitlements for future use. This

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1 Because auctions determine the initial allocation of marketable permits, the differential impacts of emissions from different sources may need to be considered in comparing bids.

would increase the number of bidders, especially if these entitlements could be banked with some payments deferred until use.

Barring collusion, it must be expected that any auction will result in substantial money transfers to the government. Transfers will be larger with English-type auctions than Dutch-type because the latter provide for bids to be filled at a single, and lower, market clearing price. Because these transfers occur industry may prefer allocation mechanisms other than auctions. This could encourage criticism of auctions on the basis of problems which are solvable.

Collusion or other strategic bidding can occur with auctions. Sources may attempt to keep their costs low, or they may attempt to deny needed entitlements to competitors. The possibility of noncompetitive behavior decreases as the number of participants in the auction increases. Noncompetitive outcomes can be discouraged by using price/quantity information obtained in legally-binding sealed bids or by restricting the amount or percentage of entitlements that can be obtained by each bidder. Of course, to the extent that firms themselves face uncertainty about the future, they may miscalculate in their demand for permits. A market in "futures" and "options" should minimize any inefficiencies arising as a result of this situation.

o Allocation of Additional (Future) Control Obligations

After control obligations are initially assigned, trading approaches can differ in the manner in which future assessments (additional control obligations) are imposed on existing sources, on trades and on banked credits. Such assessments may be necessary to secure additional emissions reductions because an agency has learned more about the ambient impacts of existing emissions or because uncontrolled emissions have increased more than was expected.

The ability of an agency to impose additional control obligations can either contribute to or jeopardize the success of a trading approach. If an agency is secure in its ability to impose additional obligations when necessary, there will be no need to rely on turnover of capital stock to reduce emissions, and there will be less incentive to impose restrictions on how and when emissions reduction credits may be created and used. Trading can be made more widely available, and greater cost savings can be achieved. On the other hand, unpredictable assignment of new control obligations can create enough uncertainty in the private sector about "baseline" control requirements to inhibit trading and jeopardize the cost savings trading is intended to permit. Trading approaches will work well only where sources are reasonably secure in their expectations about the continuing value of entitlements. Trading can be inhibited if an agency imposes assessments directly and specifically on already banked credits or trading transactions, pressures sources to donate entitlements to new sources to promote economic growth, or refuses to certify (confiscates) reductions from shutdowns. Imposition of assessments on trades and on banked credits may occur where an agency attempts to exploit opportunities to improve air quality without increasing total control costs.

From the agency's point of view assessments on banked credits and on trading transactions which bypass banking can be attractive opportunities to improve air quality. Reductions are clearly technically feasible, and the gains from a trade may be great enough that a "tax" on the emission reductions generated may not prevent some potential trades from remaining financially attractive.[1] So long as the source selling emissions reduction credits continues to profit from the transaction, it may appear that no serious equity or efficiency problems are presented by this kind of practice.

In reality, direct assessments against trades or banked credits imply that the control agency has not yet succeeded in balancing air quality goals and costs as it wished and intends to move toward a better balance by relying on cancellation or discounting of banked credits, allowance of excessively small

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[1] Banked emissions reduction credits clearly reflect technically feasible controls, which a source could afford at the time to undertake in expectation of a profit without endangering the viability of its business. (Viability could be endangered if credits cannot be sold.) In most cases the reductions reflect relatively low cost controls which have already been installed. Total control costs and economic disruption may be lower if these credits are never used or are used only partially due to an assessment than if other sources are required to undertake additional controls to generate the same improvement in air quality. Finally, the very existence of the credits is based largely on a concern with reducing control costs, a goal which an agency may see as of secondary importance when air quality is thought to be inadequate.

credits for emissions reduction, and "taxation" of trades (through use of excessively low offset ratios). These approaches are also discriminatory; only sources which propose to trade have their stock of entitlements reduced. As a result, sources may trade or bank less. Because banked and traded credits may be based on innovative approaches to pollution control, measures directed at these credits may have an adverse effect on innovation as well as on trading.[1] Of course, there may be cases where, if trading itself is not discouraged, a new source that must obtain a 2:1 ratio of offsets reduction instead of a 1:1 ratio may have a greater incentive to economize on its use of the air resource -- and may innovate to do so.

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[1] An exception to these concerns exist where assessments against sources affect banked credits or trades; changes in requirements imposed on sources can affect the measure of "excess" reductions, and this may have to be traced through to banked credits, reductions proposed for use in trades, or even to sources which purchased credits with fair warning.

IV

EPA ON-GOING EXPERIENCES AND STUDY CAPSULE SUMMARIES

This section briefly describes and assesses (1) EPA's analyses, on-going experiences with economic incentives, and plans to proceed with implementing such approaches under the current statute and (2) EPA-sponsored studies of economic approaches that have not as yet resulted in implementation efforts. (These studies have also been used in preparing earlier sections of this report.)

A. BRIEF SUMMARIES OF STUDY RESULTS

EPA studies have examined charge-based and trading approaches to air quality control, in some cases comparing both approaches to the same specific problem. Exhibit IV.1 and IV.2 identify these studies, and major conclusions are summarized briefly below. A more detailed discussion of the methodologies and implications of each study is provided in the Appendix.

A.1 STATIONARY SOURCE STUDIES

Eight recent studies which contain fairly detailed examinations of charge-based or trading approaches to stationary source emissions control are briefly summarized in this subsection. Seven of these studies were done for EPA and one for the Council on Environmental Quality. Three studies examined both stand-alone charges and trading approaches, two examined only one of these approaches, and one study examined the economic impacts of noncompliance penalties. These studies covered a wide range of control problems and economic approaches, and they generally confirm the results which can be predicted on the basis of theory; all of the stationary source studies (except the narrowly focused study of noncompliance penalties) found that economic approaches offered substantial benefits over command and control approaches in terms of the effectiveness or the costs of control, or both.

The Rand Corporation compared mandatory controls and economic incentives for reducing nationwide chlorofluorocarbon (CFC) emissions (a noncriteria pollutant) from nonaerosol applications. Rand found that using economic approaches in place of regulation would reduce the costs of control from $185 to

Exhibit IV.1

Summary of Stationary Source Studies

Study	Approaches Examined	Pollutant Characteristics	Source Description	Selected Study Conclusions
Rand	o stand-alone charges: uniform rate o marketable permits	o noncriteria o nonhazardous o area impacts	o unusually varied o nationwide	o Cost savings of 40% at same emissions. o Greater emissions reduction feasible than with traditional approach.
Nichols	stand-alone charges: uniform rate impact-based	o hazardous o local health impacts	o all plants of same subject-type o widely dispersed	o Charges much more cost-effective than stringent uniform standards. o Charges somewhat more cost-effective than well designed or less stringent traditional approaches.
Mathtech	o stand-alone charges: uniform rate and impact-based o marketable permits	o criteria o local short-term impacts	inventoried sources, Chicago	o Economic approaches can reduce control costs by up to 90%. o uniform charges on all sources lead to higher total control costs than traditional approaches.
Meta Systems	stand alone charges: uniform rate	o criteria o area impacts	typical hydrocarbon emitters, South Coast Air Basin of California	o Marginal costs vary widely among sources. o A uniform charge could reduce control costs by 10% while reducing emissions by 25%.
Putnam, Hayes & Bartlett	marketable permits	all pollutants considered	none	Marketable permits are feasible, but better for area impact pollutants than for local impact pollutants.
Repetto	allocation approaches for PSD increments	N/A	N/A	o First-come, first-served approach has serious deficiencies. o Depending on conditions, partial offset or auction approaches are superior.
ICF	NSPS offsets	N/A	utility boilers	Cost savings of 1 to 11%.
Temple, Barker & Sloane	noncompliance penalties	N/A	o iron and steel industry o electric utility industry	o Very slight macro and industry effects. o Some firms noticeably affected.

Exhibit IV.2
Summary of Mobile Source Studies

Study	Approaches Examined	Selected Study Conclusions
TCS Management Group	charges on new vehicle emissions	o More cost effective than current approach, but would increase vehicle prices.
	charges on in-use vehicle emissions	o Analysis inconclusive.
	averaging	o Large cost advantages, without the political drawbacks of charges on new vehicle emissions.
Sobotka & Company	averaging (diesel TSP only)	o Averaging would be feasible and fair. o Cost savings of about 10%.
Policy Planning and Evaluation	charges on new vehicle emissions (NO_x only)	N/A - Study focused on design issues.
	averaging and marketable permits (NO_x only)	o Feasible and could offer cost benefits.

$108 million, although substantial dollar transfers from polluting sources to government would result if emissions charges were used. Rand is now examining the transfer problem in greater detail. Rand also found that economic approaches would allow greater reduction in total emissions than would be feasible with a traditional regulatory approach.

Albert L. Nichols of Harvard University compared various mandatory control and charge-based approaches for benzene emissions (a hazardous pollutant) from maleic anhydride plants. He found charges to be much more cost-effective than simple regulatory approaches at reducing health impacts, but these differences decreased if regulation became more sophisticated or if stringencies typical of hazardous pollutants were demanded. The situation with the plants Nichols examined has changed greatly since he conducted his study.

Mathtech, Inc., compared both charge-based and trading approaches to a complex and difficult control problem: meeting a hypothetical short-term ambient NO_x standard in the Chicago air basin. The impacts of NO_x emissions are source specific and localized. This study showed that economic approaches could be more costly than sophisticated regulation if an overly simple approach was taken. Well designed economic approaches--approaches sensitive to source impacts and control costs--offered control cost savings of up to 90 percent. Mathtech concluded that economic approaches were feasible for this complex problem, but would require sophisticated administration. Marketable permits were favored over charges because of their smaller demands for agency initiative in information collection and because of the greater certainty in achieving environmental standards.

Meta Systems, Inc., examined emissions charges to control hydrocarbon emissions in the South Coast Air Basin of California. Hydrocarbon emissions are a relatively simple control problem, since impacts are assumed to be a function of total emissions. Trading approaches were not examined. Marginal control costs for the sources and control alternatives examined were found to be highly variable but to divide easily into high and low cost groups. A uniform emission charge which made use of this division reduced total control costs by about 10 percent from a baseline using mandatory standards, while reducing total emissions by about 25 percent below the baseline level. This study was not concerned with designing an overall charge system but with case study calculation of the charge rates necessary to achieve emissions levels equal to those under existing requirements.

Putnam, Hayes and Bartlett, Inc., examined the design details of marketable permits approaches. Some contributions made by this study have been absorbed into earlier sections of this report. Putnam, Hayes and Bartlett concluded that permits were a workable approach but would be more difficult to apply to NO_x than to other pollutants.

Robert Repetto of Harvard University examined alternative approaches to the allocation of PSD increments. He concluded that the current "first come, first served" approach has serious deficiencies. Auctions were suggested as an alternative approach in areas where new source growth is relatively large; partial offset requirements were suggested for use in other areas. This study also argued that the use of ambient air quality standards can interfere with a desirable balancing of the benefits of cleaner air against control costs. EPA has examined PSD increment allocation in internal studies as well.

ICF, Inc., examined the effects of extending offsets to NSPS requirements for hypothetical utilities with similar plants in various parts of the country. Cost savings of one to eleven percent were shown, with no effect on air quality.

Finally, Temple, Barker and Sloane, Inc., analyzed the economic impacts of noncompliance penalties on the iron and steel and electric utility industries. Average impacts were extremely small, but some firms would be noticeably affected by these penalties.

A.2 MOBILE SOURCE STUDIES

Economic approaches to mobile source emissions were examined in four studies, one of which compared both charge-based and trading approaches. Much of the analysis in these studies consists of informed speculation about the feasibility and desirability of economic approaches, with special attention to emissions averaging (the mobile source equivalent of a bubble). Analysis of this kind has been absorbed into other sections of this report.

TCS Management Group, Inc., (TCS) examined both charges and a form of trading to reduce the emissions of motor vehicles while in use rather than just at the time of sale. Alternatives studied included emissions charges on manufacturers based on both tests at the time of sale and tests (as part of the state inspection and maintenance programs) of vehicles in use, emissions averaging, and modifications and supplements to more traditional regulatory approaches. TCS found that emissions averaging and charges on new car emissions would permit more cost-effective control. Averaging would reduce new car prices and be administratively and politically feasible. Charges would raise new car prices significantly and probably encounter considerable opposition.

Policy Planning & Evaluation, Inc., examined two approaches: one directed at mobile source NO_x emissions charges in one study and the other directed at trading approaches in a companion study. These studies served primarily to identify potential problems in the implementation of either of these approaches. Testing and certification programs were seen as one area in which changes might be needed to support any economic approach.

Finally, Sobotka & Company, Inc. (Sobotka), examined averaging for light duty diesel vehicle particulate emissions, as an alternative to the recently promulgated standards for model year 1985. This study found cost savings of about 10 percent with averaging, at a slightly reduced level of total emissions. Averaging was found to be both feasible and fair.

B. EPA ON-GOING EXPERIENCES WITH INCENTIVES

EPA analyses, experiences, and plans regarding four on-going areas of implementation of incentive approaches are discussed in this section. First, EPA's current stationary source controlled trading programs are discussed. EPA is well along in its efforts to support the states' implementation of offset banking and trading and the bubble reform and has had significant experience with those parts of the controlled trading programs which have existed for the longest time. However, banking and the bubble reform are relatively new programs and are still evolving fairly quickly. The second area discussed is mobile source averaging proposals (a form of controlled trading). EPA has not yet implemented an approach of this kind, but has taken some steps in this direction. Third, penalty systems with some similarity to supplemental charges are discussed. EPA has begun to use such penalty systems as the basis for calculation of civil fines for the phasedown of lead in gasoline, in noncompliance penalties for stationary sources, and in nonconformance penalties for heavy duty trucks. EPA is willing to consider marketable permits or stand-alone charges where found appropriate, but has not yet proceeded to promulgate regulations. Statutory change to facilitate use of these approaches is discussed in Section V.

Programs which EPA is implementing are described in more detail here than in the previous sections. For each of these EPA programs, this section sets out the program's status (including implementation history and problems being experienced now), and describes EPA's current and planned activities.

B.1 STATIONARY SOURCE CONTROLLED TRADING

Status of Programs

o Offsets Banking and Trading

When first adopted in 1970, the CAA prevented major new sources of air pollution from locating in nonattainment areas. In 1976 EPA adopted a policy which allowed such sources to enter nonattainment areas, provided emissions that remained after stringent controls were installed were offset by reductions in the emissions of existing sources.[1] The offsets policy is now well established for use in connection with new source siting in nonattainment areas.

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[1] This policy was incorporated in the 1977 amendments to the CAA, and EPA issued an interpretation of the new provision in January 1979. The general applicability of this federal policy ended as of July 1 1979, when the states were required to submit revised SIPs. States which wished to allow industrial growth in nonattainment areas were required to provide a mechanism for controlling ambient air impacts in these SIPs. The options available to the states were to set SIP requirements for existing sources at a stringent enough level to generate a margin for growth or to establish an offsets policy. All but eight states submitted draft SIPs which provided for an offsets approach. Those which did not do so have no pressing nonattainment problems. Many of the states established their offset programs by incorporating EPA's 1979 interpretation of the CAA revisions into their SIPs; some added specifications requiring new sources to more than offset their emissions.

Under an offsets program, companies that wish to site new facilities in nonattainment areas may either reduce emissions at existing facilities which they operate in these areas (internal offsets), or purchase or otherwise secure offsets from non company-owned facilities (external offsets) that exist in these areas. As of August 1979 about 500 permits for new sources had been approved in the various states under applicable offsets policies, and more were pending. Ninety-five percent of these cases involved internal offsets. In all but two or three of the 15 or so external offset cases, offsets had been donated to the new source without charge. In some of these donation cases the air quality agency encouraged the donation and in some cases even encouraged existing sources to take the steps needed to generate the offset. In other cases the control or state agency themselves implicitly asserted control over offsets growing out of source shutdowns in the area and assigned these to the new source without charge. Finally, in some cases state agencies took steps to generate offsets, which were donated to new private sources of pollution. In short, commercial offset transactions have been very rare. More recent offset cases probably involve a somewhat higher proportion of external offset trades, but the pattern of heavy reliance on internal and agency mediated offsets continues.

The limited role now being played by commercial offset trades, and the lack of an effective and pervasive set of state-run institutions for offsets trading, are matters of concern to EPA and CEA. Occasional ad hoc external offset arrangements cannot provide as significant reductions in total control costs as is otherwise possible or significantly increase incentives to innovate. Because so few offset proposals involve commercial transactions, existing programs have provided little incentive for existing sources to reduce their emissions in anticipation of an offset sale. New sources have not been able to predict whether offsets will be available in an area or what they are likely to cost. Siting decisions for new facilities may be strongly affected by these uncertainties and by the ultimate availability and price of external offsets.

A major barrier to commercial offset transactions in the past has been the lack a of mechanism by which credits for emissions reductions could be saved until a purchaser was found or a company chose to expand its operations in a nonattainment area. With no opportunity to save or "bank" credits for reductions, existing sources had no incentive to generate in advance a pool of credits which they might use for growth or which new sources might purchase. Instead, existing sources had an incentive not to reduce emissions until a use for the credits was identified. Where a future need for credits was anticipated, uneconomic production processes might be kept in operation to avoid losing an offset opportunity. Similarly, the size of a pollution control system to be installed might be chosen to just meet current standards, even if replacement with a larger control system (which could economically achieve more stringent control of emissions than required by current standards) would otherwise be selected.

New sources also faced problems with this system, since it could be a formidable task to locate and come to terms with existing sources which could reduce emissions but had not yet done so. Given the difficulty of the search and negotiation problems faced by potential new sources, the leverage available to an air quality agency, and the interests of localities in facilitating industrial growth, it is not surprising that so few of the hundreds of offsets which have been proposed to date have involved commercial transactions between firms.

In order to address this problem, EPA integrated banking of emissions reduction credits into its offset policy in January 1979. So far, very few states have taken the steps necessary to establish an operating banking system, but EPA believes that banking will eventually play a major role in making external offset trades more common in nonattainment areas. Banking will also help to facilitate bubbles (discussed below), and help new sources either meet their offset obligations under PSD programs or avoid triggering thresholds for PSD review.

o The Bubble Policy

The bubble policy encourages industry to develop less costly ways to meet pollution control requirements for existing plants than the measures specified in SIPs. It is premised on the belief that plant managers have far more information about their plants and far greater incentive than the government to reduce the costs of meeting air pollution control requirements. Subject to New Source Review procedures, the policy is as follows: as long as the area affected by the plant's emissions continues to attain and maintain NAAQS, the policy permits a plant to relax controls at emission points where control costs are high in exchange for extra controls at emission points with lower control costs. Bubbles which involve more than one plant may also be proposed, whether the plants are under the control of a single company or not. In order to assure that new requirements which result from a bubble will be enforceable, state SIPs must either impose aggregate emissions limits on groups of sources which bubble, or be revised to reflect the changes involved in each bubble. SIP revisions involve public hearings at both the state and federal levels.

EPA promulgated its bubble policy in December 1979 as the culmination of several years of effort to integrate market incentives into the existing regulatory structure. Because of the division of authority which exists under the Clear Air Act, the policy is an option which states may (but need not) include in their SIPs. Some states have embraced the policy enthusiastically; others have chosen not to implement the policy at this time. EPA is continuing to evaluate and refine the bubble policy and its procedures for reviewing and approving bubble applications in order to improve the policy's usefulness. Policy issues receiving attention now include the requirements for demonstrating equivalent impacts, the potential for parallel state and federal processing of applications to expedite reviews, one-time EPA approval of states' own criteria for approving bubbles, and the broadening of exceptions that permit bubble trades in nonattainment areas. In addition, implementation of the policy has served as a catalyst for efforts to reform the SIP revision process.

Although the bubble policy is a new program, early indications are that the policy will be successful where implemented. Industry has shown a high degree of interest in using bubbles despite the short period of time available for devising new approaches to meet 1982 SIP requirements. As of early November 1980, about 20 formal bubble proposals had been received by the states and a few had reached EPA for review. Industries proposing bubbles include steel and other metals, paper and plastic manufacturing, paper and can coating and utilities. Pollutants include VOC, SO_2 and TSP. Control approaches include process changes, fuel switching and new control hardware. The majority of current bubble proposals involve changes in hydrocarbon controls for product coating lines.

The first proposals submitted estimate significant savings in annual operating costs and in capital expenditures. The Naragansett Electric Company's multiplant bubble for SO_2 emissions was approved and is expected to reduce fuel costs by $3 million per year. ARMCO Steel estimates reduction of $14-16 million in capital costs by replacing controls on process TSP emissions with open dust controls. The majority of the bubbles being developed are expected to improve air quality. A few proposals involve innovative control approaches. For example, 3M Company is planning to use waterbase solvents and a solventless coating process to reduce VOC emissions at a tape coating plant.

Two bubbles have received preliminary EPA approval. Actual approval of several bubbles is expected to stimulate further interest in using bubbles, as will the need for companies to retire and replace older pollution control equipment.

Current Efforts Regarding Implemented Controlled Trading Activities

The nature of EPA's activities in the controlled trading area has been determined largely by the fact that implementation of banking and trading and bubble programs is primarily a state responsibility under the existing statute. EPA is therefore initially confined to interpreting the statute and defining policies which may be used by the state, encouraging the states to establish programs and assisting them should they choose to do so, and encouraging industry to take advantage of the opportunities presented by these programs. Because offset trades and bubbles will involve SIP revisions (which EPA must approve or disapprove), EPA can also effectively establish minimum criteria for the acceptability of these proposals.

Banking and trading and the bubble policy all involve similar kinds of activities. EPA's banking and trading project has published several manuals describing particular aspects of the establishment and operation of different banking and trading systems, as well as papers detailing the benefits these systems can provide. EPA has also published a manual for industry on use of the bubble policy; this manual emphasizes the advantages of working closely with the states and EPA during the development of bubble proposals. A second booklet on multiplant bubbles is being prepared. The banking and trading project has developed models and analytical tools for use by the states and provides the states with other direct technical assistance. Members of the project are available to make presentations, participate in workshops, help resolve issues, and perform research in selected areas. EPA staff involved in the bubble reform also participate in numerous industry briefings, seminars and conferences, and have worked closely with particular companies that are considering bubble proposals.

Public information activities in connection with controlled trading programs are extensive. Newsletters have been established for both banking and trading and the bubble. The banking and trading project publishes an annotated bibliography which covers both of these programs and the wider context of economic approaches to regulation. The bibliography is kept up to date and includes useful material published by EPA and others. New banking and trading and bubbles proposals are identified by the regions and tracked by headquarters. Headquarters helps measure progress and spot problems, helps the regions coordinate these issues, and facilitates diffusion of experience. "Progress reports" are included in the program newsletter.

EPA is now examining the effects of the bubble policy on industrial innovation. As part of its assessment of strategies for attaining ambient air quality standards in nonattainment areas, EPA has also attempted to assess the potential effects of offset trading in particular areas. A draft report by Energy and Environmental Analysis, Inc. in April 1979 proposed analytic procedures for this task. Key cost assumptions underlying the proposed model are still being evaluated. No comprehensive quantitative analyses of the effects or potential effects of offset banking and trading, or of the bubble policy, exist at this time. EPA has focused its attention on identifying and solving problems in the implementation of these programs and on identifying useful future steps.

Controlled Trading Plans Under Current Legislation

EPA's future activities in the controlled trading area will focus, in particular, on emissions banking and integrating the banking and trading and bubble programs. The establishment of active banking programs should encourage and greatly facilitate offsets trading and bubbles, since operation of a trading program should be a relatively simple matter once a banking system is in place. Bubbles involving more than one plant or firm can also be more easily arranged if one party's emission reductions do not have to occur simultaneously with the emission increases of another party.

In addition, EPA will increasingly focus its attention on the administrative and procedural complexities involved in the banking and trading and bubble programs. EPA is already examining changes in the SIP revision process to speed the review of trading and bubble proposals. EPA will continue to look for ways to streamline procedures where this can be done under the CAA, while providing adequate assurance that air quality is not jeopardized.

In the long run, controlled trading programs should be developed into a more flexible and useable system that will integrate trading in emission entitlements and obligations and will consider futures and options in these assets as appropriate.

B.2 MOBILE SOURCE AVERAGING

EPA is continuing to examine mobile source averaging approaches, and has issued an Advance Notice of Proposed Rulemaking to implement such a program for NO_x emissions from heavy duty engines and light duty trucks. A public workshop took place in January 1981 in connection with this proposal, and a proposed rule is planned for Spring 1981. This activity reflects EPA's and CEA's conclusion that allowing tradeoffs of emissions from different sources is as promising for mobile as for stationary sources. Averaging can reduce costs for manufacturers while maintaining emissions levels, and could lead to improved fuel economy. Manufacturers could use the flexibility provided by averaging in several ways. For example, manufacturers might test new models in the market before investing large amounts in pollution control or they might design particular models to conform to standards in export markets.

EPA's initial analysis of averaging approaches (in connection with the recent rulemaking on TSP standards for light duty diesels) preceeded completion of the contractor reports on mobile source averaging discussed elsewhere in this section and in the Appendix. While the contractor reports demonstrated the large potential benefits of averaging, these studies and the early EPA study also made it clear that averaging could raise difficult problems involving equity, program administration and competition between manufacturers. Some of the potential problems with averaging can be minimized by careful program design. For example, EPA has determined that averaging probably should be restricted to within the same vehicle class (cars, light duty trucks, heavy duty trucks), and should be applicable only at the level of individual engine families (i.e., families within the same class could be averaged but not vehicles within a family, or vehicles or families in different classes).

B.3 SUPPLEMENTAL CHARGES

Supplemental charges can be used to induce compliance with regulatory requirements, or to limit marginal control costs by providing sources with an alternative to control. EPA has implemented a system with a similarity of purpose to supplemental charges of the first kind under Section 120 of the CAA for stationary sources (noncompliance penalties) and has also begun to implement such charges for mobile sources (nonconformance penalties). Unlike stand-alone emissions charges and supplemental "safety valve" charges, noncompliance penalties are not assessed on the degree emissions exceed a standard but solely on the cost of compliance technology. Moreover, noncompliance and nonconformance penalties are not intended to offer the sources the continuing choice of reducing emissions or paying a fee: they are intended to encourage compliance with regulatory requirements. Nonconformance penalties do permit such a choice in the short run, but will quickly escalate beyond the point at which paying the charge penalty is a viable option.

Noncompliance Penalties

At the direction of Congress EPA has implemented a program of noncompliance penalties for stationary sources. These penalties are not subject to any ceiling and will be assessed through administrative mechanisms, avoiding the delays that often accompany legal action to impose civil fines. Objective economic considerations (costs of equipment, tax laws, prevailing interest rates, etc.) are used to set penalty levels which offset the economic benefits to polluters of delaying expenditures on pollution control measures. Noncompliance penalties are a new program at the federal level, but were proven to be effective and workable at the state level before Congress required EPA to take similar steps.

EPA promulgated its final rule on noncompliance penalties in July 1980; however, EPA delayed general implementation of the regulations until January 1, 1981 in order to train agency personnel and to better coordinate noncompliance penalty activities with EPA enforcement actions.

Penalties apply to all major stationary sources which are in violation of any SIP requirement, NSPS, or NESHAP, or which have failed to comply with interim requirements established in a court order or consent decree. Because available resources do not permit immediate action against all 2000 or so sources in these categories (without jeopardizing other agency missions) EPA has established priorities for enforcement. These focus first on those sources which have never come into compliance with applicable requirements and which are not complying with enforceable requirements in court orders or consent decrees. It is expected that many sources in these groups will negotiate consent decrees containing interim requirements before the regulations are fully implemented. EPA does not intend to impose noncompliance penalties on sources which are economically unable to simultaneously pay penalties and make the investments necessary to come into compliance. The Temple, Barker and Sloane report discussed earlier suggests that this will not be a widespread problem.

Nonconformance Penalties

EPA is also implementing nonconformance penalties for mobile sources, as specified by Section 206(g)(3) of the Clean Air Act. The statute permits EPA to allow the production and sale of heavy duty engines and vehicles which can not meet emissions standards, provided emissions are not in excess of established upper limits and provided a charge (the nonconformance penalty) is paid. Nonconformance penalties allow EPA to set standards that are expected to be within the technical capacity of most firms in the industry at the time the standards become effective, without the risk that some firms will be unable to meet these standards and will be forced out of the market. This approach allows firms to pursue the development of reasonable control technologies without the fear that vehicle or engine sales must cease if a specific deadline is missed. It allows manufacturers who purchase engines or control technologies to be protected against temporary shortages, and enhances competition by keeping more suppliers and more vehicle manufacturers in the market. At the same time the approach can enhance the credibilty of EPA standards by making it less likely that standards will need to be changed or delayed. This can result in more effective protection of the environment. The requirement that emissions be below established ceilings prevents the sale of grossly polluting engines and vehicles.

In addition to providing that penalties should be set so as to protect the competitive positions of manufacturers who do comply with emissions standards, the CAA specifies penalties are to be larger the further the emissions are from meeting standards and they are to increase over time. This last characteristic assures that the penalties will provide a continuing incentive to manufacturers to bring their engines and vehicles into compliance.

EPA intends to promulgate initial nonconformance penalties for 1984 model year heavy duty engines in March 1981, and thereafter to provide for nonconformance penalties where there is evidence that compliance with a standard cannot be achieved without substantial development and/or substantial design work. Thus subsequent promulgations will be directed to penalties for 1985 (and later) heavy duty engines and for light duty truck emission standards. Penalties are (by statute) aimed at the technological laggard. Because manufacturers are currently meeting those emissions standards required through model year 1983, 1984 is the first year nonconformance penalties are applicable.

After considerable analysis and discussion of alternative bases for calculating nonconformance penalty levels, EPA has decided to propose a fee-setting approach based on a uniform penalty rate for each unit of emissions in excess of the standard. Where the data are available, the penalty rate will be based on the marginal costs of control for the same pollutant in similar engines or vehicles produced by other manufacturers. Penalties will be adjusted upward over time, in conformance with the statute. This approach may often result in total penalty payments which exceed the costs conforming manufacturers incur to come into compliance. However, this approach is expected to protect these conforming manufacturers from adverse competitive impacts and to provide incentives for nonconforming manufacturers to come into compliance, as is required by statute. In addition, the technical difficulties involved in alternative approaches to setting penalty levels are severe.

Economically-Based Civil Fines

EPA has applied the economic penalty idea to the calculation of civil fines on petroleum refiners for violation of the schedule for phasedown of lead content in gasoline. Lead is used as an additive to increase octane levels in gasoline; octane levels may also be increased in other ways but these are usually more expensive than adding lead. Thus, in the absence of penalties equal to cost savings, firms which do not comply with EPA's regulations in this area would experience a direct and readily measureable economic benefit. Unfortunately, the implementation of an economic penalty based on cost savings has had to be compromised in this program, because under the Clean Air Act the maximum civil penalty that can be assessed for these violations is $10,000 per day. The economic benefits to refiners larger than roughly 125,000 barrels per day of production from a violation of these provisions may exceed $10,000 per day; these refiners will find that it is still economically advantageous to violate the statute.

B.4 OTHER ON-GOING STATIONARY SOURCE INCENTIVE EFFORTS

In addition to the economic incentive approaches which EPA has begun to implement, EPA is examining other economic incentives that could contribute to the solution of difficult problems under the current regulatory system. This subsection briefly describes the approaches EPA is examining. These include:

- the use of permits or charges to reduce chlorofluorocarbon emissions;
- allowing the use of offsets to meet NSPS requirements (this is a form of "new source" bubble);
- a wide range of approaches to the allocation of PSD increments;
- the use of emissions density zoning; and
- the use of tradeable "rollback" obligations and supplemental emission charges to address chronic nonattainment problems.

Reducing Chlorofluorocarbon Emissions

EPA is planning to propose regulations in the spring of 1981 for control of chlorofluorocarbons (CFC) emissions to the atmosphere from non-aerosol uses. A marketable permit approach applicable either to producers or first purchasers of CFC's is anticipated. CFC's are particularly appealing for the application of economic incentives because: (1) they represent an area previously unregulated; (2) there is a direct relationship between emissions and ambient impacts; (3) at current and anticipated emission levels, there do not appear to be significant exposure levels beyond which especially serious environmental effects occur; (4) CFC emissions do not result in localized or "hot spot" effects; (5) there is a fairly long lag between emissions and subsequent effects on the atmosphere (cumulative effects are the most significant); and (6) because emissions are directly related to the amounts purchased and used in production, no serious measurement problems exist.

Because of the need for more detailed information to support the option of establishing a cap on CFC emissions at 1980 levels and to explore the relative merits of an incentive system applicable to purchasers as well as producers, the Rand Corporation is performing additional analyses for EPA regarding the implied control technologies, costs, and resulting economic impacts. Problems arising as a result of potentially large transfer payments generated by the operation of an economic incentive system and the effects of CFC regulation on innovation in the U.S. and abroad are included in the analysis. Associated studies by Resources for the Future (to design charge systems for auctioning CFC permits) and a professor at the University of California (Berkeley) (to design a system for auctioning CFC's) will also contribute to the development of an approach to CFC regulation.

NSPS Offsets and New Source Bubbles

Currently, new sources cannot trade because technology-based standards must be met. The implications of the restriction were discussed in Chapters I and III, which cast doubt on the need for such restrictions. Moreover, the ICF analysis of NSPS offsets demonstrated that allowing trades between new and existing sources can substantially reduce control costs, even if trades are confined to internal offsets for electric utilities. Even larger cost reductions may be available if electric utilities could purchase "external" offsets from other industries (e.g., from smelting operations), and trades between other new and existing sources are also likely to offer significant cost savings. These savings may be sufficient in particular cases or identifiable classes of cases to make such transactions financially attractive even if high "offset ratios" are required of the new source.

EPA is continuing its analysis of NSPS offsets. The analysis of NSPS offsets now in progress is focusing on the utility situation, and examining potential cost savings (under improved assumptions and in different situations), differential regional impacts, energy impacts and possible effects on coal use.

New source trades which are not constrained by technology-based standards (such as NSPS, BACT and LAER) represent an expansion of the bubble policy to include new sources in some situations. Even though technology-based standards could still determine emission reduction obligations, neither NSPS offsets nor new source bubbles more generally would be permissable under the current statute (which has been interpreted to require meeting technology-based standards at the plant site). EPA may recommend legislative changes to permit new source trading in some situations, depending upon the results of additional analysis now in progress. Initial conclusions about legislative changes are contained in Chapter V.

Analysis of new source bubbles as a general approach is focusing on determining the implications for long-term emissions.

New source bubbles relax the requirement that new sources directly meet technology-based standards, requiring instead that an equivalent emission reduction be secured somewhere. While emissions will initially be equal with or without new source bubbles (and may even be less with the bubble, if the offset ratio is greater than unity), trading can always reallocate emissions between sources with different remaining lifes and thereby affect long-term emissions. When this occurs, different steps may need to be taken to create room for future economic growth or to assure improvements in air quality as the capital stock turns over. As discussed in Chapter III, these effects will be present whenever (and only if) a trade increases the expected lifetime of an entitlement. This can of course only occur as a result of trading rules if entitlements are forfeited to the government when a source shuts down, and it can thus occur whether or not a new source purchases entitlements. If entitlements are available for trading when sources shutdown, unless the source that is closing is in a low growth area so there is no market for its entitlements, there should be no concern over the implications for long-run emissions. Increased lifetimes can be prevented by specifying lifetimes for traded entitlements that reflect expectations in the absence of a trade.

Where the lifetime of entitlements is increased by a new source bubble, the potential adverse impacts on long-term emissions may need to be offset in some way. A high initial offset ratio is one approach. Alternatively, a control agency could set goals for future emission reductions independently of turnover in capital stock and assign new control obligations to generate target reductions.

PSD Increment Allocation

PSD increments are currently allocated by most states on a first-come, first-served basis. As discussed in Chapter III, this allocation rule can be inefficient. Therefore, EPA has examined a range of alternatives that could be implemented by states in the near term and under the current statute. The EPA-funded study by Repetto showed that the most cost-effective approach to PSD increment allocation is likely to depend on local conditions. EPA's (still limited) internal analysis has also recognized that states may prefer different approaches based on their own needs, political constituencies, growth patterns and capabilities for air quality management.

EPA's internal analysis shows that it would not be easy to design a PSD fee or an increment auction to achieve all of the potential benefits often claimed for these economic approaches. However, this analysis has not yet fully explored the potential of resale markets to reduce the importance of some of the problems associated with auctions.

Among the alternative approaches EPA has examined are emissions density zoning (discussed in the next subsection), partial offset requirements like those examined by Repetto, generating a growth margin by imposing stringent requirements on existing sources (this approach is now in use in some states), rigorous BACT review of all new sources, "administrative reservation of the increment" (explained below), and allocation according to local preferences favoring the presence of certain kinds of sources.

Partial offset requirements (another allocation rule introduced in Chapter III) would increase costs to industry to site in PSD areas, since new obligations would be created. While partial offsets could in theory provide for more efficient allocation of the increment, it would be difficult to set offset ratios which achieved a fully efficient outcome. Ideally, the ratio should balance added cost now (relative to expected control costs in the future) against the greater value of emissions reduction earlier in time. The benefits of partial offsets are limited, because it is only feasible where offsets are available, and if offsets are available there should be no absolute exclusion of sources which place a high value on use of the air.

"Administrative reservation of the increment" involves directly restricting (and specifying in advance) the percentage of the remaining increment that a single source could use, or the percentage that could be used by all sources in a given time period. This approach does not increase efficiency and would probably encounter considerable opposition from industry. Moreover, it addresses a problem that is not important in practice, since sources which consume large percentages of the increment usually do so only in a small geographic area.

Rigorous BACT review is likely to be sufficient to permit siting in most areas in the forseeable future. Where this is not feasible, local assessment of the costs and benefits of allowing one source to site rather than another is an option that should be considered.

<u>Emissions Density Zoning</u>

Emissions density zoning is essentially a way to simplify and express the results of air quality modelling. Once the impacts of different levels of emissions in different areas have been assessed by modelling, it is possible to specify an acceptable scenario for apportioning total emissions of a particular pollutant in each small subdivision or "zone" within a large geographic area. This specification may need to be somewhat conservative, because source characteristics can affect impacts and because groupings of sources near zone boundries could lead to a violation of air quality standards.

"Zoning densities" can be used to allocate PSD increments or to make it easier for sources to plan and execute trades under the offset and bubble policies. PSD review might be simplified for sources within density limits, or entitlements to emit from within zones might be auctioned. As the limits established by zoning densities were approached, a return to more conventional and cumbersome case-by-case review would always be possible.

Nonattainment Strategies

As discussed earlier, continuing nonattainment problems can resist solution by conventional means because of the difficulties that exist in identifying additional emission reduction opportunities and in allocating them to sources. This is likely to occur because sources in these areas have typically already undertaken standard control measures and agency information about new control opportunties is likely to be limited. Moreover, political considerations may make it difficult to impose yet additional control obligations on particular sources of emissions. As a result, EPA has been examining several potential economic approaches to the problem of reducing emissions in areas that continue to have nonattainment problems. The approaches being examined can be used separately or in combination.

The information problem can be reduced by relying on economic approaches that lead to cost-effective results regardless of the initial allocation of control requirements. Thus, for example, states could identify the overall control obligations that will lead to attainment, and allocate them through a uniform percentage rollback in allowable emissions. If these obligations (or "emission reduction assessments") are tradable as under the bubble policy, then trading should lead to cost-effective controls overall. In addition, the consequences of allocating transferable emission reduction assessments

(TERAs) to sources that are technically incapable of fully reducing emissions is minimized because such sources can purchase reductions in the trading market.

As an alternative, an emissions charge could be applied to all remaining emissions or to the amounts allocated as emission reduction assessments. If charges were applied to all remaining emissions, sources would undertake control efforts until the marginal cost of control equals the charge and would have a continuing incentive to find ways to reduce emissions at lower cost. If charges apply only to emission reduction assessments, sources would elect to pay the charge if it were less than the cost of reducing emissions. These sources would have ongoing incentive to find ways to reduce emissions at a cost lower than the charge. Of course, the essential difference between these trading and charge-based approaches is that trading approaches allow better control over the timing of reductions while charges allow better control over the cost of reductions.

These approaches can be combined to achieve the benefits of both trading and charges. To accomplish this, charges would serve to supplement trading. Thus, the primary control approach would be to allocate emission reduction assessments and allow trading to occur, and supplementary charges could be designed to serve any of several purposes. The charge could be designed to provide a safety valve for sources which are unable to meet their new control obligations directly or through purchase of entitlements, or for sources which preferred to delay compliance for a short period of time. Alternatively, the emission reduction assessments could be considered to be technology-forcing and the charge could be designed as a nonconformance penalty that is low enough to provide a credible alternative to noncompliance but high enough to encourage the development of new control approaches. Finally, a supplementary charge could be assessed for emissions remaining after emission reduction assessments to provide a continuing incentive to reduce emissions beyond required levels.

While these economic approaches are likely to be more effective, cost-effective and feasible than traditional approaches, they require careful evaluation. As discussed in earlier chapters, there are a wide variety of important design parameters that range from setting the level of the charge to the involvement of the control agency in trading markets. EPA's analysis of potential alternative incentive approaches to nonattainment problems is still at a relatively early stage. Approaches such as those discussed above have been identified and thought has been given to some of their attributes and operating characteristics. Further analysis is planned.

Mobile Source Strategies for the 1980's

EPA has begun to implement mobile source nonconformance penalties, and begun a rulemaking to consider use of mobile source averaging. EPA is also considering expansions and combinations of these approaches, and is examining enforcements and alternatives to mandatory inspection and maintenance (-I&M programs.

Emissions averaging could be the cornerstone of a more flexible and cost-effective mobile source emissions control program. EPA is currently studying averaging for possible implementation to control NO_x emissions from heavy duty trucks. One approach would be to administer averaging at the time of sale in the same way that corporate average fuel economy (CAFE) requirements are administered, by relying primarily on manufacturer certifications and vehicle counts. Alternatively or in addition, inuse emissions (of vehicles which had not been abused) could be averaged. A relatively small number of yearly inspections of each model year's vehicles (a few thousand annual inspections per model year for two or three years) would provide a high level of statistical confidence about the range of actual in-use emissions, and reduce the need for emissions and durability testing prior to sale. Once average in-use emissions were known, manufacturers could be assessed a charge if their average fleet-wide emissions were not in compliance, and could be given a credit against future charges if average fleet-wide performance was better than necessary. The use of charges and credits would permit averaging over time, and could be implemented to provide both flexibility and the same strong incentive toward compliance as nonconformance penalties will provide. A manufacturer could build cleaner new vehicles rather than recall old ones, but would not intentionally incur the expense of being out of compliance.

This system or something similar would probably allow more effective control at less cost than the current approach. However, it would not solve the problems of tampering and neglected maintenance of pre-model year 1981 vehicles, or of nonfunctioning computer control systems on newer vehicles. Mandatory I&M solves this problem directly and completely, but even if mandatory I&M is confined to areas which cannot demonstrate attainment it is often opposed by vehicle owners and the states. EPA will therefore consider economic incentives to aid in encouraging the implementation of mandatory I&M.

The TCS study summarized earlier in this chapter examined two economic "enhancements" to mandatory inspection and maintenance: direct financial rewards to vehicle owners who respond to recall notices, and indirect rewards (in the form of waiver of inspection requirements in the following year) to those who pass a mandatory inspection. The idea of penalties and incentives to vehicle owners could be expanded, in the context of mandatory or voluntary inspections. Rewards could be paid for undertaking repairs to pass a voluntary inspection (records would be needed to prevent "double dipping"), or an emission fee could be assessed on a fixed schedule unless scheduled maintenance was performed or voluntary inspections were passed.

Some of these programs could be difficult to administer, and any fee which varied with predicted rather than measured emissions would probably encounter substantial opposition. Moreover, designing a fee which was fair could be so difficult as to make program implementation infeasible unless a simple program tied to the age of registered vehicles was acceptable. To provide sufficient incentive, rewards or fees might have to be large. This is because most excess emissions from in-use vehicles are accounted for by a relatively small number of grossly polluting vehicles, whose owners might not respond to small rewards or might pay a small fee rather than take corrective action.

As an alternative to fees or rewards, manufacturers could be required to perform scheduled maintenance without charge, or even to reward vehicle owners for bringing vehicles in for maintenance (vehicle owners would bear the cost of these programs in the form of higher new vehicle prices). Such programs might encounter as much political opposition as mandatory I&M, and could lead to the added expense of unnecessary scheduled maintenance.

In the long run it would appear that the success of I&M programs will require emission control systems that last for the lifetime of motor vehicle (e.g., 100,000 miles). To provide manufacturers the incentive to design such systems, consideration should be given to (1) longer lived but more limited warranties (restricted to primary emission control equipment), (2) innovative technology waivers (whereby development of 100,000-mile emission controls might permit a delay in meeting certain standards), and (3) grants to pollution control equipment manufacturers. While meeting environmental goals will likely necessitate mandatory I&M programs in nonattainment areas, opposition from the public can be significantly reduced if periodic inspections merely determined whether or not a long-lived emission control system is in place and operable. Only where evidence of damage (covered by warranty) or tampering (requiring out-of-pocket owner expenses to repair) was found would an emissions test be necessary. Failing the test would then require repairing the system and retesting.

V

ANALYTIC CONCLUSIONS AND LEGISLATIVE PROPOSALS

A. ANALYTIC CONCLUSIONS

A.1 CURRENT PROGRAMS

- REPLACEMENT OF THE IN-PLACE REGULATORY SYSTEM WITH STAND-ALONE EMISSIONS CHARGES OR MARKETABLE PERMITS IS NOT NECESSARY. ALL SIGNIFICANT BENEFITS OF ECONOMIC INCENTIVES CAN BE ATTAINED THROUGH CAREFUL SELECTION AND DESIGN OF CHARGE OR TRADING APPROACHES WHICH SUPPLEMENT THE CURRENT REGULATORY SYSTEM. If the full potential of supplemental charges and "controlled trading" programs could be achieved, no significant incremental benefits would be available from use of stand-alone charges or a "pure" system of marketable permits. However, stand-alone charges and permits would offer a fresh start that may be important to achieving the potential benefits of economic approaches in certain unregulated areas.

- WITH ITS OFFSET, BUBBLE, AND EMISSIONS BANKING POLICIES, EPA HAS MADE SIGNIFICANT STRIDES TOWARDS INCORPORATING MARKET INCENTIVES IN ITS AIR PROGRAM. In each of these policies, polluters have incentives to seek out sources of low-cost emission reductions. The result will be a more cost-effective pollution abatement program. However, these policies have not yet been fully implemented by the states. One reason has been the cumbersome administrative procedures associated with these policies. EPA is currently working on streamlining this process.

A.2 ECONOMIC EFFICIENCY

- CHARGE-BASED APPROACHES WILL CONTRIBUTE TO EFFICIENCY IN THE ALLOCATION OF SOCIETY'S PRODUCTIVE RESOURCES BY FORCING SOURCES TO TAKE INTO CONSIDERATION THE DAMAGE WHICH THEY CAUSE TO THE ENVIRONMENT. Traditional command-and-control approaches are no better than trading approaches in duplicating this desirable feature of charge-based approaches. Where the marginal social costs of emissions are known, no approach is more economically efficient and cost-effective than stand-alone charges.

- IT IS DIFFICULT TO DIRECTLY PURSUE ECONOMICALLY EFFICIENT OUTCOMES. Economic efficiency requires that damages from emissions and control costs be equalized at the margin. In the absence of an ability to determine damages accurately, efficient outcomes cannot be identified. Thus, the operational test of efficiency is that of cost-effectiveness, i.e., achieving an environenvironmental objective at least cost. This is the standard of efficiency pursued by EPA in its consideration of incentive approaches. Any approach that is economically efficient will also be cost-effective.

A.3 EFFECTIVENESS

- NONCOMPLIANCE PENALTIES SIGNIFICANTLY STRENGTHEN THE EFFECTIVENESS OF CURRENT REGULATORY REQUIREMENTS BY ENCOURAGING COMPLIANCE. Noncompliance penalties are a special form of economic incentive intended to neutralize the economic benefits which would otherwise accrue to stationary sources that delay compliance with regulatory requirements. EPA has implemented these penalties, and EPA and CEA expect them to be highly effective.

- BOTH SUPPLEMENTAL CHARGES AND "CONTROLLED TRADING" CAN PROVIDE INCENTIVES TO ABATE POLLUTION TO A GREATER DEGREE THAN IS REQUIRED BY CURRENT STANDARDS. Supplemental charges imposed on some or all residual emissions can be as effective as stand-alone charges in providing a continuous incentive to sources to go beyond current standards and to find innovative ways to reduce control costs. "Controlled trading" (the buying and selling of obligations to reduce emissions and of credits for abatement which was not required) provides identical incentives for each source and can lead to a reduction in total emissions as emission reduction credits are created for later use or sale.

- STAND-ALONE CHARGES AND THE "PURE" FORM OF MARKETABLE PERMITS CAN BEST SERVE AS A PRIMARY MEANS TO CONTROL THOSE AIR POLLUTION PROBLEMS WHICH ARE NOT ADDRESSED OR DEALT WITH SUCCESSFULLY BY CURRENT REGULATIONS. Air pollution problems which are not being addressed by the current approach should receive careful scrutiny as candidates for implementing emission charge or marketable permit approaches. In these cases, economic incentives cannot disrupt an existing program, and may provide a better approach to as yet unsolved problems.

o IN GENERAL, TRADING APPROACHES PROVIDE GREATER SHORT RUN CERTAINTY ABOUT ACHIEVING SPECIFIED LEVELS OF EMISSIONS AND IN MOST CASES LESS CERTAINTY ABOUT COSTS THAN CHARGE-BASED APPROACHES. Trading involves a fixed quantity of entitlements and therefore a strict limit on total emissions. The control costs that will be incurred to meet this limit are difficult to predict in advance except where polluters are required to submit certain "demand for permits" data prior to an auction. Charge-based approaches will limit marginal control costs to the level of the charge, but the amount of control that can be undertaken at costs below the charge will be difficult to predict in advance. The effects of a given charge rate on emissions will vary with inflation, economic growth and innovation. The price of entitlements under a trading approach will vary with these factors, but total emissions will not vary.

A.4 COST-EFFECTIVENESS

o SUBSTANTIAL CONTROL, COST SAVINGS AND INCREASED COST-EFFECTIVENESS ARE LIKELY TO RESULT FROM THE USE OF ECONOMIC APPROACHES. This is true because economic incentives vest greater decision-making responsibility in sources, and allow the market to reward good decisions. (Sources themselves will also have better information on which to base (control) decisions. Studies conducted for EPA produced savings estimates ranging from about 10 percent to about 90 percent of base level control costs at equal or greater levels of abatement as a result of the use of economic approaches. Even larger long-term savings, may be possible, because incentives should be better able to stimulate technological change than command-and-control approaches alone.

o TRADING APPROACHES ARE LIKELY TO BE FEASIBLE WHENEVER DIFFERENT SOURCES WITH OVERLAPPING ENVIRONMENTAL IMPACTS ARE SUBJECT TO REGULATION. No information beyond that required to establish initial regulatory requirements is needed to design a trading approach.

o A MARKETABLE PERMITS POLICY AND AN EMISSIONS CHARGE POLICY BOTH RESULT IN LOWER CONTROL COSTS THAN DOES A REGULATORY POLICY. Moreover, a marketable permit policy offers as great certainty about resulting emissions and ambient air quality as does a regulatory policy, and both permits and traditional regulation result in greater environmental certainty than does an emissions charge policy, at least in the short run.

- o EMISSION CONTROL STRATEGIES, WHETHER COMMAND-AND-CONTROL OR ECONOMIC INCENTIVE, THAT TAKE MAKE GOOD USE OF DIFFERENCES IN EACH INDIVIDUAL SOURCE'S COST OF CONTROL AND AMBIENT IMPACT WILL ACHIEVE AMBIENT GOALS AT SIGNIFICANTLY LOWER COSTS THAN STRATEGIES FOR WHICH EMISSION LIMITATIONS ARE DEVELOPED ACROSS CATEGORIES OF SOURCES. A quantitative assessment of pollution control strategies in the Chicago area showed that the approach that exploited this relationship on a source-by-source basis to minimize the cost of meeting ambient concentration targets was roughly thirteen times less expensive than the "traditional" approach to air pollution control. However, because of implementation problems, it is unlikely that an air pollution control agency could ever capture all these potential cost savings. Yet, these savings are of such magnitude that even limited implementation of cost-effective abatement programs would result in substantial cost savings.

A.5 FEASIBILITY

- o ALTHOUGH MARKET INCENTIVE SCHEMES SHOULD BE USED WHEREVER FEASIBLE, THEY WILL BE EASIER TO IMPLEMENT FOR POLLUTANTS FOR WHICH A SOURCE'S EMISSIONS ARE REPRESENTATIVE OF ITS AMBIENT IMPACT. The reasons for this are:

-- simplicity and ease of administration: When emissions are representative of a source's contribution to an ambient problem, a control agency does not have to undertake (or supervise) elaborate ambient air quality modeling to ensure that Source A can trade emissions limitations with Source B without degrading air quality. It needs only to know both A's and B's emissions.

-- market size: For some pollutants all emissions are thought (or assumed) to contribute equally to the ambient air quality within an area -- regardless of where emitted within the airshed. Emitters of these pollutants could thus trade emission limitations with any source within the airshed without degrading air quality. The potential market in emission limitations is therefore quite large. However, for pollutants where ambient impact depends not only on the quantity of the pollutant emitted, but on the stack parameters and location of the source, trading of emission limitations must be restricted to sources that can demonstrate equivalent impacts on air quality within the same location. This has the effect of decreasing market size.

- o <u>IN GENERAL, A MARKETABLE PERMIT SYSTEM IS PREFERABLE TO A CHARGE SYSTEM FOR ATTAINING AND MAINTAINING AN AMBIENT STANDARD</u>. We base this conclusion on the following findings of our comparative analysis of these two economic policies:

  -- Under a charge system the quantity of pollutants emitted depends upon the response of sources to the costs imposed by a charge. Thus, the administering agency has greater certainty in the short run that standards will be met under a permit system.

  -- To implement an efficient charge system, the administering agency must acquire information about sources' control costs. This is a difficult and expensive undertaking if costs are to be determined accurately. Under a permit system, the quantity of emissions is fixed by the quantity of permits issued, so the agency does not need detailed source-by-source cost data. Cost data would still be useful to design permit systems that operate smoothly. These data will be revealed by sources as they buy and sell permits from one another.

  -- A marketable permit system self-adjusts to inflation and growth. A charge system requires that the agency make periodic adjustments to these factors, adjustments which depend upon uncertain and perhaps expensive data. Furthermore, frequent changing of charge rates may undercut the credibility of a charge system.

  -- A marketable permit system is administratively and legally similar to permit programs now operated under regulatory control programs. Consequently, it could be administered alongside existing regulatory programs more easily than could a charge system, and would probably encounter less opposition from vested interests. A marketable permit system is also similar to the Offset and Bubble Policies currently in force.

- CHARGE-BASED APPROACHES ARE A FEASIBLE WAY TO MEET AMBIENT AIR QUALITY STANDARDS ON A FIXED SCHEDULE ONLY IF SUBSTANTIAL INFORMATION ABOUT CONTROL COSTS IS AVAILABLE. Information of this kind is needed to predict the response of sources to charges. Thus, in the absence of this information, achievement of air quality standards on a fixed (particularly short-term) schedule cannot be guaranteed.

- CHARGE-BASED APPROACHES ARE MOST ATTRACTIVE WHERE TRADITIONAL APPROACHES WILL HAVE A DIFFICULT TIME MEETING AIR QUALITY STANDARDS ON SCHEDULE, WHERE THERE IS A FAIRLY LONG LAG BETWEEN EMISSIONS AND SUBSEQUENT ENVIRONMENTAL EFFECTS, OR WHERE MAXIMUM FEASIBLE CONTROL EFFORT IS SOUGHT. Where attainment of air quality goals on schedule is in doubt or there is no grave concern over short-term damages during the period of necessary adjustment in charge rates, charges can provide a means to induce cost-effective control steps with very little information on hand. Where maximum feasible efforts are sought, charges can induce control efforts that it would not have been feasible to identify in advance and efforts that could not have been induced through enforceable regulatory obligations.

- EITHER STAND-ALONE CHARGES OR A TRADING APPROACH CAN BE USED WHEN THE REGULATORY GOAL IS TO ACHIEVE A TARGET LEVEL OF TOTAL EMISSIONS OR AIR QUALITY. Trading approaches will be at a disadvantage when markets would be very thin, however, and charges will be at a disadvantage when information about control costs is limited and when environmental goals must be achieved in a relatively short time frame.

- CURRENT APPROACHES TO THE ALLOCATION OF CONTROL OBLIGATIONS WILL BECOME LESS FEASIBLE AS CONTROL REQUIREMENTS BECOME MORE STRINGENT. ECONOMIC APPROACHES CAN FACILITATE THE USE OF ALTERNATIVE ALLOCATION METHODS. Where additional control is required to meet air quality goals and all easily identifiable and affordable controls have already been required, it is difficult to assign more stringent requirements to particular sources. Because economic approaches allow sources additional flexibility, they can permit assignment of control obligations with less information.

A.6 EQUITY

o BOTH ECONOMIC AND TRADITIONAL APPROACHES RAISE SIMILAR EQUITY ISSUES AND PROVIDE GOVERNMENT WITH THE TOOLS TO ADDRESS THESE ISSUES. ECONOMIC APPROACHES CAN MAKE THE EXISTENCE OF EQUITY ISSUES MORE OBVIOUS, HOWEVER. All regulation involves the assignment of rights and obligations that affect the economic positions of regulated entities. Because economic approaches can make these assignments explicit and because they may involve transfers of money (either from sources to the government or between sources), the distributive effects of environmental control are likely to be more prominent.

A.7 INNOVATION

o ECONOMIC APPROACHES PROVIDE STRONGER INCENTIVES TO INNOVATION THAN TRADITIONAL APPROACHES. Traditional approaches create incentives for sources to reduce the costs of required controls and for vendors to develop new equipment that may form a basis for future standards. Economic approaches allow sources greater flexibility in reducing costs and increasing abatement and create incentives for sources to take advantage of this flexibility.

A.8 DESIGN CONSIDERATIONS

o GAINS IN COST-EFFECTIVENESS WITH ECONOMIC APPROACHES WILL BE GREATER THE MORE THAT SOURCES ARE PERMITTED TO VARY CONTROL LEVELS IN RESPONSE TO CHARGE RATES AND ENTITLEMENT PRICES. If sources are required to meet certain control requirements regardless of entitlements purchased or fees paid, or if some emissions reductions receive no credit under the economic approach, an economic approach will do less to reduce total control costs than would otherwise be the case.

- ALLOWING "BANKING" OF ENTITLEMENTS CONTRIBUTES TO THE SUCCESS OF A TRADING APPROACH. BANKING HAS NO ECONOMIC DISADVANTAGES. If potential suppliers of entitlements can undertake additional control effort when it is convenient for them and have the ownership and size of resulting entitlements certified for later use or sale, more sources are likely to undertake unobligated emission reductions. The existence of a bank of available entitlements will facilitate business planning by potential users of entitlements.

- THE USEFULNESS AND FEASIBILITY OF A MARKETABLE PERMIT APPROACH DEPENDS UPON WHETHER AN ALTERNATIVE CONTROLLED TRADING APPROACH COULD APPROXIMATE THE CHARACTERISTICS OF PERMITS. Marketable permits offer little incremental benefit if controlled trading works well. This requires that restrictions on trading be minimized and that states have the authority and will to allocate control obligations in a manner that will assure attainment.

- THE APPROACH AN AGENCY TAKES TO ORGANIZING ENTITLEMENTS MARKETS AND TO DETERMINING THE EQUIVALENCE OF EMISSIONS WILL AFFECT THE SUCCESS OF A TRADING APPROACH. Agency involvment in a market that is able to sustain itself will interfere with trading. Predictablility in determining the equivalance of emissions will facilitate trading.

A.9 OTHER

- THE PRINCIPLES BEHIND EXISTING HEAVY-DUTY TRUCK NONCONFORMANCE PENALTIES ARE EQUALLY APPLICABLE TO STATIONARY SOURCES. Nonconformance penalties are a form of supplemental charge that can improve cost-effectiveness, avoid economic disruption, and make regulation more feasible by providing a safety valve in situations where control requirements cannot be met by all sources at an acceptable cost. However, such charges can disrupt trading if set below the market-clearing price for entitlements.

- MOBILE SOURCE "AVERAGING" APPROACHES, WHICH APPLY PRINCIPLES SIMILAR TO THAT OF THE BUBBLE POLICY, ARE A PROMISING AREA FOR EXPANSION OF THE USE OF ECONOMIC APPROACHES. Allowing manufacturers of vehicles to meet emissions standards on an average basis would, like the bubble policy, contribute to more cost-effective control efforts.

o <u>CHARGE-BASED APPROACHES AND AUCTIONS OF ENTITLEMENTS RESULT IN MONEY TRANSFERS FROM INDUSTRY TO THE GOVERNMENT.</u> These transfers can be reduced by charging only for emissions in excess of some threshold level or by distributing some entitlements without charge. Revenues from charges or auction proceeds could be returned to the Treasury, used to compensate the victims of pollution, used for the purchase of emissions reductions, or used to fund agency operations.

B. LEGISLATIVE IMPLICATIONS

APPENDIX
SPECIFIC STUDY DESCRIPTIONS

1. The Rand Study of Chlorofluorocarbon Emissions

Background

The Rand Corporation study of chlorofluorocarbon emissions examined one of the simplest cases for use of economic approaches which is likely to be encountered. Chlorofluorocarbon (CFC) is a noncritera pollutant, so the control objective is simply to reduce emissions rather than to attain a particular air quality standard. CFC is believed to damage upper atmospheric ozone in direct proportion to emissions, and damage is independent of source location or other source characteristics. Therefore, trades can take place easily. Furthermore, emissions are easy to measure because all CFC used in a product is eventually emitted, and there are only a few manufacturers of CFC. These unusual factors make application of an economic approach at the manufacturer level simple and effective, and application at the user level feasible.

Approach

The quantitative analysis in the Rand study did not distinguish between charge-based approaches (in this case, excise taxes) and trading approaches (quotas or marketable permits). Instead, the study assumed for quantitative purposes that charges would be set at a level that would result in the same total emissions as a permit system and that this level could be known with certainty. Rand compared economic approaches to a benchmark set of mandatory standards devised by Rand to include all control measures which were enforceable, technologically feasible, and able to make a contribution to reduced emissions by 1990.

Results

Total CFC emissions increased over time in Rand's benchmark case, but declined relative to a "no controls" case. The cumulative costs of this benchmark program were estimated to have a present discounted value of $185 million. A charge program to achieve the same total emissions reduction involved a present discounted cost of only $108 million. However, the present discounted value of transfer payments (payments from sources to the government) associated with such a charge system was estimated by Rand to be about $1.5 billion. Rand's approach did not provide any quantitative basis for determining whether one economic approach was superior to another. Rand did note that in practice permits allow greater certainty about emissions levels than do charges; however, permits also require attention to allocation issues and operation of a permit market.

Economic approaches allowed more effective control than mandatory standards because they provided incentives to sources to take steps which Rand believed could not be compelled through mandatory standards. Thus, charges could be set at a level which would prevent any permanent increase in CFC emissions as the economy grows; at this level charges could generate roughly twice the emissions reduction that could be achieved with mandatory standards, at about 150 percent of the cost of the less effective mandatory standards. However, transfer payments at this high rate could exceed $6 billion. These could be reduced or recycled, but any step in this direction would reduce the ability of these payments to internalize the social costs of emissions and thereby promote more efficient allocation of resources. Rand is now examining the transfer payment problem in greater depth for EPA.

2. The Nichols Study of Benzene Emissions

Background

Under an EPA grant, Albert L. Nichols of Harvard University studied benzene emissions from the eight (of nine) maleic anhydride plants in the nation which used benzene as a feedstock at the time of the study. Like CFC, benzene is a noncriteria pollutant, but the situation studied differed from CFC in important respects. Benzene is a hazardous hydrocarbon pollutant which affects health near the source of emissions, thus the impacts of each plant are localized and depend upon population exposure factors. These factors were fifty times greater at the highest exposure plant than at the lowest. The eight plants examined are sufficiently separately located that they have no overlapping environmental effects, thus precluding use of a trading approach.

Marginal control costs per unit reduction in emissions also varied between the plants, because three plants lacked any controls while five already achieved removal levels of 90 to 99 percent to meet state requirements for control of hydrocarbons. In fact, the plant with the highest population exposure factor had no controls in place and therefore a relatively low marginal cost of control. This coincidence made it possible to design either mandatory standards or charges (based on emissions or population exposures) which induced additional control primarily at plants with low control costs and relatively large local health impacts.

Approach

Nichol's study examined two mandatory control programs. The first would have required a uniform percentage reduction in emissions for all sources; the second would have divided plants into two groups facing different standards to improve cost-effectiveness. Nichols also looked at uniform emissions charges of various rates, and at population exposure charges which reflected the differences in impacts of emissions at different plants. These approaches were compared under different assumptions about the value placed on lives saved.

Results

Nichols found that a uniform emissions charge was only slightly more cost-effective than a mandatory control approach that divided sources into two groups facing different standards. However, the more common mandatory program for a hazardous pollutant would involve a high and uniform percentage removal requirement for both groups. In fact, EPA collected data only on 97 and 99 percent removal levels, and Nichols found that the most cost-effective uniform emissions charge was much more cost-effective than even the less stringent (97 percent) uniform reduction standard; the emissions charge provided 86 percent of the benefits (0.332 lives saved, versus 0.386) at only 28 percent of the costs ($600 thousand annually, versus $2 million annually). A charge related to population exposure offered performance similar to this "optimal" emissions charge. Nichols also found that exposure charges provided an additional $1.2 to $1.8 million in net benefits per year compared to the uniform 97 percent emissions reduction standard. The value within this range would depend upon the value assigned to lives saved.

Nichols' favorable judgment on charges did not rest primarily on the cost/benefits improvements charges offered in the situation he examined. In fact, in this situation some well designed mandatory programs nearly matched the performance of economic approaches. Nichols stressed instead that charges could provide a basis for a consistent balancing of control costs and benefits for different sources, including sources of benzene other than maleic anhydride plants. Nichols favored this outcome over an approach based on benzene's status as a hazardous air pollutant, which now requires EPA to set regulations based on use of the best demonstrated technology considering costs. Of course, Nichols' approach is severely limited under existing interpretations of Clean Air requirements. Moreover, some confusion over the control technology required may have caused the regulatory approach to fare worse by comparison with charges than is warranted.

Nichols' strong expressions of concern about the reliabilty of the data available to him, and physical changes in the examined plants since the data was collected, suggest that the general pattern of these results should receive more attention than specific dollar values. Currently, all but two of the eight plants no longer use benzene in their production process. Hence such developments may change the feasibility of a charge system for this industry segment.

General Implications for Economic Approaches

The pattern of cost-effectiveness which Nichols found in his study appears to have been largely determined by the structure of marginal control costs and impacts for the eight plants rather than by the inherent characteristics of the approaches which he studied. Factors of this kind will play an important role in determining whether an economic approach can make a useful contribution in a particular case. In this case, all approaches give similar results; all resulted primarily in additional controls being installed on a plant which by coincidence combined very high impacts with low marginal control costs.

The kinds of data that were available to Nichols cannot be expected to be available in most cases. Even in this case Nichols questioned the reliability of the data that he had, and it quickly became obsolete. Careful program specification based on extensive analysis of the effects of different kinds and levels of charges will not normally be possible.

3. The Mathtech/EPA NO_x Study

Background

The Mathtech, Inc., study of NO_x in Chicago examined a difficult case for economic approaches--attaining a short-term ambient standard for a reactive pollutant with highly local impacts. Control over total emissions in a region is not adequate to meet a stringent short-term standard for a reactive pollutant; emissions from particular sources must be limited or trade-offs between sources carefully calibrated in order to avoid local violations of the standard.

Since the Mathtech study was completed, EPA has made corrections in the inventory of stationary sources emitting NO_x and in the model used to evaluate quantitatively the efficiency and effectiveness of alternative approaches. The results reported here are based on EPA's updated quantitative analysis. Complete EPA results are reported in An Analysis of Economic Incentives to Control Emissions of Nitrogen Oxides From Stationary Sources, a report to Congress called for under Section 405(f) of the CAA Amendments, completed in January 1981.

Approach

Mathtech compared a mandatory control baseline to several economic approaches. The mandatory control alternative specified in the Mathtech/EPA study was unusually sophisticated and therefore fairly cost-effective. The baseline did not require control by all sources or all major sources, and it took account of differences in ambient impacts and control costs for types of sources. A uniform technology-specific control requirement was imposed, but only on those classes of sources which could contribute to attainment at least cost. The control requirement specified in the baseline was sufficiently stringent to attain the NO_x air quality standard.

Mathtech compared this mandatory program to three emissions charge programs: a uniform charge on all sources; a source-category charge system which set different charge rates for each of the three categories of sources on which control requirements were imposed in the mandatory baseline; and a set of charges which were tailored to the control costs and ambient impacts of each source, to minimize the costs of achieving ambient standards. The study also discussed the use of marketable permits.

Where an ambient air quality goal must be attained for a pollutant with highly localized effects, it is not an easy task to determine optimal charge rates for each source. Charge rates must not only reflect effects on air quality at different locations, but also the relationships between sources which have overlapping impacts. It must be known whether control by a specific source will be sufficient to reach attainment in a given area or whether a higher charge rate that will also induce control by a second source will be necessary. The Mathtech study solved this problem with a sophisticated mathematical programming model that considered each source's costs of control and moved toward attainment in each area in a step by step fashion.

Results

The total annual cost of the controls required in Mathtech's baseline program was estimated to be $130 million. A uniform emissions charge on all sources involved much higher control costs than this regulatory baseline. This is not surprising, since any uniform approach affecting all sources discards information about relative ambient impacts and control costs that was used in setting up more selective mandatory baseline program. The charge rate was necessarily set high enough for all sources to assure the specific emissions reductions required to prevent local violations of the standards. At this rate, the total cost to sources was $719 million, of which $414 million was emissions fee payments. Total emissions under this charge were sharply reduced from the baseline because the charge would induce a great deal of control that would make little contribution to attaining standards. Thus, the uniform charge would be more cost-effective than the relatively sophisticated mandatory baseline in reducing emissions, but would be less cost-effective than the baseline in attaining the NO_x air quality goal.

The source-category charge system examined by Mathtech reduced total control costs below the mandatory baseline used in the Mathtech/EPA study. At charges sufficient to reach air quality goals at all locations, this approach resulted in total costs to sources of $155 million, of which $66 million were emissions fee payments. Direct control costs under this program would therefore be about half those in the mandatory case.

The "customized" source-by-source charge rate approach examined by Mathtech improved substantially on the performance of category-based charges and standards; costs to sources under this approach were only $13 million annually, of which $4 million were emissions fee payments. This is a 93 percent reduction in control costs from the baseline, and a 90 percent reduction in total costs incurred by sources. Mathtech's analysis of marketable permits focused on generic properties and design issues.

Mathtech suggested that trading should occur frequently and extend to "options" and "futures" based on permits (as well as on trading in the permits themselves), so that sources could insure themselves against uncertainty about their future situations. The cost savings actually achieved with trading would depend on the extent to which trading was successful in reallocating control obligations to the least cost sources. Therefore, impacts would be intermediate between the source-category charge system and the source-by-source charge system. If trading worked perfectly, the pattern of control effort would be identical to that with source-by-source emissions charges; if sources traded in such a way as to reduce but not to minimize costs, savings would be less.

While some reviewers disagreed, Mathtech concluded that charges and permits were feasible even in this complex control situation. Feasibility would depend upon use of a computerized system (incorporating air quality and cost modelling) to set charge rates or control trades; however, Mathtech concluded that this kind of system would be workable, efficient, and low in cost compared to the cost savings that an economic approach could generate. A potential problem identified by Mathtech is that sources with different air quality impacts would, in effect, pay different prices for permits to emit the same amount of pollutant; this could be seen as unfair if the relationship of prices to air quality impacts were not well understood.

General Implications for Economic Approaches

Specification of charge rates for the Mathtech study required use of a complex analytical tool using a complete set of high quality data. Data requirements were met for study purposes through the use of expediencies which may not be generally available; the study was set in Chicago because unusually good data on NO_x emissions sources existed, and control costs were estimated in a simplified and idealized fashion because the control technology required to meet the hypothetical standard has not yet been developed. Greater difficulties can generally be expected in gathering and working with actual cost data.

The sophisticated modelling approach used by Mathtech led to results which may not be generally applicable. Mathtech's model solved for the lowest cost pattern of control consistent with attainment. Once this was known, charge rates could be set at levels consistent with each sources marginal costs of control in equilibrium. If control by a source was not optimal in equilibrium, charge rates for that source could be set at zero. Emissions fees were therefore paid only by sources which also undertook additional control, and fee payments were held to a minimum. This will not be a typical situation with charges, which usually are expected to induce sources to sort themselves out by control costs. Since this task had already been performed by the Mathtech model, fees served only to induce the behavior the central planners had determined was most efficient. The Mathtech/EPA figures for emissions fee payments under this approach may therefore not be typical of what would usually be expected of charge-based approaches of this kind.

The Mathtech study directly addressed the question of whether a charge based or a trading approach would be best, and showed that total control costs with a trading approach would be equal to those with a charge-based approach if both programs could be implemented in an optimal fashion. Mathtech concluded that trading (in the form of marketable permits) would be superior to charges in practice, and the reasoning used should have some general applicability. Trading offers the same potential for cost reductions as charges, but achieved the same level of certainty as traditional regulation regarding achievement of air quality goals. Moreover, trading required less initiative on the part of the control agency to gather information about control costs and would adjust automatically to inflation, economic growth and technical change.

These results provide some indication that substitution of a charge-based approach for mandatory controls (supplemented by trading) to meet ambient standards will not automatically result in lower total control costs, at least not for NO_x control. Where ambient impacts depend on source location or other source characteristics, an emissions charge must discriminate among sources about as well as the mandatory baseline does in order to reduce costs. Mandatory programs with trading can discriminate sufficiently well to question the advisability of abandoning on-going programs and replacing them with untested alternatives.

4. The Meta Systems Hydrocarbon Study

Background

Meta Systems, Inc., examined charge-based approaches to the control of hydrocarbon emissions in the South Coast Air Basin in a study funded by EPA but with project responsibility at the Council on Environmental Quality. In keeping with current environmental practice, the impacts of hydrocarbon emissions on ambient air quality within an air basin are assumed independent of source location or characteristics. This simplifies the use of economic approaches to pursue ambient standards related to hydrocarbon emissions. Like the Nichols study on benzene, this study focused on a limited number of plants. However, in the Meta Systems study these plants did not constitute the universe of plants of a particular kind; plants were selected to be representative of a broad range of hydrocarbon-emitting activities in a single air quality control region. This study did not address implementation problems associated with charge systems.

Approach

Meta Systems began its analysis by calculating the charge rates that would be required to induce each source to take the same steps as would be expected under mandatory controls. The costs and emissions reductions which would result from application of various charge rate to each source were then examined.

Results

Cost-based charges to induce equivalent control varied among sources from zero to $9,560 per ton of hydrocarbon emitted. Only one of the nine sources sampled, however, had an associated charge in excess of $1,000 per ton. This wide range of charges reflects a wide range of marginal control costs under the requirements in place. Because control cost varied so widely it was relatively easy to divide the sources into two groups with a uniform emissions charge, set so that high cost sources could avoid controls while low cost sources generated necessary emissions reductions. A wide range of charges existed which would provide increased control and reduced costs simultaneously, relative to what would have been expected as a result of alternative command-and-control approaches. When all sources were faced with a charge of $500 per ton, total emissions were 25 percent lower than under the mandatory controls, and expenditures for controls were reduced about 8 percent, from $12.9 million to $11.9 million. After-tax control costs exclusive of fee payments also fell from $8.5 million to $8.0 million. However, emissions fee payments resulted in total costs to sources roughly equivalent to those with mandatory controls.

General Implications for Economic Approaches

The Meta Systems study demonstrates the feasibility of using engineering analysis to gather information about control costs for specific facilities. In the case examined by Meta Systems, marginal control costs varied so widely that it was easy to specify a uniform emissions charge rate which simultaneously reduced costs and emissions. If this is a typical situation and if administration of charges is feasible, charge approaches as an alternative to mandatory controls can achieve cost savings. A major unresolved question is whether information from specific facilities can be used in setting charge rates for sources that have not been as extensively characterized as those in this study.

5. The Putnam, Hayes and Bartlett Marketable Permits Study

Approach

Putnam, Hayes and Bartlett, Inc., studied the design and application of marketable permit systems. This conceptual exercise set out to define the conditions for and describe the operations of marketable permit systems, and to evaluate the applicability of this approach to NO_x, SO_2, HC, TSP, and CFC. Further work is now being done on CFC permits. The study devised and used a simplified model of an air quality control region consisting of a limited number of sources for which emissions and cost characteristics were specified.

Results

Putnam, Hayes and Bartlett concluded that marketable permits could be used to implement current regulatory policies, but were less readily applicable to the control of NO_x than to other pollutants. Specific recommendations on system design were that permanent permits be allocated without charge to continuous major point sources in amounts (and in units) consistent with attainment of NAAQS, and that government play a major role in designing the system, monitoring market operations, and enforcing compliance.

The model devised for the study demonstrated that if trading ended after a single round of exchanges, the amount of control cost savings achieved would depend upon the specific trades which were undertaken. A similar conclusion about savings from trades was reached in the Mathtech study; however, there is no reason why sources should not continue to trade and retrade permits so long as cost reductions are available.

6. The Repetto PSD Study

Background

Under an EPA grant, Robert Repetto of Harvard University examined alternative approaches to PSD increment allocation. No particular pollutants or groups of sources were studied.

Approach

The four alternative approaches to allocation of PSD increments which Repetto examined were first-come, first-served allocation; allocation via auction; imposition of a requirement to secure offsets at less than a one-to-one ratio from existing sources; and permitting excess emissions upon payment of a fee. Internal EPA analysis has also examined the use of better trucking, more stringent BACT review, retrofits, administrative reservation of the increment and allocation to locally preferred sources as potential approaches to the PSD allocation problem. The first two approaches examined by Repetto ration the supply of entitlements in a PSD area, and the third makes supply dependent upon the willingness of existing sources to reduce emissions. The implicit assumption of the fourth approach is that there is some cost of control above which it is not worthwhile to maintain ambient standards. Repetto explored the relationships between these allocation approaches and market conditions to assess potential effects on the environment and on industrial expansion. Four demand and four supply conditions, two offset ratios and two fee levels, and three different competitive situations were examined, for a total of 768 numerical cases. Nine criteria were examined in each case. Offset ratios that were continuously variable were discussed but not numerically analyzed. Ideally, offset ratios would vary over time to reflect the anticipated cost of and need for future controls, and the time value of money, but this would involve difficult data collection and administrative problems.

Repetto also examined the available evidence on what market conditions might be in the future and addressed the broader efficiency issues involved in the use of NAAQS. Repetto added some relevant evidence on the costs of control to the question of whether use of NAAQS is efficient in the broadest sense.

Results

Repetto concluded that the present first-come, first-served allocation system contributed less to efficient control than the alternatives he examined, since incentives toward cost-effectiveness in meeting air quality targets when a new source enters an area are provided neither to new or existing sources by this approach. However, EPA's internal analysis suggests that the gains from implementing an auction approach in lieu of other alternatives which are workable and could be implemented in the short run would probably be small in most cases.

Repetto's extensive analysis of hypothetically possible cases did not identify a single alternative approach that was likely to be preferrable to all others under several criteria and in most conditions. Under a wide range of market conditions requiring partial offsets tended to provide the strongest incentives for abatement, the highest payments to existing sources, and the lowest net increase in emissions. No other ranking of approaches over the nine criteria was possible over a wide range of market conditions. Repetto therefore concluded that the most cost-effective approach to allocating the entitlements would depend upon local conditions in each case. Repetto made two generalizations about the effects of local conditions on cost-effectiveness:

° If projected new source growth is large relative to the level of existing emissions, and if BACT cost levels do not greatly exceed RACT levels, an auction mechanism is most likely to promote cost-effectiveness.

° If the existing emissions inventory is large relative to projected growth, then a variant of the offset market might be more conducive to cost-effectiveness.

EPA's analysis demonstrates that PSD auctions would be complicated to administer for pollutants with local impacts, if potential sources had to acquire bundles of entitlements to impact air quality at all relevant measurement points at auction. This problem can be eased if some needed entitlements can be obtained in a market for entitlements, or if incomplete sets of entitlements can be sold in such a market.

The evidence on market conditions assembled by Repetto indicated that market conditions might lead to domination of local markets at particular times by one or a few buyers or sellers. Demand would usually involve one major source seeking entitlements in a given air quality region in any given year; rarely would more than one new source seek entitlements in the same air quality region, and even sources within one region might have different areas of impact. Similarly, most air quality regions contain few large sources of emissions which could be expected to sell offsets, limiting the potential for competition on the supply side.

The importance of these competitive conditions is lessened by the likelihood that the available PSD increment will exceed the total demand for such entitlements in most areas and for most pollutants. The conditions under which a good is allocated become important only if that good is in scarce supply relative to demand. Available evidence indicates that this situation will be rare for TSP, and rare for SO_2 by the year 2000. An SO_2 increment allocation problem will exist in the near term, however.

Repetto's discussion of the efficiency of NAAQS combined theoretical and empirical analysis. The theoretical argument against NAAQS as currently set rests on the assumption that environmental control should be an exercise in trading off environmental and economic costs under conditions of uncertainty. If it is believed that the social costs of emissions are approximately proportional to total emissions, while marginal costs of control increase rapidly over the relevant range, then Repetto suggests that it makes little sense to set inflexible limits on emissions. Repetto argues that outside of pristine air areas where aesthetic damages are an issue, the social costs of emissions in PSD areas are likely to be proportional to total emissions. Where aesthetic damages are an issue, low emissions levels can do great damage, but once this damage is done additional emissions are not a source of additional costs. Repetto also concludes, on the basis of earlier studies of abatement costs for SO_2, that marginal control costs do escalate rapidly in the relevant range. The implication is that in Class I areas emissions should be very tightly controlled, to the point of compelling sources to locate elsewhere, but that in the rest of the country the allowed level of emissions should be sensitive to control costs.

7. The ICF Study of NSPS Offsets

Approach

ICF, Inc., examined the impacts of allowing utilities to use emissions reductions in existing coal-fired boilers to offset emissions in excess of

NSPS SO_2 requirements for new coal-fired boilers. Five hypothetical utilities in different regions of the country were examined, and each utility was assumed to offset emissions from one new 500 Mw boiler with reductions in emissions from an existing 500 Mw boiler. Different assumptions about SIP requirements were made in different regions; operating parameters were also varied from case to case. These differences, and differences in the costs and availability of particular coals, resulted in different control approaches being used in different scenarios.

Results

In eight of the nine cases involving the recently revised NSPS for utility boilers, allowing NSPS offsets would make it unnecessary for a utility to install a scrubber. This results in considerable cost savings. The magnitude of these savings ranged from 0.7 to 10.2 percent of annualized costs or $1.1 to $18.2 million per year for a 500 Mw unit. Capital cost savings ranged from 6 to 29 percent of total facility costs, or $26 million to $148 million per 500 Mw unit.

8. The Temple, Barker and Sloane Study of Noncompliance Penalties

Background

The Temple, Barker and Sloane, Inc. study of noncompliance penalties analyzed the potential economic impacts of EPA's program on the iron and steel industry and the electric utility industry. These two industries account for a substantial portion of major sources known to be out of compliance and a substantial percentage of excess emissions of TSP and SO_2.

Approach

The report made macroeconomic, industry-wide and company-specific estimates of effects. These estimates used EPA-estimated total penalty payments of $165 million for iron and steel and $181 million for electric utilities, and assumed rapid progress toward compliance.

Results

The economic effects of the penalties in these industries as a whole would be very slight. However, about half the individual firms in the iron and steel industry would be "noticeably" affected by penalties, and some utility companies could be significantly affected. Electricity prices could increase by up to 10 percent for some electric utilities if the entire amount of penalties were passed through, although the average increase would be only 0.2 percent. Earnings for two sample utility companies would decline by over 20 percent, although the average decline in earnings for the industry would be only 0.7 percent. These large variations make it clear that some utility companies are enjoying substantial economic benefits from delayed compliance with environmental requirements.

9. The TCS Mobile Source Study

Approach

TCS Management Group, Inc., examined two economic enhancements to mandatory inspection and maintenance programs, and three other economic approaches. The economic enhancements to I&M were waiver of subsequent inspection when an inspection was passed, and payment of a reward for response to an emissions recall. Both enhancements were reasonably cost-effective.

The three other economic approaches were compared to a mandatory control baseline. One such approach, use of a corporate (fleet-wide) average standard for control of NO_x and CO (HC data were not adequate for analysis), was examined as an alternative to currently applicable individual vehicle standards. As specified by TCS, this approach did not involve trading among manufacturers but did allow trade-offs in controls among different model lines of the same manufacturer. TCS also examined both manufacturer charges based on new car emissions as a replacement for the current regulatory system, and charges based on NO_x and CO emissions of vehicles tested in state inspection and maintainance programs as a supplement to the current system.

TCS defined the parameters of its alternative programs and of the potential responses of manufacturers to fit the data that were available. Cost data were available only for meeting 1980 and 1981 emissions levels; therefore, manufacturer behavior under averaging and new car charges was restricted to controlling model lines either to the levels specified in 1981 standards or to the levels specified in the 1980 standards. Cost data limits affected which programs could be analyzed. The stringency of the average standard had to be set below the existing standards so that manufacturers would be able to meet the average standard while controlling some model lines at 1980 levels. Since averaging was not compared to other approaches at the same overall level of control, cost-effectiveness ratios for the program appeared to be more favorable than otherwise. Similarly, new car charges were based on the average costs and average emissions reductions expected from the 1981 standards. With charges at this level, manfacturers with above average costs will chose to pay the charge rather than control emissions, assuring that cost-effectiveness ratios would improve and emissions would increase. These biases were offset by other factors. Since the control alternative assumed to be available to manufacturers were so restricted, cost-effectiveness ratios appeared to be less favorable than otherwise. It is not possible to say which of these offsetting biases predominates.

In the case of in-use emissions charges (as supplements to the existing control system), biases were not offsetting. TCS found it necessary to artificially restrict the range of possible responses by manufacturers to in-use charges and concluded that this would bias downward the measurement of cost-effectiveness.

Results

TCS concluded that corporate average emissions standards could offer great cost advantages over individual vehicle standards, without significant economic or political drawbacks. New car charges were also seen as much more cost-effective than the current system. TCS concluded that difficulties in predicting the effects of an in-use charge made quantitative analysis unreliable. Both charge-based approaches were seen to involve substantial political and economic problems resulting primarily from higher new car prices.

TSC found that emissions averaging would lead to a decrease in average per-vehicle control costs of $258 (in 1980 dollars), which would show up as a

3.3 percent decrease in new car prices. Program administration and vehicle certification costs increased slightly, by about $1 million and $10 million per year, respectively, relative to the base case. Emissions increased because controls were less stringent. Cost-effectiveness ratios indicated a potential for substantial savings from use of an averaging approach. The 1981 standards without averaging resulted in CO removal costs of $3,533 per ton and NO_x removal costs of $16,299 per ton. Averaging reduced these costs to $2,720 and $15,000 respectively.

TCS found new car charges to be more cost-effective than the current regulatory approach. Under the current approach the controls required to meet 1981 standards would result in average control costs of $423 per vehicle above those required to meet the 1980 standards, causing a 5.4 percent increase in vehicle prices. The new car charges examined would induce less total control, but would involve a 1980 to 1981 cost increase of only $90 per vehicle. Mandatory controls were substantially less cost-effective than new car charges, eliminating CO at a resource cost of $3,533 per ton and NO_x at a resource cost of $16,299 per ton, in contrast to $1,337 and $11,750 respectively. However, the combined costs of installing controls and paying charges for emissions which were not eliminated would force manufacturers to impose average price increases of $852 per vehicle, a 10.9 percent increase. These higher prices would contribute to inflation and reduce new car sales. On the other hand, the higher prices would reflect an internalization of the presumed social costs of emissions, and lead to a more economically efficient allocation of resources.

Although in-use charges appeared to be less cost-effective in the TCS analysis than new car charges or averaging approaches, TCS cautioned against a conclusion that this would be true if any of these programs were actually put in place.

10. The Sobotka Study of TSP Averaging for Diesel Vehicles

Approach

Sobotka & Company, Inc., examined averaging for TSP emissions from diesel vehicles as an alternative to the recently promulgated 1985 standards. Programs based on averaging across only a manufacturer's diesel fleet, and across both the gasoline and diesel fleet (corporate averaging) were discussed, but quantitative analysis was confined to diesel-only averaging. The impacts of trading among manufacturers in connection with averaging and the impacts of allocating entitlements by auction were also measured.

The technology which is expected to be used to meet the 1985 standards for light-duty diesel TSP has not yet been fully developed, so data of the quality used by TCS were not available for this study. Sobotka therefore extrapolated available data on the costs and performance of early prototypes of the control hardware into a set of cost and performance relationships that depended upon specific vehicle characteristics.[1] Manufacturers were allowed to use any level of control on any vehicle to meet the average standard. Because manufacturers could be given this flexibility, Sobotka set the average standards at a level that resulted in approximately the same level of total emissions as the 1985 standard without averaging, and compared the costs of reducing emissions to this single level under each of the two approaches.

Results

Sobotka found that averaging approaches could be substantially more cost-effective than individual vehicle standards. Cumulative 1985 through 1989 costs to meet the 1985 standard were estimated to be $1.7 billion (in undiscounted 1980 dollars); with diesel-only averaging, total emissions declined by about three percent and total cumulative costs fell by $100 million. The study found that allowing trading among manufacturers in addition to averaging would permit an additional $20 million in savings, would not have adverse economic impacts, and would probably be perceived as fair and be feasible. Total payments for entitlements under an auction, assuming that

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[1] Because the data used by Sobotka are extrapolations from a small number of prototype tests, they are probably not very reliable. The apparent precision of the study's scenarios and results should be assessed accordingly. Some results in the Sobotka study are sensitive to data characteristics that may not hold up when hardware to control diesel TSP has been fully developed.

bidding was competitive and based on control costs, were estimated at about $350 million. This greatly exceeds the cost savings available from averaging.

11. The Policy Planning and Evaluation NO_x Studies

Approach

Policy Planning and Evaluation, Inc. (PP&E), examined mobile source emissions charges and averaging in separate studies; these studies focused on program design to a greater degree than the TCS and Sobotka studies. PP&E also examined a marketable permits system that would impose a ceiling on total emissions from new vehicles regardless of production levels, rather than controlling emissions or average emissions per vehicle. No quantitative analysis of charges was undertaken, and quantitative analysis of trading approaches was limited.

Results

PP&E generally concluded that any of the trading approaches it examined would be feasible and could offer benefits. PP&E also identified specific areas in which difficulties in implementation would have to be overcome. The only quantitative analysis in the PP&E averaging study, based on data from the TCS study, looked at the potential benefits of allowing trading between manufacturers in connection with an average standard. A control cost reduction of about six percent was indicated.

PP&E reached mixed conclusions about new vehicle NO_x emission charges. This study found charges to be theoretically sound, but the authors remained uncertain of their feasibility and likely impacts. No quantitative analysis was undertaken.

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