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STUDY OF VOLATILE ORGANIC COMPOUND EMISSIONS FROM CONSUMER AND COMMERCIAL PRODUCTS

Economic Incentives to Reduce VOC Emissions from Consumer and Commercial Products

Office of Air Quality
Clean Air
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STUDY OF

VOLATILE ORGANIC COMPOUND EMISSIONS

FROM

CONSUMER AND COMMERCIAL PRODUCTS

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ECONOMIC INCENTIVES TO REDUCE VOC EMISSIONS FROM CONSUMER AND COMMERCIAL PRODUCTS

March 1995

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EXECUTIVE SUMMARY

This report presents a preliminary assessment of the feasibility and desirability of employing Federal economic incentive programs to reduce volatile organic compound (VOC) emissions from the use of consumer and commercial products. This investigation of economic incentives responds to the mandate to apprise Congress of the desirability of different regulatory strategies that may be appropriate for consumer and commercial products.

The principal tasks of the study are to examine alternative economic incentives and to compare them to a hypothetical command-and-control program, VOC content standards, which would consist of product-specific limitations on maximum VOC content (grams of VOC per unit of product). It is the basis of comparison because the ultimate purpose of this investigation is to search for the most desirable instrument in the set of potential instruments, which obviously would include instruments based on command-and-control.

The purposes of comparison are to determine how well the instruments accomplish certain policy objectives and to appraise their ability to cope with the complexities inherent in the task of environmental regulation. The specific bases of comparison are the following:

- program costs and initial information requirements when effects are uncertain,
- monitoring and enforcement,
- flexibility in distributing the economic impacts of regulation,
- adaptation to economic growth,
- incentives for technological innovation and diffusion, and
- unintended damages.

These criteria ensure a fairly comprehensive examination of the issues involved in designing environmental policy instruments. Further, a broad basis of comparison more fully reflects differences between economic incentives and command-and-control approaches.

This report does not serve as the final assessment of economic incentive strategies to reduce VOCs from the many consumer and commercial products that may ultimately be regulated. Rather, it serves as a general assessment of the most prominent economic incentives for reducing air pollution, and it serves to set the stage for the future development of more detailed and industry-specific economic incentives.

The Environmental Protection Agency's authority for the study and regulation of VOC emissions from consumer and commercial products derives from Title I, Section 183(e) of the Clean Air Act Amendments (CAAA) of 1990. Section 183 (e)2(A) instructs the EPA to conduct a study of VOC emissions from consumer and commercial products to determine their contribution to ozone levels, to establish criteria for their regulation, and to assist with determining the sequence in which products shall be regulated. Section 183(e)4 explicitly states that the EPA may consider economic incentive regulatory strategies.

Economic incentives may be particularly appropriate for the control of VOCs from consumer and commercial products. The emissions source of concern is the use of the product but not the manufacture. This aspect of the pollutant leads to the existence of a great many small sources for which "end-of-pipe" control is practically infeasible. The products are very diverse. The types of consumer and commercial products and product forms number in the thousands. Product diversity reflects the adaptation of products to consumer demands, which vary from region to region and change from one year to the next. The core of the dynamics of consumer and commercial product industries is product innovation—each year, manufacturers and importers introduce hundreds of new products. In these circumstances, economic incentives may have great advantages over command-and-control strategies, such as VOC content standards, because (1) the Agency may need to accumulate less information on product technology and on performance and (2) manufacturers have more flexibility to find the best balance between reducing VOC emissions and satisfying consumer demands.

VOCs have specific characteristics that influence the design of a regulatory program. VOCs are assimilative and uniformly mixed implying that emissions do not accumulate in the atmosphere and that the concentration of ozone is independent of the location of sources in the airshed. Therefore, efficient economic incentive programs need only to target current total emissions of the pollutant in an airshed.

Emission fees and emissions trading are the economic incentives most commonly proposed for the purposes of air pollution control. A comparison of these designs makes explicit the requirement for the consideration of certain fundamental policy issues, including the tradeoffs between: (1) certainty over the cost of emission reductions versus certainty over the quantity of emissions reduced, (2) the cost to control emissions versus administrative, monitoring, and enforcement costs, and (3) distributional flexibility versus the provision of incentives to advance technology. This report examines these tradeoffs in some detail.

Emission fee programs can be used to obtain real and quantifiable reductions in the emissions of VOCs from consumer and commercial products. The basic rationale for these programs (and economic incentive programs in general) is to bring the full "social cost" of using VOCs into the economic system. A fee on the emission of VOCs would increase the cost of using the atmosphere as a waste sink. The fee would have the same effect as the prices for the goods and services exchanged in conventional markets: for example, manufacturers would economize on their use of VOCs because the "price" of using VOCs would be higher, just as they would economize on the use of labor if wage rates were to increase.

Designing a fee program to reduce VOC emissions from consumer and commercial products presents many choices. Many of these design options are summarized in Table E-1.

TABLE E-1

SUMMARY OF FEE PROGRAM DESIGN OPTIONS

Design Element	Option 1	Option 2	Option 3	Option 4	Option 5
Program Purpose	Achieve VOC reductions at lower cost	Provide greatest incentives for technological change	Affect distribution of impacts	Combination of options	
Activity Charged	Impose fee in input market	Impose fee in wholesale product market	Impose fee at intermediate node in distribution channel		
Payer of Fee	Input user	Product supplier	Product demander		
Sources Included	All sources	Sources above size cutoff			
Phasing-in Sources	None	By size			
Fee Variability	With respect to season	With respect to VOC content	With respect to nonattainment status	With respect to emissions reduction progress	
Method for Setting Initial Fee Level	Economic model	Value of Federal/State marketable emission rights	Negotiation	Combination of methods	
Collection of Fees	Sources remit fees to EPA	Sources purchase VOC stamps from EPA			
Monitoring	Sources self-report VOC content & sales	EPA verifies reports	EPA checks remitted fees against VOCs in products	Combination of options	
Use of Revenues	Fund R&D for VOC-reducing technologies	Fund labeling and/or education programs	Rebate revenues	Pay for program administration	Combination of options

Quantity-based, emissions trading programs are alternative ways to generate economic incentives to obtain real and quantifiable reductions in the emissions of VOCs from the use of consumer and commercial products. The two types of trading programs studied in this report are marketable emission permit programs and emissions averaging programs. Particular emphasis is given to emission permit programs because of their unique advantages and other unique characteristics.

The distinguishing characteristics of marketable emission permit programs are inter-source trading of emissions and the cap on the aggregate, absolute quantity of emissions. Unlike emission fee programs, VOC content standards, and emissions averaging programs, the absolute quantity of emissions is fixed in marketable permit programs. The restriction ensures the achievement of the environmental goal regardless of changes in the economy including the expansion of existing and entry of new sources (e.g., companies) of emissions. Emissions averaging programs also rely on emissions trading and are most cost-effective when trades occur between companies, but they characteristically place an upper limit on emission rates instead of total emissions. The nature of the environmental goal is an essential difference between marketable permit programs and emissions averaging programs. Table E-2 summarizes many of the design options for marketable emission permit programs.

In all emission trading programs that allow external trades, companies have the incentive to seek potential trading partners. Opportunities for trade exist when the incremental or marginal cost of emission reductions differ in the industry. The consumer and commercial products industry is diverse, and manufacturers very probably will reduce emissions through unique combinations of product reformulation, packaging redesign, and reducing production. Therefore the marginal cost of emission reductions is likely to vary from company to company, and the company for which a reduction is more expensive will

TABLE E-2

SUMMARY OF TRADING PROGRAM DESIGN OPTIONS

Design Element	Option 1	Option 2	Option 3	Option 4	Option 5
Program Purpose	Achieve VOC reductions at lower cost	Provide greatest incentives for technological change	Minimize adverse distributional impacts	Combination of options	
Emissions Limit	Aggregate mass of emissions	Average rate of emissions			
Scope of Trading	Only internal trades	Internal and external trades			
Permit Differentiation	By season	By nonattainment status	Annual permit		
Sources Included	Based on type of business	Based on size (emissions)			
Phasing-in Sources	None	By size (emissions)			
Opt-ins & External Groups	"Small" sources	Other C&CP manufacturers and importers	Manufacturers and importers of other VOC-containing goods	Environmental interest groups	Combination of options
New Sources	Purchase permits from existing sources	Reserved permit auction	Fixed-price sale of reserved permits		

(continued)

TABLE E-2

SUMMARY OF TRADING PROGRAM DESIGN OPTIONS (CONTINUED)

Design Element	Option 1	Option 2	Option 3	Option 4	Option 5
Retiring Sources	EPA detracts permits at shutdown	EPA allows transfer at shutdown			
Type of Entitlement	Sources possess property rights	Sources possess temporary permission to emit			
Type of Commodity	Emission allowance (1 ton in 1 year)	Emission reduction credit			
Initial Allocation Mechanism	Zero-revenue auction (annual)	Revenue auction (annual)	Grant (annual)		
Permit Banking	None	Allowed			
Permit Duration	Limited	Unlimited			
Monitoring and Enforcement	Sources self-report VOC content & sales	EPA verifies reports	EPA checks permit holdings against VOC emissions	Combination of options	
Noncompliance Penalties	Financial penalty	Offsetting reduction in permit holdings	Criminal penalty	Schedule of penalties	Combination of options
Market Facilitation	Ancillary projects to reduce transaction costs	Rely on private sector	Combination of options		
Use of Revenues	Fund R&D for VOC-reducing technologies	Fund labelling and/or education programs	Pay for program administration	No revenues	Combination of options

pay another company (i.e., one with lower costs) to reduce emissions. The benefit to the former company is reduced costs, and the benefit to the latter, increased profits.

Table E-3 compares the performance of economic incentives and hypothetical VOC content standards on the criteria listed above. This criteria, though not exhaustive, provides a reasonable basis for comparing alternative strategies. Table E-3 assumes that every program aims to achieve the same environmental goal, a predetermined reduction in VOC emissions. The table includes the most important variants of fee and tradable permit programs: emission fee programs with and without rebates, and permit programs in which the EPA allocates permits to existing sources through an ordinary auction, zero-revenue auction, or grant. The ranking of each program on a given criterion indicates relative performance and may not hold in every circumstance.

Abatement Costs. In theory, marketable permit programs with unrestricted trading as well as fee programs will lead to the least costly emission reductions. In practice, however, none of these strategies will likely achieve the truly least cost solution that might be obtainable in a world of zero transaction costs and perfect certainty. In marketable permit programs with freely granted permits, transaction costs may restrict trading and hence reduce potential abatement cost savings, though costs of obtaining the same level of emission reductions would never exceed those resulting from content standards. Permit auctions may reduce the need for trading, but periodic auctions may impose uncertainty costs. Similarly, fee programs with adjustable fee rates may impose planning uncertainty or transition costs. Nevertheless, economic incentive strategies will generally result in reduced abatement costs compared to content standards because economic incentives provide the flexibility to obtain emission reductions from the least costly sources.

TABLE E-3

COMPARISON OF ECONOMIC INCENTIVES AND HYPOTHETICAL VOC CONTENT STANDARDS WHEN THE ENVIRONMENTAL GOAL IS A FIXED QUANTITY OF EMISSIONS

	Fees		Trading			
Criteria	**Without Rebates**	**With Rebates**	**Free Permits and Zero-Revenue Auction**	**Ordinary Auction**	**Emissions Averaging**	**VOC Content Standards**
Abatement Costs	Good	Good	Good	Good	Fair to Good	Poor
Monitoring	VOC content & sales	VOC content & sales	VOC content & sales & permit holdings	VOC content & sales & permit holdings	VOC content & sales	VOC content
Distributive Flexibility	Limited	Great	Great	Limited	Limited	Limited
Adaptation to Economic Change	Possibly slow & expensive	Possibly slow & expensive	Automatic	Automatic	Slow & expensive	Slow & expensive
Incentives for Technological Progress	Very Good	Good	Good	Excellent	Fair to Good	Poor
Unintended Damages	Possible	Possible	Possible	Possible	Possible	Probable

Monitoring and Enforcement. For the purpose of comparison, nothing is lost by assuming that the penalty for noncompliance and probability of detecting noncompliance ensure a reasonable level of deterrence. With equal levels of deterrence, the comparison of policy instruments is a matter of differences in the activities and hence costs of detecting noncompliance. The economic incentive programs all require the collection of companies' reports of VOC content in the regulated consumer and commercial products and report verification; verification involves product sampling and reviewing product sales information. Marketable permit programs also require the Agency to track permit holdings. VOC content standards are less demanding than economic incentives because the Agency does not absolutely need to obtain sales information to monitor compliance nor does it need to track permit holdings. Sales information, however, would be necessary to monitor program performance.

Distributive Flexibility. At issue is not whether one pattern of distributive effects is preferred to some other pattern but rather the dialogue over distributive considerations. The ranking of policy instruments indicates the degree of flexibility to incorporate distributive values into instrument design. Fee programs with rebates and marketable permit programs with freely distributed permits or permits distributed through a zero-revenue auction may serve to minimize adverse distributional impacts on industry.

Adaptation to Economic Growth. All instruments can adapt to the changes in the economy that may strain the ability of the instrument to achieve the environmental goal, but the quickness of the adaptation and the costs to the EPA and regulated companies differ substantially. All permit programs adapt without action by the Agency because of the cap on emissions and hence are ranked the highest.[1] All fee programs, even those with formulas for

[1] Permit banking requires a qualification of that judgment because aggregate emissions will exceed the cap in a year when previously banked permits are withdrawn and used, everything else equal. Nonetheless, without action by the EPA, the annual average emissions equals the emissions cap.

the automatic but potentially sluggish adjustment of the fee rate, are likely to require the EPA to take corrective action when economic growth leads to an undesired increase in VOC emissions in nonattainment areas. Emissions averaging programs and VOC content standards would require the EPA to tighten the standards and, if new consumer and commercial products have appeared, to issue new standards; adaptation is likely to be slowest and Agency expenditures greatest.

Incentives for Technological Change. The rankings are sensitive to the incentives that companies have to innovate, sell, and adopt cost-reducing technologies for reducing VOC emissions from consumer and commercial products. All of the economic incentive strategies promote technological innovation to a similar degree, but some strategies promote technological diffusion more than others. As a class, economic incentives are superior to standards with regard to promoting technological progress.

Unintended Damages. Narrowness in the design of traditional or economic incentive regulatory programs may cause problems during implementation: intermedia transfers of pollutants, increased VOC emissions due to inferior product performance, increased health risks, and increased air pollution in some areas. These unintended consequences are possible with all the policy instruments under review. Some of these potential problems, such as those due to product performance, appear to be more probable and to have greater avoidance costs with standards because companies have reduced flexibility to modify their products under the restrictions imposed by standards.

Conclusion. Overall, economic incentive programs appear superior to VOC content standards as strategies to reduce VOC emissions from consumer and commercial products. However, content standards may still be preferable if monitoring and other implementation costs are excessive.

The choice between traditional and economic incentive regulatory strategies is not necessarily an all or nothing choice. Combination content limit/economic incentive approaches are possible and may provide significant advantages, though these advantages need to be weighed against the shortcomings they may create.

The optimal selection of a regulatory strategy will depend on the specific characteristics of the universe of sources being regulated. For example, potential abatement cost savings, administrative and monitoring costs, and distributional implications of employing economic incentive strategies to regulate different industries will vary substantially.

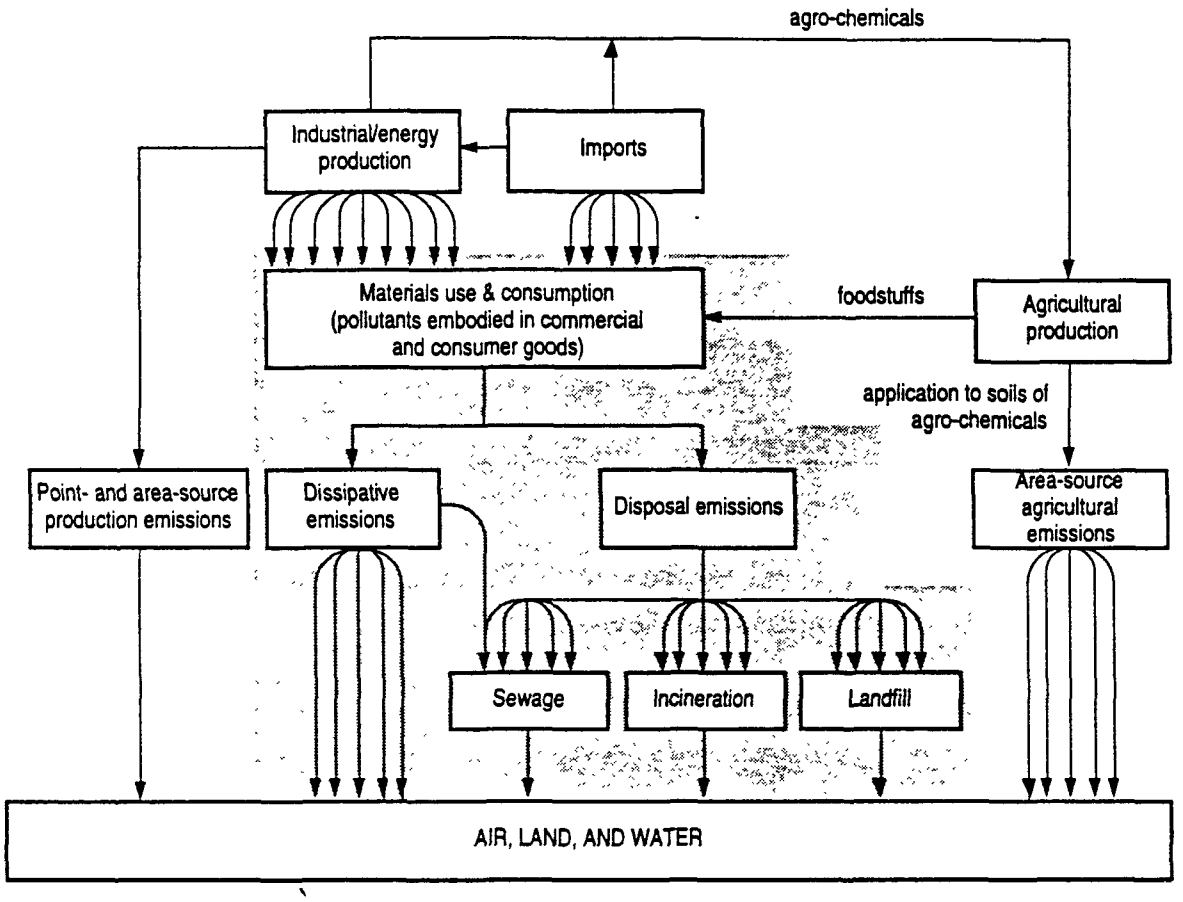
The optimal selection of a regulatory strategy will also depend upon the program's objectives. For example, if stimulating technological advancement is considered of most importance, a marketable permit program with an ordinary auction might be most preferable. Alternatively, if distributional considerations are considered more important, a permit program with freely granted or zero-revenue auctioned permits, or perhaps a fee program with rebates, might be most preferable. Similarly, marketable permit programs might be best if certainty of emission reductions is of most importance (especially if product performance problems exist), but might be the worst if protecting consumers from potential future product price increases is of most importance. Tradeoffs are intrinsic to policy design, and the best regulatory strategy will depend upon the particular universe of sources being regulated and the priority of objectives.

SECTION 1.0
INTRODUCTION

This report studies the feasibility and desirability of using economic incentives to reduce the emission of volatile organic compounds (VOCs) from the use of consumer and commercial products. The report is not intended to serve as a final assessment of alternative economic incentive strategies. Rather, it is intended to serve as a general, preliminary assessment of the most prominent economic incentives and to set the stage for the future development of more detailed, industry-specific economic incentive programs.

Section 183 (e)(1)(B) of the Clean Air Act Amendments of 1990 defines a consumer or commercial product as "any substance, product (including paints, consumer and commercial products, and solvents), or article (including any container or packaging) held by any person, the use, consumption, storage, disposal, destruction, or decomposition of which may result in the release of volatile organic compounds." Thus, generally speaking, the environmental purpose of regulation is to reduce the flow of VOCs into the atmosphere from consumption and disposal. Figure 1-1 shows the dissipative emissions and the disposal emissions into the air that would be the target of regulation, distinguishing them from the production-related emissions that would be beyond the scope of the regulation (as would emissions to land and water).

The Environmental Protection Agency's mandate to regulate consumer and commercial products channels the design of economic incentives in several important ways, as do the characteristics of the pollutant. This section of the report describes the context of the economic incentives that could constitute the regulatory strategy, or one component thereof, to be promulgated under Section 183(e) of the Clean Air Act as amended.



Note: Shaded area indicates consumption-related emissions.

Figure 1-1. Comprehensive Classification of Emissions from Consumer and Commercial Products

Source: Adapted from Stigliani, William M. 1990. "Chemical Emissions from the Processing and Use of Materials: the Need for an Integrated Emissions Accounting System." *Ecological Economics* 2(4):325–341 (Figure 2).

1.1 SIGNIFICANT CHARACTERISTICS OF THE POLLUTANTS

The pollutants (VOCs) have specific characteristics that influence the design of an effective economic incentive. VOCs mix uniformly with nitrogen oxides in the troposphere to form ozone, one of the main components of urban smog. The characteristic of being uniformly mixed implies that the concentration of ozone is generally independent of the location in the airshed of sources emitting VOCs, but were dependent upon the total amount of VOC emissions in an airshed. At current rates, VOC emissions do not accumulate in the

atmosphere from year to year and hence the injury to human health and the environment is due not to the historical mass of emissions, but from current emissions. Therefore, at least within an airshed, cost-effective incentives do not need to differentiate among the locations of sources and receptors and incentives may target the rate of current emissions of VOCs.

1.2 POLICY CONTEXT

In addition to the characteristics of the pollutant, the design of economic incentives to reduce VOCs emitted from consumer and commercial products is shaped in specific ways by the Clean Air Act as amended. The parameters established by legislation involve the following important topical areas:

- sequence of regulations,
- regulated entities, and
- best available controls.

The last area refers to the environmental goal of regulation, and the other areas to the approach to be taken to achieve the goal.

Section 183(e)3(A) directs the EPA to create a list of categories of consumer or commercial products which account for at least 80 percent of VOC emissions from those products in ozone nonattainment areas. EPA is to divide this list into 4 groupings, establishing priorities for regulation. EPA shall regulate one of those groups no later than every 2 years after promulgating the list until all four groups have been regulated. Thus the regulation of consumer and commercial products involves a sequence of regulations.

An economic incentive program could apply to any single group or to all four groups comprehensively. A comprehensive economic incentive program should be compatible with the sequence of regulations. For example, architectural and industrial maintenance (AIM) coatings may constitute the first group of products to be regulated. Therefore, a potentially

important sequencing issue is how to mesh an economic incentive (or some other regulation) applying to AIM coatings with economic incentives (or some other regulation) applying to the remaining consumer and commercial products.

Regulations developed under Section 183(e) may be imposed only with respect to "manufacturers, processors, wholesale distributors, or importers of consumer or commercial products for sale or distribution in interstate commerce in the United States" or certain entities which supply such products to the former [Sections 183(e)(1)(C) and 183(e)(3)(B)]. The definition of regulated entities excludes retailers and users.

The regulations affecting consumer and commercial products shall require best available controls (Section 183(e)(3)(A)). The Administrator, on the basis of "technological and economic feasibility, health, environmental, and energy impacts," shall determine the desired degree of emissions reduction that "is achievable through the application of the most effective equipment, measures, processes, methods, systems or techniques, including chemical reformulation, product or feedstock substitution, repackaging, and directions for use, consumption, storage, or disposal" (Section 183(e)(1)).

The requirement for best available controls establishes the general environmental goal of regulation, not the means by which regulated entities will comply. The discussion in this report of potential economic incentive programs will refer to an assumed environmental goal without attempting to specify the magnitude of the goal. Further, it is assumed that the goal

for each of the four groups of consumer or commercial products takes the form of an overall goal, and that regulation does not mandate emission reductions for individual products.[1]

Although the goal itself is outside of the scope of the report, the significance of "economic feasibility" to the determination of the desired degree of emission reduction implies an interaction between the goal and the policy instrument. Cost-effective policy instruments allow the greatest improvement in environmental quality: for any given cost, the cost-effective instrument achieves the greatest emission reduction (and for any given emission reduction, the cost-effective instrument is the least costly). If an economic incentive were cost-effective, then it would achieve the most desirable environmental goal that could be achieved at any given level of cost deemed to be economically feasible (see Figure 1-2).

1.3 CONSISTENCY WITH ECONOMIC INCENTIVE PROGRAM RULE

Design of a Federal economic incentive program to reduce VOCs from consumer and commercial products should be consistent with or, at least, not contradict the proposed Economic Incentive Program Rule, which the EPA proposed on February 23, 1993 (58 FR 11110). The proposed rule encourages creativity and flexibility while at the same time

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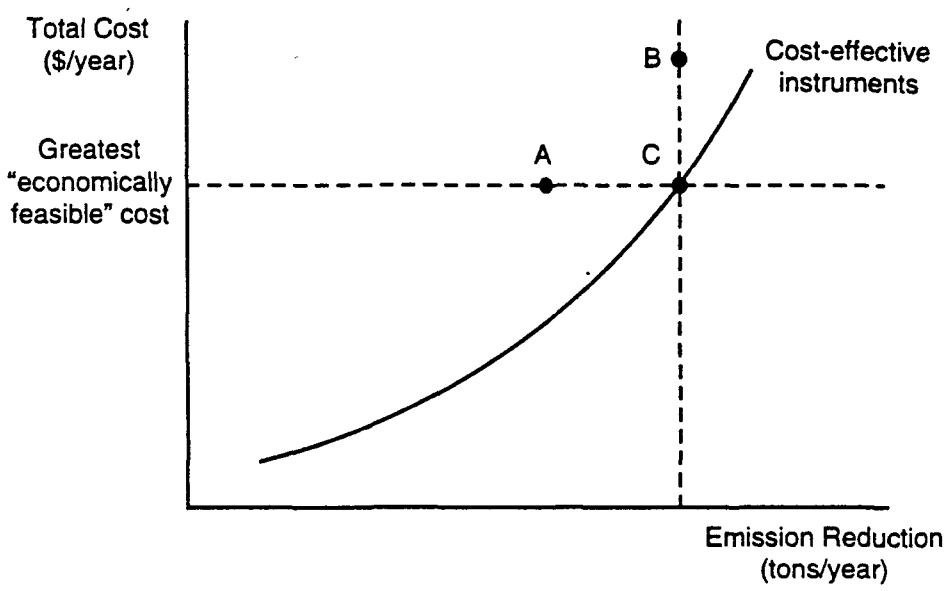
[1] Hypothetical goals for individual products are consistent with the assumption of an overall goal, and they may be used in a "bottom-up" approach to determining the overall goal. For example, the first step in determining the goal could be to determine hypothetical VOC content limits for each regulated product (VOC_i). Second, using the content limits and historical sales data, calculate the hypothetical implied total allowable emissions for each manufacturer and importer (VOC_{Sj}). Third, sum allowable emissions over all manufacturers and importers to determine the actual environmental goal for the regulation. The second and third steps are expressed in the following equations (in which Q_{ij} is the sales of coating i by source j in the base year).

$$\sum_i VOC_i * Q_{ij} = VOC_{Sj}$$

$$\sum_{Sj} VOC_{Sj} = \text{VOC Goal}$$



Economic incentive "C" sets the greatest feasible emission reduction target.

Figure 1-2. Hypothesized Relation Between Economic Incentives and Economically Feasible Environmental Goals

ensuring that the programs meet the same degree of accountability and enforceability as traditional regulatory programs.

The proposed Economic Incentive Program Rule establishes criteria for economic incentive programs (EIPs) that States develop to meet certain Clean Air Act requirements that apply to the regulation of criteria pollutants in nonattainment areas.[2] The Agency also intends to use the rule to guide the development of EIPs included in any Federal

[2]In some cases the CAA mandates that states adopt EIPs, or that they consider them as one option to address failures to meet statutory requirements for nonattainment areas. States also may voluntarily choose to adopt an EIP to help meet progress requirements. The proposed EIP Rule applies to both statutorily-mandated and discretionary programs. Specifically the EIP rule applies to (1) any statutory EIP submitted to EPA as a state implementation revision plan revision to comply with sections 182(g)(3), 182(g)(5), 187(d)(3), or 187(g) of the Clean Air Act, and (2) discretionary EIPs submitted as implementation plan revisions for any purpose other than to comply with the statutory requirements specified in (1) (58 FR 11110).

Implementation Plan or in other Federal measures promulgated under the authority of the criteria pollutant provisions contained in Title I of the Act .[3]

Therefore, the Economic Incentive Program Rule will apply as guidelines for any Federal economic incentive program for consumer and commercial products. Some specific requirements may not literally apply to a Federal consumer and commercial products program because this program is not subject to all requirements that apply to State Implementation Plans.

The programs to which the EIP criteria apply include market creation (i.e., marketable emission permits); direct market incentives (i.e., emission taxes and fees); and indirect market incentives (i.e., tax code changes and subsidies). Further, depending on both whether a program directly specifies an emission reduction and whether results are quantifiable, the EIP rule establishes three regulatory categories: emission limiting, market response, and directionally sound. Emission limiting programs set limits that must be met, but allow flexibility in how sources reduce emissions. A marketable permit program with a cap on the total mass of emissions is an example of an emission limiting program. Market response programs, such as fees or taxes on emissions, create incentives to reduce emissions without mandating emission reduction requirements for individual sources or groups of sources. Directionally sound programs directly or indirectly rely on market mechanisms, but differ from the other programs in that reliable quantification of emission reductions is infeasible.

The proposed EIP rule sets forth general requirements and principles. Programs shall be designed such that they:

- do not discriminate in favor of intrastate commerce or against interstate commerce;

[3]Much of the following discussion in the text of the proposed EIP rule is taken from Martin, Richmond, and Beal (1993).

- have quantifiable emission reductions that may be credited to the program;
- are consistent with attainment and RFP demonstrations:
- limit emission reductions credited to the program to those that are surplus to other SIP-credited programs;
- are enforceable at the Federal and State levels;
- achieve emission reductions that are permanent within the time frame specified by the program;
- do not interfere with other requirements of the CAA (58 FR 11110; Martin, Richmond, and Beal, 1993).

In addition to general principles, the proposed EIP rule requires specific program elements for economic incentive programs. Table 1-1 lists specific requirements and provides a brief description of each. A clear purpose and well-defined environmental and economic goals are prerequisites to choosing an appropriate economic incentive strategy and are necessary to ensure that the proper mechanisms needed to achieve these goals are included in the program design. Without specific goals, the tradeoffs that are inherent in the design of economic incentives will go unrecognized. Clarity in the goals of regulation facilitates the design of the EIP that achieves the most important goal with the least sacrifice of competing goals.

A well-defined program scope identifies the affected sources and defines provisions for new sources and for sources exiting the program, whether they are closing operations or have reduced emissions to zero. The scope must be defined such that requirements of the EIP do not interfere with other CAA regulations, and procedures must be in place for solving conflicts with other Federal regulations affecting the universe of sources. Compliance with a Federal EIP must be monitored through enforceable source requirements. Many of these

TABLE 1-1

REQUIRED ECONOMIC INCENTIVE PROGRAM ELEMENTS

EIP Requirement	Description
Statement of Purpose, Goals, and Program Description	• Clear statement of purpose, including environmental problem being addressed and intended environmental and economic goals • Economic incentive strategy to be used • How program mechanisms will reach goals
Program Scope	• Affected sources • Procedures for dealing with sources entering or exiting affected source categories • Designed so the program will not interfere with Federal requirements of the Clean Air Act
Program Baseline	• Used as a basis for projecting program results • Determined from information of sufficient quality to provide for at least as high a degree of accountability as currently exists for traditional regulations
Quantification Procedures	• Replicable and credible methods to quantify emissions and changes in emissions for SIP credit • Projection of program results from affected sources using specified quantification methods and averaging times (directionally sound programs exempt) • Must include accounting for shutdowns and production curtailments; for batch, seasonal, and cyclical operations • Procedures for determining emissions from affected sources when data monitoring is missing or inaccurate
Source Requirements	• Actions of source necessary for compliance • Emission limits, monitoring, recordkeeping, and reporting requirements
Projected Results and Audit/Reconciliation Procedures	• Projected emission reductions associated with implementation of program • Quantitatively projected results shall be adjusted by uncertainty factors for incomplete compliance and programmatic uncertainty • Audit procedures to evaluate program implementation and track program results • Reconciliation procedures (for market response strategies) to make up for any shortfall between SIP credit predictions and actual results
Implementation Schedule	• Dates for notifying potentially affected sources • Program initialization and start-up procedures • Submittal requirements from affected sources
Administrative Procedures	• Procedures appropriate for the type of incentive strategy necessary to implement the program
Enforcement Mechanisms	• Requirements which are legally binding and State and Federally enforceable • Penalties for noncompliance

Source: *Federal Register*. February 23, 1993. Vol. 58, No. 34, p. 11110. Washington, DC: U.S. Government Printing Office.

reporting, monitoring, and recordkeeping requirements may be performed by the source, but with adequate incentives to promote reporting integrity. Ideally an EIP should be designed with administrative procedures which operate efficiently without placing a large burden upon sources or regulatory staff, while at the same time providing incentives to comply with the program through effective enforcement mechanisms.

The EIP rule also identifies guidelines for the use of any revenues generated by mandatory economic incentive programs to which the rule applies.[4] However, these guidelines do not apply to this study since guidelines for the use of revenues generated from the regulation of consumer and commercial products are specified in Section 183(e)(5). Any use of revenues from a Federal economic incentive should consider the approved revenue uses outlined in the EIP rule.

The economic incentives discussed in Sections 3 and 4 of this report follow the principles of the proposed EIP rule. The program designs discussed below come into contact with the EIP rule primarily at the points that pertain to program purpose, scope, source requirements, reconciliation procedures, initialization, administrative procedures, and enforcement mechanisms. The design of an actual incentive program for consumer and commercial products will require additional attention to the more specific requirements contained in the EIP rule, for example, quantification procedures. The program design elements that are discussed in this report have been chosen with certain fundamental tradeoffs in mind: certainty over the cost of emission reductions versus certainty over the quantity of emissions reduced; cost to control emissions versus administrative, monitoring, and enforcement costs; and distributional flexibility versus the provision of incentives to advance technology.

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[4]Revenues generated from discretionary EIPs are exempt from these requirements.

1.4 DESIGN CONSIDERATIONS FOR ECONOMIC INCENTIVES

The potential of economic incentives for improving ambient air quality in the nation is great, and this potential is achieved with a program design that is sensitive to the complexities inherent in environmental regulation. A program that meets the following criteria will accomplish most policy objectives.[5]

- Does the program achieve the environmental goal?
- Is the environmental goal achieved with the least expenditure by regulated entities on emission abatement and expenditure by the EPA on information?
- Will monitoring produce data that merit high confidence, and are monitoring costs acceptable within the context of either the program itself or other regulatory efforts that the program could assist?
- Are potential enforcement actions credible?
- Does the program incorporate distributive values in a way that enhances the initial and continuing acceptability of the program? Does the design process identify potential inequities in the distribution of programmatic benefits and costs among regulated entities and users of commercial and consumer products?
- Does the design process enhance public discussion of the objectives and techniques of environmental policy?
- Will the program enhance the EPA's capacity for effective policy-making in the future with respect to regulation of consumer and commercial products?
- Does the program minimize the cost of using inaccurate or incomplete information on the costs of abating VOC emissions and on the benefits of the program?
- Will the program adapt without unnecessary strain to future changes in the economy and in values?

[5]The purposes of economic instruments for pollution control are evolving as program designers respond more fully to the complexities of regulation. The given list of criteria reflects the insights of Stavins (1991), Hahn, McRae, and Milford (1988), and Bohm and Russell (1985).

- Does the program provide incentives for the invention and diffusion of environment-saving technology or cost-saving abatement technology?
- Will the program avoid or limit unintended damages?

This report conducts an assessment of economic incentives based on the criteria listed above, with particular emphasis on obtaining an environmental goal at least cost. This assessment requires the development of prototypical economic incentives that are informed by the relevant characteristics of the potentially regulated commodities, the companies that manufacture or distribute these commodities, and users of the commodities.

1.5 SCOPE OF THE REPORT

The EPA is increasingly looking toward economic incentives to reduce the costs of pollution reduction to industry, to government, and to consumers (U.S. EPA, 1991). The Clean Air Act Amendments heralded the Agency's interest in economic incentives in at least two ways. It provided specifically for the design and implementation of an economic incentive program to reduce sulfur dioxide emissions from utilities. It also called, in some sections, for the consideration of economic incentives as regulatory tools. Section 183(e)4 provides a list of regulatory systems which may be employed for the regulation of VOC emissions from consumer and commercial products. This section explicitly states that such systems may include economic incentives concerning the manufacture, processing, distribution, use, consumption, or disposal of products.

This report examines three types of economic incentives:

- fees on VOC emissions,
- marketable VOC emission permits, and
- VOC emission averaging systems.

The last two economic incentives may be considered alternative forms of emissions trading strategies.

Although Federal policy appears to have favored emissions trading programs over fee programs in the past, the study of both fees and emissions trading makes the greatest contribution to the analysis of potential approaches to regulating consumer and commercial products. A comparison of these designs makes explicit the requirement for the consideration of certain fundamental policy issues, including the tradeoffs between: (1) certainty over the cost of emission reductions versus certainty over the quantity of emissions reduced, (2) the cost to control emissions versus administrative, monitoring, and enforcement costs, and (3) distributional flexibility versus the provision of incentives to advance technology. This report examines these tradeoffs in some detail.

1.6 REFERENCES

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SECTION 2.0

CONSUMER AND COMMERCIAL PRODUCTS AND ECONOMIC INCENTIVES

Information on the consumer and commercial product industries assists with observing the special opportunities and challenges to using economic incentives to reduce VOC emissions from the use of these products. The design of efficient and effective economic incentives is adapted to certain characteristics of the industry, the products, and the users. Product diversity and product innovation affect the ease and efficiency with which consumer and commercial products can be regulated. Further, the preference for a marketable emission permit program—a very prominent economic incentive—or a command-and-control alternative depends upon expectations regarding expenditures on program administration and pollution abatement, which are influenced by the universe of sources and the implied structure of the permit market. This section therefore presents a tightly focused overview of the commercial and consumer product industries, investigating program design issues stemming from or involving product diversity, the universe of sources, and conflict between environmental regulation and health and safety regulation.

This section draws on profiles that cover the potentially regulated products, the firms that manufacture or distribute these products, and the product users. The companion document, *Economic Incentives to Reduce VOC Emissions from Consumer and Commercial Products: Industry Profiles and Technical Appendixes* (U.S. EPA, 1993), contains profiles of the following industries:

- soaps and detergents,
- polishes and sanitation goods,
- cosmetics and toiletries,
- adhesives and sealants,
- pesticides,
- drugs and health use products,

- automotive after-market products and miscellaneous household chemicals (chemical preparations),
- allied paint products, and
- office supplies.

These profiles were developed to provide the basic information needed for assessing the applicability and desirability of employing economic incentives in regulatory strategies for consumer and commercial products.

2.1 INFORMATION NEEDS

Various information needs are relevant to the design of a regulatory strategy to reduce VOC emissions from consumer and commercial products. It would be desirable to have information regarding the:

- emissions reduction potential,
- ease of monitoring emissions,
- competition in product markets,
- industry dynamics—introduction of new and changed products,
- product distribution channels,
- potential cost-savings from emission fees or emissions trading,
- potential cost-savings accruing to small firms,
- potential VOC-reducing product or packaging reformulation (in advance of Federal regulation),
- potential impacts on consumers (by income class), and
- potential unintended damages (e.g., increased use of toxic chemicals).

The above information would facilitate the design of economic incentives and better allow the comparison of different programs on the specific criteria that are especially important: attainment of the ozone standard, cost-effectiveness (including administrative costs), and an equitable distribution of benefits and costs. Another important use of such information is to raise issues that may pose difficulties later on when (and if) the Environmental Protection Agency undertakes the actual design of an economic incentive. The *Industry Profiles and Technical Appendixes* document (U.S. EPA, 1993) fills some of these information needs, but

more information would be needed to optimally design specific economic incentive programs for consumer and commercial products.

2.2 SOURCES OF EMISSIONS AND IMPLICATIONS FOR REGULATORY DESIGN

For consumer and commercial products, the emissions of concern occur during either use of the product or disposal of the product (and, perhaps, container)—not during manufacture of the product. This aspect of the pollutant leads to the existence of a great many dispersed and individually small sources for which "end-of-pipe" controls are infeasible. Hence, VOC content limits may generally be the only practical traditional regulatory strategy.

Another conceivable approach to regulating consumer and commercial products is to influence the user of a product by, for example, levying an emission fee on the product at the point of retail sale. Many commodities sold in the United States are subject to this type of fee (although they are not motivated by environmental concerns): cigarettes and alcoholic beverages are obvious examples. By increasing the emissions fee (which is now zero) levied on users of consumer and commercial products, users would respond by purchasing products with reduced VOC content, by using such products less frequently, and by foregoing use of some products.

The regulation of users could be an effective strategy for reducing emissions but not necessarily the most efficient strategy, even if allowed under the Clean Air Act Amendments of 1990 (which prohibits it). One source of inefficiency would be the higher administrative costs involved in collecting fee payments from retail outlets. Every retail outlet in the country would need to be included in the record keeping and monitoring programs. The volume and hence costs of such activity would be far less if manufacturers or distributors and importers were to be regulated instead. A regulatory strategy that operates at a higher level

in the distribution channel for consumer and commercial products could be just as stringent and could cost less than the regulation of users (or retailers).

The nature of the source of emissions—product users—is still relevant to the analysis of economic incentives. Because the regulated entity will be either a manufacturer, distributor, or importer but not the user, the pattern of trades in an emission permit program (see Section 4) will not necessarily correspond to changes in the pattern of emissions. For example, a manufacturer who purchases permits will not by that action necessarily retard progress in his or her community toward attainment with the ozone air quality standard because the company's products may be distributed outside of the community (as is typically the case for large manufacturers). Therefore, problems associated with permit trades that go in the "wrong direction" may be less likely under a marketable permit program for consumer and commercial products than they might be for similar programs to reduce pollutant emissions from other sources.

2.3 PRODUCT DIVERSITY, PRODUCT INNOVATION, AND ADVANTAGES OF ECONOMIC INCENTIVES

Consumer and commercial products are very diverse and constantly change as manufacturers market new products and new forms of existing products. Product diversity reflects the tailoring of formulations and product forms to the technical requirements of product usage, differences in required performance and ease of use, and users' aesthetics. Even when the overall growth in sales volume in an industry is slight, change is occurring, the outcome of product introductions determining companies' shares of the market. The headline in an advertisement from a manufacturer of cosmetics chemicals states a truth about industry dynamics: "If your product isn't to miss tomorrow's trends even by a hair's breadth, we must develop today the ingredients for the day after tomorrow" (*Household and Personal Products Industry*, 1991, p. 107).

In one recent year alone, over fifteen thousand (15,879) new products were introduced in drugstores and supermarkets (*Household and Personal Products Industry*, 1991, p. 10). Manufacturers of food, health and beauty aids, and other household products sold in supermarkets introduced 520 "environmentally friendly" products in 1990 (Fucini, 1991, p. 22). Although these examples portray trends in a much broader group than consumer and commercial products as defined in the Clean Air Act Amendments of 1990, sales of all these products depend upon manufacturers' success in offering products that satisfy many different demands for performance, ease of use, and aesthetics.

Several examples will illustrate current trends specifically in the consumer and commercial products industries. Research and development in the soaps and detergents industry are the key to creating improved and innovative products that are important for increasing a manufacturer's market share (O'Reilly, 1991b). Manufacturers of polishes and waxes are researching ways to formulate their products with reduced VOC content while retaining product efficacy (Carson, 1990). Despite expectations that growth in the next few years will be modest for the industry, manufacturers of cosmetics and toiletries will continue to aggressively exploit product niches with the introduction of new products, allowing some manufacturers to grow faster than the average (Standard and Poor's Corporation, 1991). Growth in the domestic market for pesticides is expected to occur from the introduction of more effective and environmentally safer products (O'Reilly, 1991a).

Several new coating technologies may greatly reduce or eliminate VOC emissions. Reactive diluent technology uses chemical reactions during film-forming to make organic compounds an integral part of the coating, preventing release to the air. Radiation curing technologies use ultraviolet light or electron beams to dry and harden a solventless coating. Another recently introduced solventless coating is in the form of an electrically charged powder that adheres to metallic surfaces. Although these coatings are technically appropriate for only some of the applications for which conventional architectural and industrial

maintenance coatings are commonly used, the new technologies illustrate research and development in the paints and coatings industries.

Even a cursory survey shows that product innovation is widespread in the consumer and commercial products industries. The pattern of funding for research and development further makes the point. In the pharmaceutical industry, new product development is a key component of expenditures on research and development; a survey of the members of the Pharmaceutical Manufacturers Association found that 83 percent of R&D funds for human and veterinary use spent in the United States were for research and development of new products and that 17 percent went toward improvement of existing products (Pharmaceutical Manufacturers Association, 1991). Therefore, information on new products and on R&D funding establishes the importance of continually changing the product line.

Product diversity and product innovation are fundamental structural characteristics of the consumer and commercial products industries. The attempt to fit a command-and-control regulatory approach, such as a VOC content standards only strategy, into this structure may generate unnecessary friction and costs because the EPA may have to revise its regulations to keep abreast of the industry. A standard may have to be developed for each new product or product form, or an agreement may need to be reached concerning which existing standard is applicable before the product could legally be sold. Either effort is likely to be frequently repeated and, because standard-setting takes time, to retard marketing new products.

Economic incentive programs may be more adaptive to the product diversity and innovation characteristics of consumer products. An emission fee program (see Section 3) smoothly adapts to industry dynamics because the fee would be applied to the emissions from the use of new products, exactly as it applies to emissions from existing products. In a marketable emissions permit program (see Section 4), the manufacturer or distributor of the new product would increase his or her demand for permits, and the increase in permit price

would induce other permit holders to sell additional permits. Friction is avoidable and costs may be lower with economic incentives because adjustment occurs at the margin of the program rather than in the basic components.

2.4 PRODUCT PERFORMANCE AND ADVANTAGES OF ECONOMIC INCENTIVES

A risk exists that the regulation of VOC content in consumer and commercial products may jeopardize the performance of certain products. It is even possible that such regulation, if imposed too strictly, could cause an increase in aggregate emissions from certain products. For example, VOC content limits for paints could, at least theoretically, make it necessary to apply more coats and to paint more often which could possibly lead to more VOC emissions.

The issue of product performance may be less problematic under an economic incentive regulatory strategy. Manufacturers would have the flexibility and some incentive to allocate VOCs to products where performance would be threatened without sufficient VOC content.

It may also be possible to design an economic incentive strategy that would ensure that the desired emission reductions are obtained even when product performance is problematic. For example, a VOC allowance strategy (see Section 4) could cap each manufacturer's allowable current and future VOCs. In making reformulation decisions to reduce VOCs, manufacturers would not want to sacrifice product durability since additional future sales would require the purchase of additional VOC allowances. Generally durability would be maintained, at the potential sacrifice of other quality attributes, and emission reductions could be achieved with some certainty.

2.5 POTENTIAL FOR REDUCING A LARGE PROPORTION OF EMISSIONS WITH A SMALL UNIVERSE OF SOURCES

The products and companies to which regulation applies constitute the universe of sources, a very important component of the design of any regulation. The universe of sources has the right size and composition when the administrative and pollution abatement costs associated with a marginal expansion of the universe just offset the value of the environmental gains of the expansion. Although the difficulties of quantifying these costs and benefits make the implementation of this rule problematic, the rule keeps in the foreground the question of whether it may be sensible to regulate some but not all sources.

This question is relevant to all regulatory strategies, but an additional complexity arises in constituting the universe of sources for a marketable emission permit program.[1] A large proportion of emissions may be reduced by constituting the universe of sources with a small proportion of the companies in the industry. If the emissions are concentrated in the products of a few manufacturers, then constituting the universe of sources with these companies would reduce the EPA's administrative costs because fewer emission permit transactions would need to be recorded and monitoring activities would be reduced. Furthermore, exemptions may be used to lessen impacts on small businesses.

Some insight into emissions concentration can be obtained with statistics on the concentration of production, which describe the proportion of production manufactured by the largest companies in the industry. The 50-firm concentration ratio, for example, gives the proportion of output manufactured by the 50 largest firms; the other concentration ratios are similarly interpreted. If production and emissions were perfectly correlated, then the concentration ratio would accurately measure the proportion of emissions attributable to the

[1] No special difficulty arises with emission fees. Imperfect competition in the product market should lead to an adjustment of the optimal fee (Cropper and Oates, 1992, p. 684), but the fee program does not introduce a market distortion as could the marketable emission permit program.

firms' output. A perfect correlation requires that $1 worth of one product produces the same emissions as $1 worth of any other product. The actual correlation is undoubtedly weaker.

Table 2-1 shows the concentration ratios and the number of companies in consumer and commercial product industries for 1987. In every industry listed, the 50 largest companies produced more than 60 percent of the total value of shipments, and the median was 87 percent; in the pesticides industry, the 50 largest companies produced 94 percent of the total. Despite the imprecision of inferences about emissions drawn from concentration ratios, economies in the administration of economic incentives may be feasible without compromising on the emissions reduction goal.

However, it is possible that a small universe of sources may inadvertently lead to excessive expenditures on pollution abatement by the companies participating in a marketable permit program because the conditions for imperfect competition are enhanced. Given the large number of companies in the consumer and commercial products industry, this possibility should not be a problem unless the universe of sources is substantially restricted to reduce administrative costs or small business impacts. The likelihood and potential significance of imperfect competition are more fully discussed in Section 4.

The potential for imperfect competition in the permit market could be diminished by including in the universe of sources companies that do not compete in the product market. Information on each industry's production can give a general idea of which companies do not compete in the product market. Tables 2-2 and 2-3 summarize the data on production in each of the potentially regulated industries. Table 2-2 gives the value of production, and Table 2-3 indicates the degree of specialization of production. For example, the manufacturers in the paints and allied products industry (SIC 2851) made over $8 billion worth of commodities that are classified as paints and allied products (i.e., primary products), and they made other types of commodities (i.e., secondary products) valued at several hundred million dollars.

TABLE 2-1.

CONCENTRATION OF PRODUCTION IN CONSUMER AND COMMERCIAL PRODUCT INDUSTRIES

Industry (SIC Code)	Concentration (Percentage) of Production in:[a]				Number of Companies
	Four Largest Companies	Eight Largest Companies	20 Largest Companies	50 Largest Companies	
Soaps and detergents (2841)	65	76	84	89	683
Polishes and sanitation goods (2842)	44	60	70	79	669
Cosmetics and toiletries (2844)	32	49	72	86	648
Adhesives and sealants (2891)	23	34	52	70	537
Pesticides (2879)	49	69	88	94	233
Drug and health use products (2834)	22	36	65	88	640
Automotive and miscellaneous chemicals (2899)	23	33	47	62	1,366
Paint and allied products (2851)	27	40	53	66	1,121
Pens and mechanical pencils (3953)	49	65	84	97	106
Carbon paper and inked ribbons (3955)	37	56	80	95	108

[a]Based on value of shipments in 1987.

Source: U.S. Department of Commerce. 1992. *1987 Census of Manufactures, Concentration Ratios of Manufacturers.* Washington, DC: U.S. Government Printing Office.

The primary product specialization ratio for this industry was 96.6 percent. The manufacturers of cosmetics and toiletries (SIC 2879) are less specialized, but they did not produce any paints or allied products. Conversely, the manufacturers of paints and allied products did not produce any cosmetics or toiletries nor any other product also manufactured by cosmetics and toiletries companies. None of their products overlap, and the manufacturers in these two industries would have nothing to gain from discriminating against each other in a permit market.

TABLE 2-2

PRODUCTION OF PRIMARY AND SECONDARY PRODUCTS WITHIN POTENTIALLY REGULATED INDUSTRIES

			Value in Millions of Dollars at Production in 1982															Other Secondary	
	Industry/SIC Code	Total	2841	2842	2844	2891	2879	2834	2899	2851	3951	3953	3955	2022	2026	2079	3861	$	Number
2841	Soaps and Detergents	8,532.9	7,144.5	462.8	423.0	1.6	20.2	6.0	101.2	23.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	349.9	30
2842	Polishes and Sanitation Goods	4,309.5	493.5	3,179.7	247.1	3.8	218.1	35.4	58.7	5.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	67.0	33
2844	Cosmetics and Toiletries	9,714.7	87.6	38.5	9,285.9	0.0	1.4	197.1	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	97.4	18
2891	Adhesives and Sealants	2,744.6	1.4	1.5	0.0	2,459.6	0.0	0.0	23.9	68.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	189.4	37
2879	Agricultural Chemicals	5,166.1	0.7	4.5	2.3	0.0	4,198.5	144.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	814.7	20
2834	Drugs and Health Use Products[a]	23,588.2	3.9	1.5	372.8	0.0	40.7	22,082.0	32.4	6.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	1,043.4	42
2899	Automotive Aftermarket (Chemicals)	6,210.0	59.3	39.6	5.6	8.9	0.0	1.6	5,302.0	14.6	0.0	0.0	0.0	0.0	0.0	0.0	12.3	766.1	61
2851	Paints and Allied Products	8,532.0	8.3	19.1	0.0	74.4	0.0	0.0	9.2	8,243.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	177.7	34
3951	Pens and Mechanical Pencils	744.0	0.0	0.0	0.0	1.3	0.0	0.0	3.1	0.0	680.3	6.4	0.0	0.0	0.0	0.0	0.0	52.9	23
3953	Marking Devices	318.2	0.0	0.0	0.0	0.5	0.0	0.0	2.7	0.0	2.6	299.6	0.5	0.0	0.0	0.0	0.0	12.3	21
3955	Carbon Paper and Inked Ribbons	707.8	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	592.5	0.0	0.0	0.0	1.4	110.5	16
2022	Cheese	9,970.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,857.2	705.4	0.0	0.0	408.1	11
2026	Milk	17,060.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	221.3	14,247.8	1.6	0.0	2,589.6	15
2079	Cooking Oils	4,807.3	8.5	6.9	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	4,102.4	0.0	687.5	25
3861	Photographic Equipment and Supplies	16,352.7	0.0	0.0	0.0	0.0	0.0	0.0	15.0	16.3	0.0	0.0	0.6	0.0	0.0	0.0	15,367.2	953.6	53
Total Value Produced		118,759.0	7,807.7	3,754.1	10,336.7	2,550.1	4,478.9	22,466.1	5,561.8	8,378.5	683.3	306.0	593.6	9,078.5	14,953.2	4,104.0	15,386.4	8,320.1	

[a] Statistics for this industry are aggregated by three digit SIC codes and therefore include four other drug related industries

Source: U.S. Department of Commerce. 1990a *The 1982 Benchmark Input-Output Accounts of the United States.* Washington, DC: U.S. Government Printing Office.

TABLE 2-3
PRIMARY PRODUCT SPECIALIZATION IN POTENTIALLY REGULATED INDUSTRIES

			Percentage of Value at Production in 1982															
	Industry/SIC Code	Total	2841	2842	2844	2891	2879	2834	2899	2851	3951	3953	3955	2022	2026	2079	3861	Other Secondary
2841	Soaps and Detergents	8,532.9	83.7	5.4	5.0	0.0	0 2	0.1	1.2	0.3	0.0	0.0	0 0	0.0	0.0	0.0	0 0	4.1
2842	Polishes and Sanitation Goods	4,309.5	11.5	73.8	5.7	0.1	5.1	0.8	1.4	0.1	0.0	0.0	0.0	0.0	0 0	0.0	0.0	1.6
2844	Cosmetics and Toiletries	9,714.7	0.9	0.4	95.6	0.0	0 0	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	1.0
2891	Adhesives and Sealants	2,744.6	0.1	0.1	0 0	89.6	0.0	0.0	0.9	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0 0	6.9
2879	Agricultural Chemicals	5,166 1	0.0	0.1	0 0	0.0	81.3	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0 0	15.8
2834	Drugs and Health Use Products[a]	23,588.2	0.0	0 0	1.6	0 0	0.2	93 6	0.1	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4
2899	Automotive Aftermarket (Chemicals)	6,210.0	1 0	0.6	0.1	0.1	0.0	0 0	85.4	0.2	0.0	0 0	0.0	0.0	0.0	0.0	0 2	12 3
2851	Paints and Allied Products	8,532.0	0.1	0.2	0.0	0.9	0.0	0.0	0.1	96.6	0.0	0 0	0.0	0.0	0.0	0.0	0.0	2.1
3951	Pens and Mechanical Pencils	744 0	0.0	0.0	0.0	0.2	0.0	0 0	0.4	0.0	91.4	0.9	0.0	0.0	0.0	0.0	0.0	7.1
3953	Marking Devices	318.2	0.0	0 0	0.0	0.2	0.0	0.0	0.8	0.0	0.8	94.2	0.2	0.0	0.0	0 0	0.0	3.9
3955	Carbon Paper and Inked Ribbons	707.8	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	83.7	0.0	0.0	0.0	0.2	15.6
2022	Cheese	9,970.7	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	88.8	7.1	0.0	0.0	4.1
2026	Milk	17,060.3	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0 0	0.0	0.0	1.3	83.5	0.0	0.0	15.2
2079	Cooking Oils	4,807.3	0.2	0.1	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	85.3	0.0	14.3
3861	Photographic Equipment and Supplies	16,352.7	0.0	0 0	0.0	0.0	0.0	0 0	0.1	0.1	0 0	0.0	0.0	0.0	0.0	0 0	94.0	5.8

[a] Statistics for this industry are aggregated by three digit SIC codes and therefore include four other drug related industries.
Source: U S Department of Commerce. 1990a. *The 1982 Benchmark Input-Output Accounts of the United States.* Washington, DC: U.S. Government Printing Office.

To summarize, the diversity and large number of companies in the consumer and commercial products industries suggest that potentially substantial control cost savings may be obtainable by employing flexible market-based regulatory strategies, although the administrative, monitoring, and enforcement costs may be substantial unless smaller companies are excluded. This discussion has observed a tradeoff between reducing the universe of sources to reduce administrative, monitoring, and enforcement costs and small business impacts, and increasing the likelihood of imperfect competition under marketable permit programs, which may offset some of the (theoretically achievable) control cost savings. However, if imperfect competition is not problematic, substantial control cost savings may be possible while still achieving emission reductions by excluding, or perhaps treating differently, small companies.

2.6 EXISTING REGULATORY REQUIREMENTS FOR CONSUMER AND COMMERCIAL PRODUCTS AND IMPLICATIONS FOR REGULATION

Several categories of consumer and commercial products are already regulated under Federal law. Pesticides are regulated under the Federal Insecticide, Fungicide, and Rodenticide Act. Drugs and certain cosmetics are regulated under the Federal Food, Drug, and Cosmetic Act. In this section, the implications of the existing regulatory requirements, which are described in the *Industry Profiles and Technical Appendixes* document (U.S. EPA, 1993), for the design of economic incentives and the choice of regulatory strategy are briefly discussed.

A manufacturer of pesticides, drugs, or drug-like cosmetics is likely to find that a completely new product, or a reformulation of an old product, developed in response to an air quality regulation will also be subject to either the Federal, Insecticide, Fungicide, and Rodenticide Act or to the Federal Food, Drug, and Cosmetics Act. The process of registering pesticides or of applying for approval of a drug probably will increase the total cost of

complying with a consumer and commercial products regulation. The additional cost would be incurred regardless of the regulatory strategy.

However, for products that are subject to these additional regulatory requirements, economic incentive strategies may be preferable to command-and-control strategies because of the flexibility that economic incentives provide. For example, VOC standards might make it excessively costly or impossible to produce and sell certain drugs because of FDA requirements. Economic incentives may allow some drugs to be produced at lesser cost than with VOC standards and would not prohibit the manufacture or sale of any drug.

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SECTION 3

FEE PROGRAMS FOR REDUCING VOC EMISSIONS FROM CONSUMER AND COMMERCIAL PRODUCTS

A system of regulation that uses emission fees can obtain a real and quantifiable reduction in the emission of VOCs from consumer and commercial products. The basic rationale for emission fees is to bring an environmental service provided by the troposphere—its capacity to assimilate VOCs—into the economic system.[1] A fee would have the same type of effect as the prices for the goods and services exchanged in actual markets: for example, manufacturers would further economize on the use of VOCs just as they would further economize on the use of labor if wage rates were to rise.

If the fee is charged in the input market, manufacturers have a direct motivation to reformulate consumer and commercial products. Products with lower emissions will become relatively less expensive than products with a higher VOC content. As the effect of the fee on product price becomes clear to users, they have a motivation to substitute less polluting products.

Input and product substitutions are only some of the environmentally beneficial reactions that will occur with fee programs (wherever the fee is imposed). Fee programs leave manufacturers and users free to choose their response and continually encourage additional reductions in the emission of VOCs. These features may reduce the information burden on the Environmental Protection Agency, reduce the cost of attaining the ozone standard, and enhance the likelihood of environmentally beneficial technical change. The latter effect is especially important: emission fee programs create rewards for the "green" entrepreneur who includes environmental protection in the product design strategy.

[1] Freeman and Haveman (1972) simply and succinctly state the basic rationale for emission fees.

Designing a fee program presents many choices. This section discusses the critical elements of a fee program and explores several options for the most important elements. To facilitate a comparison with alternative regulatory strategies, the section ends with an example of a specific fee program for reducing VOCs from consumer and commercial products.

3.1 PURPOSES OF A FEE PROGRAM

The purposes of a fee program influence the choice of specific options for the many elements in the design of the program. A primary purpose of a fee program for consumer and commercial products would be to provide incentives for actions leading to the attainment of a specific reduction in total VOC emissions from the regulated products. It is important to note that the achievement of the goal is not a one-time accomplishment, but must be met on a continuous basis thus requiring a permanent incentive.

The environmental goal could be set in the following way. The Environmental Protection Agency, independently or in consultation with affected parties, could determine a hypothetical VOC content standard for each regulated product category; then the implied emission reduction could be summed over all regulated products to determine the overall goal. The Agency could impose a fee to provide regulated entities an incentive to reduce their emissions by the desired amount.

Figure 3-1 illustrates the basic principle of an emissions fee program whose goal is the attainment of a specific level of emissions at least expenditure on pollution abatement. Two companies emit a total of 30 units of pollution, and the government intends to reduce pollution to 15 units. A fee of $500 per unit of pollutant will induce Source 1 to reduce emissions from 15 units to 5 units. Source 2 reduces emissions from 15 units to 10 units.

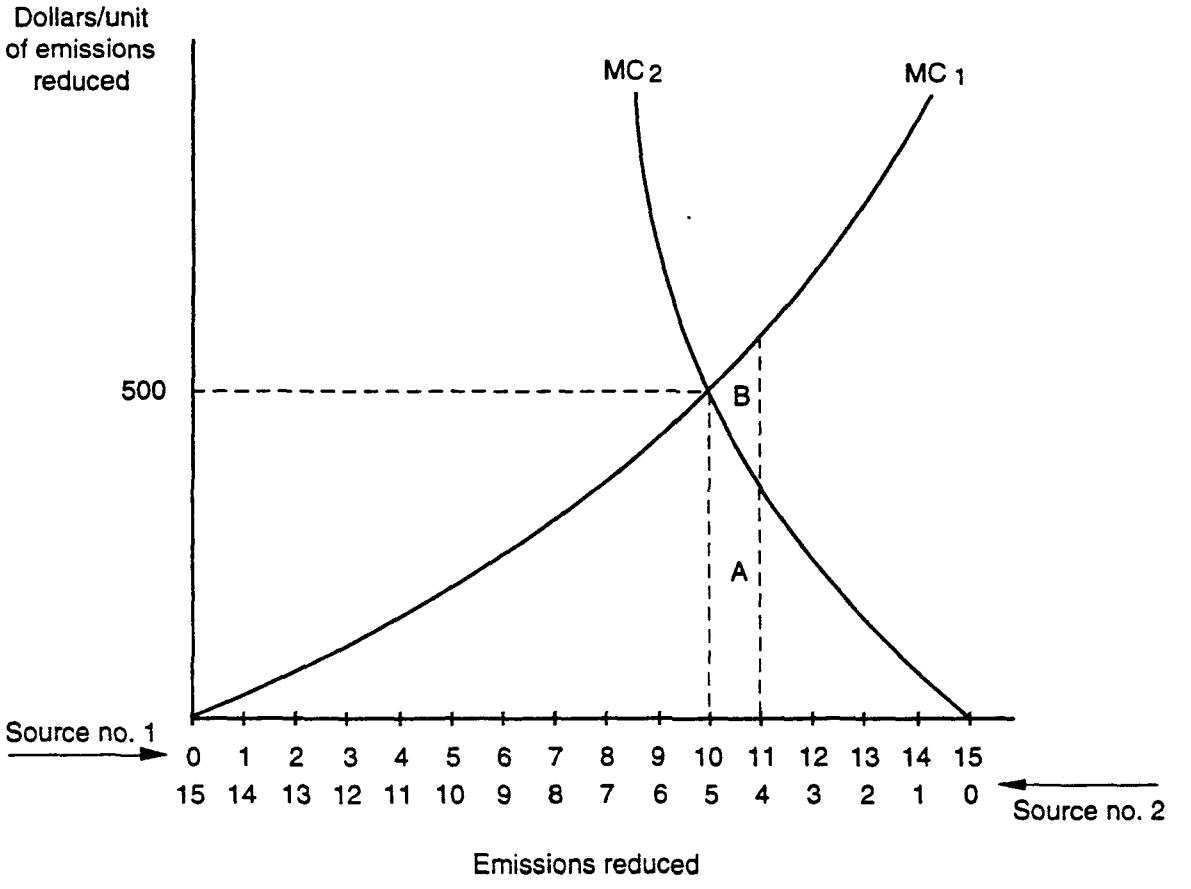

Figure 3-1. The Basic Principle of Emission Fee Programs

Source: Adapted from T.H. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* (Washington: Resources for the Future, 1985), p. 20.

That allocation of responsibility for emission reduction minimizes costs. The figure readily shows that any other pattern of emissions increases total costs; for example, Source 2 would save the amount indicated by area A if it were to increase emissions by one unit, but Source 1 would spend A plus B. An emissions fee program leads to the cost-minimizing pattern of emission reductions by levying a uniform fee on each unit of pollutant.

An alternative purpose of a fee program is to internalize the costs of pollution, leading to an efficient allocation of resources. When individuals release pollutants into the air they use a natural resource service (the assimilative capacity of the air) without paying for the use

of that service. While there is no cost, or inadequate cost, to the polluter for using the resource, there is a cost to all persons whose health or well-being is diminished by the air pollution. One way to correct the misallocation of resources is to charge the polluter a fee equal to the marginal or incremental damage caused by the pollution. A program with this purpose would reduce VOC emissions although the determination of the desired reduction explicitly would consider the health effects of exposure to ozone and the monetary equivalent of the loss in well-being.[2]

Any fee program may raise revenue even if revenue-raising is not the purpose of the program. The total revenue generated by a Federal program could be large enough to make the uses of the revenue an important secondary purpose. In general, many activities are suitable for funding from fee revenues: technological development and risk communication are two examples. Alternatively, revenues may be rebated to reduce adverse impacts on industry. A more specific discussion of these uses and the constraints imposed by the Clean Air Act as amended appears later in this Section.

A fee program may serve more than one purpose. The multipurpose aspect of fees does not mean that a fee program will serve each purpose equally well. In fact, as will be shown, the designated purpose of the program determines important characteristics of the program design.

3.2 ECONOMIC BASIS OF THE FEE

If the primary purpose of the fee is to achieve a specified quantity of emissions reduction, the most accurate basis of the fee is a model of the markets that are directly and indirectly affected by the fee program. Such a model would quantitatively describe a complex set of relationships governing how users will change their purchases of the

[2]Those considerations would not necessarily be explicit in the prior approach to determining the environmental goal of the program.

commodity on which the fee is charged and how manufacturers will change the commodity itself in response to the fee. The model would characterize the relationship between fee rate and emissions reduction, but would not by itself indicate the desired fee rate or the desired reduction in emissions. Once the environmental goal had been determined, the model would indicate the initial fee that should be levied (see below for a discussion of revising the fee rate in response to contingencies that arise during implementation).

If the primary purpose of the fee is to correct the market failure associated with the absence of a cost to the product user for discarding VOCs to the atmosphere, the appropriate basis of the fee is the damage resulting from air pollution. Ambient ozone is injurious to human health, to materials, and to plants. The estimation of damages reflects the sequence of processes that begins with the photochemical transformation in the troposphere of VOCs to ozone and ends with the application of economics methodologies to determine the monetary value of the injuries caused by exposure to ozone.

The most precise estimate of damages involves the detailed modeling of ozone concentrations, exposures to ozone, concentration-response functions for human health, materials damage, and ecosystem risks, and valuation. This effort would require a very large amount of information, much of it difficult to obtain, for each nonattainment area and for attainment areas as well, if the Federal program were to apply to the entire nation. The manufacturers of consumer and commercial products would face greater fees on products used in areas where the ozone problem is more severe. One strength of damage-based emission fee rates is that manufacturers would be more likely to incorporate environmental costs into strategies for product reformulation and packaging redesign.

Although better information on damages facilitates the more precise estimation of fee rates, full information is not a prerequisite for designing fees that reflect regional differences in the environmental costs of VOC emissions. An approximate, but more implementable

approach to setting fee rates is to scale fees to the severity of each region's nonattainment status and to the size of the population in the region.[3] Still, the ease of movement of consumer and commercial products across regions may make differentiated fee rates too difficult to implement effectively.[4]

Given the difficulties with estimating the benefits of improving air quality in different regions, this Section emphasizes the primary purpose of achieving emission reductions at least cost. Fee programs may also achieve other purposes, for example, stimulating technological change, and thus these objectives are also discussed.

3.3 MARKET RELATIONSHIPS AND RESPONSES

Input suppliers, product manufacturers and importers, and users of consumer and commercial products form a complex system of related markets.[5] Changes in one market directly and indirectly affect the other markets in the system. For example, a fee on VOCs levied on purchasers of solvents (i.e., product manufacturers) increases the price paid by manufacturers for a solvent, which changes the relative prices of the inputs to consumer and commercial products. The changes in input prices motivate manufacturers to substitute the now lesser expensive inputs, in particular, materials formulated with a lower concentration of VOCs, for the more expensive inputs (solvents formulated with a higher concentration of VOCs); actual reformulation depends upon consumer and commercial products technology. The cost of manufacturing consumer and commercial products increases, and the increase will be greater for consumer and commercial products which are higher in VOCs. Users of consumer and commercial products react to the higher prices by reducing purchases of some

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[3] A theoretical examination of regionally differentiated emission fee programs shows that this approach sets fee rates that accurately reflect relative differences in environmental costs, although the determination of the absolute levels of the fees would require additional analysis and, most likely, trial-and-error (Tietenberg, 1974).

[4] This point is discussed more fully in Section 3.4.3.

[5] The industry profiles (see U.S. EPA, 1993) describe the basic materials used to manufacture consumer and commercial products, types of products, and substitution possibilities available to users of those products.

consumer and commercial products and increasing purchases of relatively less expensive consumer and commercial products. Overall VOC emissions from consumer and commercial products decline; however, emissions from some types of consumer and commercial products may actually increase despite reformulation because of increased demand.

The final state of the markets—the new prices, sales volume, and emissions—depends upon technological possibilities, the behavior of product users, and the secondary effects of the initial changes in the markets. One cannot a priori determine the magnitude of change and the direction of change for all prices, sales volume, and emissions. Therefore, without further investigation, program designers cannot predict the gainers and losers from the fee program or the social costs. An empirical model of the markets is necessary to completely investigate the economic and environmental consequences of the program.

To illustrate market interrelationships, a model has been developed to investigate the effects of imposing a VOC-based fee on the purchase of solvents by manufacturers of architectural and industrial maintenance coatings. The *Industry Profiles and Technical Appendixes* document, Appendix B describes the model and identifies the data which are required to operate the model.[6] This document also presents the results of one simulation of a fee program. Because the data were contrived, the simulation illustrates but does not project the precise effects that one would really expect to occur following the imposition of the indicated fee. The model represents coating technology with a two input production function and represents coating usage as allowing substitution between a high- and a low-VOC formulation. The emission reductions attributable to an initial fee level cannot be rigorously estimated without a model like the one described.[7]

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[6]The *Industry Profiles and Technical Appendixes* document, Appendix B also presents a graphical analysis of the effects of imposing the fee in the coating market (rather than the solvent market).

[7]Multiple models (for different coatings) may be required for an investigation of the fee program for architectural and industrial maintenance coatings; further investigation is required to determine the appropriate level of aggregation for analyzing this very heterogeneous set of commodities.

For fee programs, the uncertainty in projecting emission reductions is due to both the intrinsic nature of fee programs (i.e., emissions will increase if the industry expands production) and limits on modeling markets. One significant limitation is the uncertainty in estimating the parameters of the model (see the *Industry Profiles and Technical Appendixes* document, Appendix B for a description of the parameters), which causes uncertainty in estimating the total emission reduction which any particular fee will elicit. A sensitivity analysis can determine the frequency distribution of emission reductions that results from uncertainty about the parameter estimates. Thus market models could help determine the degree of "reasonable certainty" (U.S. EPA, OAQPS, 1991b: p. 9) of projected emission reductions attributable to an initial fee rate and the consequences for progress toward compliance with the statutory deadlines for attainment with the ozone standard.

3.4 FEE RATE VARIABILITY

A fundamental design choice for a fee program is the uniformity or variability of the rate of the fee. This design choice arises with respect to several factors: season, VOC content, location, and progress in reducing emissions.

3.4.1 Season

The EPA could make the fee effective only during a particular time of the year. Since the presence of ambient ozone is strongly related to heat and humidity, the Agency could make the fee effective (or greater) only during the seasons characterized by that type of weather. Seasonally differentiated fees may lower the aggregate cost of emission reductions without reducing the decrement in ozone concentration.

However, opportunistic behavior appears to make seasonally differentiated fees inappropriate for consumer and commercial products. It is possible and even likely that

users would purchase consumer and commercial products during the season when the fee was ineffective (or less) and store the product until the time of use. For example, because many paints last in storage and are applied outdoors, users are likely to buy them in the winter and to apply them in warm weather, thus negating the intended effects of a seasonal fee on VOCs. Agricultural chemicals (insecticides and pesticides) also are typically applied during warm weather, and users would have the incentive to circumvent seasonally differentiated fees. Many other consumer and commercial products are used for purposes such as sanitation, personal hygiene, and grooming that are largely independent of the ozone season. These products are also stable and are sold in packages of which the volume is sufficient for an extended period of time. Therefore it is doubtful that seasonally differentiated fees would alter the pattern of use because circumvention would be easy.

3.4.2 VOC Content

The uniformity-variability consideration also arises in designing the fee structure which relates the fee rate to VOC content. A uniform or flat rate fee structure requires the regulated entity to pay the same amount for each unit of VOC potentially emitted regardless of the total emissions potential of a unit of product. A variable rate fee structure also requires the regulated entity to pay a fee for each unit of VOC; however, the per-unit amount of the fee depends on the total amount of VOCs potentially emitted. Figure 3-2 shows a flat rate and a variable rate fee structure plotted against the amount of VOCs potentially emitted from a unit of product.

Under the flat-rate fee structure, the total fee is computed by multiplying the amount of VOCs potentially emitted by the constant fee, f_c. Under the variable rate fee structure, the fee is computed by multiplying the amount of VOCs (x units) by the fee rate specific to that

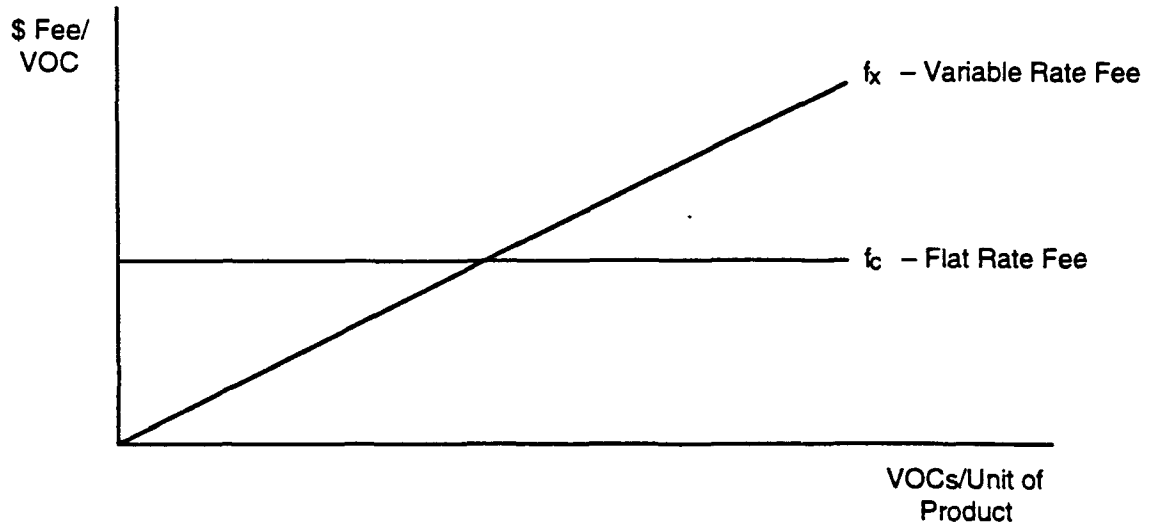

Figure 3-2. Flat and Variable Rate Fee Structures

"concentration" of VOCs (f_x). Under the variable rate fee structure, a manufacturer can reduce the fee rate applied to his or her product by reducing the VOCs potentially emitted by a unit of product.

In a static analysis of the efficiency of fee structures, the variable rate fee does not minimize the total cost of achieving an emissions reduction goal. This result occurs because the marginal costs of control would not be equal across all regulated consumer and commercial products. However, an advantage of the variable rate is that the fee burden on a manufacturer decreases as its products approach very low VOC content and it encounters possibly insurmountable barriers to further reducing VOCs. The possibility of a barrier to reducing VOCs may make a modification of the continuously variable rate fee structure attractive: the fee is zero below a threshold VOC content. For example, the fee could be imposed on every unit of VOC only when the VOC content of a regulated product exceeds a threshold value. For example, if the threshold value for VOCs in a particular type of coating were 100 grams per liter of coating then there would be no fee on a coating containing 99

grams of VOC, but a per unit fee would be imposed on a coating containing 125 grams of VOC (i.e., the fee would apply to the 25 grams above the threshold). This type of fee structure, however, has the disadvantage of eliminating the incentive to invent a formula in which the VOC content is substantially less than the threshold.

3.4.3 Location

In nonattainment areas, excess concentrations of ozone pervade the area. High ozone values registered at the monitors reflect air quality in a large part of the metropolitan area.

In contrast, the ozone problem differs remarkably across nonattainment areas. Peak concentrations in the Los Angeles South Coast Air Basin are extremely high; in Kansas City, they are marginally excessive. Therefore, in general, air quality differences within any one nonattainment area are not significant for the design of economic incentives, but the differences between nonattainment areas may justify a tailoring of the program fo air quality.

The fee rate is the most important element in a fee program that could be used to modify the incentive to reduce emissions, increasing the incentive in areas where the greatest reduction is necessary to comply with the air quality standard. An emission fee that increases with the severity of the nonattainment status is the simplest way to tailor the fee to air quality.

A greater fee provides both a stronger incentive to reduce emissions and comes closer than a uniform fee to indicating the environmental significance of decrements in emissions. Figure 3-3 illustrates the principle that the emission fee should be greater where the benefits of emission reductions are greater. Because the risk to human health increases with exposure to ozone, the benefits of emission reduction—avoided damage—increase. The curve labeled MB_0 could correspond to a severe nonattainment area, and curve MB_1, to an extreme nonattainment area. The fee rate should be higher in the extreme nonattainment area.

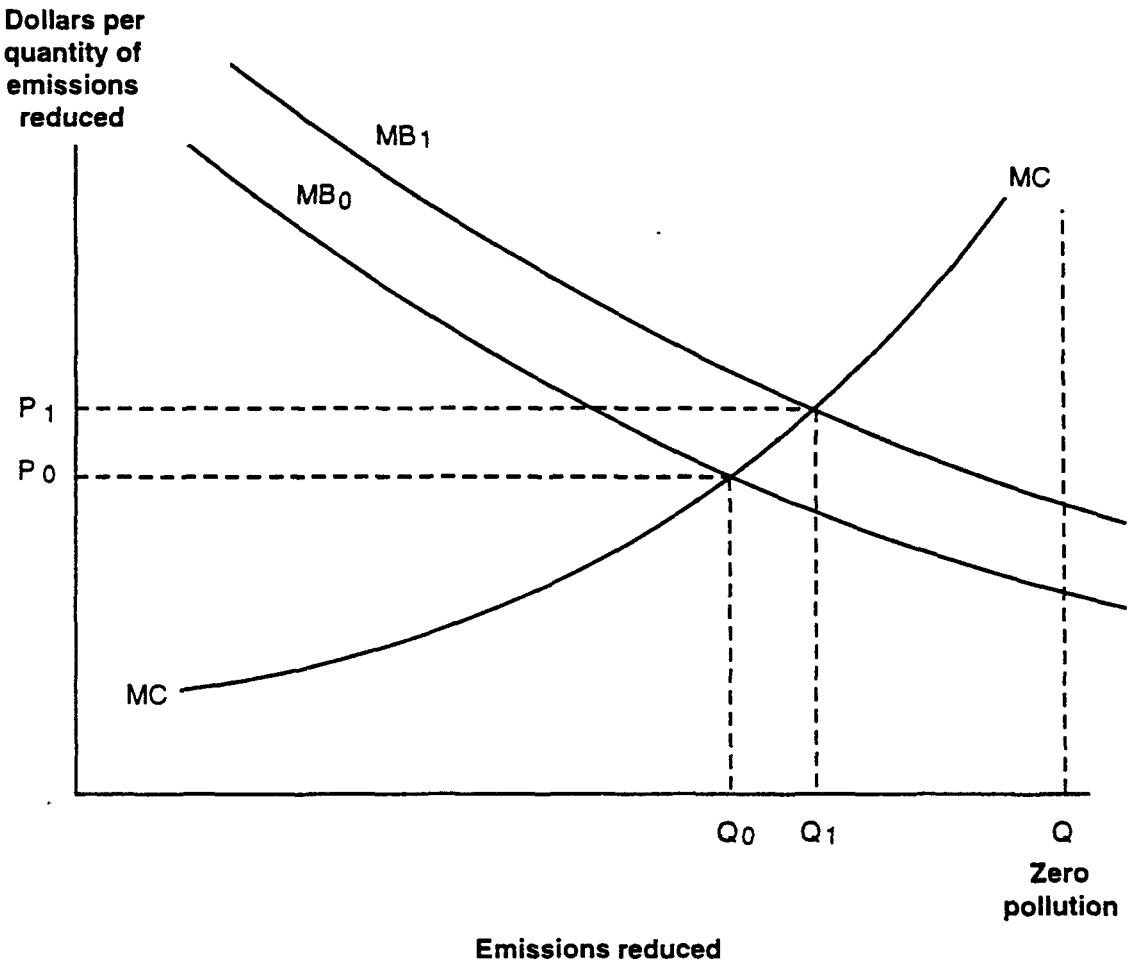

Figure 3-3. Emission Fee Should Be Greater Where Benefits Are Greater

If the Federal program were to use regionally differentiated fees, then combining approaches to setting the fee may be desirable. The damage-based approach, if feasible, would indicate the relative magnitude of the fees, and the market model would inform the selection of the absolute level of fees. The administrative costs of a fee program with differentiated fees would be somewhat higher than the costs of a program with a uniform fee, but the least attractive feature of the former program is a difficulty in enforcement. Users of consumer and commercial products would pay higher prices for products sold in more polluted areas. They would have an incentive to buy products where they are less expensive,

in some cases transporting products across attainment area boundaries to take advantage of fee differentials. Opportunistic behavior would undercut the program without extremely intrusive monitoring. Nonetheless, geographically differentiated fees may be practical for products the value of which is small enough to render uneconomical a trip that would be made to take advantage of price differences.

3.4.4 Emission Reduction Progress

It is unlikely that the EPA will have enough information to set the initial fee such that the program exactly achieves the environmental goal. The realistic expectation is that actual emissions will overshoot or undershoot the target. Consequently, it is advisable to build sufficient flexibility into the fee system so that the fee may be adjusted. A schedule of adjustments could be laid out in advance or the adjustment could be made mechanically at predetermined time periods according to a formula. Adjusting the fee rate is discussed more thoroughly in Section 3.6.

3.5 INITIAL FEE RATE

A critical task in the initialization of a fee program is the selection of the fee rate. The rate is important because it influences the effectiveness of the fee program in two ways. First, the fee is the instrument for motivating regulated entities to search for new product formulas and packaging. Second, the acceptability—technical reasonableness, fairness—of the process by which the initial fee is set affects peoples' intentions to delay the start of the program or to circumvent the program once implemented. Either result would be costly: the anticipated emission reductions would occur later than desired or would require more resources devoted to monitoring. The following discussion of the method for setting the initial fee rate begins with a market model, but, recognizing potential problems with acceptability, alternatives are also considered.

The market model described in Section 3.3 and the *Industry Profiles and Technical Appendixes* document, Appendix B can be used to estimate the initial fee rate required to achieve any aggregate emission reduction goal. However, the strength of the model's results depends on the accuracy of the data used in the model and assumptions about elasticities and opportunities for input substitution.

The difficulty associated with rigorously justifying the appropriate fee rate may be a weakness of the fee program. This difficulty derives from the necessity for information about the current technology of manufacturing consumer and commercial products, users' and manufacturers' likely responses to the fee, manufacturers' costs of reducing VOCs in consumer and commercial products, and the likely success of research and development in reformulation, repackaging, and new product development. In light of the expectation that not all parties who are affected by regulation may agree on the accuracy of the data used to estimate the market model or the estimated parameters, it is germane to consider alternative methods for setting the initial fee.

One alternative method for setting the initial fee rate is negotiation between the EPA, representatives of the consumer and commercial products industry, and representatives from interested citizen and environmental groups. On the table for negotiation could be the initial fee rate, the length of the period in which the emissions reduction goal would be achieved, a set of interim goals, and a backstop measure (such as fee rate increases) that would become effective if progress toward the goal were judged to be insufficient.

A second alternative method for determining the initial fee rate is to make a fee on the VOC content of consumer and commercial products comparable to the cost to firms of buying VOC credits or the cost of obtaining VOC reductions from other industries. Thus the fee rate could be determined by the market value of VOC emission rights. One such market already exists: the market for offsets created under the aegis of the EPA's emissions trading

policy (U.S. EPA, 1986). State and regional authorities are forming other markets now. Alternatively, the fee could be based on estimates of the marginal cost to achieve additional VOC reductions from other industries.

A third alternative is to combine the initial fee rates computed by different methods or to combine the methods themselves. One possibility would be to obtain estimates of elasticities of demand and supply from experts inside or outside of the consumer and commercial products industry. These estimates could then be used in the market model. One other approach is to use the initial fee rate calculated by the model or the value of traded rights as a starting point for negotiations.

A number of states and air quality management districts have already promulgated VOC content standards, and other regulatory agencies may promulgate standards prior to the promulgation of Federal regulations for consumer and commercial products.[8] Such standards require an adjustment in the fee rate to make the economic incentive effective. The necessary adjustment is to set the fee rate above the rate that would be desired in the absence of content standards (see the *Industry Profiles and Technical Appendixes* document, Appendix A).

Considering the uncertainty in the regulated entities' and product users' responses to the fee, concern with the initial fee rate should not overshadow provisions for adjusting the rate. A properly designed adjustment mechanism will ensure eventual progress toward the emissions reduction goal.

3.6 FEE ADJUSTMENT MECHANISM

It is not possible to perfectly forecast the responses of users and regulated entities to the fee because the modeling of response involves economic parameters that, when formally

[8]Consumer and commercial products are currently regulated in several states, including California, New York, New Jersey, Texas, and Arizona.

estimated with statistics, are estimated imprecisely or are informally estimated with far less precision. Consequently, the fee rate that will meet an emissions reduction goal cannot be determined with precision. By including an adjustment mechanism in the fee program, the fee can be made responsive to unsatisfactory or too rapid progress toward achieving the emissions reduction goal.[9] If the objective is to achieve an emissions reduction goal, a fee adjustment mechanism is an essential element in the design of an effective fee program for consumer and commercial products.

There are three steps in designing an adjustment mechanism. The first step is to set interim emissions reduction goals. For example, if the overall emissions reduction goal is to be achieved over 10 periods, then one could set a schedule of interim goals such that ten percent of the overall goal would be achieved in each period.[10] Column 3 of Table 3-1 shows an example of a set of interim goals. Note that the interim goals can be constant over time, increasing, or decreasing as long as the sum of the interim goals equals the overall emissions reduction goal (151,000 units in the example).

The second step is to project the fee rates necessary to achieve the interim goals. One could use any of the methods described in Section 3.5 to determine these fee levels. Column 2 in Table 3-1 shows a fictitious set of projected fee levels to meet the interim goals.

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[9]This reason for adjusting the fee is independent of the increase in the fee that may be necessary to obtain the desired emission reductions in a program whose universe of sources expands according to the sequence of increasing cost of emission reductions, which could occur in the regulation of consumer and commercial products.

[10]The choice of the length of a period might reflect both statutory requirements for air quality improvement and the time that regulated entities must take to redesign products and packaging. Early adjustment can lead to an unnecessarily high fee because apparently slow progress can reflect the time sources need to respond (as well as lack of incentive).

TABLE 3-1

FEE SYSTEM WITHOUT AN ADJUSTMENT MECHANISM

(1) Period	(2) Projected Fee	(3) Interim Goals	(4) Actual Reductions	(5) Cumulative Goals	(6) Cumulative Reductions
1	0.05	16,500	16,500	16,500	16,500
2	0.06	16,500	16,200	33,000	32,700
3	0.07	16,500	15,900	49,500	48,600
4	0.08	16,500	15,600	66,000	64,200
5	0.09	16,500	15,300	82,500	79,500
6	0.10	16,500	15,000	99,000	94,500
7	0.12	16,500	14,700	115,500	109,200
8	0.14	16,500	14,400	132,000	123,600
9	0.16	16,500	14,100	148,500	137,700
10	0.18	16,500	13,800	165,000	151,500

Columns 4, 5, and 6 illustrate what might occur if no adjustment mechanism were used. The cumulative actual reduction falls further behind the cumulative interim goal. The cumulative emissions reduction achieved by the end of the tenth period is less than the overall emissions reduction goal. The projected fees were insufficient to obtain the emissions reductions necessary to meet the goal. The example in Table 3-1 represents just one possible scenario. It is also possible that the projected fees are set too high, leading to the achievement of the overall emissions reduction goal several periods early. Because one cannot accurately project the fee rate necessary to meet the overall goal, and because this will result in undershooting or overshooting the goal, a mechanism that automatically adjusts the fee rate in each period is desirable.

The third step in designing the adjustment mechanism is to develop a system of formulas that relates the fee to progress toward the overall goal, changes the interim goals,

and further refines the fee to reflect the new interim goals. Therefore adjustment requires a triple mechanism, each serving a separate but complementary purpose. The first adjusts the projected fee rate by the percentage of the interim goal achieved in the previous period. For example, if the emissions reduction achieved in period 3 falls short of the goal for period 3 by 15 percent, the projected fee level in period 4 would increase by 15 percent. The reverse operation is executed when actual reductions exceed the interim goal in the previous period, decreasing the projected fee level by the appropriate percent.

A hypothetical case is constructed in Table 3-2 based on the scenario depicted in Table 3-1. The numbers in column 6, labeled Rate Adjustment Factor #1, are calculated by the following formula, in which ERA is the emissions reduction achieved and ERG is the interim emissions reduction goal:

$$\text{Rate Adjustment Factor \#1}_{(t+1)} = 2 - \frac{\text{ERA in period t}}{\text{ERG in period t}}$$

TABLE 3-2

FEE SYSTEM WITH AN ADJUSTMENT MECHANISM

(1) Period	(2) Projected Fee	(3) Interim Goal	(4) Actual Reductions	(5) Interim Goal Adjustment	(6) Rate Adjustment Factor #1	(7) Rate Adjustment Factor #2	(8) Adjusted Fee
1	0.05	16,500	15,000	149	1.00	1.000	
2	0.06	16,649	17,000	-37	1.09	1.009	0.066
3	0.07	16,612	14,000	258	0.98	1.007	0.069
4	0.08	16,870	17,000	-17	1.16	1.022	0.095
5	0.09	16,853	15,000	180	0.99	1.021	0.091
6	0.10	17,033	16,500	47	1.11	1.032	0.115
7	0.12	17,081	17,100	-9	1.03	1.035	0.128
8	0.14	17,072	20,000	-301	1.00	1.035	0.145
9	0.16	16,771	18,000	-132	0.83	1.016	0.135
10	0.18	16,639	17,000	-46	0.93	1.008	0.168

To obtain the adjusted fee rate, one simply multiplies the projected fee rate (in column 2) by the first adjustment factor. For example, if the emissions reduction achieved in period t were only 91 percent of the emissions reduction goal for period t, then the adjustment factor would be 1.09. If the fee rate scheduled for the next period was $0.06, then the new fee rate, without any further adjustments, would be $0.06*1.09, or $0.065. This adjusted fee rate is higher than the fee rate initially computed for period 2, and should provide a greater incentive in period 2.

The second adjustment mechanism changes the interim goals to make up for shortfalls or excesses in the actual reductions in previous periods. It allocates the difference between the goal in period t and the actual reduction in period t evenly to all future interim goals. For example, if in period 5, the actual reduction fell short of the goal by 20,000 units, then each of the goals for periods 6 through 10 would be increased by 4,000 units. In contrast, if in the following period, the actual reduction exceeded the goal by 12,000, then the adjustment mechanism would decrease the interim goals for periods 7 through 10 by 3, 000. Column 5 in Table 3-2 shows the number of units added to or subtracted from the interim goals in future periods.

Interim ERG adjustments are calculated by the following equation:

$$\text{Interim ERG Adjustment}_t = \frac{ERG_t - ERA_t}{10 - t},$$

assuming that the total number of periods allotted to achieve the overall emissions reduction goal is 10. Each remaining interim goal (i.e., ERG_{t+1}, ERG_{t+2}, ...) is adjusted by adding the interim ERG adjustment calculated above. Hence the interim goal in any period will be a function of the progress in meeting the past interim goals.

In addition to adjusting the interim goals, it is necessary to further adjust the fee rate to account for changes in the interim goals. For example, if one increases the interim goal without increasing the fee, then actual reductions that period are likely to still fall short of the interim goal. Consequently, both the interim goal and the fee rate need to be adjusted. This second adjustment to the fee level is shown in column 7 of Table 3-2 and is computed by the following equation.

$$\text{Rate Adjustment Factor \#2}_{(t)} = \frac{\text{Adjusted Interim ERG}_t}{\text{Original ERG}_t}$$

The final adjusted fee rate (shown in column 8) is computed by multiplying the projected fee rate by the two adjustment factors. In this manner, progress toward the overall goal feeds back to the program to ensure effectiveness.

The use of such a mechanism to adjust the fee sends a clear message to regulated entities that future fee rates are dependent upon progress in meeting emission reduction goals. Manufacturers play an especially important part in meeting emission reduction goals through the development of new products and packaging. Hence the adjustment mechanism reinforces the incentive to invest in VOC-reducing research and development.

However beneficial fee adjustment, it is not costless. A balanced discussion of fee adjustment involves the costs that regulated entities will incur as they respond to changing but uncertain fees (Walker and Storey, 1977).[11] After fees change, manufacturers, for example, may find that they incur greater manufacturing costs and fee payments than they would incur if they had known the fee in advance and adopted the most appropriate response. Some manufacturers will adjust their technology, but others will prefer to stay with the existing technology (and pay higher operating expenses and fees). The expectation of those

[11]Fee adjustment might also involve additional costs to be borne by the EPA or the general population: the cost of information used to determine whether unsatisfactory progress is due to a lack of incentive or the reaction lag, and the cost of polluted air.

capital adjustment and lock-in costs will motivate some manufacturers to plan for change by adopting more flexible strategies for reducing emissions, which could entail adaptations of the manufacturing process as well as product and package redesign. Flexibility is not free—regulated entities will incur costs to reduce the costs of change. Therefore the costs of an emission fee program with a fee adjustment mechanism include capital adjustment and lock-in costs and the costs of flexibility, although the extent to which such costs are significant is uncertain. The alternative to fee adjustment is to gamble on the initial fee, at the price of increased risk of failure to achieve the environmental goal.

3.7 UNIVERSE OF SOURCES

The universe of sources comprises the regulated entities (companies) on whom the fee would be levied. Regulated entities are manufacturers, processors, wholesale distributors, and importers of consumer and commercial products (Clean Air Act Amendments of 1990, Section 183 (e)(1)(C)). The definition of regulated entity excludes suppliers of the raw materials for the manufacture of consumer and commercial products and, at the opposite end of the product distribution channel, retailers and users. Inclusion in the universe of sources implies that the company is legally responsible for paying the fee and must comply with, at a minimum, monitoring and record keeping requirements.

The following characteristics of regulated entities are relevant to the composition of the universe of sources:

- type of product,
- type of business, and
- size.

Each characteristic implies a criterion for determining whether a regulated entity will be in the universe of sources. Inclusion may also depend upon the simultaneous satisfaction of multiple criteria. Further, pursuant to Section 183(e)(3) of the Clean Air Act Amendments of

1990, the universe of sources may progressively expand over time as regulation encompasses more groups of consumer and commercial products.

3.7.1 Selection of Sources by Type of Product: Sequence of Regulation

The most general issue in the selection of regulated entities for inclusion in the universe of sources is the grouping of products by priority of regulation. Although the identification of those groups is beyond the scope of this report, it is germane to consider whether the sequence of regulation should influence other elements of a design of fee program that encompasses multiple groups of consumer and commercial products.

Cost-effectiveness suggests that the order in which products are regulated should correspond to the projected costs of emission reduction, the least costly reductions being obtained first. Under this regulatory sequence, if continual progress toward an overall emissions reduction goal is desired, the magnitude of the fee may need to increase over time to elicit the desired emission reductions.[12] In this scenario, the fee increases whenever a group of products is added to the universe of sources. Otherwise, with a constant fee rate, more emission reductions would be forthcoming from the earliest product groups regulated than from product groups regulated subsequently.

3.7.2 Selection of Sources by Type of Business

Figure 3-4 portrays a generalization of the manufacture-distribution system for consumer and commercial products. It shows the markets where the fee may be imposed and the entities on whom the fee may be levied. Manufacture comprises several activities: specification of the product-package system by the marketer, preparation of the product (formulation), and filling the package. Distribution refers to the shipment of finished goods

[12]This increase in the fee is in addition to any adjustment for inflation.

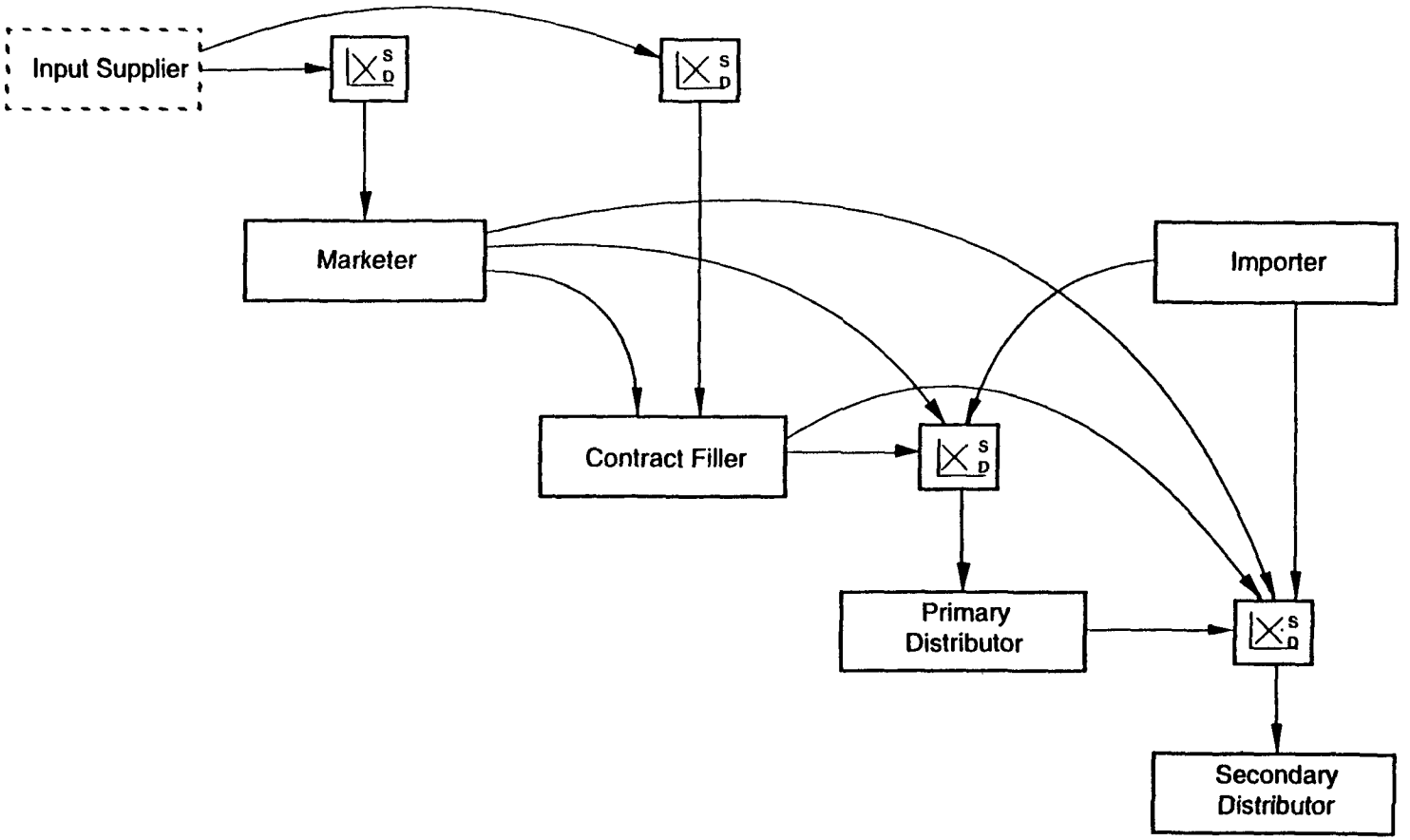


Figure 3-4. Markets Where Emission Fee May Be Imposed and Entities on Whom Fee May Be Levied

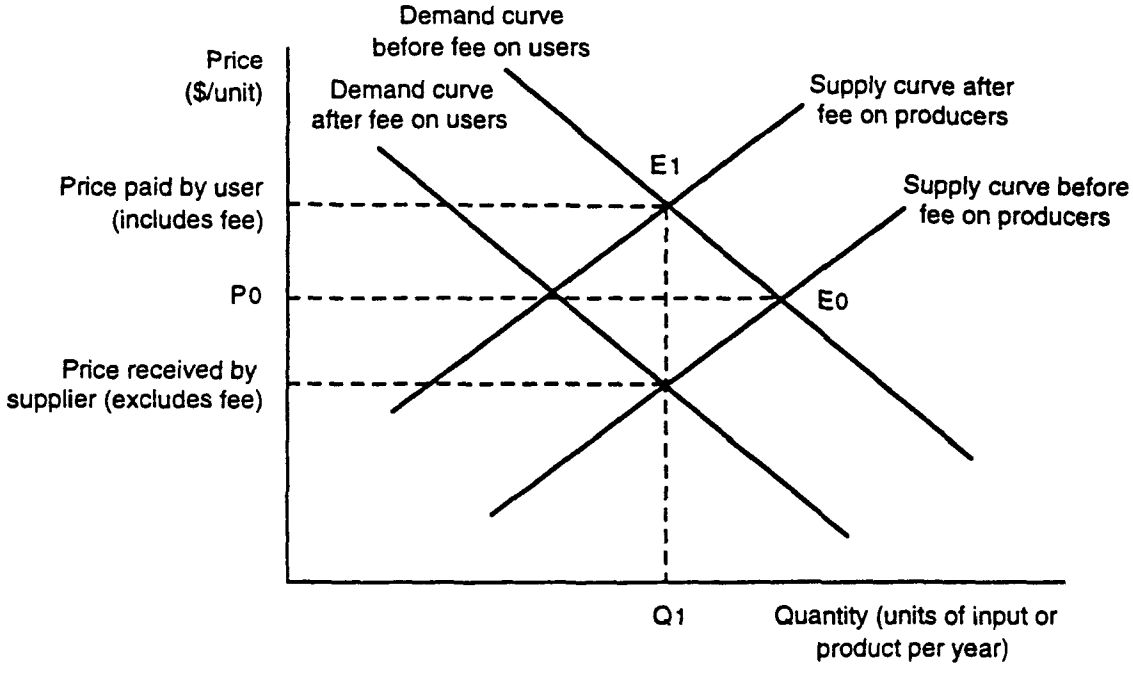
Source: Adapted from Michael Gibbs, August 1990, *Study of Economic Incentives to Control Photochemically Reactive Organic Compound Emissions from Consumer Products,* report prepared by ICF Consulting Associates, Inc. for the California Air Resources Board, Sacramento, California, p. 43.

but excludes retail sales. In any actual consumer or commercial product industry, the course of a product involves a shorter or longer path depending upon whether formulation and filling occur on the site of the marketer's operations and the number of distributors as well.

A fee may be imposed on either the VOCs in the products or the product itself, and this choice has implications for the selection of source by type of business. If the fee were to be imposed on the product itself, then a fee rate would be chosen to be applied to each unit of product. The next choice would be the node in the distribution channel and the side of the market—supplier or demander—on whom to levy the fee.

If the fee were charged in the wholesale product market, the manufacturer or product distributor could be made responsible. Alternatively, the fee could be levied at an intermediate node in the distribution channel, and either the selling or buying distributor could be responsible for paying the fee. (For complete coverage, all importers should be included in the universe of sources.)

The incidence of the fee and the ease of collection may be thought to be criteria for the choice of entity on whom to levy the fee. The incidence of a fee is the weight of the fee borne after markets adjust. As shown in Figure 3-5, the incidence of the fee is independent of the entity on whom the fee is levied. In general, the portion of the fee paid by suppliers or demanders of a commodity will be determined by the market supply and demand curves, but the portion is unaffected by the attribution of legal responsibility for paying the fee. Whether levied on the suppliers or demanders in a given market, the fee reduces total emissions from consumer and commercial products by the same amount and otherwise has identical effects. Therefore, the ease of collection should be the deciding factor once the node in the distribution channel has been chosen.



The fee is imposed on either the supplier or user.

Figure 3-5. Incidence of Fee

One rationale for the product fee is that every consumer and commercial product contains and releases VOCs and, therefore, every product should be subject to a fee. Also, this type of fee might be easiest to implement, involving only the total quantity of consumer and commercial products sold in the United States by each manufacturer or distributor and importer and each company's remittance.

However easy to administer, a fee on the product itself may not be the most efficient approach to reducing VOC emissions. Cost-effectiveness in the allocation of effort to reduce VOC emissions requires equality of the marginal cost of emission reductions for all sources; a uniform fee on VOCs will lead to cost-effectiveness (Fisher, 1981: p. 188). The problem with a product fee is that the fee is not uniform with respect to VOCs. Therefore, a uniform fee on consumer and commercial products implies a nonuniform fee on VOCs.

A fee on the VOC-containing inputs to the manufacture of consumer and commercial products could be cost-effective.[13] If the fee were charged in the input market, for example, propellant market, the user of the input (i.e., the product manufacturer) would be made responsible for paying the fee but not the supplier of the input because the definition of regulated entity excludes input suppliers. Again, importers should be included in the universe of sources for complete coverage of emissions.

The input fee would induce manufacturers to redesign consumer and commercial products but would not prohibit the manufacture of any product. Product prices would increase, and some product users would switch from high-VOC products to low-VOC products in response to relative price increases. Total VOC emissions from consumer and commercial products would decrease, and the cost of achieving the desired reduction in emissions would be minimized.

The method for quantifying emissions in an input-based program assumes that emissions occur in the year in which the input is purchased by a product manufacturer. Similarly, the quantification method in a product-based program assumes that emissions occur in the year in which the product is manufactured in the United States or imported. These assumptions may be imprecise; for example, the purchase and use of a product may occur in different years. The resulting discrepancy between assumed and actual emissions may be negligible and might not justify changing the methodology for quantifying emissions.

3.7.3 Selection of Sources by Size

The EPA must consider the economic impact of proposed regulations on small businesses and develop alternatives when the impacts are onerous. Regardless of this requirement, the exemption of "small" companies from a fee program may benefit such

[13]The assumption that the mass of emissions equals the mass of VOCs in the inputs may not be not entirely accurate.

companies without substantially affecting the effectiveness or efficiency of the program, especially if size is defined in terms of annual emissions.

The companies on whom the fee is levied will search for ways to reduce their fee payments and comply with reporting and record keeping requirements. These activities may be costly, and although the costs correlate with the volume of trade, costs may be proportionately greater for small companies than for large companies. The EPA will also incur costs in identifying and communicating with small companies and keeping the appropriate records. The value of the emission reductions obtained from small companies may not outweigh the total costs (including the companies' costs and the EPA's costs) of including these companies in a fee program.

In most potentially regulated industries, a small number of manufacturers is responsible for a large percentage of sales (see U.S. EPA, 1993). Therefore it may be possible to control a large percentage of VOC emissions from consumer and commercial products by including only a small number of companies in the fee program. Small companies could be excluded either permanently or temporarily from the requirements of a fee program.

However desirable it is to lessen onerous impacts on small businesses, a selection criterion based on size could have undesirable side-effects. First, after the division of large and small companies was determined (where large companies are included in the program and small companies are not), a mechanism would have to be designed to handle small companies which become large companies. Second, basing inclusion on company size could provide an incentive for large companies to divest themselves of some product lines. As new, smaller manufacturing companies were established, they and their products could conceivably be small enough to be excluded from the program.

3.8 COLLECTION OF FEE PAYMENTS

The method of collecting fee payments is important for both program effectiveness and administrative efficiency. The following discussion of collection methods assumes that the regulated entity is a manufacturer, but these methods could easily be applied to other sources.

One method for collecting fees would require manufacturers of consumer and commercial products to compute the fees owed to the government for each product and to remit this amount to the government, along with the data used to compute the fee, on a periodic basis (annually, for example). The manufacturers' computations would be based on the VOC content and the sales volume of each product. This strategy takes advantage of the manufacturers' wealth of information concerning their own production and sales, and also places the burden of collection/remittance on the manufacturers. This approach has the additional advantage of continually supplying the government with detailed information for a complete emissions inventory.[14]

An alternative collection method is to require manufacturers to purchase "VOC stamps" from the government. The manufacturer would affix a stamp onto each regulated product indicating that the emissions fee had been paid, and the stamp could indicate VOC content as well. One possible implementation problem with this collection method is that the EPA would have to concern itself with possible counterfeiting of stamps.

3.9 MONITORING AND ENFORCEMENT

Compliance is a necessary condition for the successful operation of any economic incentive program. If noncompliance is tolerated, the regulatory program fails to achieve the

[14]Thus fee programs also provide an incentive to manufacturers to adapt their management information systems to the requirements of cost-effective emissions control.

environmental goal and serves as an instrument to disadvantage complying companies vis-à-vis noncomplying companies (through changes in costs and in market share). In designing a fee program, it is important to take into account the feasibility of ensuring compliance. Because the overall gains of a regulatory program are dependent upon compliance and administrative costs, it may be necessary to make trade-offs between simple and sophisticated designs.[15]

The operating principle behind a strategy to ensure compliance is deterrence. An effective strategy will lead regulated entities to perceive that the expected costs of noncompliance outweigh the expected gains of noncompliance. Effective deterrence has two primary components: sufficient monitoring and credible enforcement.

Under cost-effective fee programs, manufacturers (importers) could be required to monitor and periodically report the VOC content of each formulation of regulated consumer and commercial products the company manufactures (imports). The states or EPA could check for falsification of companies' reports through a random audit of products on shelves in retail establishments or at wholesale distribution centers. Incorrect reports (either through falsification or incompleteness) could be a form of noncompliance.

In practice, monitoring compliance in a fee system involves determining whether or not regulated entities are paying the correct amount of fees. In a fee system based on the VOC content of consumer and commercial products, the correct fee payment has three components:

1. VOC content per unit of product,
2. total sales volume (in units) for each product, and
3. correct fee rate.

[15]Noncomplying companies who underreport emissions may still reduce emissions to the desired level (Harford, 1978). Therefore, air quality may improve as expected, although activities funded by fee payments may suffer.

If the fee is imposed in the input market, the correct amount of fees to be remitted by regulated companies is based on the amount and type of input the companies use in regulated consumer and commercial products. Because the same inputs may be used to manufacture regulated and unregulated products, the correct calculation of the fee payment cannot be based solely on the use of inputs. Inputs used in regulated products, for the purposes of compliance with the fee program, must be tracked separately. The use of inputs can be monitored with auditing of company records and product sampling.

Auditing and product sampling would also be followed if the fee were to be levied on the product itself. The purpose of sampling would be only to verify that a purportedly VOC-free product is in fact not a source of emissions. Therefore, monitoring compliance with a fee imposed in the solvent market requires the same types of activity as a fee imposed in the product market, but the latter might be less expensive.

In one of the collection schemes described in the previous section, regulated companies would be required to remit the fees owed and to submit reports of VOC content and quantities sold. To determine that the regulated companies were reporting true sales of regulated products, the states or EPA could conduct record keeping audits. The subject of the audit would be required to show how sales volume (and destination, if necessary) of regulated products is tracked for the purpose of compliance with the consumer and commercial products regulation, and to demonstrate consistency with reports prepared for other purposes.

Under the collection scheme involving the VOC stamp, compliance could be monitored in three ways. First, random audits could verify the VOC content of the coating as stated on the stamp. The second step in monitoring compliance would require the government to verify that a stamp is affixed to every regulated product. The government could alert retailers of regulated products to the new regulations making it illegal to sell

regulated products without a stamp. Third, the government would have to ensure that the stamp is genuine. Checking for counterfeiting of stamps could be accomplished by government examination of stamps on the containers at the retail level and unannounced inspections of plants where consumer and commercial products are packaged.

Both monitoring programs rely heavily on self-reporting by the manufacturers and random audits. To the extent that self-reported sales volume information may be difficult to corroborate, compliance may be more difficult to monitor under the scheme relying solely on manufacturers' self-reports. However, identifying counterfeited stamps, and even designing a stamp that is difficult to counterfeit are disadvantages of the alternative scheme.

Geographically differentiated fees entail a unique monitoring problem. It is reasonable to expect that the volume of consumer and commercial products transported across air quality regions will depend upon the fee differential, the cost of transportation, and any product quality differences. Users of large volumes of regulated products are most likely to circumvent the fee program because they are best able to take advantage of economies of scale in transportation. An effective program may require some form of monitoring of large-volume users of regulated products.

The enforcement component of an effective compliance strategy must have two qualities. First, penalties must be severe enough to deter unacceptable levels of underreported emissions. Second, regulated companies must perceive the EPA as willing and able to determine and apply the appropriate penalty in a timely manner. If a company believes that the EPA will not follow through on an enforcement action, it may not comply regardless of the severity of the stated penalties.

Section 113 of the CAA outlines the Federal enforcement procedures which apply to persons in violation of the Act or any regulations promulgated under the Act's provisions.

Section 113(b) authorizes EPA to assess civil penalties of up to $25,000 per day of violation and/or to obtain a temporary or permanent injunction against a non-complying source. In assessing the amount of the penalty, the court is to consider such factors as the size of the business, the economic impact of the penalty on the business, the violator's full compliance history and good faith efforts to comply, the duration of the violation, previous penalties assessed for the same violation, the economic benefit of noncompliance, and the seriousness of the violation. Under §113(d) administrative penalties may be assessed for the same violations for which civil penalties may be sought and as with §113(b) penalties, may be assessed in an amount of up to $25,000 per day of violation and established by the factors listed above. In addition to the civil and administrative penalties, under §113(c) criminal penalties may be enforced in cases where it is determined that a person has knowingly violated a requirement. Thus, the CAA provides clear authority to impose substantial noncompliance penalties.

3.10 USE OF REVENUES GENERATED BY FEE PROGRAMS

An efficient and effective fee program achieves its purpose by guiding manufacturers and product users to change behavior in specific ways. The use of fee revenues can have a positive, negative, or neutral effect on these changes in behavior. Consequently, the use of fee revenues is an important design consideration of any fee program.

Although the Clean Air Act Amendments of 1990 constrain the uses of fee revenues (see Section 183 (e) (5)), a variety of uses may be consistent with the amendments. These uses include: product labeling, public education, subsidizing technological development, and rebates.

Using fee revenues to fund a labeling and public education program could enhance the effectiveness of a fee program by promoting awareness of the air quality impacts of

consumer and commercial products. Informing users about the VOC content of their purchases and the consequences to the environment may lead to additional changes in behavior and in additional emission reductions.

Creating an organization to fund technological development in the consumer and commercial products industry is another potential use of fee revenues. Applications for funding could be accepted solely from companies manufacturing consumer and commercial products, or could be accepted from any R&D organization. Alternatively, the fees paid by each company could be held in a trust account that could be accessed only by the contributing company, and only after the company had submitted a reasonable plan for research and development to reduce emissions. Ideally, technology developed with money from the technological development fund could be made available to all consumer and commercial products manufacturers. This feature may have added benefits for small manufacturers who are unable to conduct aggressive R&D on their own. However, requiring companies to give away the newly developed technology, and with it a competitive advantage, will also be a disincentive to apply for and use those R&D funds.

Employing a rebate scheme to refund fee revenues back to manufacturers could have a negative, positive, or neutral effect on the changes in behavior originally intended by the fee program. The most preferable scheme returns the fee revenues to the contributing sources without nullifying the original incentive to reduce VOC emissions. Four desirable qualities for the rebate scheme might include the following:

- The rebate scheme should be budget-neutral in each time period: there should neither be a surplus of unrebated fee revenues nor a deficit of excess rebates.
- The rebate that each company receives should be insensitive to any strategic action that company might take (such as increasing VOC content in any period).
- The rebate scheme should be insensitive to mergers, acquisitions, or divestitures in the industry. Furthermore, the rebate scheme should not encourage or discourage such actions.

- The rebate scheme should be able to accommodate and not discriminate against companies entering or retiring from the industry.

One rebate scheme that possesses most of these qualities is illustrated in Table 3-3. The first step in computing rebates is to determine a historical baseline that quantifies companies' shares of total VOC emissions. For example, sulfur dioxide allowances in the acid rain emissions trading program were initially distributed according to each utility unit's share of emissions in the base year. The same principle could be used to determine a historical baseline for consumer and commercial products, possibly using VOC emissions from consumer and commercial products in 1990. If no recent year by itself is appropriate for establishing an historical baseline, one could average shares of emissions over the past three or four years.

The rebate given to any company in the universe of sources is calculated by multiplying the total fee revenues collected in the year by the company's historical share of emissions. For example, in Table 3-3 Company A historically accounts for 50 percent of VOC emissions. The rebate given to Company A in period t is computed by multiplying the total amount of revenues collected in period t ($204,000 charged at $1 per unit of VOC) by the company's baseline percentage (50 percent), giving the Company a rebate of $102,000. Rebates in every year of the fee program for every company in the universe of sources are calculated on the same basis. The rebate scheme is budget-neutral in each period.

As shown in the table, this rebate scheme is insensitive to the acquisition of one company by another. When Company E acquires Company B in period t+1, Company E also acquires Company B's baseline share of emissions. The rebate scheme is also insulated against strategic behavior of companies trying to manipulate the rebate scheme to their advantage. For example, when Company F increases VOC emissions in period t, the company's net position after the rebate (indicated by the rightmost column in Table 3-3) is

TABLE 3-3
EXAMPLE OF PROPOSED REBATE SCHEME

Time: T Company	Historical Baseline (%)	VOCs (T)	Percentage of Current Emissions	Rebate (T)	Net to Company
A	50	95,000	47	102,000	7,000
B	5	9,000	4	10,200	1,200
C	6	8,000	4	12,240	4,240
D	3	7,500	4	6,120	-1,380
E	12	22,000	11	24,480	2,480
F	20	55,000	27	40,800	-14,200
G	4	7,500	4	8,160	660
H[a]	—	—	—	—	—
Total	**100**	**204,000**	**100**	**204,000**	**0**

Time: T+1 Company	Historical Baseline (%)	VOCs (T+1)	Percentage of Current Emissions	Rebate (T+1)	Net to Company
A	50	90,000	49	91,750	1,750
B	0	0	0	0	0
C	6	8,000	4	11,010	3,010
D	3	7,500	4	5,505	-1,995
E	17	30,000	16	31,195	1,195
F	20	41,000	22	36,700	-4,300
G	4	7,000	4	7,340	340
H[a]	—	—	—	—	—
Total	100	183,500	100	183,500	0

Time: T+2 Company	Historical Baseline (%)	VOCs, (T+2)	Percentage of Current Emissions	Rebate (T+2)	Net to Company
A	50	90,000	49	91,250	1,250
B	0	0	0	0	0
C	6	7,500	4	10,950	3,450
D	3	7,500	4	5,475	-2,025
E	17	30,000	16	31,025	1,025
F	20	41,000	22	36,500	-4,500
G	4	6,500	4	7,300	800
H[a]	—	—	—	—	—
Total	100	182,500	100	182,500	0

Time: T+3 Company	Historical Baseline (%)	VOCs, (T+3)	Percentage of Current Emissions	Rebate (T+3)	Net to Company
A	50	85,000	42	87,750	2,750
B	0	0	0	0	0
C	6	7,500	4	10,530	3,030
D	3	7,000	3	5,265	-1,735
E	17	29,000	14	29,835	835
F	20	41,000	20	35,100	-5,900
G	4	6,000	3	7,020	1,020
H	0	25,000	12	0	-25,000
Total	**100**	**200,500**	**100**	**175,500**	**-25,000**

[a] Company H enters the industry in period T + 3.

less in period t and in subsequent periods than it would have been if Company F had not increased emissions. This rebate scheme deters companies from increasing their emissions to obtain a greater share of the rebates.

Some form of discrimination against entering companies is difficult to avoid with this rebate scheme.[16] The fee payment made by a company during its first year of operation cannot be rebated to the company in a future year because the incentive for emission reduction would be nullified. Budget-neutrality would require that the fees be returned to the industry in some manner, but if the entering company's fees were distributed to existing companies, then it would be placed at a competitive disadvantage. An alternative is to channel new companies' fee payments into a fund that would subsidize technological development or some other purpose related to environmental improvement. New (as well as old) companies would be eligible for the subsidy, making the alternative less disadvantageous to them.

Rebates could also be combined with one of the other options for the use of program revenues. For example, the total amount of fees rebated could be limited to 50 percent of all fees collected in that year, and the remainder could be used to promote technological development or a product labeling program. An alternative is to set aside a percentage of total fee revenues for administration of the fee program. Still another alternative would be to use revenues to fund award programs for manufacturers who develop lower no-VOC technologies.

Promoting technological development could encompass subsidies for both research and development on low-VOC formulations of consumer and commercial products and research and development on VOC-free products that are substitutes for existing consumer

[16]This difficulty is shared by marketable emission permit programs in which the EPA freely grants permits only to sources who existed at the time of program initiation (see Section 4).

and commercial products. Subsidies for the latter are in accord with an approach to regulation that aims at reducing not just emissions from coatings but more generally the environmental impact of the means that consumers use to obtain the services provided by consumer and commercial products (Morton and Madariaga, 1993).[17] For example, the regulation of VOC emissions from paints and coatings could both increase the cost to coating manufacturers of using VOCs and subsidize the development or use of materials that do not require surface coatings.

Table 3-4 identifies several specific uses for fee revenues. Other uses are of course possible. Fee revenues could support any single use or a combination of uses.

TABLE 3-4

USES OF FEE REVENUES

- Fund public education program
- Fund labeling program for regulated products
- Subsidize research and development on low-VOC formulations
- Subsidize research and development on VOC-free substitutes for regulated products
- Direct revenues to U.S. Treasury for general use
- Direct revenues to the EPA to administer fee program
- Rebate revenues to companies in universe of sources

[17]An analogous objective guides demand-side management in the electricity market. Electricity is valuable because it is a source of energy for lighting and heating, which are directly consumed, not because electricity itself directly provides services that people value. The distinction between electricity and the services that it provides leads to a recognition that society may be better served by reducing electricity demand through increasing energy efficiency rather than by increasing the degree of pollution control at power plants.

Another consideration which bears on the desirability of rebates is their effect on the incentives for companies to create new products (i.e., technological innovation) and to adopt technologies invented by other companies (i.e., technological diffusion). The willingness of a company to promote innovation and diffusion—the two steps in technological change—depends on the company's potential private gain. A company's gain depends on the net change in profits from product manufacture and sale, gross fee payments, and rebates (if any). Different regulatory strategies imply different incentives to promote technological change (Milliman and Prince, 1989).

A fee program without rebates and a budget-neutral fee program imply different gains to companies from the overall sequence of technological change. Without rebates, the innovator's gain from creating a less polluting product equals the sum of the change in profits and the reduction in gross fee payments. The changes in profits and gross fee payments will be same with or without rebates because rebates do not affect product supply or demand. With rebates, the innovator's rebate from the government also could change, but a more realistic assumption is that his or her rebate stays constant because of this one company's small contribution to aggregate emissions. Therefore, both fee programs provide an equal incentive for innovation.

The effect of diffusion on the innovator comes from two sources: the change in its rebate and the change in its competitive advantage. Diffusion does not change the innovator's gross fee payments. Diffusion reduces the industry's emissions, thus reducing the size of the pool from which the innovator's rebate is drawn, and the innovator's rebate declines. Because the innovator also could lose its competitive advantage by providing its technology to competitors, the total incentive for diffusion is especially low in a fee program with rebates. Any loss in competitive advantage also occurs in an ordinary fee program. Therefore, the rebate provides an additional negative incentive to the innovator to promote

diffusion. The fee/rebate program is more disadvantageous to an innovator than an ordinary fee program, although the additional disadvantage is difficult to measure.

In summary, a budget-neutral fee program and an ordinary fee program equally promote technological innovation, but a budget-neutral fee program may slow the pace of diffusion of a new technology. This investigation shows that a tradeoff exists between enhancing technological diffusion and redistributing economic impacts on manufacturers through rebates.

The assessment of budget-neutral fee programs should also consider the implications of the special fund provision contained in Section 183 of the Clean Air Act.[18] Fee revenues would be deposited in a special fund in the United States Treasury. Withdrawals, including rebates, could be made only if authorized by annual appropriation Acts. The special fund provision may limit the usefulness of fee and rebate programs.[19]

3.11 INFORMATION NEEDS

Information needs fall into two categories: program design and program administration. The most important uses of information for program design are to determine the initial fee rate and to establish the baseline (VOC emissions) against which progress will

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[18]"Any amounts collected by the Administrator under such regulations [i.e., Federal consumer and commercial products regulations] shall be deposited in a special fund in the United States Treasury for licensing and other services, which thereafter shall be available until expended, subject to annual appropriation Acts, solely to carry out the activities of the Administrator for which such fees, charges, or collections are established or made" [Section 183(e)(5)].

[19]Nonetheless, important functions of budget-neutral fee programs can be performed by a certain type of emissions trading program. An emissions trading program in which the rate of emissions per unit of product (X grams VOC/unit of product) is capped is in important respects equivalent to an emission fee program with rebates. In a ratio-based emissions trading program, total emissions from the regulated sources are not capped, and each source creates permits when the VOC content of a product is below a particular threshold. Manufacturers of low-VOC products may sell permits to manufacturers of high-VOC products. The program is budget-neutral, the mass of emissions may increase as industry output expands, and the program avoids new-source bias. The absence of new source bias is an advantage that ratio-based trading programs have over fee/rebate programs. In addition, administrative costs might be lower because the government does not need to develop and operate an accounting system for rebates. Ratio-based trading programs are discussed more fully in Section 5.7 of this report.

be measured. The most important use of information for program administration is to monitor compliance. For concreteness and comprehensiveness, the discussion in this section assumes that the specific fee program involves a fee imposed in the input market, manufacturers and importers are legally responsible for paying the fee, and fees are rebated.

Table 3-5 lists information needs for program design. Some of these needs are more critical than others. The first part of the table lists the information needs when the design team sets the initial fee rate without using economic modeling. As discussed in Section 3.6 above, several means for doing so are possible, and the information requirements will differ accordingly. Consequently the table indicates that some of the requirements will be specified by the design team. The other requirements specified in the first part of the table allow the creation of the current emissions inventory, form the parameters of the rebate formula, and enhance the credibility of the expectation that manufacturers and users of consumer and commercial products can adapt to the increased cost of emissions.

The second part of Table 3-5 lists the information needs when the initial fee rate is set using economic modeling (for example, the model described in the *Industry Profiles and Technical Appendixes* document, Appendix B). The economic model could represent markets for solvents, propellants, other inputs, and consumer and commercial products. Information on the state of the markets, supply, demand, and technology would be employed. The specific data to be obtained and parameters to be estimated will vary with the consumer and commercial products being modeled. The *Industry Profiles and Technical Appendixes* document, Appendix B describes the information used to model a market system involving two coatings, two solvents, and two types of other inputs. This model uses 30 sales, price, and parameter values. Increasing the richness of the model by working with more specific manufacturing inputs or additional coatings would increase the information needs.

TABLE 3-5

INFORMATION NEEDS FOR THE DESIGN OF EMISSION FEE PROGRAMS

Initial Fee Rate Set Without Using Economic Modeling

- As required by design team
- EPA's administrative costs for the program
- Annual VOC emissions from regulated consumer and commercial products in a recent period (for example, 1989–1991) by manufacturer and importer
- Qualitative information on alternative formulations of existing consumer and commercial products
- Qualitative information on product substitution by product users

Initial Fee Rate Set Using Economic Modeling

- Annual VOC emissions from regulated consumer and commercial products in a recent period (for example, 1989–1991) by manufacturer and importer
- EPA's administrative costs for the program
- Qualitative information on alternative formulas and packaging of existing consumer and commercial products
- Qualitative information on product substitution by product users
- Purchases and prices of VOC-containing inputs
- Purchases and prices of other inputs
- Sales and prices of consumer and commercial products
- Elasticities of supply of VOC-containing inputs
- Elasticities of supply of consumer and commercial products
- Own-price elasticities of demand for consumer and commercial products
- Cross-price elasticities of demand for consumer and commercial products
- Elasticities of substitution between VOC-containing inputs and other inputs
- Cost-share of VOC-containing inputs in manufacture of consumer and commercial products
- Cost-share of other inputs in manufacture of consumer and commercial products
- VOC content of consumer and commercial products

Table 3-6 lists the information needs for program administration. The information would allow the EPA to determine the accuracy of fee payments, make rebates, calculate VOC emissions, and communicate changes in the fee rate.

TABLE 3-6

INFORMATION NEEDS FOR THE ADMINISTRATION OF EMISSION FEE PROGRAMS

- Name and address of every company in the universe of sources
- Fee rate adjustment mechanism
- Economic model to determine emission reductions due to program
- Remittance from every manufacturer and importer
- VOC content of each regulated product
- VOC content of sampled products
- Sales of consumer and commercial products by product and manufacturer and importer
- Rebate formula
- Reliable method for communicating with manufacturers and importers

3.12 SUMMARY OF DESIGN OPTIONS

The preceding sections describe various design options for a fee program to reduce VOC emissions from consumer and commercial products. These design options are summarized in Table 3-7 for programs of which the primary but, perhaps, not only purpose is to achieve VOC reductions at lower cost than is achievable with command-and-control regulatory strategies.

One specific example of a fee program is described in Table 3-8. The selection of options for this example is based on: (1) the administrative cost of implementing the program and (2) the ability to incorporate values related to the distribution of the cost burden

TABLE 3-7

SUMMARY OF FEE PROGRAM DESIGN OPTIONS

Design Element	Option 1	Option 2	Option 3	Option 4	Option 5
Program Purpose	Achieve VOC reductions at lower cost	Provide greatest incentives for technological change	Affect distribution of impacts	Combination of options	
Activity Charged	Impose fee in input market	Impose fee in wholesale product market	Impose fee at intermediate node in distribution channel		
Payer of Fee	Input user	Product supplier	Product demander		
Sources Included	All sources	Sources above size cutoff			
Phasing-in Sources	None	By size			
Fee Variability	With respect to season	With respect to VOC content	With respect to nonattainment status	With respect to emissions reduction progress	
Method for Setting Initial Fee Level	Economic model	Value of Federal/State marketable emission rights	Negotiation	Combination of methods	
Collection of Fees	Sources remit fees to EPA	Sources purchase VOC stamps from EPA			
Monitoring	Sources self-report VOC content & sales	EPA verifies reports	EPA checks remitted fees against VOCs in products	Combination of options	
Use of Revenues	Fund R&D for VOC-reducing technologies	Fund labeling and/or education programs	Rebate revenues	Pay for program administration	Combination of options

TABLE 3-8

EXAMPLE FEE PROGRAM DESIGNED TO MINIMIZE ADVERSE IMPACTS ON INDUSTRY

Design Element	Recommendation
Program Purpose	Achieve VOC reductions at lower cost
Activity Charged	Impose fee in input markets
Payer of Fee	Input user (product manufacturer and importer)
Sources Included	All "large" manufacturers and importers
Phasing-in Sources	By size
Fee Variability	With respect to emissions reduction progress
Method for Setting Initial Fee Level	Combination of methods
Collection of Fees	Manufacturers and importers remit fees to EPA
Monitoring	Combination of options
Use of Revenues	Rebate revenues to industry

(distributive flexibility). In addition, the program outlined in Table 3-8 intends to achieve a well-defined and predetermined environmental goal at a lesser cost than command-and-control regulatory strategies such as VOC content standards. The goal takes the form of a definite reduction (compared to the baseline), over a period of several years, in the quantity of VOC emissions from regulated consumer and commercial products.

The basis of the fee in this example program is the VOC content of consumer and commercial products rather than the product itself because the former type of fee leads to the least costly allocation of emission reductions. That consideration implies the desirability of an input fee.

Product manufacturers and importers could be legally responsible for paying the fee. Of all regulated entities involved in the manufacture and distribution of consumer and commercial products, manufacturers have the most knowledge about product formulas and packaging. A fee on solvents, propellants, and other VOC-containing inputs is a charge on the materials that are responsible for the air pollution from consumer and commercial

products. The emission fee would stimulate manufacturers to economize on the VOCs that are released during use of the product.

In the example program, initially only large companies would pay the fee. After some period of time, small companies might also be required to pay the fee or perhaps pay a lesser fee (which would interfere with achieving the least costly allocation of emission reductions).

Due to inflexibility in the timing of the use of consumer and commercial products, the fee may need to be uniform with respect to season. Geographical differentiation of fee rates is attractive, but the possibility of opportunistic transportation of regulated products across the boundaries of air quality regions makes this option contingent upon the demonstration of satisfactory program performance without intrusive monitoring. A fee with a variable rate structure may increase administrative and record keeping costs and would not lead to the least costly allocation of emission reductions. However, the environmental purpose of the program entails varying the fee with respect to emissions reduction progress in accordance with an adjustment mechanism similar to the one described in Section 3.6.

A combination of methods for establishing the initial fee rate may best address the affected parties' concerns over the difficulty of determining the desired fee. Economic modeling is the preferable method but may raise concerns over cost, or it may not be possible if sufficient information is unavailable.

To collect the fees and monitor companies' compliance with the program, the example program uses the self-reporting system in which manufacturers and importers send to EPA the total amount of fees owed and the data on which the fee payment was calculated. The data would provide valuable information for evaluating the success of the fee program and for compiling a complete emissions inventory. This collection method implies that the

states or EPA would have to check for companies' compliance with the regulations by random audits of companies' records and laboratory tests of the VOC content of regulated products.

Rebates can make the program budget neutral. In this way, adverse industry impacts may be minimized.

The example fee program suggests that distributional flexibility is of primary importance. If instead providing incentives for technological advancement is deemed of utmost importance, rebates would be less attractive. Rebates decrease incentives for technological diffusion. Further, revenues raised from fees could be used to fund research and development efforts to reduce VOCs. This discussion illustrates a tradeoff between distributive flexibility and promoting technological advancement.

3.13 REFERENCES

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SECTION 4

EMISSIONS TRADING PROGRAMS FOR REDUCING VOC EMISSIONS FROM CONSUMER AND COMMERCIAL PRODUCTS

A marketable emissions permit program or an emissions averaging program is an alternate way to obtain real and quantifiable reductions in the emissions of VOCs from the use of consumer and commercial products. A restriction on the aggregate quantity of emissions is essential to all marketable permit programs. In contrast, a VOC content standard—a maximum proportion of VOCs—is essential to emissions averaging programs. Marketable permit programs and emissions averaging programs have in common the "trading" of emissions; the trades may occur within companies and between companies (although emissions averaging programs do not generally entail external trading).

The most important difference between the two types of programs is that marketable permit programs place a cap on emissions from the universe of sources, but emissions averaging programs allow aggregate emissions to increase. Their most important similarity is that they allow companies much more flexibility in choosing strategies to reduce emissions compared to product-specific VOC content standards, which are the command-and-control analog to economic incentives for consumer and commercial products.

This section emphasizes marketable permit programs because the relative advantages of these programs are substantial and because these programs are most consistent with the goal of achieving a given emissions reduction at least cost. Section 4.10 considers emissions averaging programs.

For the most commonly discussed types of marketable permit programs, the quantity restriction is on either pollutant concentration measured at specified air quality monitors or

aggregate emissions of a pollutant.[1] Thus the restriction ensures the achievement of the environmental goal regardless of changes in the economy, including the expansion of production of existing products and the introduction of new products.

Equally important, companies may "trade" emission reductions in a marketable permit program, and they have the incentive to seek potential trading partners.[2] Opportunities for trade exist when the incremental or marginal cost of emission reductions differ in the industry. Emission reductions are costly to a company because it undertakes research and development, changes the manufacturing process or inputs, or experiences losses due to product substitution and other adaptations by product users. The consumer and commercial products industry is diverse, and manufacturers very probably will reduce emissions through unique combinations of the options just sketched. Therefore the marginal cost of emission reductions is likely to vary from company to company, and the company for which a reduction is more expensive will pay another company (i.e., one with lower costs) to reduce emissions. The benefit to the former company is reduced costs, and the benefit to the latter, increased profits. If the market for permits functions well, permit trades will occur whenever marginal costs differ.

A marketable permit program allows companies the flexibility to determine the best (for them) method of reducing emissions. Such a program reduces the information burden on the EPA, promotes search for the least expensive emission reductions, and continually stimulates technological change (to reduce the marginal and hence total costs of emission reductions).

If the States or EPA were to regulate (by product) the VOC content of consumer and commercial products, then these products would be more homogeneous within a product category because the maximum VOC content of each product would be lower than it is now.

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[1]The first type of program is commonly referred to as an ambient permit program, and the second and more common, an emission permit program.

[2]Program participants literally trade permits.

Companies might face a narrower range of options for further reducing VOC emissions. The marginal costs of emission reductions may be higher than under a marketable permit program.

The SO_2 allowance trading program mandated by the 1990 amendments to the Clean Air Act has strongly influenced the following discussion of marketable permit programs for reducing VOC emissions from consumer and commercial products. The SO_2 program is relevant because the characteristics of the pollutant that are significant for designing economic incentives are similar to the significant characteristics of VOCs: uniform mixing in the atmosphere and assimilation.[3] Also, the SO_2 program has proven to be politically acceptable. It therefore provides valuable insights into designing an effective and politically acceptable marketable permit program for consumer and commercial products.

Just as Congress established an annual cap on SO_2 emissions from power plants, the EPA could establish an absolute maximum (per defined time period) for the quantity of VOCs contained in and hence emitted by all or some subset of the regulated consumer and commercial products. To start the program, EPA could distribute this aggregate level of emissions in the form of VOC emission permits to the manufacturers and importers of the regulated products included in the universe of sources. Each company in the universe of sources would own permits (denominated, for example, in tons of VOC per year) which it could retain or sell to other participants in the program. Companies would be required to possess a sufficient number of permits to cover the total quantity of VOCs contained in their domestically sold products. Companies could trade permits according to considerations of profitability.

The design of an implementable marketable permit program is complex because of the many details and options for these programs. The most important are examined below.

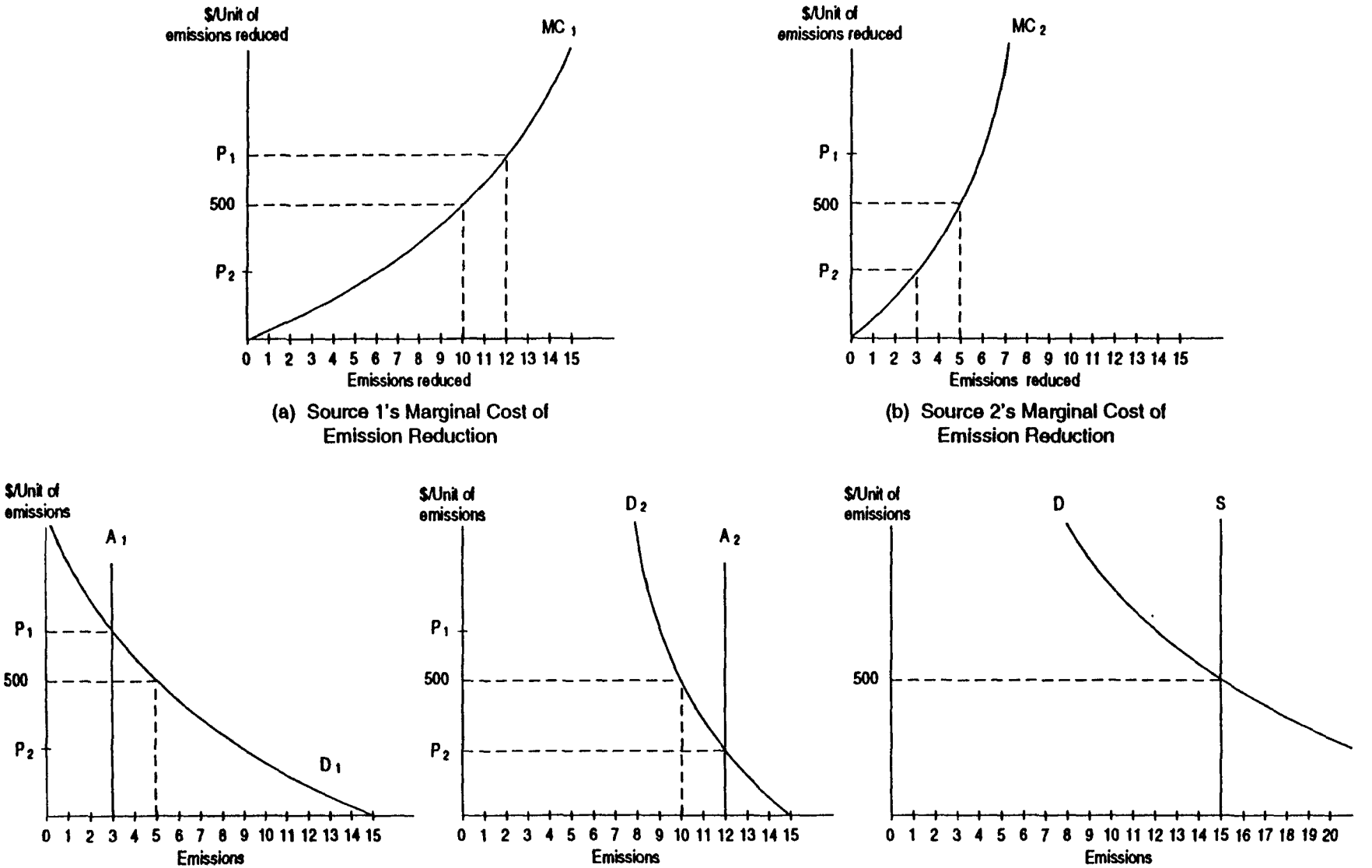
[3]See Section 1.1 above.

4.1 PURPOSES OF A MARKETABLE PERMIT PROGRAM

A primary purpose of a marketable permit program is to achieve a reduction in VOC emissions at lower overall expenditure on pollution abatement than the most likely command-and-control regulatory strategy, product-specific VOC content standards. Another important purpose is to provide a continual incentive for cost-reducing technological change that is potentially beneficial to the environment.

Figure 4-1 illustrates the basic operation of a marketable permit program. Overall, Figure 4-1 describes the derivation of each source's demand for permits and in turn the aggregate demand curve for permits, which, in conjunction with the fixed supply of permits, determines the price of an emission permit. The figure also shows how the permit market leads to the least expensive allocation of responsibility for emission reductions. Lastly, the figure illustrates that, in a competitive market, any initial allocation of permits is consistent with the achievement of least cost.

Each source emits 15 units of pollutant in the absence of emission control. Panels (a) and (b) in Figure 4-1 show the marginal cost of emission reduction for Sources 1 and 2, respectively. The marginal cost curves are the same as in Figure 3-1, which illustrated the basic operation of an emission fee program. The marginal cost curve implies the emission permit demand curve because, for any quantity of emissions reduction, the source will demand permits for the remaining emissions at the price indicated by the marginal cost curve. A source has found its optimal level of control when it is indifferent between increasing emissions (purchasing a permit) or decreasing emissions. For example, when Source 1 has reduced emissions by 10 units, its marginal cost of emissions reduction is $500, and the source is willing to pay $500 for the last permit purchased. Similarly, when the first source has reduced emissions by 12 units and demands 3 permits, the marginal cost of emissions reduction and the source's willingness-to-pay



(a) Source 1's Marginal Cost of Emission Reduction

(b) Source 2's Marginal Cost of Emission Reduction

(c) Source 1's Demand for Emission Permits and *Initial Allocation*

(d) Source 2's Demand for Emission Permits and Initial Allocation

(e) Aggregate Emission Permit Supply and Demand

Figure 4-1. Emission Permit Market

for a permit equal P_1, as indicated by panel (a). The rationale for the second source's demand curve is the same. Panels (c) and (d) portray each source's permit demand curve.

The aggregate permit demand curve is obtained by the horizontal summation of each source's demand curve. Panel (e) shows the aggregate demand curve and the aggregate supply curve, which is vertical at 15 units because in this example the regulator has set the environmental goal at 15 units of emissions. The price which clears the market is $500 per permit.

To initiate the permit program, the regulator could allocate 3 permits to Source 1 and 12 permits to Source 2. Initially, Source 1 would be responsible for reducing 12 units of emissions, and Source 2, 3 units. Assuming negligible transaction costs, trading would occur: Source 1 would prefer to buy permits from Source 2 at a price less than P_1, and Source 2 would be willing to sell them at a price above P_2, which is less than P_1. The marginal costs of emissions reduction are different ($P_1 > P_2$), giving both sources the incentive to trade. Source 1 will buy a permit if it obtains a net reduction in costs (including transfer payments), and Source 2 will sell a permit if it obtains a profit. In the example, Source 1 buys just two permits. Source 1 reduces emissions from 15 units to 5, and Source 2, from 15 units to 10. Trading establishes the permit price of $500.

As in the example of the emission fee program (see Figure 3-1), that allocation of responsibility between the sources for emission reductions requires the least expenditure on pollution abatement. Another similarity is that the correct fee rate and market-clearing permit price are both $500 (and must be equal for the programs to achieve the same environmental goal).

To summarize, the equilibrium allocation of responsibility for emission reductions clears the permit market and equates the marginal costs of emissions reduction across sources. The

permit program, by allowing trading, achieves the environmental goal while requiring the minimum total expenditure on emission reductions. In a competitive permit market, any initial allocation of permits is consistent with cost-minimization in the short-run, although the pattern of permit buying and selling and the consequent inter-company transfers will vary across allocations.

4.2 FUNDAMENTAL ATTRIBUTES OF THE PERMIT

Under a marketable permits program, the emission permit is the tradable commodity. The environmental purpose of the program is incorporated into the type of permit. Sources base their valuation of a permit on the specific attributes of the permit. This section discusses the attributes of the permit that are fundamental in the sense that they are essential to the definition of the permit regardless of any further specification of the permit.

4.2.1 Detraction

The possible mechanisms for allocating marketable emission permits lie on a spectrum: at one extreme, the government would own the entitlement to emit air pollutants and sources would pay to pollute; at the other extreme, sources would own the entitlement to pollute and the government would pay to improve the environment (Tietenberg, 1980: p. 399). The acid rain program shows that a third mechanism is also possible: the EPA, even though it owns the entitlement, will freely grant SO_2 allowances to utility units. Therefore the issue of who pays to obtain an initial allocation of permits is conceptually separate from the issue of who initially owns the entitlement. Although the Federal government is the initial owner of the entitlement, an issue related to ownership that must be resolved is the right to rescind or diminish emission permits from their current owner without compensation.

The acid rain program assigns this right—referred to as detraction—to the EPA. At any point in time, the EPA may reduce the number of SO_2 allowances to conform emission reductions to the emissions cap.

Detraction is important because the EPA, sometime after the start of a marketable permit program, may find that air quality has not improved sufficiently. The complexity of the program may have inadvertently resulted in an excessive level of emissions, or societal goals for environmental quality may have increased. The only backstop measure that preserves the integrity of a marketable permit program is a reduction in the number (or lower denomination) of permits and hence emissions from the participants. If the EPA were to possess the right of detraction, it would be able to act unilaterally to enhance the stringency of the program without committing an unconstitutional taking of the detracted permits.

Although a discussion of the EPA's authority is beyond the scope of this report, it is appropriate to observe that Title IV of the Clean Air Act Amendments of 1990 appears to give an unlimited right of detraction to the Federal government.

> An allowance allocated under this title is a limited authorization to emit sulfur dioxide in accordance with the provisions of this title. Such allowance does not constitute a property right. Nothing in this title or in any other provision of law shall be construed to limit the authority of the United States to terminate or limit such authorization (Section 403(f)).

The acid rain program may provide a precedent for assigning the right of detraction to the EPA for the purposes of implementing a marketable permits program for consumer and commercial products.

Possession of the right is not costless. If a company is uncertain over whether it will continue to own an excess permit, then the value of future use or sale is less than when the government does not possesses the right of detraction. One potential cost of this assignment of rights is that permit owners may be less certain of the future value of permit holdings, increasing

reluctance to bank permits and to engage in intertemporal trades. Therefore, the efficiency of the permit program may be somewhat reduced.

One criticism of marketable permit programs asserts that detraction, viewed as a virtual necessity due to the "extreme uncertainties involved in calculating sustainable levels of pollution" (Colby, 1991: p. 206), is made costly by permit owners' demand for compensation. This evaluation overlooks the possibility of creating a marketable permit program without establishing new private property rights.

4.2.2 Ambient Permit or Emission Permit

Depending upon the environmental problem, the tradable commodity could be either an ambient permit or an emission permit. Emission permits allow emissions per se, but ambient permits allow air quality impacts at specific monitoring sites. Ambient permit programs are more efficient when emissions from different sources impose different air quality impacts. However, ambient permit programs are more complex, requiring detailed air quality modeling information.

Volatile organic compounds are precursors to the formation of tropospheric ozone, and they mix uniformly in the atmosphere with the other precursors. The total quantity of precursor emissions in an airshed but not necessarily the location of the sources influences the concentration of ozone. For a uniformly mixed, assimilative pollutant, an emission permit program is cost-effective because control of the total quantity of emissions is sufficient to achieve an environmental goal at least cost (Tietenberg, 1985: pp. 16–22). Therefore, a marketable permit program for consumer and commercial products that employs emission permits would not require air quality modeling information and may be as effective as an ambient permit program.

For purposes of quantification, it would be assumed that emissions occur in the year in which the product is manufactured in the United States or imported. The assumption would be imprecise if either manufacture and distribution occur in different years or purchase and use occur in different years. Although some manufacturers, distributors, and users probably behave in ways that have those consequences, the resulting discrepancy between assumed and actual emissions is probably negligible and would not justify changing the methodology for quantifying emissions. Most important, any discrepancy would not affect the incentive to reduce emissions.

The emission quantification method treats as equivalent the emission reductions that occur from redesign of the product or package and the reductions from operational contingencies (i.e., production curtailments and shut-downs).[4] This aspect of quantification is appropriate because neither the particular means which sources employ to reduce emissions nor the motivations for the emission reduction are significant to the achievement of the environmental goal of a marketable permit program.

4.2.3 Emission Allowances or Emission Reduction Credits

In the acid rain trading program, the Phase I emission limitation for each included utility unit is 2.5 pounds of SO_2 per million BTUs of fuel combusted during the base year, and each unit receives as a free grant from the EPA the implied number of SO_2 allowances less a fraction retained by the EPA for special reserves. (Therefore, the emission limitation exceeds the allocation of allowances.) Each unit's control requirement equals the excess of actual emissions over the allocation of allowances.[5] The key point is that the commodity in the program is an emission allowance rather than an emission reduction credit, which is valid only after

[4] Add-on controls (for example, paint booths with carbon absorbers) are generally infeasible for consumer and commercial products. Reductions in VOC emissions can come from reformulation, packaging redesign, and reduced production.

[5] Trading allows utilities to comply with the control requirement by achieving on-site emission reductions or acquiring allowances from other utility units.

government certification, prior to trading or banking, of over-control of emissions and which can be used only in trades approved by the government.

With emission allowances, the EPA's certification of a participant's compliance with the program occurs at an aggregate level instead of the level involving individual emission reductions and trades. At the end of the year (or other defined period), the EPA would compare each participant's actual emissions to its permit holdings for the year. A participant is in compliance with the permit program if its emissions do not exceed its holdings. Emission allowances may involve less administrative costs, may provide more certainty to participants, and may allow trades to occur sooner.

4.2.4 Banking Provisions and Duration of Permits

A very important objective of establishing a permit market is cost-effectiveness: in a competitive market, buyers and sellers of emission permits will exhaust all mutually beneficial trades and reduce emissions with the least total expenditure on abatement. To achieve these gains, different sources will trade with each other. Some sources will assess current and future demands for permits and conclude that their best interest is served by reducing emissions now and selling or using permits in the future—banking permits. Restrictions on current or intertemporal trading reduce the potential gains from trade and increase the aggregate expenditure on abatement.

Allowing sources to bank permits for an indefinite period conduces to the minimization of emission reductions cost but may increase administrative costs.[6] Banking also makes possible an increase in emissions in some future but predictable year. Thus banking implies a tradeoff between cost-minimization and certainty about future emissions in any particular year.

[6]If detraction applies to active permits, then it should also apply to banked permits.

4.3 SEASONAL AND GEOGRAPHICAL DIFFERENTIATION OF PERMITS

4.3.1 Seasonal Differentiation

The national ambient air quality standard for ozone specifies that the daily maximum hourly average concentration (0.12 ppm) shall not be exceeded more than once a year. Because of the chemistry of ambient ozone formation, peak concentrations "typically occur during hot, dry, stagnant summertime conditions (high temperature and strong solar insolation)" (U.S., EPA, OAQPS, 1991: p. 3-29). Emissions of VOCs during warm weather are more likely to result in a high peak hourly concentration than emissions during cool weather.

For that reason seasonal differentiation of permits could be desirable. Two types of permits could be created: one for VOC emissions during the ozone season and the second for the rest of the year (the "off-peak season"). The price of the ozone season permit would be higher because greater emission control would be required to reduce the formation of ozone. Sources would economize on emission control by switching emissions from the ozone season to the off-peak season. Therefore, the most cost-effective—with respect to the cost to reduce ozone rather than VOCs—marketable permit program may involve seasonally differentiated permits.

However desirable seasonal differentiation is in theory, a major problem would arise when applying this idea to a marketable permit program for consumer and commercial products. The primary purpose of the program would be to reduce emissions of VOCs from the use—not manufacture—of consumer and commercial products. Therefore, for the seasonal differentiation of permits to result in a seasonal shift of emissions, the program must shift the use of consumer and commercial products to the off-peak season.

The problem arises because, in a program whose universe of sources conforms to the statutory definition of regulated entity, the owners of permits generally will not be the users of consumer and commercial products, and the incentives for switching to off-peak use would be

weak. The price differential of emission permits may induce a price differential in consumer and commercial products: within a product category, a product made from "ozone season" VOCs would be more expensive than a product made from off-peak season VOCs. Product users would respond by shifting the timing of purchase but not the timing of use. For example, users of architectural and industrial maintenance coatings may still favor application of the coating during the ozone season because of superior adhesion to the substrate and shorter drying time. They may respond to the coating price differential by buying coatings when they are cheap (i.e., during the off-peak season) and applying them when the weather is warm (i.e., the ozone season). The response would defeat the purpose of the program (and bid up the price of the cheaper coating, nullifying the impact on coating users).

One can imagine an enforcement scheme that would guide behavior in the preferred direction, but the requisite monitoring of many thousands of users would be extremely intrusive and expensive. Seasonal differentiation of permits appears to be inappropriate for reducing VOC emissions from using consumer and commercial products—unless a more acceptable approach to monitoring is found.[7]

4.3.2 Geographical Differentiation

Tropospheric ozone is a regional pollutant. Emission reductions in one nonattainment area or transport zone, for example, Los Angeles, improve air quality in Los Angeles but do not affect air quality in San Francisco, Houston, or any other nonattainment area.

The regional nature of the ozone problem is an argument for geographically differentiated permits: every regulated entity in the universe of sources could hold emission permits for each nonattainment area or transport zone in which the entity's consumer and commercial products

[7]The temporal differentiation of permits also could include diurnal and episodic dimensions (Tietenberg, 1985: pp. 149-167)) but the monitoring problem is similar.

emit VOCs. Theoretically, geographical differentiation would allow the EPA to exactly limit emissions from the consumer and commercial products used in an area.

For example, in the program with the greatest geographic differentiation, if the universe of sources consists of manufacturers, then every manufacturer would be required to hold the requisite number of permits to cover the emissions from products used in Los Angeles, Houston, and every other nonattainment area in which its products are used; if its products are used in every nonattainment area, then the manufacturer would be required to hold as many types of permits. Because this program strictly incorporates the principle that emissions in different areas have different and incommensurable effects, permits could not be traded across geographical boundaries. If instead it is decided that the effect of emissions in one nonattainment area is the same as the effect of emissions in another area, then both areas should be treated as one for the purposes of structuring the permit market.[8] The comparative effect of emissions in different areas is a crucial parameter for geographically differentiated marketable permit programs.[9]

An economic consideration that is relevant to the determination of the number of permit markets is the impact of increasing geographical differentiation on the competitiveness of the permit market. It is reasonable to conjecture that the smaller the nonattainment area—in which size is probably most usefully and simply defined as population—the smaller the number of different manufacturers of the same type of consumer or commercial product. As the number of potential trading partners decreases, fewer trades occur because the cost of finding a suitable partner increases, and dominance of the market by one buyer or seller becomes more likely. The

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[8] Between these extremes is the intermediate case in which the effect of emissions in one area is proportional to the effect of emissions in a different area. The corresponding permit program creates as many types of permits as areas but allows trading across areas, the relative exchange ratio being determined by the "transfer coefficient" or constant of proportionality.

[9] A permit program with geographically differentiated permits requires a greater expenditure on administration by the EPA and permit holders, reducing somewhat the gain from a more desirable spatial pattern of emissions. A compromise between differentiation and ease of administration can be achieved with a hybrid program in which small sources participate in a national system, but large sources participate in multiple regional systems (Tietenberg, 1980: p. 407).

reduction in competitiveness reduces the abatement cost savings achievable with the permit program.[10]

It is also appropriate to repeat the conjecture that the incentive to product users to transport products across boundaries to take advantage of price differentials (reflecting differences in permit price) leads to an ineffective program without extremely intrusive monitoring. Therefore, the benefits of geographic differentiation come at the price of increasing the monitoring of users and decreasing the cost-effectiveness of marketable permit programs.

4.4 UNIVERSE OF SOURCES

The universe of sources refers to the regulated entities who participate in the marketable permit program. The potentially regulated entities are manufacturers, processors, wholesale distributors, and importers of consumer and commercial products (Clean Air Act Amendments of 1990, Section 183 (e)(1)(C)). The definition of potentially regulated entity excludes suppliers of the raw materials for the manufacture of consumer and commercial products and, at the opposite end of the product distribution channel, retailers and users.

The following characteristics of regulated entities are relevant to the selection of the universe of sources:

- type of product,
- type of business, and
- size.

Each characteristic implies a criterion for determining whether a potential participant will be in the universe of sources; inclusion may also depend upon the simultaneous satisfaction of multiple criteria. Much of the discussion of the significance of type of product, type of business, and size for the universe of sources in fee programs is relevant to marketable permit programs;

[10]The deterioration of competitiveness could be offset by increasing the scope of the universe of sources to include additional products.

that material is repeated below. Permit programs do present unique issues such as the participation of environmental organizations and the elective participation by regulated entities that opt-in. These issues are also discussed below.

4.4.1 Selection of Sources by Type of Product and Sequence of Regulation

The greater the variety of consumer and commercial products that are included, the greater the opportunities for permit trading. A corollary is that a permit buyer is more likely to find a permit seller who does not compete in the product market. Increasing the variety of included products increases emissions reduction cost savings.

The universe of sources and the calculation of the emissions limitation are linked in the most efficient permit programs. If the universe of sources is planned to expand in the future via the inclusion of additional product categories, then determination of the emissions limitation formula at the outset enhances the ability of future program participants to undertake strategic planning and hence reduces the aggregate cost of emissions reduction.

The SO_2 trading program allows the universe of sources to change over time, and provides a model for the consumer and commercial products program. The SO_2 program has two phases. During the first phase, the universe of sources includes only large utility units that also have a high emissions rate. During the second phase, nearly all other utility units are added to the universe of sources. All sources know the formulas to be used to determine their emissions limitation.

This feature of the SO_2 trading program required the Congress to choose an overall cap on emissions. Similarly, the EPA may need to choose an overall cap on VOC emissions to minimize costs in an expanding permit program for consumer and commercial products.

Another issue in the selection of regulated entities for inclusion in the universe of sources is the grouping of products by priority of regulation. Although the identification of those groups is beyond the scope of this report, it is germane to consider whether the sequence of regulation should influence other elements of the design of marketable permit programs.

4.4.2 Selection of Sources by Type of Business

Product manufacturers control VOC emissions from the use of consumer and commercial products by changing solvents, changing propellants, redesigning packaging (for example, substituting a pump sprayer for an aerosol can), reducing production, and reformulating paints and coatings to reduce emissions during film-forming. Manufacturers are good candidates for participation in a permit program because the incentives provided by potential sale of emission permits motivates appropriate responses. To extend the coverage of the permit program to imported products, importers also should be included in the universe of sources.

However desirable the inclusion of manufacturers and importers, distributors are also potential participants. A practical problem with operating the permit program at the level of the distributor is ensuring complete coverage of emissions because some but not all consumer and commercial products pass through a distributor on their way to a retail outlet. Complete coverage could be ensured by defining "distributor" sufficiently broadly.

Distributors can discontinue products, carry other products than what they have been carrying, and increase wholesale prices. These responses to the permit program would motivate users of consumer and commercial products to change purchasing patterns and would provide information to manufacturers on the salability of products with different VOC content. Manufacturers would then be prompted to reformulate products, to redesign packaging, and to discontinue some products. Therefore manufacturers would receive the same incentives as if they participated in the permit program, but the incentive would be indirect.

A distributor-based program achieves the same environmental goal as a manufacturer-based program, but increases administrative costs for both the EPA and sources. Administrative costs are higher because the number of participants is greater: there are typically more distributors than manufacturers and, in addition to distributors, manufacturers who distribute products directly would need to be included.

4.4.3 Selection of Sources by Size

The size (e.g., quantity of emissions, value of sales, etc.) of a source is relevant to the construction of the universe of sources for two reasons. First, the EPA must consider the economic impact of proposed regulations on small businesses and develop alternatives when the impacts are onerous. Second, the exemption of "small" sources from mandatory participation in the marketable permit program may benefit both the source and the EPA without substantially affecting the effectiveness or efficiency of the program. Although this report does not investigate the magnitude of small business impacts of marketable permit programs, it is desirable to briefly investigate the conditions under which they might arise and to consider adaptations of the permit program.

Any source which participates in a marketable permit program evaluates its own demand for permits, searches for buyers or sellers of permits, judges offers, and complies with reporting and record keeping requirements. Those activities may be costly, and although the costs correlate with the volume of trade, it is reasonable to expect that costs will be proportionately greater for small sources than for large sources. The EPA will also incur costs in identifying and communicating with small companies and keeping the appropriate records. The value of the emission reductions obtained from small companies as a result of their participation in a permit program may not outweigh the total costs (including the companies' costs and the EPA's costs) of including these companies in the universe of sources.

A small number of product manufacturers appear to be responsible for a large percentage of sales (see Table 2-2). Therefore it may be possible to control a large percentage of VOC emissions from consumer and commercial products by including only a small number of companies in the permit program.

A selection criterion based on size, however desirable from the standpoint of reducing costs, could have some unintended consequences. First, after the division of large and small sources was determined (where large sources are included in the universe and small sources are not), a mechanism would have to be designed to handle small sources which grow and become equal in size to large sources. Second, basing inclusion in the universe of sources on company size could provide an incentive for large companies to divest themselves of some product lines. As new, smaller companies were set up to manufacture the products, they could conceivably be small enough to be excluded from the universe of sources. (Exclusion may not be problematic if these small companies were to be subject to VOC content standards rather than exempt from regulation.) Third, including only a small number of large manufacturers in the universe may not provide for active trading in the market for permits because of too few buyers and sellers and could enhance the likelihood of permit price manipulation.

Independently of the sequence of regulations, sources included in the permit trading program could be phased-in. For example, on the basis of volume of emissions, the largest manufacturers or distributors and importers could be selected for inclusion in Phase I of the program.[11] All other manufacturers, distributors, and importers then could be added to the universe of sources in Phase II.

[11]The universe of sources should also be sufficiently large to create an active and competitive permit market.

4.4.4 Opt-Ins

Another way in which the universe of sources could expand over time is to allow manufacturers and importers to "opt-in" to the permit program. Opting-in could encompass 1) the voluntary inclusion of a company who would not otherwise be included in the universe of sources and 2) a company already included in the universe of sources could elect to have additional product lines (other than its regulated consumer and commercial products) included in the permit program.

Depending upon the sequence of regulations and the universe of sources to be regulated, additional consumer and commercial products releasing VOCs would be outside of the reach of a permit program. Opting-in would allow the permit program to increase the VOC emissions brought under control and enhance trading opportunities, thus providing additional compliance flexibility to all participating sources and reducing abatement costs. Because opting-in would be voluntary, companies electing to participate would only do so if they anticipated making profits from permit sales or if they were subject to more costly alternative regulatory requirements (e.g., content standards). No company would have anything to lose from having the freedom to opt-in to the permit program.

Opting-in requires a procedure for allocating permits to opting-in sources. The SO_2 trading program provides an example. Sources that opt-in to the SO_2 program receive an allocation of emission allowances from the EPA based on the following formula (Lock and Harkawick, 1991, p. 21):

$$\text{Unit's baseline fossil fuel use} \times \left(\begin{array}{c}\text{lesser of its actual or} \\ \text{allowable 1985 } SO_2 \text{ emissions rate}\end{array}\right)$$

In the consumer and commercial products program, opting-in sources could receive permits according to a formula that similarly takes into account either actual or allowable emissions.

4.4.5 Participation in a Marketable Permit Program by Environmental Organizations

The EPA could extend participation in the program to groups outside the consumer and commercial products industry, specifically, environmental interest groups. The value that environmental interest groups attach to marketable permits is based on the emission reductions to be obtained by permanently removing the permits from circulation and use by manufacturers, distributors, or importers. The discussion also applies to other external groups such as local environmental agencies and city governments.

There are two opportunities for environmental organizations to participate in a marketable permit program: during the initial allocation of permits and in the trading of permits. If the EPA employed an auction to distribute a finite number of permits, environmental organizations could participate in the auction and purchase as many permits as they desired and could afford. Their interest in participating in the auction presumably is due to the ability to reduce the aggregate emissions by taking permits out of circulation.

The second possible opportunity for environmental organizations to actively participate in the program is to buy and sell permits in the market. If an environmental organization wanted to reduce the number of permits that could be used during a particular time period, it could offer to purchase permits from existing sources or the EPA if it has a permit reserve. Likewise, existing sources that had generated excess emission reductions could potentially find buyers for permits in environmental organizations.

There are advantages and disadvantages to allowing environmental organizations to participate in a marketable permit program. One potential advantage is direct, continuing public participation in the determination of the amount of environmental protection. If, in setting the overall emission cap, the EPA underestimates the amount of environmental protection society wants, then public participation in the permit market may be desirable.

A related argument for including environmental organizations in permit trading is that the organizations' purchase of permits could make the permit program more responsive to changing environmental conditions and technological change. For example, if the introduction of a new technology reduced the marginal costs of abatement, or if new information substantiated an increase in the estimated marginal damage of emissions, then environmental organizations could purchase permits and hold them indefinitely. In this situation, adaptation of the program to changed circumstances (new technology or new information on damages) may occur faster than if the government were to change the program (by reducing the emissions cap).

One potential disadvantage of allowing participation by environmental organizations is that the additional demand for permits that they create could make it less costly for existing sources to engage in anti-competitive behavior. For example, an existing source that generates excess emission reductions can either sell or bank the extra permits. There is an opportunity cost to the source in hoarding permits (from competitors) in the form of foregone revenues from the sale of the permits. By selling to an environmental organization, the source can reduce its opportunity cost of taking permits out of circulation by the amount which it receives from the environmental organization for the sale of the permits. A second, though probably minor, disadvantage to allowing environmental organizations to participate in the permit program is that it may raise the costs to administer the program.

One frequently encountered objection to environmental organization participation is that environmental organizations have had their opportunity to participate at the stage of program design and formulation of the environmental goal. The objection expresses the concern that environmental organizations, if allowed to buy and sell permits, would buy enough permits to restrict industry growth. However, existing sources could voluntarily decide whether to sell permits to environmental organizations. If sources legitimately were to feel that environmental organization purchases of permits would restrict their growth, they could simply refuse to sell permits to environmental organizations.

The issue of participation by environmental organizations in permit markets may be of minor importance given the limited budgets of these organizations. Oppenheimer and Russell (1981) suggest that environmental organizations are not likely to have sufficient funds to purchase a significant number of permits and that their resources might be more effectively spent lobbying the legislature in an attempt to influence the environmental goal, initial distribution of permits, and trading rules. They conclude that allowing environmental organizations to participate in the permit market would not significantly reduce the supply of permits available to existing sources and hence would not threaten the continuing operation of these sources.

4.5 ENTRY AND RETIREMENT OF SOURCES

The previous section described how the universe of sources may change when sources are phased-in over a period of time or when companies not originally included in the universe opt-in. The universe of sources may also change when new companies enter the consumer and commercial products industry and when existing companies cease to exist. This section discusses program design issues that arise in connection with entering and retiring companies, including the expansion of existing companies.

The entry of new sources is potentially important to the total cost of emission reductions obtained through the permit trading program and is relevant to the maintenance of a competitive, dynamic consumer and commercial products industry. When new manufacturers enter an industry, they are likely to enter with modern technology and equipment. Modern technology can include new and possibly cheaper products which result in lower VOC emissions. In addition to contributing less expensive emission reductions, new sources may also lower production costs, increase competition, and offer new products to consumers.

The retirement of inefficient existing companies is also important in a productive economy. Less efficient consumer and commercial products manufacturers with older

equipment and technology are likely to face higher costs to obtain emission reductions than new manufacturers. In addition, older factories are likely to have higher production costs. A permit program should not impede the retirement of inefficient plant and equipment. Therefore a permit program should develop a method for handling the entry and retirement of sources.

4.5.1 Entry of New Sources

If new sources are required to participate in a permit program, and hence required to hold permits for their emissions, there are two potential sources for them to obtain permits: existing sources (and brokers) and the EPA. If new sources can obtain permits only from existing sources, then, if the permit market is thin, existing sources could act strategically to deny new sources the permits they need to begin operation. Theoretically, this treatment of new sources could lead to a decrease in competition in the product market.

Note that an existing source expanding operations is analogous to a new source. Existing sources could act to prohibit another existing source from expanding operations by refusing to sell permits or charging discriminatory prices. Therefore similar concerns about the ability to obtain additional permits also arise for expanding sources.

Tietenberg (1985, p. 140) observes that the likelihood of predatory behavior—discriminatory permit pricing—by existing sources declines with the heterogeneity and number of sources. The potentially regulated consumer and commercial products are very diverse, and they are made by thousands of manufacturers. More specifically, as Table 2-3 (above) shows, some potentially regulated industries produce few commodities made by some of the other potentially regulated industries. For example, in the year covered by the table, the manufacturers of paints and allied products (SIC 2851) did not produce any commodity also produced by the manufacturers of cosmetics and toiletries (SC 2879) and vice versa. The manufacturers in these two industries are unlikely to compete in the product market, and would have nothing to gain

from discriminating against each other in the permit market. Other similar examples can be found. Information on the products made by each manufacturer could be used to evaluate the potential for permit trades to occur between companies that do not compete in the product market. In addition, allowing manufacturers and importers of unregulated products to opt-in would enhance the breadth of the universe of sources. A judicious construction of the universe of sources—its size and composition—appears to be able to protect new and expanding sources.

To provide additional protection to new and expanding sources, the EPA could reserve a number of permits from the initial allocation to existing sources. There are two basic implementation issues that need to be addressed if permits are to be reserved. One is how many permits ought to be reserved from the initial allocation and from whom the permits should be obtained. Because existing sources may refuse to sell a new source any permits at all, the minimum number of permits to be reserved should equal the number of permits new sources would need to begin operation. Equity may require that the burden of providing permits should not be concentrated on a subset of existing sources and hence the responsibility for creating the permit reserve should be shared equally by existing sources. This sharing could be accomplished by reserving an equal percentage of each existing source's initial allocation, the sum of which would equal the total number of permits to be reserved.

The second implementation issue is the manner in which new and expanding sources obtain the reserved permits and what price, if any, do they pay. One possibility is for the EPA to use an auction to distribute permits to new and existing sources and to require bids at least equal to the market price of permits. The purpose of the reservation price would be to enhance competition when few sources are bidding; the administrative burden on the EPA would thus increase because it would need to stay current with the permit market. Another possibility is for

the EPA to offer permits for sale to new and existing sources at a fixed price, giving priority to new sources.[12]

The SO_2 program provides a precedent for reducing any bias toward new sources in a consumer and commercial products permit program. Approximately three percent of each existing source's initial permit allocation is withheld each year. These reserved permits are auctioned to both new and existing sources and the revenues paid out to the existing sources from whom the reserved permits were withheld. Thus the price for auctioned permits is set competitively, not by the EPA. Because existing sources could possibly obtain all of the permits at auction, to the exclusion of new sources, the EPA also offers for direct sale a limited number of permits. New sources have priority to purchase these permits over existing sources. Thus the EPA serves as the supplier of last resort (through direct sales of permits) should new sources be unable to purchase permits from existing sources. The price of these direct-sale permits has been set two to three times higher than the expected trading price of the permits in the open market.

Regardless of the method by which the price of permits to new sources is determined, if existing sources receive an initial allocation of permits for free, there is an implicit disadvantage in general to new sources in requiring them to pay for their initial allocation of permits. If permits are valid for only one period, for example, a year, then the source must incur the same costs or similar costs in the following and all later years because it does not receive a free initial allocation from the government. The purchase of permits in this case would not be a one time expense, and would to some degree be an operating expense that existing sources would avoid on average because of the free grant of permits to them.

The extent to which new sources would have difficulty obtaining permits is uncertain. Elman, Braine, and Stuebi (1990) analyzed the availability of allowances for new coal-fired

[12]It may be that new sources deserve more favorable treatment than expanding sources because the former do not have the capacity to internally supply permits as do expanding sources (for example, by reducing the VOC content of another product).

generating plants in the SO_2 program. Their analysis indicates that there should be sufficient allowances available for new sources and that additional allowance costs relative to annual operating costs for new sources should be small (ranging from 1 to 5 percent). However, there are significant and obvious differences in production, demand, and structure between the utility industry and the consumer and commercial products industry. Those differences prevent one from easily extrapolating the results from Elman's study to the consumer and commercial products industry.

The diversity of manufacturers and importers in the consumer and commercial products industry can provide a sufficient safeguard against discriminatory permit pricing targeted against new sources. If the universe is broad, additional measures such as a permit reserve and preferential treatment of new sources may not be necessary.

4.5.2 Retiring Sources

As stated in the introduction to this section, the primary concern about exiting sources is that the permit program could result in an incentive for inefficient companies to remain in operation. One way to avoid this problem is to allow retiring sources to sell their permits to other (new or existing) sources.

The EPA could detract the permits of retiring sources and thus permanently reduce emissions through the attrition of existing sources. However, such action is likely to provide an incentive for existing sources, who might otherwise find it profitable to sell their permits and go out of business, to continue operation of potentially inefficient plant and equipment. When making the shutdown decision, the owners of a company compare the salvage value of the company's assets to the value of continuing operation. Emission permits are assets because they can be sold to other companies and hence increase the salvage value of a company. If the EPA allows retiring companies to sell permits, then the salvage value will be more likely to exceed the

value of continuing operation and a company facing a shut down decision will more likely close. The EPA's decision to allow retiring companies to sell their permits will accelerate rather than retard the retirement of inefficient plant and equipment.

Other existing or new companies may employ better technology which could manufacture more product than the exiting company with the same number of permits. By allowing retiring companies to sell permit holdings (including its annual initial allocation of permits), the EPA could allow for expansion of production without increasing emissions and at the same time provide another way for new sources to obtain permits.[13]

4.6 INITIAL ALLOCATION OF PERMITS: GRANTS AND AUCTIONS

To start the marketable permit program, the EPA establishes: 1) the total allowable emissions of VOCs from all program participants and 2) the allocation of emission permits to each participant.[14] A source's allocation and its actual emissions when the program starts implies a source's initial emission reduction requirement. Thus the EPA assigns the initial responsibility for emission reductions and influences the distribution of the burden of the program.

A participant's initial control responsibility may take any value: positive when uncontrolled or actual emissions exceed the permitted amount; zero when uncontrolled and permitted emissions are equal; negative when permitted emissions exceed actual emissions. If the government possessed the entitlement to emit, the use of an auction to allocate permits would reflect the judgment that each participant's control responsibility is equivalent to total control because the participant must either reduce emissions entirely or purchase permits to cover emissions. If instead the source possessed the entitlement to emit, the control responsibility must

[13]Production can increase while holding emissions constant if the exiting source sells its permits to a new or existing source which manufactures products with lower VOC content.

[14]For a program in which the EPA periodically issues permits, the "initial" allocation refers not to a single event but to regularly repeated allocations.

be presumed to be zero, and permitted emissions would equal actual emissions.[15] It is only when the EPA authorizes a partial control responsibility that it encounters a choice with any latitude for the handling of individual companies.

If the EPA were to authorize partial control responsibility, then it would have two choices for allocating permits. It could freely grant permits according to a distributional rule, or it could auction them, collecting revenues for various purposes.

Granting emission permits is attractive because it allows the EPA the greatest latitude to allocate permits and it may enhance the ability of the EPA in an uncertain world to obtain emission reductions (detractions) beyond those contemplated at the start of the marketable permit program. The EPA can make the allocation without regard to static efficiency: in a competitive permit market, regardless of the initial allocation of permits, trading will result in the least aggregate expenditure of resources on emission reductions (Montgomery, 1972).[16] This result assumes that transaction costs are minimal; in general, transaction costs otherwise will preclude trades from occurring, increasing expenditures on emission reductions above the theoretical minimum.

The following steps illustrate the implementation of this approach for existing companies and assumes that the total cap on emissions has been selected by aggregating over hypothetical VOC-content standards for each regulated product.

1. Calculate each company's emission limitation (VOC_{Sj}) using this formula:[17]

$$\sum_i VOC_i * Q_{ij} = VOC_{Sj}$$

2. Grant the implied number (VOC_{Sj}) of allowances to each company in the first period.

[15]The EPA could purchase permits thus subsidizing emission reductions.

[16]In general, the starting point of a company does not affect its desired level of emission reductions, but the initial allocation does affect whether a company is a net buyer or seller of permits.

[17]VOC_i is the hypothetical VOC content limit for product i and Q_{ij} is the company's sales of product i in the base year.

3. If the aggregate emissions cap declines in the future, grant proportionately fewer allowances to each company.

In the example, the EPA grants emissions allowances to companies. Other allocative mechanisms are feasible and may be more desirable.

Although distributive flexibility is important, grants do have disadvantages. The areas of concern are competition in the permit and product markets and technological change. It is most informative to evaluate the desirability of grants by comparing them to auctions, which are the most probable alternatives.

Permit markets may be imperfect in various ways (Tietenberg, 1985, pp. 125–148). One or more companies may attempt to manipulate the auction permit market to reduce the permit price and its financial burden (permit payments plus abatement expenditures). Alternatively, companies may attempt to sequester permits (thus raising the price) to injure competitors in the product or input markets. In each case, imperfect competition increases aggregate control costs above the optimum.

A heterogeneous and large universe of sources thwarts the company intent on injuring competitors because the permit market contains many other potential trading partners. They reduce the aggressive source's leverage over the permit price (because its demand is less significant the larger is the total demand[18]), and competition in the product or input markets is not a consideration, at least for some sources. Thus the tools for limiting discrimination in the permit market are to be found in the construction of the universe of sources, just as they were when the problem was reducing the potential bias against new sources. Special types of auctions provide another means for enhancing competition and are discussed more fully below.

[18]Specifically, the price-making source's excess demand for permits—the difference between its initial allocation of permits and permit use—but not the source's use of permits per se (i.e., equilibrium emissions) is the basis for market power (Hahn, 1984).

An artificially low permit price is also undesirable because it induces an inefficient allocation of control responsibility. Simulation studies of permit auctions and permit grants provide insights into the possible quantitative effects of this type of distortion.

After reviewing simulated auctions in which the dominant source reduces the permit price, Tietenberg comes to the "strong conclusion" that control costs would increase by a very small amount (by one or two percent in the simulations) even when circumstances are conducive to permit price manipulation.

> We have examined a very congenial setting for market manipulation, one involving few sources, low marginal control costs for the price-setting source, and high control costs for the competitive fringe. Despite finding circumstances where prices and total financial burden were dramatically affected, regional control costs were remarkably insensitive to market manipulation in all simulations (1985: p. 132).

Further, "incentive-compatible" auctions, which cleverly frustrate intentions to manipulate permit prices, may be available for use in auction markets which are prone to manipulation.[19]

The free distribution of permits also creates opportunities for companies to manipulate the permit market. Tietenberg reviewed simulation studies of controlling SO_2 in Los Angeles and hydrocarbons in the United States. In these studies, the dominant source chooses the permit price that minimizes its own expenditures on pollution abatement and permits. He concluded that the studies "support the notion that high degrees of cartelization are necessary before control costs are affected to any appreciable degree and that even high degrees of cartelization [e.g., 90 percent] do not significantly erode the large savings to be achieved from permit markets" compared to command-and-control regulation (1985: p. 136).

The special type of auction known as the "zero-revenue auction" is one defense against attempts to exercise power in the permit market, and it has other advantages as well (Hahn, 1983;

[19]The efficacy of incentive-compatible auctions in the context of marketable permits is controversial. Tietenberg expresses optimism (1985: p. 133), but Marin, doubt because the theoretical investigations of auctions have not examined the implications of the type of bid that is characteristic of permit auctions (i.e., a demand schedule) or the existence of the post-auction permit market (Marin, 1991: p. 298).

Hahn and Noll, 1983). Several steps are involved in allocating permits through a zero-revenue auction. The government first gives permits to each participant, following a method or formula that reflects diverse considerations, including equity. Then the auction itself begins. Every participant offers for sale all permits that it received, and every participant submits a bid for the permits that it wants to buy. A bid describes the number of permits that are desired at various prices.[20] The government uses these bids to redistribute permits. The participants who are net buyers of permits make a payment to the government; the participants who are net sellers receive a payment from the government. The government's receipts equal disbursements. Because each participant is on the demand side of the market, the zero-revenue auction precludes some of the distortions that could arise if the EPA were to simply grant permits, specifically, the emergence of aggressive sellers—at least initially when information on the value of permits is most uncertain.

The zero-revenue auction quickly establishes an equilibrium price using the maximum amount of information that is available at the start of the economic incentive program, and it allows the EPA to freely grant permits. Experiments show that even when the initial allocation of permits is very different from the least-cost allocation, such that some participants may be in a position to dominate the market, the participants do not manipulate the permit price (Hahn, 1983). The zero-revenue auction therefore promotes efficiency without requiring participants to transfer wealth to the government (Harrison and Portney, 1982, p. 175).

This review of permit market imperfections implies that any potential imperfections in the consumer and commercial products permit market are probably insignificant (i.e., will have negligible effect on aggregate control costs) regardless of the permit allocation mechanism. Further, should evidence on the potential for price manipulation be adduced, incentive-compatible or zero-revenue auctions may be used to lessen this potential.

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[20]In effect, each participant submits its demand curve to the government, which acts as the market clearing agent.

Permit allocation methods can affect the static efficiency of the permit market, but this effect is not the only attribute which is relevant to program design. Permit allocation methods should also encourage new ways of making low-VOC consumer and commercial products.

From a macroeconomic perspective, new technology can decrease the conflict between environmental quality and economic growth. Society continually redefines the terms of engagement for those conflicting goals, and technological change adapts the economy to heightened demands for environmental quality.[21] "Over the long haul, perhaps the most important single criterion on which to judge environmental policies is the extent to which they spur new technology toward the efficient conservation of environmental quality" (Kneese and Schultze, 1975: p. 82).

Theoretical analysis shows that the initial allocation of permits influences the dynamic efficiency of marketable permit programs. Milliman and Prince (1989) have shown that the method of allocating permits influences the willingness of program participants to promote innovation in pollution control and diffusion of the innovation—the two steps in technological change. Their willingness to promote technological change depends upon their potential private gain. Specifically, a company's gain depends on the net change in profits from product manufacture and sale, profit from permit sales, and reduction in expenditures on permits. Different allocation methods imply different incentives to promote technological change.

Freely granted permits and auctioned permits provide equal incentives to innovate, but free permits provide less incentive to promote diffusion.[22] When permits are auctioned, all regulated companies (permit buyers) gain from the diffusion of low-VOC technologies because

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[21]Economists who equate economic growth with economic progress would make the point with a different emphasis: technological change permits demands for environmental quality to be tolerable. "Unless we want to blight the fruits of economic growth, we shall have to be continuously pressing on the technological frontier in the search for means of accommodating economic progress within a clean environment" (Kneese and Schultze, 1975: p. 83.)

[22]The auction analyzed creates revenue for the government as permit seller.

the aggregate demand for permits falls, reducing permit prices. When permits are given away, this gain from diffusion is absent. The innovator's gain from diffusion is greatest with auctioned permits because, after diffusion, he or she buys permits from the government at a reduced price, but with freely granted permits, the innovator loses the permit sales revenue that was obtainable prior to diffusion. As in emission fee/rebate programs, because the innovator also could lose its competitive advantage by providing its technology to competitors, the total incentive for diffusion is especially low in freely granted permit programs. Any loss in competitive advantage also occurs in auctioned permit programs. The freely granted permit program is more disadvantageous to an innovator than an auctioned permit program, although the additional disadvantage is difficult to measure.

Therefore, one disadvantage of freely granting permits in a consumer and commercial products program would be that the pace of diffusion of technological change would not be as great as with auctioning permits.[23] One cannot be specific because the Milliman and Prince analysis only compares incentives in relative terms and does not provide a methodology for correlating potential gains from diffusion into actual rates of diffusion.

In forming an overall comparison of different permit allocation methods, the certain advantages of freely granting permits (including the homologous zero-revenue auction)—distributional flexibility and demonstrated acceptability to the EPA, industry, and environmentalists—are strongly influential but may not be decisive. The counterpoint to these advantages may be somewhat slower diffusion of cost-reducing technology.

[23]Zero-revenue auctions are equally disadvantageous. Zero-revenue auctions and freely granted permits provide the same incentives for technological change because the distributional impacts of permit price changes are subsumed within program participants in both allocations.

4.7 MONITORING AND ENFORCEMENT

Given the design of a marketable permit program, a profit maximizing company determines its level of emissions based on the costs of compliance and the expected costs of noncompliance. The expected cost of noncompliance is the product of the penalty for noncompliance and the probability of detection of noncompliance. Consequently the efficiency of the permit program is intimately tied to monitoring and enforcement.

Compliance with a consumer and commercial products permit program occurs when participants hold a sufficient number of permits to cover the total amount of VOCs which their products emit. Consequently, the objectives of monitoring must be to observe the quantity of VOCs contained in each company's regulated products and permit holdings.

To reduce the EPA's monitoring costs, participants will be required to provide information on VOC content and product sales. Then monitoring compliance in the permit program involves three separate steps.

1) Verifying accuracy of participants' reports of VOC content.
2) Verifying participants reports of the volume of each regulated product they manufacture, distribute, or import for domestic sale.
3) Ensuring that each participant's permit holdings cover total VOC emissions from its regulated products.

The states or EPA could verify reports of VOC content by sampling and testing products from retail establishments and wholesale distribution centers. To determine if participants' reports of sales volumes are correct, the states or EPA could randomly audit their sales records and compare the records with similar reports prepared for other purposes. In addition to ensuring compliance with the permit program, this information (VOC content and sales volume) is valuable to the EPA as a means to evaluate the success of the permit program in reducing VOC emissions.

The final step in monitoring compliance with the permit program is to determine if participants hold enough permits to cover the total number of VOCs contained in their consumer and commercial products. In order to make this determination, the states or EPA would have to track each participant's holding of permits, which would change from the initial allocation if it bought or sold permits.

As discussed in the fee program section, the enforcement instrument of a pollution control strategy must have two qualities. First, penalties must be severe enough that, when combined with the chosen monitoring strategy, they deter noncompliance. Second, companies must perceive the enforcement agency as willing and able to determine and apply the appropriate penalty in a timely manner.

The following actions could constitute noncompliance under a consumer and commercial products permit program:

1) Failure to submit VOC content and sales reports to the EPA in a timely manner.
2) Falsification of any information contained in the required reports.
3) Failure to hold a sufficient number of permits.
4) Failure to remit financial penalties to the EPA in a timely manner.

Each failure could be penalized to the extent permitted under the CAA.

The resources spent on enforcement are linked to the resources spent on monitoring. A permit program which combines accurate and reliable monitoring with appropriate penalties would effectively deter noncompliance. As a result, fewer resources (administrative and legal) would be required to impose penalties and the overall program would be more efficient.

4.8 INFORMATION NEEDS FOR PROGRAM DESIGN AND ADMINISTRATION

The discussion in this section conveys the categories of information needed to design and administer marketable permit programs. An important design parameter is the aggregate emissions cap because the basic principle of the program is the creation of a market for a fixed supply of VOC emission permits.[24] An important use of information for program design is to establish the baseline of VOC emissions against which progress will be measured. An important use of information for program administration is to monitor compliance. For concreteness, this section assumes that the specific marketable permit program involves an emission allowance auction, although the section also describes additional information that could allow the EPA to develop a distributional rule for granting allowances.

Table 4-1 lists information needs for program design. The aggregate emissions cap can be determined in several ways; therefore, the specific information requirements for this design element are uncertain. The other needs specified in the table allow the creation of the current emissions inventory, enhance the credibility of the expectation that product manufacturers and users can adapt to the increased cost of emissions, and allow the EPA to set a fee to cover its administrative costs, if desired. Some of this information is valuable but not absolutely necessary. The parameters of a reasonable distributional rule for granting allowances include VOC content standards and product sales in a base year or years; this information is the same as that which could be used to set the aggregate emissions cap.[25]

Economic modeling may play a role in program design. For example, if the EPA wished to project permit prices, then a model like the one described in the *Industry Profiles and Technical Appendixes* document, Appendix B would be useful. Information needs would then

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[24]For convenience, the discussion assumes a single permit market. Multiple permit markets (for differentiated permits) require the corresponding number of aggregate emissions caps.

[25]Section 1.2 describes the use of this information in a "bottom-up" procedure to determine the aggregate emissions cap.

increase beyond those indicated in Table 4-1 and would include baseline economic conditions and model parameters (see Table 3-6).

TABLE 4-1

INFORMATION NEEDS FOR THE DESIGN OF MARKETABLE PERMIT PROGRAMS

- Aggregate emissions cap
- Name and address of every manufacturer or distributor and importer included in the program
- Annual net VOC usage in regulated consumer and commercial products in a recent year (or years) by company
- Qualitative information on alternative formulations of existing consumer and commercial products
- Qualitative information on product substitution by users
- EPA's administrative costs for the program

Table 4-2 lists the information needs for program administration. This information would be necessary to allow the EPA to track permit holdings and to calculate VOC emissions for each company in the program.

TABLE 4-2

INFORMATION NEEDS FOR THE ADMINISTRATION OF MARKETABLE PERMIT PROGRAMS

- Number of permits owned at any given moment by each program participant
- VOC content of each product
- Sales of coating by product for each manufacturer or distributor and importer

4.9 ANCILLARY PROJECTS TO INCREASE TRADING IN A PERMIT MARKET

In general, markets are most effective when neither one actor (a buyer or seller) nor a colluding group dominate and when the trades which would be beneficial to buyer and seller actually do occur. The costs of determining what one wants, finding a potential trading partner, and evaluating offers—transaction costs—reduce the gains to trade and the effectiveness of the market. The market for permits to emit VOCs from consumer and commercial products would have few precedents, and the participation of manufacturers, distributors, or importers in this type of market may be a new experience for them. The transaction costs in this market might be higher, at least initially, than in markets for more familiar goods.

The EPA could undertake or support projects to reduce transaction costs in a consumer and commercial products marketable permit program. The general objective of these projects would be to remove obstacles to trade thus reducing the aggregate expenditure on pollution abatement.

Such projects could provide assistance in different forms. They could include one or more of the following:

- guidebooks,
- instructional seminars,
- computer programs, and
- computer bulletin boards.

A guidebook could discuss the strategic issues facing participants and provide information on the record keeping and reporting requirements. Instructional seminars could cover all aspects of the marketable permit program and provide the EPA with opportunities to clarify the operation of the program. The computer programs could assist participants with the evaluation of input substitution and packaging redesign, the determination of their demand for permits, and the appraisal of current offers to buy or sell permits.

These forms of assistance are already being developed for electric utilities who will participate in the SO_2 allowance trading program. For example, the "Clean Air Response Kit," developed by the Electric Power Research Institute, in addition to including a strategic guidebook and seminars, features several computer programs which estimate the costs of several means of reducing SO_2 emissions and allow utility planners to simulate their participation in the allowance market (Lamarre, 1991).

As the utility example shows, the private sector may sponsor projects that reduce the transaction costs of a marketable permit program. In fact, private sector brokers already exist who could facilitate permit trading. It may be that private sector brokers or trade associations can most efficiently reduce transaction costs. However, if, for example, the trade associations in the consumer and commercial products industry are less prepared to provide sophisticated technical assistance or provide assistance only to a small group within the industry, then the EPA may wish to sponsor projects to increase the efficiency of the permit market.

4.10 EMISSIONS AVERAGING PROGRAMS

The characteristic feature of emissions averaging programs is a limit on emissions that is expressed in terms of a product-specific rate (for example, pounds/gallon) instead of an absolute rate (pounds/year). The emissions limit in an averaging program is thus production-based. Manufacturers are free to change the VOC content and sales of individual products in any way provided that the rate of aggregate emissions does not exceed the production-based limit.

An emissions averaging program for consumer and commercial products was recently discussed at the recent California Air Resources Board's workshop on alternatives to VOC content standards (CARB, 1992). The proposal allows internal trades but not external trades.[26]

[26]Other emissions averaging programs may allow internal and external trades (see below).

For example, under this program a company that manufactures two forms of the same product would need to conform its products to the following rule:

$$(VOC_1 \times Sales_1) + (VOC_2 \times Sales_2) \leq VOC_P \times (Sales_1 + Sales_2)$$

Thus the sum of actual emissions cannot exceed the emissions that would be allowed if the sales-weighted average VOC content of both product forms met the standard (VOC_P) for the product category. The manufacturer is free to adjust either sales or VOC content (or both) to comply with the regulation—assuming that he or she makes multiple forms of the same product, or multiple regulated products.

Emissions averaging programs are similar to the marketable permit programs previously discussed in this section. Both types of incentive are quantity-based instruments, and emissions trading is the activity that is responsible for the cost-effective allocation of responsibility for emissions reduction. Both programs may allow only intra-plant trades, or they may allow any inter-plant or inter-company trade as well. Internal trading can achieve a locally (either within the plant or the company) cost-effective allocation of responsibility for emissions reduction but not a globally cost-effective allocation (assuming the marginal cost of emissions reduction vary across companies). Emissions averaging programs that allow internal and external trades can achieve global cost-effectiveness with respect to the goal of limiting average emissions.

Emissions averaging programs also differ from marketable permit programs in one fundamental way. The environmental goal in averaging programs is quite different: a limit on average emissions at either the plant, company, or universe of sources rather than a limit on the mass of emissions from all regulated sources. Consequently, aggregate emissions may increase automatically as the sales of consumer and commercial products increase.

The incentive for environmentally-beneficial technological change with emissions averaging is weaker than with either emission fees or marketable permit programs that limit the

aggregate mass of emissions because a manufacturer may "shield" high-VOC content products by increasing the sales of lower-VOC content products. This strategy is uneconomical with emission fees because total fee payments increase. The cost of increasing permit holdings makes the strategy uneconomical with a marketable permit program.

Information on the actual performance of emissions averaging is available in a recent review conducted by EPA's Region IX and the California Air Resources Board. They studied the Alternative Emission Control Plans that were applicable to coatings used by the aerospace industry in the South Coast Air Quality Management District and the San Diego Air Pollution Control District (U.S. EPA Region IX and CARB, 1990).

The study reports that the emissions averaging programs implemented in the Alternative Emission Control Plans had not achieved emission reductions equivalent to the VOC content standards for which the Plans are substitutes. In addition, because each plan included multiple coatings, places of application, and methods of generating excess reductions, and because the emissions calculation method is complex and requires specialized information, the review of a Plan is lengthy and can be undertaken only by very experienced engineers. The records kept by sources were typically incomplete, inadequate, and erroneous. In practice, the reviews actually undertaken by district staff were insufficiently probing to reveal that the assumed equivalence of the Plans to the standards was unjustified.

The procedures for approving Alternative Emission Control Plans have subsequently been made more stringent, and it appears that the Plans now will achieve equivalent emission reductions. Therefore, effective emissions averaging programs can be designed and implemented, but the experience with the Alternative Emission Control Plans raises the issue of the distribution and size of administrative costs.

The tradeoff between increased administrative costs for the regulatory agency and decreased abatement costs for sources may be unnecessary. The regulator's administrative costs may actually be less with an emissions averaging program that allows external trades; an example is the lead credit trading program operated by the EPA during the reduction in the lead content of gasoline (U.S. Library of Congress, CRS, 1989). A potential buyer will give greater value to emission credits of which the verifiability is higher, and the seller, in the most cost-effective way, will consequently keep records and undertake other actions to ensure verification. The buyer and the regulator have the same interest in verification of emission credits. Therefore the seller of credits, in satisfying the information demands of buyers, simultaneously satisfies the demands of the regulator, reducing the latter's administrative costs.

One possible advantage of emission averaging versus marketable permit strategies involves industry expansion. New companies and expanding existing companies are not disadvantaged in averaging programs as they could be in marketable permit programs because the former offer an unlimited supply of emission permits at no cost. Industry expansion, however, could lead to increased emissions under emissions averaging programs.

4.11 SUMMARY OF DESIGN OPTIONS

This section primarily described design options for a marketable permit program to reduce VOC emissions from consumer and commercial products. The distinguishing characteristics of this policy instrument are inter-company trading of emissions and the cap on the aggregate, absolute quantity of emissions. Emissions averaging programs also rely on emissions trading, and can be made most cost-effective when trades are allowed between companies, but they characteristically place an upper limit on average emissions. The nature of the environmental goal is the essential difference between marketable permit programs and emissions averaging programs. For purposes of comparison with emission fees and VOC content standards per se, Table 4-3 summarizes permit program design options.

TABLE 4-3

SUMMARY OF TRADING PROGRAM DESIGN OPTIONS

Design Element	Option 1	Option 2	Option 3	Option 4	Option 5
Program Purpose	Achieve VOC reductions at lower cost	Provide greatest incentives for technological change	Minimize adverse distributional impacts	Combination of options	
Emissions Limit	Aggregate mass of emissions	Average rate of emissions			
Scope of Trading	Only internal trades	Internal and external trades			
Permit Differentiation	By season	By nonattainment status	Annual permit		
Sources Included	Based on type of business	Based on size (emissions)			
Phasing-in Sources	None	By size (emissions)			
Opt-ins & External Groups	"Small" sources	Other C&CP manufacturers and importers	Manufacturers and importers of other VOC-containing goods	Environmental interest groups	Combination of options
New Sources	Purchase permits from existing sources	Reserved permit auction	Fixed-price sale of reserved permits		

(continued)

TABLE 4-3

SUMMARY OF TRADING PROGRAM DESIGN OPTIONS (CONTINUED)

Design Element	Option 1	Option 2	Option 3	Option 4	Option 5
Retiring Sources	EPA detracts permits at shutdown	EPA allows transfer at shutdown			
Type of Entitlement	Sources possess property rights	Sources possess temporary permission to emit			
Type of Commodity	Emission allowance (1 ton in 1 year)	Emission reduction credit			
Initial Allocation Mechanism	Zero-revenue auction (annual)	Revenue auction (annual)	Grant (annual)		
Permit Banking	None	Allowed			
Permit Duration	Limited	Unlimited			
Monitoring and Enforcement	Sources self-report VOC content & sales	EPA verifies reports	EPA checks permit holdings against VOC emissions	Combination of options	
Market Facilitation	Ancillary projects to reduce transaction costs	Rely on private sector	Combination of options		
Use of Revenues	Fund R&D for VOC-reducing technologies	Fund labelling and/or education programs	Pay for program administration	No revenues	Combination of options

The optimal design of a marketable permit program depends upon the objective. One specific marketable permit program is described in Table 4-4. It illustrates a program designed to obtain air quality improvements that will not be eroded by expansion of the consumer and commercial product industries, reduce VOC emissions from consumer and commercial products with the least aggregate expenditure on pollution abatement, and provide the greatest incentives for technological innovation and diffusion while reducing potential impacts on small businesses. Basically the example program accomplishes these purposes by:

- creating a market for a fixed quantity of emission allowances,
- providing maximum flexibility to manufacturers and importers to find the least expensive sources of emission reductions,
- periodically auctioning allowances,
- using revenues to promote research and development, and
- requiring strict monitoring and enforcement.

The permit market will reflect equity considerations as they apply to the initial allocation of control responsibility, initiate movement toward the least-costly control of emissions, and, through auctions, publicly reveal the current demand for permits. The market may therefore perform all of its basic functions (Hahn, 1983: p. 87) and minimize barriers to entry into the industry (consistent with the environmental goal).

The justification for the mandatory participation of product manufacturers and importers is the same as that for making these companies legally responsible for paying the emission fee. Of all regulated entities involved in the manufacture and distribution of consumer and commercial products, manufacturers have the most knowledge about product formulas and packaging. Emission permits increase the opportunity cost of the solvents, propellants, other

TABLE 4-4

EXAMPLE MARKETABLE PERMIT PROGRAM DESIGNED TO MAXIMIZE INCENTIVES FOR TECHNOLOGICAL CHANGE

Design Element	Recommendation
Program Purpose	Achieve VOC reductions at lower cost and maximize incentives for technological change
Permit Differentiation	Annual permit
Sources Included	All "large" manufacturers and importers
Phasing-in Sources	By size (emissions)
Opt-ins & External Groups	Combination of options & EIGs
New Sources	Purchase permits from existing sources
Retiring Sources	EPA allows transfer at shutdown
Type of Entitlement	Sources possess temporary permission to emit
Type of Commodity	Emission allowance (1 ton in 1 year)
Initial Allocation Mechanism	Revenue auction (annual)
Permit Banking	Allowed
Permit Duration	Unlimited
Monitoring and Enforcement	Combination of options
Market Facilitation	Combination of options
Use of Revenues	R & D for VOC-reducing technologies

inputs, and formulations that are responsible for the air pollution from consumer and commercial products.

The phasing-in of small manufacturers combined with providing the option to participate attempts to lessen small business impacts while eventually including all VOC emissions from the regulated products in the program. Nonetheless, the costs of phasing-in and the uncertainty in its

desirability would need to be recognized. The postponement of mandatory participation may reduce the emissions which the program will control and constrict the permit market. A quantitative study of potential economic impacts would be helpful in determining the desirability of special treatment of small companies.

Inflexibility in the timing of the use of consumer and commercial products argues against seasonally differentiated permits. Geographically differentiated permits provide the EPA with the ability to fine tune the emissions caps in nonattainment areas. However desirable on environmental grounds, differentiated permits increase administrative costs. Again, it is appropriate to recognize the possibility of opportunistic transportation of regulated products across the boundaries of nonattainment and ozone transport areas—and to make this option contingent upon the demonstration of satisfactory program performance without intrusive monitoring.

If the program should provide the greatest incentives for technological change, then auctions are the preferred mechanism for initially allocating permits because auctions increase incentives to spread technologies once they have been developed. Auctions may also reduce transaction costs that could prevent optimal permit trading from occurring, and they may generate revenue that could be used to promote technological advance even more quickly.

The above example program design would be less desirable if minimizing adverse economic impacts on manufacturers and importers was deemed more important than providing the greatest incentives for technological change. For example, freely granting permits would allow companies to avoid having to pay for their initial allocation of permits and may increase their certainty regarding future permit availability. Hence, this discussion illustrates the tradeoffs associated with alternative marketable permit design options.

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SECTION 5

COMPARISON OF EMISSION FEE AND EMISSION TRADING PROGRAMS

The fee-based economic incentive programs described in Section 3 and the emission trading programs described in Section 4 are alternative instruments for reducing VOC emissions from consumer and commercial products. Because one instrument achieves its purposes by regulating a price variable, and the other instruments by regulating a quantity variable, a comparison of fee and trading programs reveals the essential differences of the two most commonly proposed economic incentives for pollution control. This section compares the following specific variants of each instrument:

- fees—without rebates,
- fees—with rebates,
- permits—freely granted permits,
- permits—zero revenue permit auction,
- permits—ordinary permit auction, and
- emissions averaging.

It is assumed that the same environmental goal has been set for all programs: a particular quantity of VOC emissions from the use of consumer and commercial products.[1]

The purposes of comparison are to determine how well the instruments accomplish certain policy objectives and to appraise their ability to cope with the complexities inherent in the task of environmental regulation. The specific bases of comparison are the following:

- program costs and initial information requirements when effects are uncertain,
- monitoring and enforcement,
- distributive flexibility,
- adaptation to economic growth,
- incentives for technological innovation and diffusion, and
- unintended damages.

[1]The comparison may be undertaken without specifying the goal.

Those criteria are standard for the comparative analysis of environmental policy instruments (Bohm and Russell, 1985; Hahn, McRae, and Milford, 1988).

The comparisons made in this section will also include a third type of instrument: a hypothetical VOC-content standard. The content standard (described below) would be a command-and-control analog to the economic incentives for reducing emissions. It is included because the ultimate purpose of this investigation is to inform the search for the most desirable instrument in the set of potential instruments, which obviously would include instruments based on command-and-control.

5.1 PROGRAM COSTS AND UNCERTAINTY

This comparison of policy instruments begins with a simple theoretical examination of the costs and efficiency associated with employing alternative regulatory approaches under conditions of uncertainty. In a certain world where specific emission reduction technologies and costs for each source are known to the EPA and in which only total emissions from consumer and commercial products matter, the question of efficiency is trivial because the Agency could design a fee-based program, marketable emission permit program, or set of VOC content standards for which compliance costs are equal. Efficiency really is an issue when uncertainty in cost or benefit estimates is present.

The interest in uncertainty arises because uncertainty makes it easier to be wrong when designing an environmental policy instrument. In terms of social efficiency, being wrong means that any source, in response to regulation, has either not gone far enough or gone too far in reducing emissions. In the context of a static but uncertain world, and in which monitoring and enforcement are equally effective and expensive, is the cost of being wrong less with an economic incentive than with VOC content standards?

Consider first the efficiency loss of being wrong when the control cost of emissions reduction is uncertain. Figure 5-1 shows a marginal benefits curve, the best-estimate or expected marginal cost curve MC_0, and, to reflect uncertainty, high and low estimates of marginal control costs.[2] Either an emission charge equal to P*, an emissions quota of Q_s, or the equivalent emission standard is optimal when expected marginal costs equal the actual costs. When emissions are limited to Q_s, area 1 indicates the loss from overcontrol when control costs are underestimated. For the same limit, area 2 indicates the loss from undercontrol when control costs are overestimated. When the regulator charges P*, area 3 indicates the loss from overcontrol (i.e., P* exceeds the optimal tax when actual control costs are less than expected), and area 4 indicates the loss from undercontrol. Losses with the emission charge are least in this example: area 3 is less than area 1, and area 4 is less than area 2.

The constancy of the fee rate is very important in establishing the preference for emission fees. If the regulator were to change the rate to achieve the target level of emissions, the rate would fall when observed emissions (Q) exceed the emissions target Q_s, and the rate would rise when observed emissions are less than Q_s. In the first case, area 3 gradually would be reduced then eliminated, and area 2 would grow, reaching a maximum when $Q = Q_s$. In the second case, area 4 gradually would be reduced then eliminated, and area 1 would grow, reaching a maximum when $Q = Q_s$. The welfare losses that are unique to an emissions fee (i.e., areas 3 and 4) are the short-run losses which occur until the program achieves the fixed environmental goal. Adjustment of the fee basically transforms an emissions fee program into a quantity control.

Therefore, when marginal benefits do not decrease especially rapidly as emissions are reduced and marginal control costs rise steeply, the efficiency loss or social costs of being

[2]See Crandall (1983).

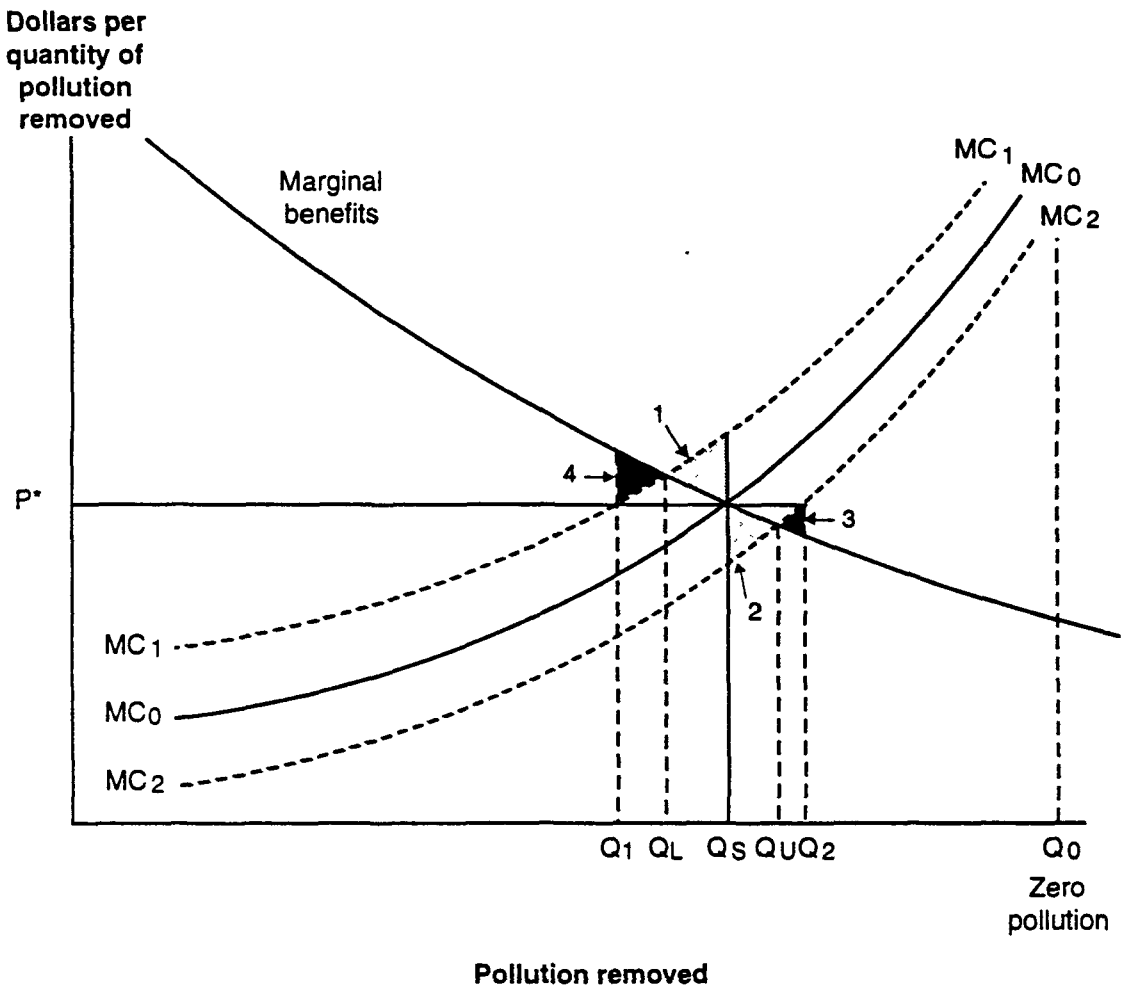

Figure 5-1. Welfare Losses When Costs Are Uncertain—No Effects Threshold

Source: Robert W. Crandall, *Controlling Industrial Pollution: The Economics and Politics of Clean Air*, Washington, DC: Brookings, 1983, p. 62.

wrong are least with a constant emissions fee when control costs are uncertain. A similar analysis shows that constant emission fees are preferable when benefits as well as control costs are uncertain (Crandall, 1983, p. 65). The advantages of an emissions fee are transitory and diminishing when the regulator adjusts the charge in pursuit of a fixed emissions target.

Given a comparatively steep marginal cost curve, the assumption that marginal benefits decline gradually is crucial to the analysis underlying the preference for emission

fees. When marginal benefits instead decline rapidly, emission standards or marketable permits are preferable.[3] Figure 5-2 shows the same marginal cost curves as in the first figure, but the marginal benefit curve is steeper. The steeper curve decreases areas 1 and 2 but increases areas 3 and 4. Losses with the emissions fee are now greater than losses with policies that establish a limit on emissions. Adjustment of the fee rate diminishes the disadvantage of the emission fee.

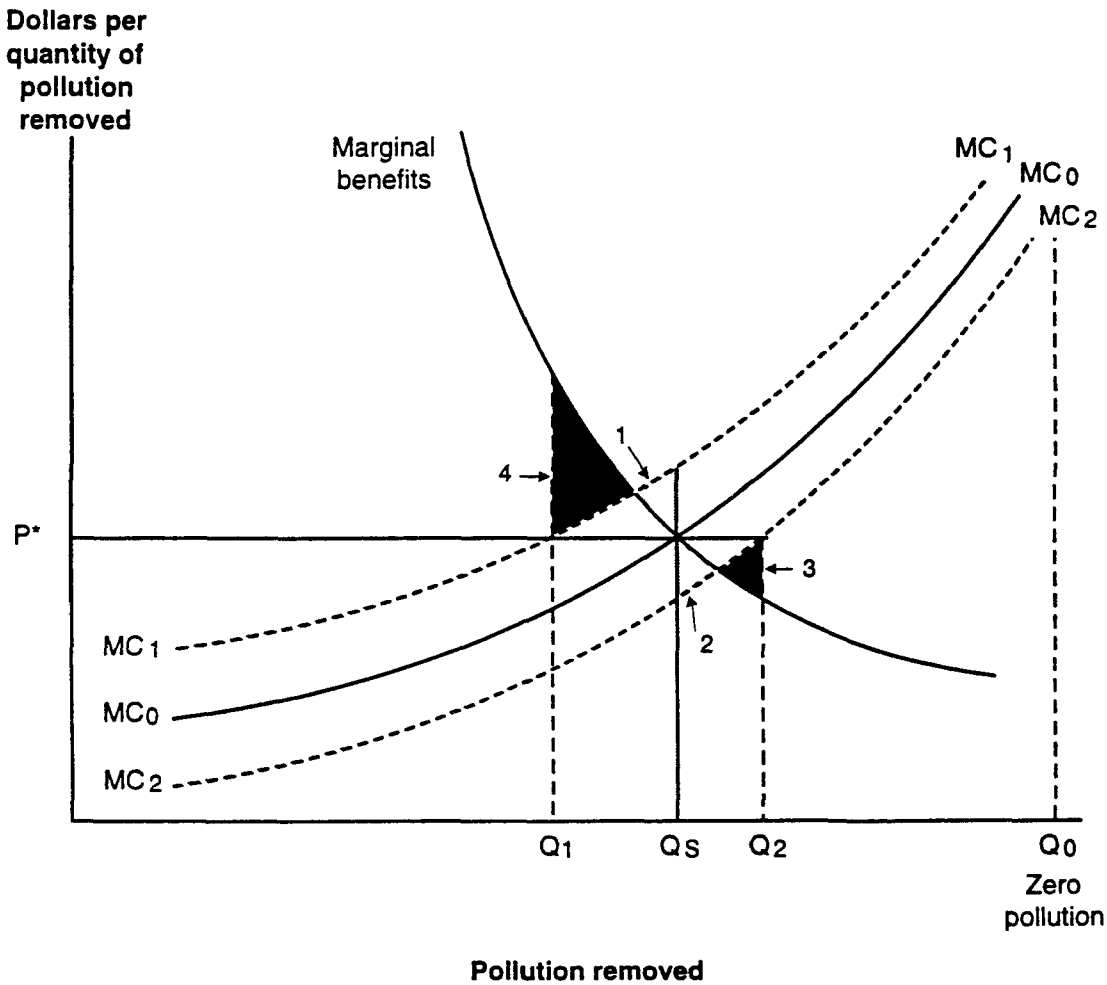

Figure 5-2. Welfare Losses When Costs Are Uncertain—Effects Threshold

Source: Robert W. Crandall, *Controlling Industrial Pollution: The Economics and Politics of Clean Air*, Washington, DC: Brookings, 1983, p. 62.

[3]Again, uncertainty in the benefits does not affect policy preferences.

Therefore, in a static but uncertain world, the preference for price-based or quantity-based instruments depends upon the relationship between the marginal benefit and cost curves, although the preference weakens somewhat when the regulator adjusts the fee rate. With rising marginal control costs, the specific factors that will determine the preferred policy are the scientific and economic facts about the transformation of VOCs into ozone and effects of exposure on human health. Effect thresholds imply a marginal benefits curve similar to the one in Figure 5-2 because total benefits increase most rapidly for emission reductions in the most polluted environments, but the increase is slight in very clean environments in which pollutant concentrations are below the (unspecified) threshold (Crandall, 1983, p. 61).

The preceding analysis featured a mild form of uncertainty that may not accurately reflect the state of the EPA's knowledge concerning the technology of consumer and commercial products and the costs of reformulation and repackaging to reduce VOC emissions. It assumes that the EPA has data on a substantial number of formulations of a particular product. A more accurate description of the actual data may be that the EPA can observe only one or two forms of each product because they are the only ones that are available in the market.

In the presence of minimal information on compliance costs, VOC content standards are most unattractive with respect to efficiency, but emissions averaging may perform better according to this criterion. Without usable knowledge about the marginal cost of emission reductions, it is highly unlikely that the EPA could find or come close to the least costly allocation of emission reductions. Expanding the scope of resource costs to include the losses from reduced product performance would probably amplify the range of uncertainty, further strengthening the expectation of inefficiency from VOC content standards. Abatement costs are likely to be less with emissions averaging than with VOC content

standards because internal trading and, especially, external trading allows sources flexibility in determining how to comply with emission limits. However, the potential for basically inefficient standards remains with emissions averaging.

Emission fees may also be unattractive in these circumstances because of the prolonged process of trial and error which may be necessary to achieve the predetermined emission goal. Trial and error is predictably costly because product manufacturers will make investments which either turn out to be "wrong" after the fee has been revised or are more flexible (and hence costly) than necessary if the correct fee had been known from the outset.

The argument for a marketable permit program is especially strong when the EPA has very little information on marginal control costs and achieving an emissions goal at least cost is the objective. To start the program, the EPA would determine the desired quantity of emissions and could freely grant the corresponding quantity of emission permits. Provided the permit market is competitive, monitoring and enforcement are effective, and transaction costs are negligible, exchanges between program participants will lead to the least costly allocation of emission reductions. To the extent that transaction costs are large, the efficiency of a marketable emission permit program will be lessened but will never be inferior to that of VOC content standards.

By efficiently distributing permits initially, permit auctions may serve to lessen the potential problem that trades will not occur due to high transaction costs. An auction itself, however, would involve some transaction or administrative costs. Furthermore, periodic auctions may increase costs associated with uncertainty regarding the future availability of permits.

Though generally reducing costs, none of the economic incentive strategies will likely yield the truly least cost solution that might be obtainable in a world of perfect certainty. A

practicable least cost strategy will depend on particular circumstances and will have to reflect tradeoffs among transaction or administrative costs, costs associated with uncertainties, and control costs.

5.2 MONITORING AND ENFORCEMENT

The purpose of monitoring is to observe actions antagonistic to the basic principle of the policy instrument—noncompliance. Enforcement involves the selection and imposition of a penalty for noncompliance. The EPA, regardless of the instrument, will seek penalties for noncompliance as allowed under the CAA. Therefore, because enforcement actions may be similar under fees, permits, VOC content standards, and emissions averaging, this subsection focuses on monitoring.

The EPA's essential task in monitoring compliance with a fee program is to determine the correctness of each source's gross payment of fees levied on the total VOC content of its consumer and commercial products used in the United States. For a marketable permit program, the Agency must determine any insufficiency in the number of permits held by each source. For a VOC content standard, the Agency must only determine the acceptability of the composition of each regulated product.

Monitoring compliance with fee programs is similar to monitoring compliance with marketable permit programs because each program requires the Agency to observe the VOC content of regulated products and the quantity of every regulated product manufactured or imported for domestic use. For example, to judge the adequacy of a domestic manufacturer's remittance, the Agency could compare actual receipts to required receipts, which would be calculated (for a single product) as the product of the emission fee ($/VOC), VOC content, and annual production. To monitor accuracy, the Agency could cross check reported production, obtain information on solvent and propellant usage, and test the VOC content of

product samples.[4] One important difference is that the Agency also must track permit holdings under marketable permit programs.

Monitoring compliance with VOC content standards would require product testing, only because the basis of a standard would be the product formula. In an emissions averaging program, the basic requirement for sources is compliance with a VOC content standard that may be met by averaging emissions over multiple products. Therefore, the EPA would need to obtain information on VOC content and on product sales, and to test products.

The expected monitoring activities and expenses are the greatest for marketable permit programs, less for fee programs and emissions averaging (when external trading is prohibited), and least for VOC content standards. It should be noted, however, that in order to assess emission reductions progress with VOC content standards, annual sales data would need to be obtained.

5.3 DISTRIBUTIVE FLEXIBILITY

Economic incentives for pollution control generate transfer payments and may also create valuable assets, for example, emission permits, which are transferred from the government to program participants. Economic incentives are intrinsically political because they create and redistribute wealth, although they are not dissimilar from command-and-control programs which may also create wealth.[5] The pattern of transfer payments reflects the distributive values that are incorporated into instrument design.

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[4]Solvent and propellant usage would help to establish a lower bound on the total required payment because some but not all VOCs are contained in those inputs.

[5]For example, conventional (i.e., untradeable) emission permits are valuable assets. Their value equals the shadow price of emissions, which reflects the aggregate marginal cost of emission reductions (assuming that sources are free to choose the least costly means for reducing emissions) and the quantity of allowable emissions.

Transfer payments take the form of either emission fees or expenditures on marketable emission permits. The fee programs in Section 3 require manufacturers or distributors and importers to pay the government for their customers' use of the assimilative capacity of the atmosphere, although, in the version with a rebate program, the EPA rebates all fees to the sources. Marketable emission permit programs also require sources to incur an opportunity cost—the permit price—for emissions, and they create a market in which buyers of permits will pay sellers; depending on the program version, the EPA will freely distribute or auction permits. All fee and permit programs create winners (those obtaining net receipts) and losers (those making net payments), but it is theoretically possible to design fee and permit programs with the same pattern of transfer payments. The program element that creates equivalence is the rebate formula or the mechanism for initially allocating permits.

The comparison between VOC standards and budget-neutral economic incentives is uncertain. Some companies will prefer standards because they avoid paying fees or buying permits. Other companies will prefer budget-neutral economic incentives because they will receive rebates in excess of fee payments or they will sell permits.

The primary criterion that differentiates among policy instruments is the flexibility of incorporating distributive values into instrument design. Distributive values underlie the desired composition of the universe of sources and the desired pattern of transfer payments. Distributive flexibility is greatest with free permits, permits allocated by a zero-revenue auction, and rebated fees because the regulator selects the universe of sources and is completely free to choose—and must choose—the formula for initially allocating permits or calculating rebates. Distributive flexibility is limited and less focused with ordinary auctions, fee programs without rebates, VOC content standards, and emissions averaging programs because the regulator only controls one variable, the universe of sources, that determines distributive effects.

5.4 ADAPTATION TO ECONOMIC GROWTH

This section studies some of the implications of dropping the assumption of a static world, and considers each policy instrument in a setting that allows for changes in the economy. The specific type of change of interest is exogenous to the policy: an increase in demand for consumer and commercial products, which could be due to population growth or an increase in per capita income, although the specific cause is not crucial. The factors responsible for increased demand are among the developments usually associated with economic growth and considered essential to any realistic description of the American economy. What changes (if any) in the policy instruments under review are necessary to adapt them to the increased demand for consumer and commercial products, and are the changes costly in terms of information, analysis, or trial and error?

Emission fees ensure that the marginal cost of emissions reduction will be constant and equal (to the fee rate) for all sources irrespective of changes in the economy or environment. Fee-based programs can neither impose nor induce an invariant limit on VOC emissions from consumer and commercial products. As the demand for consumer and commercial products increases, VOC emissions will increase unless the EPA increases the fee. All of the information and analysis that is relevant to establishing the initial fee is relevant to increasing it. Therefore, some of the effort made to start a fee-based program will be useful in the process of adjustment, but it is reasonable to expect that substantial effort will be necessary to update models of the input and product markets to reduce uncertainty over the proper value of the new fee. If the new fee is set through a process of trial and error, then sources will incur adjustment costs in addition to expenditures on emission reductions.

VOC content standards and emissions averaging programs must become more stringent to maintain the achievement of the environmental goal because they impose a limit on the quantity of VOCs potentially emitted by a unit of product or product group, but they

do not limit aggregate emissions. The EPA may incur significant adjustment costs if it must reexamine content limits in a growing economy.

Emission permits succeed in automatically constraining emissions when the demand for consumer and commercial products increases and hence sales increase. The information and analysis supporting the limit on emissions does not need to be revised as the economy changes. A marketable permit program also spares sources the trial-and-error costs which are unavoidable in an evolving fee-based program. Of course, they will spend more to achieve emission reductions. Thus, under emission permit programs, uncertainty regarding emissions reductions is replaced with uncertainty regarding the costs of achieving those reductions.

5.5 INCENTIVES FOR TECHNOLOGICAL INNOVATION AND DIFFUSION

One desirable type of technological change which environmental policy could foster is the innovation and diffusion of less expensive methods of pollution abatement.[6] Reductions in compliance costs, as Milliman and Prince observe, "can significantly expand the boundaries of environmental policy design" (1989, p. 247). The specific example which they give is new acid rain abatement technology which "may greatly spur efforts to regulate" the precursors of acid rain (Ibid.). Technological change benefits the innovator, adopting companies, and potentially the people and other organisms exposed to the pollutants.

The incentives of a company for innovation and diffusion come from three sources of savings: compliance costs, transfer payments, and income. Specifically, technological change can reduce expenditures on machinery, facility operations, emission fees, and emission permits as well as provide income from the sale of emission permits and patent royalties.

[6]Pollution abatement may include the capture of pollutants, reductions in the toxicity of emitted pollutants, and pollution prevention.

This section summarizes the results of Milliman and Prince's (1989) theoretical analysis of the incentives for cost-reducing technological change in pollution abatement. They assume a positive correlation between cost-savings and the probability that a company will undertake innovation or diffusion. Thus they are able to rank the incentive under different environmental policy instruments for each step and the entire process of technological change.

The incentive for innovation is the greatest with auctioned marketable emission permits, freely granted permits, and emission fees—all of which provide an equal incentive—and least with emission standards. In general, economic incentives provide a continual incentive for regulated companies to reduce emissions further.

The incentive for diffusion varies with the policy instrument. The incentive is greatest with auctioned permits, least and negative with free permits (see Section 4), and intermediate with emission fees and emission standards.

Sections 3 and 4 considered variants on fee-based and permit programs which differ from the pure forms examined by Milliman and Prince. The variant on emission fees featured rebates, making the program budget-neutral from the perspective of the government. Similarly, the variant on permits featured a zero-revenue auction of permits. Milliman and Prince's method is also applicable to the budget-neutral versions of the emission fee and marketable permit programs for consumer and commercial products.

The introduction of rebates or a zero-revenue auction only changes the distribution of the transfer payments for the environmental services provided by the atmosphere. The government collects payments but disperses them to the program participants. Provided that the rule for determining rebates is equivalent to the rule for initially distributing permits, the net financial position of the program participants will be the same under the fee program with

rebates, permit program with a zero-revenue auction, and permit program with freely given permits.

The gains to an innovator from the innovation step are unchanged. Regardless of the variant, fee and permit programs provide an equal incentive: the changes in expenditures on pollution abatement and transfer payments (i.e., reduction in gross fees or increase in permit sales) sum to the same amount under all policy instruments.

Zero-revenue auctions and rebates change the gains from diffusion. The alteration in the permit program changes the distribution of the economic surplus generated by changes in permit prices. When permits are auctioned in the ordinary way, all regulated companies gain from diffusion because the aggregate demand for permits falls, reducing permit prices. With free permits or a zero-revenue auction, this gain from diffusion is absent. A rebate has the effect of making a fee program distributionally equivalent to free permits. Therefore, assuming identical initial allocations of permits (when relevant to comparison), the fee program with rebates and marketable permit program with a zero-revenue auction provide equal incentives for diffusion and are equivalent to the marketable permit program with free permits. The variations of the pure programs reduce the incentives for diffusion.

The reduction of the incentives for diffusion has a negative consequence for the overall process of technological change. If a potential innovator plans expenditures on research and development on the basis of the total gain from both innovation per se and diffusion, then reducing the gains from diffusion will depress the overall incentive to undertake research and development. However, because an innovator could lose its competitive advantage by providing its technology to competitors, the significance of the additional disincentive for diffusion attributable to some incentive strategies is difficult to assess. The alteration of economic incentive programs to incorporate distributive values does

lead to unintended consequences for dynamic incentives, but the effect may be of minor importance.

Even so, the modified fee and permit programs are superior to standards because the incentive for innovation is stronger. The incentive for technological change with emissions averaging depends to some degree on whether interfirm trading of permits is allowed. Without interfirm trading, this incentive is weaker than with emission fee and marketable permit programs because the gains from innovation comprise only the value of "shielding" high-VOC products with low-VOC products—a difficult value to quantify—and the reduction in costs of pollution abatement. With interfirm trading, the incentive is greater because an innovator will generate and then may sell permits to manufacturers with high-VOC products (provided that these sales do not diminish the innovator's competitive advantage in the product market). Emissions averaging programs offer a stronger incentive for innovation than VOC content standards because the latter provides no incentive to achieve reductions below the standards.

In conclusion, theoretical considerations of technological change favor economic incentives, and the most productive are auctioned permits with an ordinary auction, followed by fees without rebates. VOC content standards provide the weakest stimulus to technological change.

5.6 UNINTENDED DAMAGES

A general observation on the nature of ameliorating environmental problems such as ambient ozone will introduce the concern with unintended damages. Narrowly defined solutions may be counterproductive when imposed on complex problems. Speaking of ecosystems, whether natural or urban, Holling and Goldberg remark that "[i]t is because of the complexity of the interactions that it is so dangerous to take a fragmented view, to look at

an isolated piece of the system. By concentrating on one fragment and trying to optimize the performance of that fragment, we find that the rest of the system responds in unsuspected ways" (1971: p. 224).

The designs of the economic incentive programs optimize the cost of reducing VOC emissions from the use of consumer and commercial products, and the narrowness of the objective may cause problems during implementation. VOC content standards also reflect a narrow objective. This section compares the potential of each policy instrument to generate these important types of unintended damages: movement of pollutants from one environmental medium to another, increased health risks, and, perhaps most unexpected, increased air pollution.

5.6.1 Intermedia Transfers of Pollutants

Intermedia transfers of pollutants could occur if reformulated consumer and commercial products are more prone to "off-specification" manufacture or have a shorter shelf life. The increasing importance of intermedia transfers and pollution prevention justifies concern. For example, the Science Advisory Board specifically refers to intermedia transfers in its report on priorities and strategies for environmental protection (U.S. EPA, 1990: p. 22).

The problem with off-specification manufacture and reduced shelf life is that the product is more likely to become a waste rather than a usable product. Disposal would increase the generation of hazardous or municipal waste. In attempting to solve an air pollution problem, regulation may worsen the hazardous waste problem and, if the spoiled products are deposited in landfills, may increase groundwater contamination. Manufacturers of consumer and commercial products probably would find and implement solutions to the

production and spoilage problems to increase profits, but the search for solutions would require expenditures on research and development.[7]

Intermedia transfers of pollutants are undesirable in general and may frustrate the intent of regulating consumer and commercial products. These problems may be more prevalent and avoidance costs greater with VOC content limits than with economic incentives because the former by definition reduce the flexibility of companies to offer consumer and commercial products which satisfy internal and external demands for ease of manufacture and product stability.

5.6.2 Increased Health Risks

Manufacturers may reduce VOC content by substituting a noxious solvent or propellant. The substitution of 1,1,1-trichloroethane or methylene chloride for mineral spirits and other aliphatic hydrocarbon solvents has already occurred in response to measures implemented by the states of California, New York, Texas, and Arizona and in response to previous regulation of air emissions from the coatings industry (Rauch Associates, 1990: p. 120). Methylene chloride is a designated hazardous air pollutant (Clean Air Act as amended, Section 112 (b) (1)). Such input substitution justifies concern for the safety of workers and users.[8]

The Federal regulation of consumer and commercial products may similarly heighten human health risk. Economic incentives and VOC content standards may be equally prone to this liability, but the solutions to any such problem may be easier to achieve with the former. A flexible economic incentive program to control VOCs may be more compatible with and reduce the costs of future regulations to reduce hazardous air pollutants.

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[7]The provision of information, say, a label stating the expiration date, would reduce the waste from stale but unused products.

[8]The change in health risk is the combined effect of the change in exposure of a substance and the intrinsic potential for harm of the substance.

5.6.3 Locally Increased Air Pollution in the Near-Term from Nonlinear Atmospheric Chemistry and Permit Trading

A third potential unintended consequence is an increase in ambient air pollution, in particular, ozone and sulfate particulates, in some airsheds. This effect theoretically could occur because of either the nonlinearity of atmospheric chemical transformations or the geographic pattern of emissions in a marketable permit program.

Models of atmospheric chemistry reveal nonlinearities in the transformation of VOCs and NO_x into ozone. Specifically, depending upon both the ratio of NO_x to VOCs and ozone concentration, it is theoretically possible that a reduction in VOCs may increase ozone concentration in certain localities, and the tendency for this effect increases with ozone concentration (Hahn, McRae, and Milford, 1988, p. 116). The gas phase reactions that form sulfate particulates also involve complex interactions with VOCs and NO_x, and the starting point concentrations of these compounds significantly influence the production of sulfate from SO_2 (Ibid., p. 115). Because of the nonlinearities in the formation of ozone and sulfate particulates, air quality starting points matter.

Regionally undifferentiated economic incentives and VOC content standards are equally likely to produce this side-effect because neither instrument is adapted to local conditions. One solution is to match the desired emission reduction to the locale; either regionally differentiated emission fees or multiple emission permit markets are appropriate. Another solution is a multiple-objective marketable permit program for NO_x and VOCs that would achieve simultaneous reductions in both pollutants.

It is also possible that air quality in a particular airshed may decline after implementation of a national marketable permit program because permit trading could go in the "wrong direction." This result is less likely to occur under a national marketable permit program to reduce VOCs from consumer and commercial products because, unlike the acid

rain trading program, permit traders would not also be the direct sources of emissions. For example, Southern California manufacturers that buy emission permits and sell their products nationwide, need not cause emissions to increase in Southern California. Thus, even if manufacturers in the worst ozone areas bought more permits than they sold, air quality in these areas would not necessarily decline.

Furthermore, the possibility of a localized increase in VOC emissions lessens as the environmental goal becomes more stringent. The probability that companies will reduce emissions from all regulated products increases as the quantity of allowed emissions declines. More important, a company would increase the VOC content of a product only if the current formulation were less profitable than a feasible alternative, but the contingency is unlikely. Companies now offer the most profitable, feasible consumer and commercial products. Under a marketable permit program, increasing the VOC content would be more costly than it is now because a company would incur the opportunity cost of using emission permits in addition to the costs of reformulation per se. Therefore, even if a company were to possess a sufficient quantity of permits to allow an increase in the VOC content of a product, it would lack the incentive. Thus, the possibility of environmentally adverse permit trading is very unlikely.

The more likely contingency is that emissions in any particular airshed will decrease, but not sufficiently in some ozone nonattainment areas. The most efficient adaptation of the marketable permit program might be to create separate subnational permit markets and to set more stringent environmental goals for the areas requiring the greatest reduction in VOC emissions to comply with the ozone national ambient air quality standard.[9]

[9] Such markets would not be without potential drawbacks: they would require increased administration, markets might be thin, and product users might circumvent the program by purchasing products from vendors outside of the boundaries of the user's permit market.

5.6.4 Increased Air Pollution in the Long-Term from Product Life-Cycle Effects

Paints and coatings provide good examples of the unintended effects on product life-cycle characteristics that regulations can cause. A paint or coating with reduced VOC content may not perform as well as the higher-VOC formulation. For example, a reformulated paint may form a film that is less durable, and users might reapply the coating more frequently. The emissions from any one application of the coating will decline, but emissions over the life of the substrate may increase.

As with intermedia transfers of pollutants, product-life cycle impacts are likely to be worse with VOC content limits than with economic incentives. Standards are more likely to constrain manufacturers' choices, thus preventing them from balancing the tradeoffs of reduced emissions and product performance.

5.7 COMBINATION VOC LIMIT/ECONOMIC INCENTIVE REGULATORY STRATEGIES

This section has focused on a comparison of fee, emissions trading, and content limit regulatory strategies to reduce VOCs from consumer and commercial products. It is also possible, and in some cases may be desirable, to combine VOC content limits with economic incentive strategies.

An example where a combination approach might be desirable would be as follows. Suppose that a VOC fee strategy is deemed appropriate, except that the economic burden to industry of paying a fee based on all VOC content is expected to be too great. A better strategy under this scenario might be to employ VOC content limits, but allow firms to exceed these limits if they pay a fee based on the difference between their actual VOC content and the VOC content limits. Such a strategy might also reduce administrative costs if only a small number of sources exceed their content limits. The drawbacks of this

combination VOC limit/fee strategy compared to a comprehensive VOC content fee program would be somewhat reduced abatement cost savings and reduced incentives for technological innovation to reduce VOC content below the limits.

Another example where a combination approach might be desirable would be as follows. Suppose that a marketable permits program is deemed appropriate, except that administrative costs are expected to be too high because the number of sources is great. The best strategy under this scenario might be to include only the largest sources in a marketable permits program and require VOC content limits for other sources. One option would be to allow smaller sources to opt in to the marketable permits program. The drawbacks of this combination VOC limit/marketable permits strategy compared to a comprehensive marketable permits program would be reduced permit trading and hence reduced abatement cost savings, and potential problems associated with imperfect competition in the permit market if the number of sources included in the marketable permits program is too small.

Thus, the choice between traditional and economic incentive approaches is not necessarily an all or nothing choice. Combination approaches may have advantages which need to be weighed against the shortcomings they create. The best regulatory strategy will depend on the objectives for the program and the particular characteristics of the industries being regulated.

5.8 SUMMARY

This section has described the criteria for a comparison of policy instruments designed to reduce VOC emissions from consumer and commercial products and has evaluated the alternatives under consideration on each criterion. The last step in this appraisal of the instruments is to integrate the separate rankings.

Table 5-1 compares the performance of the economic incentives and hypothetical VOC content standards on the criteria discussed above. It is assumed that every program aims to achieve the same environmental goal, a predetermined reduction in VOC emissions. The table includes the most important variants of both types of economic incentives: emission fee programs with and without rebates, and permit programs in which the EPA allocates permits to existing sources through an ordinary auction, zero-revenue auction, or grant. The ranking of each program on a given criterion indicates relative performance.

Overall, economic incentives appear superior to VOC content standards. Only when monitoring and other implementation costs for incentive strategies are excessive might content standards be preferable. If these costs are substantial, combination content limits/economic incentive strategies may still be preferable to employing only limits.

The optimal selection of a regulatory strategy will depend on the specific characteristics of the universe of sources under consideration for regulation. For example, potential abatement cost savings, monitoring and administrative costs, and distributional implications of employing economic incentive strategies for different industries will vary. The selection of the most preferable regulatory strategy depends upon the program's objectives. For example, if stimulating technological advance is most important, a marketable permit program with an ordinary auction might be the most preferable. Alternatively, if distributional considerations are more important, a permit program with freely-granted or zero-revenue auctioned permits, or perhaps a fee program with rebates, might be the most preferable. Thus, the best regulatory strategy will depend upon the regulated industry and the program's objectives.

TABLE 5-1

COMPARISON OF ECONOMIC INCENTIVES AND HYPOTHETICAL VOC CONTENT STANDARDS WHEN THE ENVIRONMENTAL GOAL IS A FIXED QUANTITY OF EMISSIONS

	Fees		Trading			
Criteria	**Without Rebates**	**With Rebates**	**Free Permits and Zero-Revenue Auction**	**Ordinary Auction**	**Emissions Averaging**	**VOC Content Standards**
Abatement Costs	Good	Good	Good	Good	Fair to Good	Poor
Monitoring	VOC content & sales	VOC content & sales	VOC content & sales & permit holdings	VOC content & sales & permit holdings	VOC content & sales	VOC content
Distributive Flexibility	Limited	Great	Great	Limited	Limited	Limited
Adaptation to Economic Change	Possibly slow & expensive	Possibly slow & expensive	Automatic	Automatic	Slow & expensive	Slow & expensive
Incentives for Technological Progress	Very Good	Good	Good	Excellent	Fair to Good	Poor
Unintended Damages	Possible	Possible	Possible	Possible	Possible	Probable

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