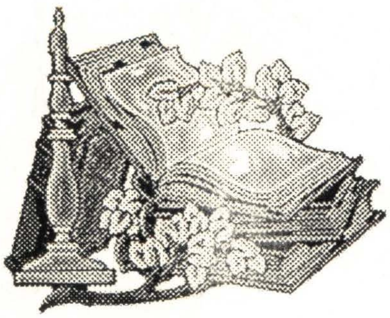

ECONOMIC SAVINGS FROM USING ECONOMIC INCENTIVES FOR ENVIRONMENTAL POLLUTION CONTROL

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Economic incentives, such as emission taxes, effluent trading, deposit refund systems, information reporting requirements, liability for harm caused by pollution, and voluntary programs have the potential to achieve environmental objectives at lower cost than traditional comand and control regulations. This report estimates the economic savings from the more significant of existing incentive-based environmental programs and examines the potential for extending these and other programs to increase the savings. Not surprisingly, the greatest potential for future savings from economic incentives lies with the reduction of greenhouse gas emissions.

To view this report in traditional form, click on the table of contents. The "Tell me about" feature highlights a number of questions and issues of particular interest and identifies where the answers may be found. The subject view organizes the material by type of instrument and by issue. The media view disaggreagtes the material according to air, water and land resources. To send comments to the author, click on "your comments."

Executive Summary

The use of economic incentives for pollution control appears to be gaining increasing acceptance. A recent (1997) report prepared for the US Environmental Protection Agency (EPA) details literally hundreds of applications in the United States at all levels of government. Further uses of economic incentives for managing the environment are being developed on a regular basis. One of the reasons for the interest is the economic savings that economic incentives can provide in achieving any given level of environmental protection. Such savings are widely believed to be of importance at a time of heightened concern with the international economic competitiveness of the United States, the increasing incremental cost of pollution control, and the continuing demand of citizens for a better environment.

If the time has indeed arrived for economic incentives, it is important to develop a comprehensive overview of the potential economic savings from and implementation opportunities available for introducing additional incentives. This report is intended to provide that overview. The conclusion is that there remain opportunities for realizing substantial economic savings in pollution control through the judicious application of economic instruments. These savings are available in both existing and in proposed new programs for environmental improvement.

OPPORTUNITIES FOR COST SAVINGS FROM USE OF ECONOMIC INCENTIVES

Economic incentives have long been advocated by environmental economists as a more efficient means to achieve environmental goals than the present predominantly command and control approach. The following savings are projected to occur in air, water, and land pollution control in the year 2000 without any changes in Federal, state, and local laws, regulations, and programs and the continuation of recent trends in their implementation:

Medium in Which Incentives Operate	Air	Water	Land	Total
Projected Savings (billions of 1992 dollars annualized at seven percent)	4.9	2.9	0.6	8.4
Projected Savings as a Percentage of Total Costs without Savings	8.0	3.8	1.0	4.3

Although in some cases appropriate changes in the relevant legislation would be required, the following additional savings are estimated to be possible in the year 2010 if the most economically efficient incentive programs were instituted (particularly for greenhouse gas emission control):

Medium in Which Incentives Operate	Air	Water	Land	Total
Additional Possible Savings (billions of 1992 dollars annualized at seven percent)	17.4	18.6	0.5	36.5
Additional Possible Savings as a Percentage of Total Costs without Savings	28.6	24.8	0.8	18.8

The $143 billion in total additional savings can be placed in perspective by pointing out that these additional possible savings come to about two percent of gross domestic product. If the projected and the possible additional savings are added together, then the total potential savings would be as follows:

Medium in Which Incentives Operate	Air	Water	Land	Total
Total Potential Savings (billions of 1992 dollars annualized at seven percent)	22.2	21.5	1.1	36.5
Total Potential Savings as a Percentage of Total Costs without Savings	36.6	28.6	1.8	23.1

If the incentives were properly designed, these savings could be achieved with no change in environmental objectives. By 2000, the total costs without savings illustrated are projected to be $156 billion in 1986 dollars and about $194 billion in 1992 dollars.

Forward

The EPA faces challenges on many fronts. Perhaps none of these challenges is greater than what is posed by the Kyoto Protocol to limit greenhouse gas emissions, assuming it is ratified by Congress. That agreement, signed in December 1997, calls on the U.S. and 37 other industrialized nations to limit their emissions of greenhouse gases by an average of 5% relative to 1990 levels by the years 2008-2012.

Such a reduction in carbon dioxide and other greenhouse gas emissions would be unprecedented during a period of economic growth. The Clinton Administration has proposed a system of marketable greenhouse gas permits to limit the costs of meeting such an agreement. Emission trading and economic instruments more broadly offer the prospect for meeting pollution control goals at much lower costs than traditional command and control regulations.

This report investigates the savings that potentially are achievable if economic instruments such as emission trading, deposit-refund systems, and product charges and pollution taxes were more widely implemented. The savings apply to both existing pollution control programs and to programs that remain in the proposal or development stage.

1. Introduction

The use of economic incentives for pollution control appears to be gaining increasing acceptance. A recent EPA report (1997) details numerous applications of economic instruments in the United States at all levels of government and indeed throughout the developed nations and a good number of developing nations. One of the reasons for this interest is the economic savings that economic incentives can provide in achieving any given level of environmental protection. These savings are widely believed to be of importance at a time of rapidly increasing marginal cost of environmental improvement through traditional command and control mechanisms, strong pubilc interest in improving the environment and heightened concern with the international economic competitiveness of the United States.

This report attempts a systematic investigation of the savings from existing instruments as well as the potential for savings in compliance costs from more widespread use of avialable and new economic instruments.

1.1. Scope and Relation to Earlier EPA reports

Economic instruments increasingly are being used as an element of environmental policy in the United States and elsewhere. Worldwide, several hundred merket-based instruments such as pollution taxes, tradable pollution permits, reporting requirements, liability, and deposit-refund mechanisms are in use. The 1997 Kyoto protocol to limit greenhouse gas emissions when implemented will represent by far the most important application of these tools to date.

If the time has indeed come for economic incentives, it is important to understand the implementation options for and potential economic savings from economic incentives for pollution control at the local, state, Federal and international levels. This report is intended to provide that overview. Although the emphasis is not on the implementation options for additional incentives at the state and local level, this will be discussed where necessary to clarify the options at the Federal level. Since many incentives can really only be instituted at the state and local level, it is important that this possibility be recognized and discussed in the report.

This report is intended as a supplement to at least three earlier EPA reports on related topics. *Economic Incentives: Options for Environmental Protection* presents a number of detailed options for using a wide variety of economic incentives to solve specific environmental pollution control problems. The second report, *The United States Experience with Economic Incentives to Control Environmental Pollution* by Alan Carlin details the U.S. experience with economic incentive-based approaches. A 1997 report, *The United States Experience with Economic Incentives in Environmental Pollution Control Policy,* by Anderson and Lohof, extends and updates Carlin's analysis to cover many new instruments in the U.S. and in foreign nations. The current report is similar to the first of these reports in that it deals with incentive options, but differs in that it explores the more general implementation options and possible economic savings from extending existing instruments and introducing additional economic incentives rather than looking at the details of specific incentives to solve particular pollution problems. This paper also may be recognized as an extension and amplification of the 1997 paper Cost Savings from the Use of Market Incentives for Pollution Control by Anderson, Carlin, McGartland and Weinberger.

1.2. Definitions

In order to bound the subject, economic incentives in this report will be defined broadly as instruments that provide continuous inducements of a direct or indirect nature for sources to make reductions in the pollutants they release. That is, those who release pollutants incur a cost for each unit of pollution that is released, rather than only amounts of pollution in excess of a standard or permitted amount. Market-based instruments are taken to represent the subset of economic incentives that relies directly on markets to transmit price signals regarding the cost of pollution. Under this definition, MBIs include pollution taxes, charges and fees; marketable permit and allowance systems; deposit-refund systems; and pollution control subsidies.

The definition of economic incentives excludes certain mechanisms that sometimes are referred to as incentives. Although such mechanisms may have many admirable characteristics and some of the attributes of economic incentives as the term is often used, they will not be discussed in this report. This class of mechanisms prices (explicitly or implicitly) activities that have pollution as a byproduct. Ride sharing, bike paths, high occupancy vehicle lanes, and parking surcharges provide examples of this type of mechanism. While these mechanisms may lead to a reduction in pollution, the mechanisms place neither an explicit nor an implicit price on incremental units of pollution. Exclusion of these mechanisms carries no implications for whether future EPA actions will or will not consider them to be economic incentives. Rather, their exclusion is primarily for the purpose of limiting the subject of this report to something manageable.

Payments per unit of pollution are the clearest example of an incentive, as the term is used in this report. Because each unit of pollution is costly, sources are penalized financially for increases and rewarded financially for any decreases in their pollution. Some variants on the approach are observed; for example, the payments may apply only on units of pollution above some threshold. Eighty percent of "baseline" levels is the threshold for payments in one instance.

Market-based systems in pollution reduction credits also operate as incentives, albeit less perfectly than pollution fees. Reductions in pollution below permitted or allowed limits earn sources credits that may be sold to firms that are operating above allowed limits (or retained by the source for future use in some cases). While existing markets in pollution reduction credits are often limited in terms of the number of potential buyers and sellers, as well as the number of actual trades, they nonetheless offer direct financial rewards for sources to reduce pollution. Sources with high incremental control costs tend to be buyers of the credits, leading to improved cost-effectiveness in pollution control.

Finally, indirect financial incentives for continuous effort at pollution abatement are created when sources must report publicly the quantities of specified substances they release and thus risk the loss of market share or a lower demand for their products. All of these incentive mechanisms operate through the ingenuity and actions of individual sources, who have an incentive to be on the alert for opportunities to make reductions in their pollution.

The contrast between incentive mechanisms as defined here and traditional "command and control" approaches is that the latter do not provide incentives to reduce the quantity of releases below permitted levels or to improve the quality of the releases of pollutants beyond permitted levels, as illustrated in the table. Under pure command and control approaches, sources view all releases below permitted quantities or above permitted quality as costless. To have gains in environmental quality, the burden is solely on regulators to tighten requirements imposed on individual sources. Sources operating within the limits of existing regulations (the shaded area in the table) have no economic reason to make pollution control investments.

INCENTIVES FOR REDUCING POLLUTION

Toxicity of Pollution	Quantity of Pollution	
	Within Regulatory Limits	Excess Above What Is Allowed by Regulations
Excess above What Is Allowed by Regulations	Fines and Penalties Because of Toxicity	Fines and Penalties For Exceeding Regulations on both Toxicity and Quantity, If Caught and Successfully Prosecuted
Within Regulatory Limits	**No Incentive to Reduce Pollution**	Fines and Penalties on Excess Quantities If Caught and Successfully Prosecuted

Unfortunately, there are a wide variety of definitions of economic incentives in common use, as well as a variety of related concepts. One of these related concepts is "market mechanisms." Generally, this term is used for a somewhat narrower concept involving only those economic incentives which are implemented through mechanisms having direct effects on economic markets. Thus, providing risk information could be an economic incentive but not a market mechanism while pollution fees would be both. Risk information can have an indirect effect on economic markets by shifting either the demand function or the supply function (either through appealing to profit-motivated market share considerations or liablility aversion), but does not directly change prices.

It must be emphasized that although this report makes a careful distinction between command-and-control and economic incentive approaches, these distinctions are often difficult to apply in practice. Some analysts have even argued that prohibitions established by command-and-control regulations operate in part by creating economic incentives to comply (through the proper setting of fines and penalties), while pollution charges and other "market" incentives rely on governmental policing of the market or governmental definition of the goods (*i.e*, pollution units). In other words, there is a continuous distribution of pollution control measures ranging from the "pure" command-and-control to the "pure" market mechanism. Expressed still another way, the dividing line between command- and-control and economic incentives can be drawn at any number of places; although the definition used above is based on what is probably the most important economic distinction between the two approaches, a case can be made for a number of other definitions.

Another important definition is what is meant by the economic efficiency of economic incentives. Theoretically, the most economically efficient incentive is one which requires the polluter to pay exactly an amount for pollution that just equals the magnitude of damage to others. In theory, the polluter would reduce pollution to the point that the cost of further reductions exactly equals the damage caused to others by the pollution. An economically efficient incentive will therefore be defined as one that either imposes an incentive that meets this criterion or that encourages polluters to act as if it had been imposed.

1.3. Types of Economic Incentives Discussed in the Report

The nation's environmental laws control pollution through a mix of strategies, most of which involve direct regulation of the quantity of pollution allowed by individual sources or the control technology sources must use. This direct regulatory approach to pollution control is termed " command-and-control."

Incentive systems create rewards for preventing or controlling and penalties for increasing one's emissions, effluents, or wastes. Incentive mechanisms can establish a system of rewards and penalties through a variety of specific mechanisms. The following table shows the mechanisms discussed in this report classified according to the time the incentive becomes effective in relation to the time the pollution occurs. Specifically, the table lists the following mechanisms:

(1) Payments based on pollution discharges. Pollution fees, charges, and taxes are payments by polluters based on the quantity of pollutants emitted. They are usually made to government agencies but are sometimes made to private waste disposal companies.
(2) Deposit-refund systems involve payments by potential polluters at the time a product is purchased, which are refunded if the product is disposed of or recycled in specified ways.
(3) Tradeable permit rights allow the transfer of pollution credits and allowances for in-kind or financial compensation.
(4) Information disclosure approaches provide for the release of information related to companies' products or activities, such as data on their emissions or compliance status.
(5) Liability for environmental damage approaches provide for future payment by polluters based on the damages caused by their emissions. A case can be made for including liability for damages to publicly-owned or managed natural resources within category (1) since payments are made to a government agency. It appears easier, however, to group them with other liability approaches.
(6) Payments from government for pollution control subsidies and tax concessions provide financial payments to polluters and tax advantages based on changes in pollution or in return for future pollution control actions.
(7) Extension of private property rights to environmental resources provides incentives for the owners of such rights to prevent pollution of their resource in order to maintain the value of their property.

Incentive Type	Time Incentive Becomes Effective			Section
	Prior to Time of Pollution	At Time of or as Direct Result of Pollution	Long after Pollution Occurred or Might Have Occurred	
(1) Payments Based on Pollution Discharges	Fees or Taxes on Inputs to Pollution Producing Processes	Fees or Taxes on Discharge	Fees or Taxes on Outputs from Pollution Producing Processes	

(2) Deposit-refund Systems	Deposits		Refunds	
(3) Tradeable Permit Rights	Allowance Trading Systems	ERC Trading	ERC Banking	
(4) Information Disclosure	Manufacturer- Provided Warnings	Reports on Incidents	Disclosure of Past Emissions	
(5) Liability for Environmental Damage	Environmental Assurance Bonds		Superfund Liability for Cleanup; Tort Law for Private Damages; Natural Resource Damages for Public Resources	
(6) Payments from Government for Pollution Control	Subsidies for Installing Pollution Control Equipment; Conservation Reserve Payments		Tax Advantages in Return for Reduced Pollution	Not in this report
(7) Extension of Private Property Rights to Environmental Resources	Owner Prevents Future Pollution to Avoid Loss	Owner Charges Polluters for Pollution	Owner Sues Polluters for Damages to Property	Not in this report

Categories (1) through (6) are those identified and used in Carlin (1992). Category (7) was not included in Carlin (1992) because of the lack of examples in the United States but is added here for completeness. The last column of the table shows the subsection in which each of the new categories is discussed

The table notes two possible approaches, (6) and (7), that are not discussed in the remainder of this report in the interest of simplifying the analysis. With regard to (7), it can be said that property rights in the United States are primarily creatures of state law, and a variety of legal doctrines affect the ability of states to adjust these boundaries or to alienate public property interests, particularly where these are held in public trust. However, the discussion of pollution fees could apply to privately assessed fees for use of privately held environmental resources. In addition, the report's discussion of liability incentives contem- plates the existence of a privately held right or set of rights (either in traditional forms of property, personal liberty, or some new form of property).

Some incentive mechanisms, generally shown in line (4), establish prices indirectly through market transactions. Within this group are information reporting requirements such as Title III of the Superfund Amendments and Reauthorization Act and California's Proposition 65. Others, such as pollution fees and various trading systems, including EPA's air emission trading program, transferable development rights, and marketable effluent discharge credits, work by directly affecting market prices.

1.4. Organization of Report

Section 2 examines the principal rationales for greater use of economic instruments as a tool of environmental management. First, the most easily identified and solved environmental problems originated with large point sources. With most of those problems adequately addressed, attention has turned to smaller, more diverse sources. It is these sources where economic instruments can be expected to have a significant advantage over traditional regulatory approaches. Second, economic incentives are likely to require lower compliance outlays for a given level of environmental improvement than traditional approaches. Third, economic incentives provide a strong stimulus for innovation and technical change, something largely absent in the command and control approach.

Section 3 provides estimates of the current and potential cost savings from the application of existing instruments for air and water pollution control and solid and hazardous waste management. Section 4 reviews potential new applications, including the use of economic instruments for reducing greenhouse gas emissions. Section 5 provides summary and concluding remarks.

2. Economic Opportunities

The primary purpose of this report is to estimate the potential economic savings that are available from using economic incentives more widely to control environmental pollution. Economic theory as well as practical experience argue that economic incentives will stimulate sources to make changes in inputs, changes in production processes and modifications to pollution control equipment to lower the cost of controlling pollution relative to a command-and-control regulatory approach.

Incentive mechanisms have several properties that should make them especially well suited to contemporary environmental problems. First, relative to traditional forms of direct regulation, incentive approaches should be more effective in dealing with pollution from diverse sources, an increasingly important problem. Second, incentive mechanisms are inherently more economically efficient; that is, they achieve environmental goals at lower cost than direct regulation. Third, incentive mechanisms provide a greater stimulus for innovation and technical change in pollution control than does a direct regulatory approach. These properties are discussed in the first three subsections. The fourth subsection summarizes what is known concerning the environmental effects of incentive systems. Finally, the last subsection (Section 2.5) estimates the potential savings already achieved and potentially available.

2.1. Diverse Sources and Little-Known Control Technology

Direct regulatory approaches generally are most effective when all the affected sources of pollution have similar emission characteristics, environmental impacts, and pollution control possibilities and when the regulators have as good a knowledge of the available abatement opportunities. These conditions do not apply to many of current environmental problems since the " easy" pollution sources have already been controlled. Many heterogeneous smaller sources discharge effluents into the nation's streams and rivers. Emissions from small dispersed area and mobile sources contribute over one-half of the precursors of ozone in most nonattainment areas. Millions of motorists change their oil and release used motor oil into the environment in a variety of places and ways. Shortages of capacity and the difficulty of siting new solid waste facilities in communities across the nation have stimulated interest in ways to reduce the generation of solid waste by households. Any program to orchestrate significant reductions of greenhouse gas emissions would require actions by billions of individuals throughout the world if it is to be successful. For these and similar environmental problems, direct regulatory action may be much more expensive and less effective than economic incentives.

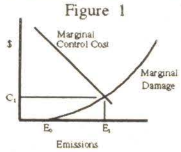
Particularly for such diverse sources, individual firms or households are more likely than regulators or legislators to have the knowledge to choose the most effective pollution control techniques for their particular situation. Acting on their own knowledge or with information provided by vendors of equipment or government agencies, individuals and firms are most likely to be aware of the full range of options available from process changes to input changes to behavioral changes to specific control technologies, and their costs and effectiveness. Regulatory bodies are not likely to have access to this range of knowledge. Regulatory approaches further fail to provide an incentive to adopt pollution controls other than those specified by regulators, even if they would be more effective.

2.2. Greater Efficiency

One means of controlling releases of pollution is to rely on private negotiations between those who bear the costs of pollution and sources of pollution. Under the assumptions of costless transactions and no strategic behavior, such negotiations can lead to an optimal level of pollution control in which the full costs of pollution are taken into account in the decision process of the source (Coase). While the assumption of no strategic behavior may be reasonable in many cases, costless transactions, which are necessary for the victims of pollution to negotiate successfully with sources, are unlikely to be a realistic assumption. The more victims there are, and the more geographically disperse are the victims, the higher transactions costs are likely to be.

Because negotiations between victims and sources of pollution cannot be relied upon as a means of control, environmental legislation dictates other mechanisms for internalizing pollution externalities. In one approach the pollution control authority specifies in considerable detail requirements for different source categories. The regulations may impose discharge limits or much more, such as the technology that must be used, the inputs that must be used, or characteristics of the outputs that are produced. This regulatory approach is termed "command and control." Market-based or incentive approaches, by contrast, provide rewards for reducing pollution (and conversely penalties for releasing pollution). The rewards may be of a financial nature, but need not be. In contrast to the command and control approach, an incentive-based regulatory strategy gives sources great flexibility in selecting both the type and magnitude of response.

Figure 1



The basic reference point is Figure 1, a stylized depiction of the incremental damage of increased levels of pollution and the incremental costs of controlling pollution. The economically efficient level of control limits pollution to E1. Up to that level of pollution the incremental damage from successive units of pollution are less than the incremental costs of control. Beyond E1, incremental damage exceeds incremental control cost. Net benefits of pollution control are maximized at E1.

Command and control approaches generally will not perform as well as incentive-based mechanisms such as pollution taxes, marketable permits, and liability in yielding the efficient level of pollution control. Several factors affect the economic efficiency of different tools for environmental management. As will be shown, market-based instruments offer a number of distinct advantages over traditional command and control approaches. Which instrument performs best, though, depends upon the specific situation. Consequently, a case-by-case approach probably is advisable in selecting the most appropriate instrument from among those potentially available.

In reviewing some of the important characteristics, consider first, the sources of pollution. Are the costs of control known with certainty? If not, how great is the uncertainty? Is the technology of pollution control static, or is it likely to change over time? Can the quantity of pollution from each source be measured (or approximated) easily? How many sources are there for each pollutant? Are incremental control costs similar for different sources, or is there considerable variation?

On the damage side, does a unit of pollution from each source have the same impact on health and the environment, regardless of where it is released? Are the impacts on health and the environment known with certainty? If not, how great is the uncertainty? At which juncture do major uncertainties arise: imprecise knowledge of the effect of pollution on environmental quality, exposures, physical effects, or economic valuation of effects? How many parties are experiencing pollution damage? Is it critical to control pollution within narrow limits to achieve environmental goals, or are damage functions such that there is a continuum of effects from less serious to more serious, with no obvious unacceptable level of pollution?

Depending upon these parameters, some tools of environmental management are likely to perform better than others. Of course, performance can be measured in a number of ways. While economists would place the emphasis on economic efficiency, other criteria such as fairness, political acceptability, stimulus for innovation and technical improvement, enforce- ability and consistency with religious and moral precepts also could be used in place of or in conjunction with efficiency. Cost-effectiveness is a compromise criterion that takes both economics and the political and legal structure into account by finding the least cost means of achieving a stated environmental goal. Alternatively under this criterion, one could identify the pollution control measure that maximized environmental gains within a given cost budget.

Evaluations of incentive systems that have been implemented typically find savings in control costs, improvements in environmental quality, or both relative to a command and control approach. Several of these systems will be described subsequently. Theoretical modeling of pollution control costs consistently demonstrates that incentive systems outperform command-and-control approaches in terms of efficiency.

Economists have long suggested that the traditional approach to environmental pollution control, which is predominantly command-and-control in nature, results in control costs that are higher than necessary to achieve a given level of environmental protection. They have suggested that costs could be substantially reduced if economic incentives were used in place of command-and-control regulations. Costs could be reduced because sources having the lowest costs of additional control would have an economic incentive to control more and those sources having the highest incremental control costs could control less rather than all polluters of a given type controlling to the same extent, as is now usually the case.

Many of the quantitative studies done by these economists are summarized in tables that appear later in this section. The ratio shown for most of the studies in the last column is the ratio of command-and-control costs to the lowest cost of meeting the same objective using economic incentives. A ratio of 1.0 suggests that the command-and-control approach is equal in cost to the economic incentive approach, so that the savings are zero. A ratio greater than 1.0 means that there are positive potential savings from using economic incentives. Since all the ratios shown are greater than 1.0, they support the assertion above that economic incentive approaches are more cost effective than command and control approaches. Some additional studies are listed for which ratios have not been worked out. A review of these studies suggests that they also support the above assertion. No studies reach the opposite conclusion.

Economic theory and common sense argue that incentive mechanisms should enhance the efficiency of pollution control relative to traditional command and control techniques. The reasons for this conclusion are several. First, some incentive-based mechanisms explicitly allow trading of pollution reduction obligations. With trading, sources with high incremental costs of control can have their obligations satisfied by sources with low incremental costs of control. Other incentive-based mechanisms levy a charge or tax on each unit of pollution. Under such an approach sources would control pollution only to the point at which the incremental cost of control equaled the charge or tax. In an idealized world without transactions costs and competitive markets, both permit/credit trading and pollution charge approaches should result in the marginal cost of controlling pollution being the same at each source. At every level of pollution, total control costs should be minimized.

A number of other incentive-based mechanisms, such as information reporting requirements, liability, and voluntary programs, rely on implicit charges for pollution. The efficiency consequences of such mechanisms is more difficult to predict because sources are reducing pollution for reasons that have only an indirect financial consequence. And sometimes that financial link is very tenuous. The motives for participating in voluntary programs are largely one of improving corporate image to customers, to employees, and to regulators, though management concern for the environment certainly could be a factor. While the motives for controlling pollution are very real, the benefit to the firm of reducing emissions is difficult to express in financial terms. Perhaps the best that could be done is to examine what firms actually spend as part of such programs to generate a willingness to pay for pollution reduction. One might find that forms respond in a systematic fashion to various of the indirect incentives. For example across a sample of firms, liability might generate higher willingness to pay for a unit of pollution reduction than does an information reporting requirement, which in turn might exceed the willingness to pay for strictly voluntary activities.

The following tables summarize results of studies that compare incentive mechanisms with command and control approaches for managing the environment. One observes that in every case the command and control approach is more costly than the market-based approach, sometimes much more costly.

QUANTITATIVE STUDIES OF SAVINGS FROM ECONOMIC INCENTIVES
AIR POLLUTION

Pollutant Controlled	Study Year, Source	Geographic Area	Command and Control Approach	Ratio of CAC to Market-Based Approach
Hydrocarbons	Maloney & Yandle (1984) T	DuPont facilities in U.S.	Uniform percent reduction	4.15
Nitrogen doxide	Seskin *at al.* (1983) T	Chicago	Proposed RACT regulations	14.4
Nitrogen dioxide	Krupnick (1986) O	Baltimore	Proposed RACT regulations	5.9
Particulates (TSP)	Atkinson & Lewis (1974) T	St. Louis	SIP regulation	6.0
Particulates (TSP)	McGartland (1984) T	Baltimore	SIP regulations	4.18

Particulates (TSP)	Spofford (1984) T	Lower Delaware Valley	Uniform percent reduction	22.0
Particulates (TSP)	Oates *et al.* (1989) O	Baltimore	Equal proportional treatment	4.0 at 90 ug/m3
Reactive organic gases and NO2	SCAQMD (1992) O	Southern California	Best Available Control Technology	1.5 in 1994 1.3 in 1997
Sulfur dioxide	Roach *et al.* (1981) T	Four Corners Area	SIP regulation	4.25
Sulfur dioxide	Atkinson (1983) A	Cleveland		
Sulfur dioxide	Spofford (1984) T	Lower Delaware Valley	Uniform percent reduction	1.78
Sulfur dioxide	ICF Resources (1989) O	United States	Uniform emission limit	5.0
Sulfates	Hahn and Noll (1982) T	Los Angeles	California emission standards	1.07
Six air pollutants	Kohn (1978) A	St. Louis		
Benzene	Nichols *et al.* (1983) A	United States		
Chlorofluoro-carbon s	Palmer *et al.* (1980); Shapiro and Warhit (1983) T	United States	Proposed emission standards	1.96
All?	Toman *et al.* (1994) O	Poland	EC and German standards	1.1 to 1.2
Sulfur dioxide	Haklos (1994) O	Europe	Uniform percent reduction	1.42
Ozone	Hahn (1995) O	United States	Vehicle mandate in CA and Northeast	25% CA 50% NE
Particulates	O'Ryan (1996) O	Santiago, Chile	1. Uniform % reduction; 2. Uniform source concentration standard	6.0 for 60% reduction 1.9 for 90% reduction
Toxics	Marakovits & Considine (1996) O	U.S. steel industry	Uniform % reduction	2.5

In many of these studies, a distinction was not drawn as to the precise nature of the market-based mechanism that would be used. Rather, the assumption was made that pollution taxes as well as marketable permits could yield the least cost outcome identified through linear programming. In practice, however, one finds that few if any of the market-based instruments that have been put in place achieve anywhere near their theoretical potential.

Searching for reasons for the wide gap between the potential and what actually is accomplished, Stavins identifies transactions costs as the primary culprit. With transactions costs as a barrier to trading, sources tend not to venture far from their initial allocation of pollution rights. As transactions costs rise, the prices that sellers receive for pollution rights fall and the prices that buyers must pay rise, making transactions less likely. Transactions costs were especially high in EPS's early Emissions Trading Program, described later in this report, with the result that fewer than one percent of the emissions potentially available for trading actually were traded (Hahn, 1989). Transactions costs were lower for programs such as lead credit trading, resulting in a far higher proportion of available credits actually being traded.

Transactions costs also feature prominently in the choice between making trades internally within a firm and externally between firms. For all of the trading programs that have been studied, firms exhibit a strong preference for internal trading when that is feasible, even when larger cost savings are available externally. (Burtraw, Kerr). Additionally, markets in rights available for sale tend to be thin (Hahn); it may be difficult to locate potential sellers of rights; and even when rights are readily available, many firms seem to distrust 'paper' credits. One other limitation of trading systems is that pollution credits have a limited life whereas engineering controls may last for the life of a facility.

For tax, charge and fee systems, the principal limitation to achieving the theoretical efficiency gains has been the generally low level of charge relative to what would be required to have a significant impact on pollution. Few jurisdictions have ever experimented with taxes that are large enough to have a significant impact on emissions. Charges typically are set to recover administrative costs for a program, not to impact pollution. The examples where emission taxes of that magnitude have been imposed included a mechanism to redistribute tax revenues to sources so that the mechanism would be (nearly) revenue neutral. Unless tax revenues are redistributed to the affected sources of pollution, emissions taxes impose large costs on sources, costs that probably spell doom for the political acceptability of the approach. With the adverse equity effects of emission taxes resolved through redistributing revenues though, there is reason to believe that a pollution tax approach could achieve *greater* emissions control than predicted by linear programming models. The reason is the dynamic effect that pollution taxes can have on innovation and technical change. The evidence from Sweden suggests these impacts can be large and unexpected.

QUANTITATIVE STUDIES OF SAVINGS FROM ECONOMIC INCENTIVES
WATER POLLUTION

Substance Controlled	Source Year, Source	Geographic Area	Command and Control Approach	Ratio of CAC to Least Cost Approach
Biochemical Oxygen Demand (BOD)	Johnson (1967) T	Delaware Estuary	Equal proportional treatment	3.13 at 2 mg/l 1.62 at 3 mg/l 1.43 at 4 mg/l
BOD	O'Neil (1980) T	Lower Fox River, WI	Equal proportional treatment	2.29 at 2 mg/l 1.71 at 4 mg/l 1.45 at 6.2 mg/l
BOD	Eheart et al. (1983) T	Willamette River, OR	Equal proportional treatment	1.12 at 4.8 mg/l 1.19 at 7.5 mg/l
BOD	Eheart, et al. (1983) T	Delaware Estuary	Equal proportional treatment	3.00 at 3 mg/l 2.92 at 3.6 mg/l
BOD	Eheart et al. (1983) T	Upper Hudson River, NY	Equal proportional treatment	1.54 at 5.1 mg/l 1.62 at 5.9 mg/l

BOD	Eheart et al. (1983) T	Mohawk River, NY	Equal proportional treatment	1.22 at 6.8 mg/l
Heavy metals	Opaluch & Kashmanian (1985) O	Rhode Island jewelry industry	Technology-based standards	1.8
Phosphorus	David et al. (1977) A	Lake Michigan		
Selenium	EDF (1994) O	Central Valley, CA	Best management practices	1.2
Hydrocarbons	Raffle and Mitchell (1993) O	AMOCO Yorktown refinery	Proposed discharge requirements	4.0

QUANTITATIVE STUDIES OF SAVINGS FROM ECONOMIC INCENTIVES OTHER POLLUTION-RELATED ISSUES

Substance Controlled	Study Year, Source	Geographic Area	Command and Control Approach	Ratio of CAC to Least Cost Approach
Municipal solid waste	Palmer, et al. (1995) O	United States	Uniform percent reduction of 10%	2.0
Fuel efficiency	Charles River Associates (1991) O	United States	CAFE standards	4.5
Agricultural chemicals	Rendleman *et al.* (1995) O	United States	Uniform percent reduction	1.1
Traffic congestion	Hau (1990) O	Hong Kong	Car ownership restraint	2.5

Sources: A stands for Anderson *et al.* (1989); they did not compute the ratio or provide the other information left blank in this table. O stands for original reference. T stands for Tietenberg (1985). See Appendix for all references.

It is important to note that one recent review of retrospective analyses of emission and effluent trading systems concluded that realized cost savings fall well short of these projections. [Atkinson and Tietenberg (1991)]. Trades have been fewer and cost savings smaller, according to this analysis, than indicated by economic modeling. A number of explanations have been offered about why the full savings have not always been realized. [See Atkinson & Tietenberg (1991), Dudek & Palmisano (1988), Hahn (1989), Hahn & Hester (1989), Liroff (1986), and Tietenberg (1985 and 1990)]. Regulatory and legal requirements of the actual programs may limit the trading opportunities to a greater extent than portrayed in the models, especially where the incentive programs is in addition to existing command and control programs. Various models have not fully reflected aspects of real regulatory programs, including the transaction costs, number of buyers and sellers, trading rules, monitoring and reporting requirements, and the administrative burden placed on both emission sources and regulatory agencies. Finally, command and control programs may be more enlightened than is modeled. For instance, the C&C alternative may offer flexibility in terms of meeting deadlines or geographic variation in the extent of control rather than a hard and fast uniform percent reduction.

Even if the cost savings are less than predicted, the actual savings are still impressive. In the appropriate circumstances, the wider use of incentive programs that are feasible in an actual policy setting will result in substantial costs savings while achieving equivalent environmental goals. In other circumstances, the cost differences between an incentive program and a well designed command-and-control program will be less, [Oates *et al.* (1989)]. although the incentive program will provide a stronger stimulus for innovation and technical change.

2.2.1. Efficiency Gains from Environmental Pollution Fees

In those cases where the economic incentive used is a payment to the government for pollution discharges, there is an added efficiency gain to the extent that the revenue gathered offsets revenue that would otherwise be gathered through other forms of taxation. Almost all other forms of taxation result in lower levels of activity for those activities that are taxed, with resulting economic losses. For example, the income tax results in less income-producing activity because the rewards to the producer are reduced by the amount of the tax. On the other hand, environmental fees, while reducing pollution producing activities, increase efficiency if set so as to produce an economically efficient level of pollution. Some estimates of the efficiency gains from shifting from other taxes to environmental pollution fees are quite large. [For a brief summary of the literature, see Repetto *et al.* (1992) Section I].

2.2.2. Cost Implications of Changes in Monitoring Technology

Generally, incentive-based approaches will be more information intensive than comparable command-and-control mechanisms. If incentives involve marketable pollution reduction credits, a pollution control agency will have to develop a mechanism for quantifying the reductions. With few exceptions (e.g., lead credit trading during the phasedown of the lead content of gasoline in which buyers' and sellers' reports were matched by the EPA to evaluate compliance and perhaps the marketable fireplace permit programs in some communities in the western U.S.), a pollution control agency must have actual physical measurements of pollutants to support a trading regime. For example, the acid rain trading program relies on continuous emission monitors to measure sulfur dioxide and nitrogen oxides emissions as they pass through a stack. In contrast, a command-and-control regime typically requires only that pollution control equipment has been installed and is working. Consequently, the cost of making pollution measurements can be a decisive factor against some incentive approaches.

Consider the U.S. Acid Rain Program. To assure that the affected utilities have sufficient allowances for their actual emissions, the program requires them to instal continuous emission monitors (CEM). The cost of monitoring in the program is quite substantial. The projected savings from the overall flexible design of the program are about $2.5 billion per year. The savings that can be attributed to allowance trading, are lower, on the order of $700 to $800 million when fully implemented. (Carlson, Burtraw, Cropper and Palmer) When fully implemented, the program will include 2,000 units, each of which must install a CEM. The total cost of CEMs will be about $250 million annually, a significant fraction of the savings attributable to ET. If monitoring costs could be reduced to negligible levels, savings from the program could be increased by nearly one-third.

The high costs of monitoring with CEMS influenced the South Coast Air Quality Management District to defer any action to include reactive organic gases within the RECLAIM program. For small sources emitting 10 to 100 tons of ROG per year, the costs of CEMS at an annualized cost of $120,000 to $250,000 per year each probably outweigh the potential gains from trading.

Most studies of the potential savings from economic incentives, such as those listed in Section 2.0, do not explicitly account for monitoring and enforcement costs. To the extent that monitoring and enforcement are more difficult and/or expensive under incentive approaches, the potential for cost savings could be overstated. In the past decade, a number of advances in monitoring have reduced substantially the cost of obtaining pollution measurements. For example, the cost of making ambient air measurement of criteria pollutants has fallen by approximately 90 percent over the last decade. More recently, remote sensing of both mobile and stationary source emissions has been confirmed as both feasible and inexpensive for a wide variety of pollutants. Bishop, Grant. Remote sensing costs can be quite modest. For example, the cost of making a remote measurement of the carbon monoxide or hydrocarbon content of a passing vehicle's exhaust is currently estimated to be 50 cents.

Advances in remote monitoring technology for water pollutants also offer the promise for reducing costs. Perchalskie and Higgins (1988). In the field of solid and hazardous waste, bar code scanning is being used to track shipments of hazardous wastes. This technology could easily be extended to household solid waste collections to facilitate charge mechanisms for each can or bag.

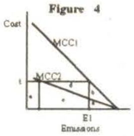
2.3. Stimulus to Innovation and Technical Change

Market-based instruments should have significant advantages over command and control mechanisms in terms of stimulating technical change and innovation in pollution control. The reason is that each and every unit of pollution is costly to the firm. In contrast, under a command and control approach, once a source has satisfied the emission limits, all pollution within those limits is costless. Why spend valuable resources instituting further controls when there is no reward? In fact, the incentives may be negative, for a firm that controls to less than permitted amounts may be inviting reductions in what is permitted. In many parts of the nation pollution control agencies are constantly struggling to find ways of meeting ambient environmental quality goals. Firms that demonstrate the possibility of making emission reductions below permitted amounts offer an easy target for obtaining some of the necessary emission reductions. These same innovative firms may supply the catalyst for regulations that require other firms in the same industry to undertake what has been demonstrated as possible.

The figure depicts graphically the difference in incentives for innovation between an emissions tax and a command and control policy. With marginal control costs of MCC1, a firm controls emissions to E1 with an emission standard set at that level, incurring costs equal to area (a+b). With an emissions tax set at t, the firm also would control emissions to E1, incurring costs equal to (a+b+c+d+e).

The incentive to the firm to find improved methods of pollution control are much stronger under the emissions tax, since total pollution control outlays are so much higher.

Figure 4



If the firm finds a new pollution control technology with marginal control costs equal to MCC2, total abatement costs under the emissions standard approach would fall by an amount equal to area b. Under the emissions tax approach, total pollution control outlays would decline by an amount equal to area (b+c).

It should not be surprising that the theoretical and empirical literature concludes that emission taxes provide the greatest stimulus for technical change and innovation, with marketable permits offering a lesser stimulus and command and control the least. (Zerbe (1970), Wenders (1975), Downing and White (1986), and Milliman and Prince (1989)) Among command and control approaches, it is safe to say that performance-based standards should provide a greater incentive to innovate than would pure technology requirements. Fischer, Parry and Pizer (RfF DP 1999-04) use a simplified model to derive analytical and numerical estimates of the welfare impacts of three instruments (emission taxes, auctioned marketable permits and grandfathered marketable permits) in the presence of endogenous technical change. They conclude that there is no clear-cut case for recommending one instrument over another because of dynamic efficneicy effects as the results are dependent on many difficult-to-quantify factors.

Long-run changes in behavior and technology are among the most difficult economic effects to document. For that reason, relatively little is known of the effects that take place as a consequence of different pollution control policies. Yet these effects are thought to be very important. One author said the rate of technological change in pollution control is "the single most important criterion on which to judge environmental policies." Kneese and Schulze (1978)Another analyst termed innovation "the key to an effective solution" of environmental problems.(Orr (1976))

The available evidence suggests that command-and-control dominated environmental policies give only a mild stimulus for technical change and innovation. (Cramer *et al.* (1990)) In contrast, the incentive-based U.S. acid rain control program has seen dramatic reductions in control costs due to major technical and behavioral changes. Outlays for research and development in pollution control are between two and three percent of total pollution control expenditures. This is about the same as the average R&D expenditure in all of U.S. manufacturing, but far lower than one might expect in a new and rapidly changing industry. A more apt comparison might be provided by drugs, electronics and information processing where R&D runs between 6 and 10 percent of expenditures. Research and development in pollution control appears to lag behind largely because of the command and control framework that has been chosen, not because of any other inherent limitation. Pollution control based more heavily on economic instruments would be expected to stimulate greater R&D and in turn reduce over the long run the costs of improving the environment.

2.4. Environmental Effects of Incentive Approaches

A full understanding of the effectiveness and economic efficiency of incentive programs requires information on the realized environmental benefits. The literature focuses almost exclusively on the cost side because of the presumption that the same environmental goals are being sought. In comparing incentive-based policies with command and control approaches, or among different incentive-based policies, there may be impacts on environmental quality that would be of interest to regulators and other parties.

Generally, incentive mechanisms based on trading are designed to produce environmental effects that closely approximate what would be achieved through a command and control approach. Some distinctions still apply, however, in that a 'cap and trade' policy is likely to give greater control over total emissions than is an 'open market' trading approach. Open market approaches do not provide a limit on total emissions; credits may be generated as sources see fit. If there is to be a control on total emissions, it would have to come from a companion command and control regime. In contrast, under a capped trading program, total emissions are limited. Either type of trading will reduce total emissions if trading ratios of greater than 1:1 are required. Some trading program described in this report have that feature (e.g., fireplace permit trading) but others do not (e.g., acid rain allowances).

While trading approaches may achieve the same reduction in emissions as a command and control program, the distribution of the reductions is likely to be different. This has been a recurring source of concern, namely what increase in pollution in one area may be tolerated in exchange for reductions elsewhere. Both the RECLAIM and Acid Rain programs have been challenged in court because of alleged adverse impacts in localized areas. EPA's Air Emission Trading Program was crafted carefully to avoid adverse localized impacts, but at a high cost in terms of barriers to trading.

Emission tax systems typically have not been designed to have an environmental impact. Rather, modest revenue raising has been the principal goal. However, in the few examples for which emission fees have been set at a level intended to have environmental impacts, the benefits were greater than forecast (Swedish NOx and SO2 charges, and United States CFC charges).

Deposit systems appear to produce environmental effects greater than would be expected through a command and control method; however, there appears to be a threshold of deposit size needed in order to induce people to achieve the desired environmental objective. For example, deposits on automobile bodies function well in assuring the proper disposal of car hulks when set at a high enough level (see the section on international experiences). In contrast, thousands of abandoned car hulks are removed at city expense in New York each year despite regulations prohibiting that type of disposal.

Variations in environmental effects can be important in evaluating the overall desirability of different approaches. Often it is not correct to simply assume various approaches yield the same result. Oates et al. (1989) describe an example of particulate matter control in the Baltimore region in which 'over control' in some areas required under a command and control approach yields environmental improvements that lessen the relative attractiveness of an incentive-based policy that produces more uniform pollutant concentrations.

3. Potential Cost Savings from Existing Economic Incentives

A 1990 EPA report estimated that the total costs for all forms of pollution control were $26 million in1972 (0.9% of GNP) but would increase to $160 billion in the year 2000 (2.6 to 2.8 percent of GNP). [a summary of the report is available for downloading]. With current interest in economic incentive approaches, it is natural to ask two related questions. First, how much do existing market-based (incentive) programs, such as the Acid Rain control program, reduce the cost of pollution control over what they would be with more traditional command and control approaches? Second, if market-based programs were applied in every instance where they were more economically efficient, by how much would pollution control costs be reduced? Section 4 investigates these latter issues.

3.1. Nature of Cost Savings Considered

The savings considered will follow the approach taken in our principal data source, EPA 1990. In particular, the costs presented in this report represent estimates of direct regulatory implementation and compliance costs. They are the first-order, claimed to be out-of-pocket costs to those entities that implement control measures and undertake compliance activities. For example, the private costs associated with existing programs represent the before-tax expenditures associated with all compliance activities, including the purchase, installation and operation and maintenance of existing pollution control equipment; the private costs of new and future programs represent, for the most part, projections of before-tax capital investment and operation and maintenance costs calculated using engineering analyses. Recent evidence suggests that what firms perceive as environmental compliance expenditures in responding to Commerce Department surveys actually include many process improvements, energy saving outlays and the like. Consequently, reported environmental compliance expenditures appear to overstate actual compliance costs by a wide margin. (Morgenstern, et al, 1997).

Direct costs, whether overstated or not, are an imperfect proxy for the social costs of pollution control regulation. The true social costs of pollution control are represented by the total value that society places on the goods and services foregone as a result of resources being diverted to environmental protection. Compliance costs do not fully reflect social costs because they neglect direct regulatory impacts that do not involve out-of pocket costs as well as the intertemporal and secondary effects of environmental protection. In other words, they do not account for the dynamic, general equilibrium effects created throughout the economy that impose costs on industries and households not directly affected by regulation. Environmental protection imposes costs on virtually all economic entities including the general public that are largely hidden. Examples of social costs imposed by pollution controls that are not reflected in direct compliance cost estimates include lost or delayed production and consumption opportunities, reduced economic productivity, and higher price inflation. Some recent research suggests that compliance cost estimates may understate substantially the true long-term costs of pollution control (Hazilla and Kopp).

It is important at the outset to note that direct regulatory implementation and compliance costs properly include agency administrative costs and other transactions costs as well as capital and operating costs. These transactions costs include outlays by polluters when they search for or attempt to sell pollution credits or allowances, the costs of negotiating the transaction, and any subsequent monitoring or litigation-related costs. Administrative and other transactions costs are not well known for most pollution control programs, particularly those involving incentives. EPA (1990) provides estimates for a subset of administrative costs, but not other transactions costs. Similarly, analyses that show the potential cost savings from incentive mechanisms often ignore transactions costs.

Certain transactions costs tend to be relatively high for incentive-based approaches. For example, marketable credit systems and pollution discharge systems require fairly accurate measures of the quantity of pollution actually released. As noted in Section 2.2.2 above, however, monitoring costs have been falling rapidly and are likely to continue to do so in the near future. Marketable credit systems also require bid and offer information from participating sources. Sometimes this information is collected and disseminated by a government entity, though in other cases brokers enter the market to facilitate trading. Further, with marketable credit systems, a government entity must certify that the credits meet statutory and regulatory requirements (*e.g.*, reductions are permanent, real, quantifiable and enforceable). Such certification involves costs. Pollution charge systems may require that pollution control agencies first estimate the probable response of sources to different charge levels before setting the charge. Some incentive systems are inherently simple and largely devoid of transactions costs, however. An example is pollution disclosure requirements.

While incentive-based approaches frequently involve significant transactions costs, they are not necessarily higher than in command and control systems. Command and control approaches require a determination by the pollution control agency of the controls that will be required. Typically, that process is complex, involving elements of engineering, economics, and the health sciences. Command and control approaches also require periodic monitoring to assure that sources are operating within prescribed limits. In the absence of any good data, this report assumes that to a first approximation administrative and regulatory costs are roughly equal with either a command and control or an incentive-based approach.

Some incentive mechanisms achieve results that could be very difficult to accomplish with traditional methods. Consider, for example, deposits imposed on purchases of lead acid batteries in ten states.(see Carlin, 1990, Sec. 2.5.4.3, p. 2-23.) Such deposits are likely to be far more effective than regulatory approaches in ensuring the return of used batteries. Per can fees imposed on household generation of solid waste are similarly viewed as more effective than regulations in reducing the volume of waste generated by households. (see Anderson et al., 1990). Consequently, the estimates provided here are conservative to the extent that traditional command and control approaches could not duplicate the pollution control results.

Cost savings are estimated in various ways. Existing published estimates are used when available. Where no estimates exist for a particular incentive, we first determine whether it is likely to produce significant compliance cost savings. If so, we make a rough estimate of the likely cost savings by making unit production cost or pollution control cost adjustments where these can reasonably be estimated. In some cases, a few of which are potentially important, there appears to be no basis for making even a rough estimate of compliance cost savings.

Cost savings from incentive mechanisms are disaggregated by medium (air, water, and land) and further disaggregated into principal EPA program areas. For example, air programs are separated into stationary sources, mobile sources, and radiation. This follows the approach taken in EPA (1990).

The savings are separated into two categories:

Existing and projected savings assuming current programs. As in EPA (1990), these represent those savings that can reasonably be expected to occur given current Federal, state, and local laws, regulations, and programs and the continuation of recent trends in their implementation. Unlike the base case used in EPA 1990, it is assumed that the "full implementation" scenario is realized for air pollution control because of the passage of the Clean Air Act Amendments of 1990. Since there has not been any change in water legislation or implementation, the "full implementation" for water is not assumed to be realized there.

Potential savings with full use of incentives. This category assumes that every economically efficient opportunity for using economic incentives is sanctioned by law and fully implemented at all levels of government. Economically efficient in this case is interpreted to mean those situations where environmental pollution control would be at least as effective as under the current approach and where the net economic benefits of the incentives would equal or exceed those of the current approach. In most cases, where the gross benefits will be identical, this is the same as saying that the incentives are assumed to be adopted in every application where they are cost-effective; that is, where incentives accomplish as much in reducing pollution as traditional command-and-control approaches yet do so at a lower cost.

It is important to emphasize that the estimates presented in Section 2.5 suffer not only from the major sources of uncertainty of the underlying cost estimates for the present EPA programs listed in Section 8.2 of EPA (1990), but also the uncertainties as to how accurately it has been possible to apply the assumptions made in the last paragraph for each program for which savings estimates have been made.

Sections 2.5.2 through 2.5.4 present estimates of the projected savings of existing programs for the air, water, and land media, respectively. Sections 2.5.5 through 2.5.7 turn to the more difficult task of estimating the potential savings. Finally, the cost savings from both approaches are summarized in Section 2.5.8 and Tables 2-2 and 2-3.

3.2. Cost Savings from Existing Incentive Systems for Air Pollution Control

Carlin (1992) and more recently Anderson and Lohof (1997) identify a number of incentive systems that involve air pollution: three fee-based programs (state air permit fees, federal nonattainment area fees, and chlorofluorocarbon taxes), an information reporting program (Title III of the Superfund Amendments and Reauthorization Act or SARA), several trading systems, and other systems. Here we will attempt to assess systematically the current or projected savings from each of these systems relative to command and control approaches. We first consider programs that affect stationary sources, then turn to mobile sources. Radiation programs currently do not utilize what could be classified as incentive mechanisms, though some have been suggested.

3.2.1. Air Emissions Trading

EPA's air emissions trading program consists of four separate activities: bubbles, offsets, banking, and netting. The components of the air emission trading program were developed through regulations and policy statements issued by EPA. The programs began independently in the mid to late 1970s and culminated in EPA's Final Emissions Trading Policy Statement, dated December 4, 1986.

Hahn and Hester (1989) estimate that bubbles produced compliance cost savings of $435 million over 6 years (about $70 million per year), offsets yielded negligible savings, banking resulted in very small savings, and netting saved some $525 million to $12 billion over 6 years ($90 million to $2 billion per year).

Foster and Hahn provide the most comprehensive evaluation of the emissions trading program, using data for offset transactions in the Los Angeles area. They obtained data on trading activity from the South Coast Air Quality Management District. The large increase in offset transactions in 1991 and 1992 reflects activity at two special funds created by the SCAQMD in 1991: the Community Bank, which serves small sources producing less than 2 tons per year; and the Priority Reserve, which secures credits for essential public services.

During the period 1985-1992, over 10,000 tons of pollutants were traded in the offset program, with total expenditure on ERCs estimated to be on the order of $2 billion (indicating an average price for traded pollutants of about $200 per ton. Nearly three quarters of the trades involved reactive organic gases (SCAQMD terminology for a subset of volatile organic compounds), but there also were trades in CO, NOx, PM, and SO2.

AER*X, a broker in the Los Angeles offset market, supplied data for prices for over 40 of the trades from 1985 to 1992. All price data are expressed in 1992 dollars. The minimum price per ton in trades of reactive organic gases (ROG) fluctuated in the $40 per ton range over this period, while the minimum value for NOx trades was about $120 per ton. High prices for ROG increased steadily over the period, from $135 to $711 per ton; and high NOx prices increased from about $320 per ton to $655 per ton over the same period. For a variety of reasons, one would not expect all tons of ROG or NOx to be valued identically. First, the markets are imperfect and information on historic trades is not widely disseminated. Second, credits that have been banked involve additional costs to the selling party. Third, offset ratios vary with the distance and location of parties to the transaction. The low end of prices could be determined largely by transactions costs to the seller (thought to be a minimum of $10,000 per transaction). In a few cases, transactions costs apparently exceeded the market value of the credits that were exchanged.

Though the highest and average prices increased over the period, most of the change in 1991 can be attributed to a change in SCAQMD rules the prior year. None of the observed prices remotely approach the typical incremental control costs for ROG and NOx in the Los Angeles area over that period: on the order of $5,000 per ton for ROG and $8,000 per ton for NOx.

Recent prices for emission trades have been higher. The brokerage firm Cantor Fitzgerald regularly posts "representative prices." These numbers are computed as the average of current bid price, current asking price and most recent trade price. In December 1977, the right to emit one pound of ROG per day in perpetuity in the SCAQMD was valued at $754; one pound per day of NOx at $2,908; one pound of PM10 at $1,947; and one pound of SOx at $1,740. The per ton equivalents (discounting at 20% per year) are $826 for ROG, $3,185 for NOx, $2,134 for PM10, and $1,907 for SOx.

Emission trading has not lived up to expectations; trades have been fewer and offset prices lower than many had expected. Several factors seem to have limited the appeal of the emissions trading policy. In order to assure that air quality did not deteriorate, state environ- mental administrators often required expensive air quality modeling prior to accepting proposed trades between geographically separated parties. Deposits to emission banks typically were "taxed" by the air quality management authority to meet state SIP requirements or to generate a surplus the area could offer to attract new firms. Offset ratios greater than unity further depressed the value of ERCs. In many areas it appears that ERCs had an economic value less than the transactions costs of completing a sale to another party.

In other respects, the emission trading program revealed the myriad possibilities for emission trading and many of the features that would be necessary to make trading viable. It served as the foundation for the enormously successful lead credit trading program and the many emission trading features of the 1990 Clean Air Act Amendments. In some respects, however, the 1990 Amendments reduced the scope of trading programs. For example, Section 173(b) restricts the use of growth allowances in State Implementation Plans, limiting the use of offsets. A number of states have redesigned their offset programs as trading programs without emission caps (examples include Delaware, Massachusetts, Michigan, New Jersey, Texas, and Wisconsin as described below). The South Coast Air Quality Management District that has responsibility for the Los Angeles area has developed a much more significant trading initiative known as RECLAIM with an emissions cap and phased reductions in allowable emissions of SO2 and NOx. Illinois expects to have a similar program with an emissions cap in place soon.

A new regional NOx trading program that involves several states in the Northeastern US is described in section 3.2.6. EPA's design builds on a 1993 NESCAUM (Northeast States for Coordinated Air Use Management) Demonstration Project to trade *discrete emission reductions* (DERs), as well as work by the Ozone Transport Commission (OTC) "cap and trade" model for NOx emission allowances, and Ozone Transport Assessment Group (OTAG) studies regarding a regional trading program for NOx and perhaps also VOC that would cover the eastern one-half of the U.S.

3.2.2. Chlorofluorocarbon Taxes and Allowance Trading

The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer called for a cap on chlorofluorocarbon and halon consumption at 1986 levels, with reductions scheduled for 1993 and 1998. This agreement was ratified by the United States and 22 other countries in September, 1987. At a second meeting in 1990, the parties to the Montreal Protocol agreed to a full phaseout of the already-regulated CFCs and halons, as well as a phaseout of "other CFCs," by 2000.

In accordance with the terms of the Montreal Protocol and subsequent amendments, production of ozone-depleting chemicals such as chlorofluorocarbons (CFCs) for most uses in the United States was phased out by January 1, 1996. Unless otherwise stated, the term "CFCs" refers throughout this section to a variety of ozone-depleting chemicals, including halons and methyl chloroform. To facilitate the phaseout, the United States imposed a tax on selected CFCs on January 1, 1990 and expanded the tax to other CFCs the following year. EPA has a web page that describes the science and consequences of ozone depletion and activities to protect stratospheric ozone.

1. Trading of CFC Production Rights Iternationally

The Montreal Protocol created a system for the international trading of ODS. This trading took place between parties to the agreement or legal entities designated by parties. These entities included many large industrial producers. Parties to the Protocol had the responsibility for keeping their consumption of ODS within allowed levels. To assure parties were in compliance the MP created an Implementation Committee with special powers.

The 2nd Meeting of the Parties (MOP) of the Montreal Protocol in 1990 established procedures and an interim committee to deal with issues of non-compliance:

- to identify instances of non-compliance
- to recommend treatment for Parties found to be in non-compliance
- to recommend potential solutions

During the formative years of the Implementation Committee (IC) between 1990 and 1993, a several principles guided its operation:

- keep things simple
- try not be confrontational or judgmental
- keep activities transparent
- remain under the authority of the MOP

Responsibilities of the Implementation Committee include evaluation of performance and general monitoring. Initially, the IC reviewed compliance with obligations to report data. The IC began work slowly to establish a common understanding of its responsibilities. The IC respected fully the authority of the MOP and maintained full transparency of its activities. Members in the IC are representatives of specific parties, rather than named individuals. Geographic and regional balance in the selection of members and institutional links to other elements of the MP committee structure have been instrumental to the success of the IC. When necessary the IC may establish links to the Funding Mechanism, to the Technical and Economic

Advisory Panel, and to agencies that implement the MP (i.e. UNEP, UNDP, and the World Bank).

The Implementation Committee identifies innovative solutions to improve performance of Parties to the MP. The Committee tries to avoid disputes by emphasizing solutions and methods for achieving compliance under the MP. The small size of the IC has allowed it to function more efficiently than if it had representatives from more parties. Linkage to financial mechanisms is provides a powerful incentive for parties to cooperate with the IC since the IC can help to make financial assistance available to facilitate compliance by a non-complying party.

2. Domestic CFC Allowance Trading

Parties to the Protocol (signatory nations) could establish mechanisms to assure that they were in compliance. As a party to the convention and the largest producer of these substances, the US established a parallel system for domestic trading of ODS. The Montreal Protocol defined consumption as production plus imports, minus exports. Consequently, in implementing the agreement, The US Environmental Protection Agency (USEPA) distributed allowances to companies that produced or imported CFCs and halons. Based on 1986 market shares, USEPA distributed allowances to 5 CFC producers, 3 halon producers, 14 CFC importers, and 6 halon importers.

The marketable permit system for producers and importers resulted in a number of savings relative to a program that directly controlled end uses. EPA needed just 4 staffers to oversee the program, rather than the 33 staffers and $23 million in administrative costs it anticipated would be required to regulate end uses. Industry estimated that a command and control approach to end uses would cost more than $300 million for record keeping and reporting, versus only $2.4 million for the allowance trading approach. CFC Regulatory Impact Analysis

Title VI of the Clean Air Act Amendments of 1990 modified the trading system to allow producers and importers to trade allowances within groups of regulated chemicals segregated by their ozone depleting potential. Canada, Mexico and Singapore also implemented trading programs in CFCs. In late 1991 EPA issued a temporary final rule that apportions baseline allowances, provides a schedule for reducing the allowances, and allows for trading of allowances among firms. In the rule EPA assigned producers and importers allowances for five types of CFCs (CFC-11, CFC-12, CFC-113, CFC-114, and CFC-115). Producers and importers could trade allowances within this group. For example, 14 million kilograms of CFC-11 and CFC-113 were traded for CFC-12 in 1992 as air conditioner makers and foam producers reduced use of these substances, while CFC-12 users maintained their demand. By 1994, the quantity of CFC-11 and CFC-113 swapped for CFC-12 grew to 26 million kilograms. EPA rules implementing Title VI specify that each time a production allowance is traded, one percent of the allocation is "retired" to assure further improvement in the environment.

Nearly 600 million kilograms of CFCs were apportioned among producers in the EPA rule. Allowing trading among producers helps to assure that as CFC production is phased out production becomes concentrated with at the most efficient facilities. The market price of most of the CFCs is well in excess of $1 per pound. With the phaseout their market value is expected to rise significantly, indicating that trading provisions potentially have a large value to producers. However, CFCs also are subject to a windfall profits tax that begins at $1.37 per pound in 1990, rising to $3.10 per pound by 1995, and increasing at $0.45 per pound per year thereafter. In the context of windfall profits taxes, trading provisions have a value if the substances continue to be competitive in the marketplace (which they are). As production is phased out, trading is likely to become more valuable per pound. EPA estimated the cost savings from halving CFC use was $1.05 per kg in 1992 (about $1.00 per pound). By 1996 production was restricted sharply and the savings probably amounted to $2 per pound. This would indicate that trading provisions might have saved about $250 million in 1992 and perhaps twice as much in 1996. By the year 2000, CFC phaseout will be complete so there will be no savings from trading beyond that date.

Like the United States and Canada, Mexico and Singapore sought to ease the phaseout of CFCs through tradable production quotas. In Singapore, CFC use permits were allocated quarterly, half on the basis of historical use and half through sealed bids. In registering to participate in the bidding, users and importers specified the quantity of CFCs they wanted and their offer price. The lowest winning bid price served as the price for all allocations, including those based on historical use. This system gave firms a strong incentive to substitute other products for CFCs or adopt other measures to limit CFC use.

3. CFC Excise Taxes

The marketable allowance trading system was accompanied by excise taxes on CFC production in the US. The rationale for the excise taxes was that the restrictions on the quantity of CFCs and halons offered on the market would lead to rapidly escalating prices that potentially would reduce incentives to develop subsititutes in a timely fashion. The excise taxes were designed to capture "windfall profits," whereas the allowance trading system was designed to assure that production and import of the substances was efficient (concentrated at the lowest cost producers, who then produced the most valued CFCs).

The magnitude of the tax was determined by multiplying a base rate per pound by an ozone depletion factor that varied according to the type of chemical. Initially set at $1.37 per pound, the base tax amount increased to $3.35 in 1993, $4.35 per pound in 1994, and $5.35 in 1995. The ozone depletion factors, which are intended to indicate each chemical's damage to the ozone layer, were set by the Montreal Protocol. For example, methyl chloroform had a factor of 0.1, whereas Halon-1301 had a factor of 10.0. The tax was imposed on the production and importation of these chemicals as well as the importation of products which contained them or used them in their production processes. Barthold (1994), pp. 137-138.

Unlike most product charges, this tax is widely credited with a significant incentive impact. CFC consumption (expressed in CFC-11 equivalents) fell from 318,000 metric tons in 1989 to 200,000 metric tons in 1990, the year the tax was introduced. (Cook (1996), p. 5) A Congressional Research Service (CRS) study concluded, "the CFC tax has clearly accelerated the rate at which CFC uses are being substituted for and the rate at which CFCs are being recovered for reuse." CRS adds that the tax was also intended to raise revenue for the federal government and to capture CFC producers' windfall revenues resulting from a tightening supply situation. Congressional Research Service (1994), pp. 72-75.

According to Cook, the tax raised $2.9 billion in its first five years. Further, the phaseout cost less than EPA's original projection. In 1988, EPA predicted that the average cost of halving CFC use would be $3.50 per kg. In 1992, the predicted cost was only $2.45 per kilogram.

Although the tax is believed to have contributed significantly to the reduction in CFC use, other factors also had an impact, including a CFC trading system (it is described next in this report), well-publicized CFC phaseout intentions, and EPA's work with the private sector on CFC recycling and substitutes. As a result of the multiplicity of policy measures, it is difficult to isolate the effects of the CFC tax.

Whether CFC taxes resulted in compliance cost savings is unclear. While taxes themselves may be costs to the taxpayer, CFC producers in this case, they are simply transfers not costs within the economy. The relevant costs are those associated with manufacturing CFCs and CFC substitutes. These costs likely rose as a result of the program, since higher-cost substitutes were introduced more rapidly than they otherwise would have been. Presumed benefits also rose, as environmentally-damaging CFCs were phased out. Thus CFC production taxes result in a market equilibrium with more costs as well as more benefits. While the CFC tax approach is likely to be more cost-effective than a command and control alternative that would yield the same environmental benefit, there appears to be no basis for estimating the magnitude of reduced compliance costs since the command and control alternative does not exist and would at best be difficult to characterize. Hence, cost savings from this program, while quite possibly substantial, cannot be determined.

4. Lessons

The Montreal Protocol offers several lessons for the establishment of international trading regimes in substances that pollute the environment. First, there was a strong scientific consensus that environmental problems caused by ozone depleting substances were very serious. Second, producers of ODS were confident that substitutes could be developed (albeit with higher production costs) within a few years. Third, the Multilateral Fund, to which developed nations contributed (in proportion to their United Nations dues), created a reserve to help developing countries with the cost of formulating substitutes. The comparisons with the Kyoto Protocol are striking. First, the scientific consensus for global warming is relatively strong but the severity of environmental effects is still debated. While some nations are convinced they face serious threats, other nations anticipate benefits from warming trends. Second, the cost of reducing greenhouse gas emissions enough to have a significant impact on the rate at which the Earth warms or to eliminate warming altogether is likely to be quite high. Third, developing nations might be forgoing opportunities to bring their economies to developed nation standards were they to agree now to limit greenhouse gas emissions.

3.2.3. Acid Rain Allowance Trading

An early solution to mitigate local air pollution caused by sulfur dioxide (SO2) and nitrogen oxide (NOX) emissions from power plants was to build tall stacks to disperse pollutants away from populated areas. This strategy led to large increases in regional pollution concentrations and concerns about potential ecological damage. Coal-burning electric generating units built after 1970 were limited to 1.2 pounds of SO2 per million Btu, and by 1977 new plants were forced to meet a percent reduction requirement in addition to the 1.2 pound limit. However, older coal-burning units continued to emit pollutants at much higher rates--up to 7 pounds of SO2 per million Btu--and to operate far beyond their original design lives because of the high cost of building new units.

By the 1980s, studies began to demonstrate probable harm to lakes and forests, agricultural crops, materials, and visibility from the long-range transport of SO2 and nitrogen oxide emissions. Studies also revealed that acidification of soils and waters could release heavy metals and aluminum previously bound in soils, posing a risk to human health.

Though great scientific uncertainty surrounded almost every aspect of the acid rain issue, legislators in states affected by acid rain were understandably interested in implementing a national pollution control program for older plants. In Title IV of the Clean Air Act Amendments of 1990, Congress created such a program to cut total national SO2 emissions by approximately 50 percent at an estimated cost of about $5 billion per year. At that time, quantifiable economic benefits were believed to be lower--in the range of $1 billion per year (Portney, 1990).

The program set a cap of 8.95 million tons of SO2 per year, to be achieved in two phases. During Phase I, which runs from 1995 through 1999, the 110 highest emitting coal-fired power plants (with a total of 263 coal burning units) must reduce emissions to satisfy a tonnage cap. These so-called "Table A" units were targeted for the first phase because their emissions exceeded 2.5 pounds of SO2 per million Btu and their capacity exceeded 100 MW. Phase I will yield a nationwide reduction in emissions of approximately 3.5 million tons of SO2. In the second phase, which begins in 2000, all power plants producing more than 25 megawatts and all new facilities must meet a lower emission cap. Phase II reductions will total an additional 5 million tons and will reach the overall 8.95 million ton cap.

A major innovation of the program is the acceptance of emissions trading as a means of achieving compliance. Prior to the drafting of this title of the Clean Air Act, a number of studies had identified potential cost savings of up to $1 billion per year through emissions trading due to significant differences among utility sources in the marginal cost of abatement (ICF Resources Inc. 1989).

Allowances

The emission caps are enforced through a system of tradable emission allowances. Title IV specifies fixed numbers of allowances, each of which is good for one ton of SO2, to be given each year to each of the affected units. Political considerations dictated that allowances be given rather than auctioned. SO2 allowances may be used for 30 years, meaning allowances issued in one year may be "banked" for use in subsequent years. This provision gives utilities the flexibility to develop compliance approaches during their regular planning cycles. The basic formula for computing Phase I allowances is 2.5 pounds of SO2 per million Btu multiplied by each unit's average 1985-1987 Btu consumption; for Phase II, 1.2 pounds of SO2 per million Btu multiplied by each unit's 1985-1987 Btu consumption. There are a number of departures from the basic formula, particularly in Phase II. Sources that fail to meet these limits are subject to a penalty for each ton of excess emissions. Initially set at $2,000 per ton, the penalty is indexed for inflation and reached $2,454 per ton in 1996. In practice no utility pays the penalty because compliance with the program is far less costly.

Table A units receive 5.55 million allowances every year of Phase I. Several other provisions of Title IV also create allowances. Owners of "extension" units that propose to reduce emissions with flue gas desulfurization (FGD)/scrubbing, receive allowances, as do owners of "substitution" and " compensation" units. The substitution provision allows owners of Table A units to substitute cheaper reductions from other units, for reductions required of Table A units. The compensation provision lets a utility reduce electricity generation of a Table A unit below its baseline level provided the source of any compensating generation is designated. If the compensating unit emits SO2, an allocation of allowances is made to that unit so that the compensating unit in essence becomes part of Table I. Phase I initially included 263 units; an additional 182 combustion units joined Phase I as compensation or substitution units, raising the total of Phase I units to 445.

Beginning 1 January 1995, the USEPA could allocate up to 300,000 bonus allowances from its Conservation and Renewable Energy Reserve to utilities that undertake energy efficiency and renewable energy measures. The full accounting of provisions for allocating 1997 allowances are identified in the Table 3-1.

Sources of 1997 Allowable Emissions

Type of Allowance	Number of Allowance	Explanation of Allocation
Initial allocation	5,550,820	Granted to units based on baseline Btu output and emission rates, as specified in Clean Air Act Amendments of 1990
Phase I extension	271,334	Given to Phase I units that reduce emissions by 90 % or reassign obligations to units that reduce emissions by 90% (i.e., scrubbers)
Substitution allocation	1,024,178	These are the initial allocations of Phase II units that enter Phase I as substitution units
Auctions	150,000	Provided in CAAA in a Special Allowance Reserve when initial allocations were made
Compensation allocation	15,838	These are the initial allocations of Phase II units that enter Phase I as compensating units
Opt-in allowances	95,882	Provided to units that enter the program voluntarily
Small diesel allowances	27,578	Allocated to small diesel refineries that produce and desulfurized diesel fuel the previous year
Conservation allowances	11,834	Awarded to utilities that undertake efficiency and renewable energy measures before their first compliance year

Total (1997)	7,147,464	CAAA = Clean Air Act Amendment

In order to maintain the emissions cap, new sources receive no allowances. Rather they must buy them from existing allowance holders or in USEPA auctions.

In March 1995, USEPA expanded the acid rain program to include industrial facilities that burn fossil fuels (USEPA, 1995). The rule establishes an "opt-in" program that allows industrial and other sources to participate in the existing SO2 program that previously included only utilities. Industrial sources that participate in the program will have an allocation of allowances that they can use for compliance, sell or trade to other sources. These provisions allowing industrial sources to opt-in were little used because of high transactions costs (Atkeson, 1997). Title IV also sets allowable limits on NOX emissions from utility boilers. An owner of two or more power plants may comply with the NOX requirement by averaging emissions across all its power plants, a rudimentary form of emission trading.

Monitoring and Compliance

Utilities whose units are included in Phase I and Phase II must install continuous emission monitoring systems to verify compliance with emission limits, and file quarterly reports of their hourly emissions data with USEPA. Initially sources mailed these data to USEPA on disks, but most sources now transmit the information over the Internet. Continuous emission monitoring (CEM) systems, the accepted industry standard for measuring SO2, NOX, and CO2, provide an accurate accounting of emissions, assuring those buying and selling allowances that the commodity they are trading is real and assuring USEPA that emission limits have been met.

CEMs have an initial capital cost of just over $700,000 and annual operating costs of just under $50,000. On an annualized basis that spreads the capital costs over a capital recovery period, the cost of operating a CEM is approximately $125,000 each year. This is equivalent to about $0.16 per kilowatt of installed capacity. (Ellerman, et al., 1997).

The cost of monitoring in the program is quite substantial. The projected savings from the overall flexible design of the program are about $2.5 billion per year. The savings that can be attributed to allowance trading have not been estimated directly; however, the literature suggests that the contribution of allowance trading is less important than some other features. (e.g., see Burtraw) When the acid rain program is fully implemented, it will include 2,000 units, each of which must install a CEM. The total cost of CEMs will be about $250 million annually, a sum that could approach the savings attributable to ET. For applications of ET in DMCs, it would be desirable to find acceptable but less costly means of measuring emissions.

At the end of each quarter, USEPA receives more than 1,700 reports containing hourly emissions data and heat input for affected units. More than 90 percent of this data is received electronically. Using these data and the allowance record for each unit, USEPA tracks compliance. Across the industry, 1995 emissions measured with CEMs averaged 7 percent higher than emissions calculated with formulas based on technology and fuel use that had been used to determine compliance with environmental regulations.

Under the authority of Title IV, USEPA developed an allowance tracking system that serves as the official record of ownership and transfers. The system currently requires a paper form that is signed by both the buyer and seller of the allowances, but plans are underway to enable utilities to submit allowance transfers electronically with just the signature (or its electronic equivalent) of the seller. With just two staff members, USEPA processes most allowance transactions within one day of receipt.

Allowance Auction

In addition to private transactions in allowances, Title IV directed USEPA to offer at an annual auction, beginning in 1993, allowances equivalent to about 2.8 percent of total allowances to assure that some allowances would be available for utilities that planned on complying with their emission limits by purchasing allowances. Private parties may also offer allowances at the auction. Each offer involves both a quantity offered and a minimum acceptable price. So far, the auctions have involved only allowances for relatively nearby years.

Economists have criticized the mechanics of the auction, suggesting that it may also contribute to lower prices than otherwise would occur (Cason, 1995). The Act requires a discriminating price auction, which ranks bids from highest to lowest. USEPA has interpreted this as requiring that each seller receive the bid price of a specific buyer. The auction first awards allowances offered by the seller with the lowest asking price to the bidder with the highest bid price. Incrementally, the allocation mechanism moves up the supply list and moves down the bid list until no bidder is willing to offer what the remaining sellers are asking. The idea of having a discriminating price auction came from House staff who were convinced that such an auction maximized revenue to sellers (Hausker, 1992).

This unusual auction mechanism may cause sellers to misrepresent and under-reveal their true costs of emission control (Cason, 1995). By lowering the reservation price, a seller increases the probability of sale and the expected price if buyers are offering different prices. Therefore, sellers would set lower reservation prices in such a discriminating price auction than in a single price auction. Joskow, et al. (1998) conclude that after the first two auctions--which provided useful indications early on that allowance prices would be lower than first anticipated--USEPA auctions have become a sideshow to the much larger private market. The evidence from a detailed analysis of the auction records is that private sellers in the USEPA auction have tended to set prices above market clearing levels rather than too low, as initially hypothesized by Cason and others.

Transactions Costs

The allowance market operates on a very narrow bid-ask spread. Recently this spread has been less than $2 per ton, or about 1 percent of allowance prices. The requirement for CEMs may be viewed as another cost of the program; at an annualized cost of $125,000 each, the CEMs required for 2,000 units included in Phase II will cost $250 million each year. This represents 11 percent of the projected costs of the program in Phase II. Another element of transaction cost is the burden on USEPA. Through the first five years of the program, USEPA reported spending a total approximately $44 million.

Results

From 1995 through 1997 the Acid Rain Program has exceeded expectations, with firms over-achieving the reduction target at less than one-half the forecast cost. These results follow from the very flexible structure of the program, one component of which was the trading provision. In 1997 utilities exchanged 7.9 million allowances and purchased an additional allowances through the annual auction. This total excludes intra-firm transfers. This activity represents a significant increase over prior years: 0.9 million allowances traded in 1994; 1.9 million in 1995; and 4.4 million in 1996.

In searching for explanations for the relatively low level of initial activity, analysts have cited relatively high transactions costs at first, the behavior of public utility commissions, and legislation in some states that promoted the use of locally produced coal (Burtraw).

The price of allowances has been far below initial forecasts, an issue that has attracted considerable attention. Prior to passage of the Clean Air Act Amendments of 1990, industry estimates of abatement costs were $1,000 per ton and USEPA forecast allowance prices were in the $750 per ton range. As an ultimate backstop for compliance, Congress authorized direct allowance sales by the USEPA at a price of $1,500 per ton.

Some early allowance transactions occurred at prices as high as $300 per ton in 1992. By 1993, the price had fallen to a range of $150 to $200 per ton. Allowance prices (from the USEPA auctions, transactions through the Emissions Exchange, and through brokers) gradually fell through mid-1995 to a low of $66 per ton and generally remained below $120 per ton through 1997. In 1998, allowance prices began to increase and approached $200 per ton by the end of the year.

Lower than forecast allowance prices have several explanations. Prices for virtually every form of compliance are well below anticipated levels. The price of low-sulfur western coal delivered to mid-west and eastern markets has declined due to productivity improvements in extraction, and transport and deregulation of rail rates. Engineers have found ways to blend low-sulfur coal with high sulfur coal to meet emission limits. Innovations in the scrubber market have cut the cost of scrubbing by approximately one-half. Many utilities committed themselves to scrubbers and other relatively expensive control measures based on early engineering cost studies. If they had better anticipated SO2 control costs, utilities would have ordered fewer scrubbers. The consequence of greater than expected compliance cause a downward pressure on allowance prices in Phase I.

Analysts debate the role that allowance trading plays in stimulating cost-effectiveness in SO2 control for coal-fired power plants. There is no doubt that SO2 control has experienced tremendous technological and productivity improvement over a very short period of time, leading to lower allowance prices than had been anticipated. The issue is the extent to which allowance trading is necessary to achieve these gains. Burtraw (1995) concluded that it is the flexible, performance-based design of the program that has stimulated the development of low cost compliance measures seen in Phase I, and that within that framework allowance trading played an incremental, positive role.

Phase II of the Acid Rain program is likely to see much greater reliance on allowance trading. Phase II will involve 700 additional sources, many of which are likely to select scrubbing as their method of compliance. Because more scrubbing should result in greater variation in the marginal costs of control across sources, there should be greater incentives to trade allowances to achieve compliance in Phase II.

A recent USEPA assessment of the Acid Rain program put the costs at $1.2 billion annually in Phase I and $2.2 billion annually in Phase II (USEPA 1995). The same USEPA report estimated the mean value of annual health benefits at $10.6 billion in Phase I and $40 billion in Phase II. Interestingly, health benefits were not a major concern in the design of acid rain control legislation, yet they now appear to be the dominant benefit component, dwarfing earlier estimates of environmental effects. Recall that early estimates of the costs of acid rain control put the costs at $4.5 to $6 billion annually with a command and control approach and benefits at $1-2 billion. An independent assessment reached a similar conclusion–that benefits will be much greater than costs (Burtraw, et al, 1998).

To estimate the savings attributable to tradable allowances, Carlson, Burtraw, Cropper and Palmer estimated marginal abatement cost functions for thermal power plants affected by Title IV. For plants that use low sulfur coal as a means of compliance, they found that the main sources of cost reductions are technological improvements and the fall in low sulfur coal prices, not allowance trading. Over the long run, the authors estimate that allowance trading could result in savings of $700 to $800 million per year relative to an "enlightened" command and control approach with a uniform emission standard.

3.2.4. RECLAIM

The highest ozone levels in the nation are recorded in the Los Angeles area, with readings often exceeding twice the national ambient air quality standard of 0.12 ppm. This is a one hour standard, not to be exceeded more than once a year (averaged over three years). TheSouth Coast Air Quality Management District (SCAQMD or District) also fails to meet the particulate and CO standards, though not by such a large margin. Historically, the SCAQMD has relied on command and control rules to limit emissions of ozone precursors (as well as other pollutants).

Despite making substantial progress over the past three decades in improving air quality in the Los Angeles Basin, it was apparent to SCAQMD officials that further progress toward attaining federal standards would be prohibitively expensive using traditional regulatory approaches. By 1990 the marginal costs of NOx control for some sources in the District had reached $25,000 per ton at electric power plants, versus $500 to $5,000 nationally. Proposed SO2 controls on catalytic cracking units at refineries would have cost $32,000 per ton, versus national costs of under $500 per ton (see the section describing the Acid Rain allowance trading program). Consequently, the District began to investigate the feasibility of creating a marketable permit in the ozone precursors VOC and NOx as well as SO2 (the latter for its role in the formation of small particulate matter) as a means of accomplishing air quality goals at lower cost. (Selmi, Lentz).

The District initially proposed a marketable permits program termed RECLAIM (for Regional Clean Air Incentives Market) that would include about 2,000 sources of reactive organic gases (representing about 85 percent of permitted stationary source emissions), 700 sources (representing 95 percent of permitted NOx emissions), and about 50 sources of SO2 (representing about two-thirds of permitted stationary source emissions). Each market would start with an allocation of emissions equal to the 1994 emissions target in the District's Air Quality Management Plan (AQMP). Each marketable permit program would reduce emissions annually by amounts necessary to achieve the AQMP targets: attainment of air quality standards by 2003 for SO2 and NOx and VOC emissions goals by 2010.

For the NOx and SO2 programs, emissions originated at combustion sources with well-defined exit points to the environment. Emission monitoring would be based on stack gas measurement, a relatively simple task that increasingly is accomplished with remote sensing devices. For ROG the market was based largely on evaporative emissions, which are inherently more difficult to measure. Prospective ROG trading also was complicated by the fact that ROG are not homogeneous; some react much more readily than others to form ozone. Further, some ROG also are classified as toxic pollutants and regulated separately. After about one year of analysis and discussion, RECLAIM officials decided to defer including ROG and concentrate on program design for NOx and SO2.

A basic issue for both programs was which facilities would be included. Despite the prospect for lower control costs that would accompany participation in a marketable permit program, a number of sources argued for exemptions due to concerns about the future price and availability of marketable permits. District officials eventually exempted sewage treatment plants, landfills, and three small municipally-owned power plants. These facilities asked for exemptions as "essential public services." Participation in RECLAIM could have required a temporary shutdown to install monitoring equipment, a situation incompatible with an essential service.

Baseline emission allocations proved contentious. According to the basic design features for RECLAIM, emission allocations would be based on the 1994 emission target for each source. This was computed in the AQMP by taking reported 1987 emissions and deducting projected reductions mandated by air quality regulations. Due to a recession in the early 1990s, emissions in 1991, 1992 and 1993 were lower for many sources than what the AQMP required. Many interest groups, including the affected sources, argued that baseline allocations should be based on the AQMP. Environmental groups argued that actual 1993 emissions should serve as the baseline for emission allocations. The compromise that was struck defines the emission cap for each source as the highest year of reported emissions between 1989 and 1991, less any reductions required by regulations implemented through 1993.

Monitoring and reporting issues also proved controversial, with lengthy debates over how emissions would be measured and how often reports would be filed. Industry sought to file one report per year, while public health agencies and environmentalists wanted daily or weekly reporting. The EPA sought assurance that the hourly NOx standard would not be violated. In an attempt to allay industry concerns that frequent monitoring would be too expensive, the AQMD developed a central computer that would accept data directly from the participating facilities in RECLAIM. Sources installed continuous emission monitors on every boiler emitting 10 tons annually or more. The CEM recorded pollutant readings minute by minute and sent the readings to a remote terminal that averaged the readings over fifteen minute periods and forwarded the number to the AQMD central computer. An artificial intelligence system analyzed the data and verified compliance by each boiler. When the system detected a potential problem, inspectors were dispatched to investigate further. For sources between 4 tons per year and 10 tons per year, the District allows sources to use default emission rates calculated by monitoring process variables, with periodic sampling and testing.

The District projected that the one-time costs of installing monitoring equipment would be approximately $13 million with negligible annual operating costs. Once RECLAIM was in place, operating and mantenance costs proved to be larger than anticipated. Further, CEMs have annualized costs on the order of $125,000. It is easy to see that monitoring costs are high on a per-ton basis for small sources. For example, a source emitting just over 10 tons per year would spend about $12,500 per ton monitoring the emissions. This is quite high relative to marginal control costs and suggests a need to lower monitoring costs for smaller sources.

The actual trading works as follows. Each source has a declining allocation of RECLAIM Trading Credits (RTC) for each year from 1994 to 2003. The District originally planned to have a single expiration date of December 31 each year for all allocations. Concern that there could be a "logjam" of trading near the expiration date led District officials to randomly divide facilities into two categories of equal size: Cycle One sources with calendar year compliance dates, whose credits would expire on December 31 of each year; and Cycle Two sources with a July 1 to June 30 compliance calendar, whose credits would expire on June 30. Sources in Cycle One are free to trade with those in Cycle Two, but the expiration dates on the credits do not change. After 2003 the balance remains constant. The RTC are denominated in pounds: one RTC equals one pound of emissions. Sources are free to trade RTCs for the current year or for future years; however, all RTCs are good only for the year for which they are issued. Trades in RTCs are limited by geographical factors; for a potential buyer, the number of credits required to offset a pound of emissions varies with the location of the seller. The District maintains records of all transactions in RTCs and shares that information with market participants.

Under RECLAIM rules, the District may impose penalties for net emissions (including trades) in excess of permitted amounts. One potential penalty is a reduction of next year's emission allocation by the amount of the exceedance. Other possible actions include civil penalties and the loss of the operating permit.

In 1994, the NOx and SO2 markets began with 370 sources and 40 sources, respectively. Both markets represented approximately 70 percent of stationary source emissions. Analysis shows that the program should reduce NOx emissions by an average of 8.3 percent per year (amounting to a cumulative reduction of 80 tons per day by 2003) and SO2 emissions by 6.8 percent per year (a cumulative 15 tons per day by 2003). The District projected that RECLAIM would lower annual compliance costs by 42 percent compared to a command and control approach: $80.8 million versus $138.7 million.

As a means of jump starting the market, the SCAQMD held an auction of RTCs on July 29, 1994. Utilities, which had by then installed new emission control equipment and did not need their full allocation, were large sellers of NOx credits. A total of 114,676 NOx credits and 9,400 SO2 credits changed hands at the auction. Prices for RTC were low for near years and much higher for more distant years. In all cases, though, the cost for a ton of credits was far lower than the marginal control costs from recently enacted or proposed command and control regulations. In a privately negotiated transaction in August 1995, Unocal reported paying Anchor Hocking $3.65 million for 8.6 million pounds of NOx emission credits. The per ton price ranged from less than $20 to $2000, depending upon the credit's year of validity, prices that are very much in line with the 1994 auction.

In June 1995, the SCAQMD proposed adding ROG emissions to RECLAIM; the initiative included almost 1,000 facilities in 14 industrial categories that generated 4 tons or more of ROG annually. In contrast to the NOx and SO2 programs that were scheduled for 7 years, the ROG program would last 14 years. Officials estimated that the program would reduce emissions from these sources from 53 tons a day, the projected level for 1996, to 15 tons a day by 2010.

The proposal met with fierce opposition from environmentalists who charged that the 1989 baseline selected for emissions could result in a huge increase in emissions over 1993 levels when the program starts. The Natural Resources Defense Council contended that basing emissions allocations on 1989 emission levels could result in an increase in emissions of up to 71 percent over 1993 levels. Regulators sought the 1989 baseline to avoid locking industry into emission levels associated with recessionary conditions in 1991 through 1993. Industry representatives note that the AQMP has a schedule for orderly reductions over time toward the 2010 goals. In their view, emissions increases from 1993 to 1996 as the economy pulls out of a recession are not relevant so long as emissions remain below the target levels in the AQMP.

Unable to resolve the baseline issue, the 12-member SCAQMD governing board set aside in January 1996 the proposed rule to include trading of ROGs within RECLAIM and directed its staff to develop a program to trade ROG emissions separately.

One innovation for reducing ozone precursor emissions offers tradable "smog credits" to lawn mower retailers for accepting and scrapping the 1.7 million gasoline-powered mowers in the District. The SCAQMD estimates that a single mower used for 20 hours a year emits as much ROG emissions as a new car driven 26,000 miles. Credits for scrapping lawn mowers would complement other means available to firms for earning credits, such as scrapping older cars and increasing employee use of car pools.

RECLAIM has won praise for its progress to date. A state-mandated performance review conducted found that the District has a state-of-the-art air quality program that is performing efficiently and effectively. RECLAIM demonstration projects to stimulate technological development and outreach and compliance programs have helped save or create over 10,000 jobs while achieving air quality improvement.

3.2.5. Reporting Requirements

Although SARA Title III is not typically thought of as an air program, it does provide incentives to reduce air emissions (as well as releases to water and land). For that reason, it will be discussed as contributing to each of the major program areas. Since air emissions are treated first in this assessment of economic incentives, SARA Title III will be explained in detail here and only summarized briefly in subsequent treatments.

Enacted in 1986 as Title III of the Superfund Amendments and Reauthorization Act (SARA), EPCRA requires emergency planning and disclosure of information on releases and transfers to disposal facilities of hazardous chemicals. Section 313 of EPCRA requires certain businesses to report each year on the amounts of toxic chemicals that their facilities release into the environment and transfer to disposal facilities. The data distinguish between releases and transfers. A release is an on-site discharge of a toxic chemical to the environment, whereas a transfer is a movement of waste to another facility for recycling, energy recovery, treatment, or disposal. As a result of the 1990 Pollution Prevention Act, reporting requirements were expanded beginning in 1991 to include source reduction and recycling information. Data for a given year normally must be submitted by July 1 of the following year. EPA then compiles the information and makes it available to the public as the Toxics Release Inventory (TRI).

TRI reporting is required of all manufacturing facilities with ten or more employees in the Standard Industrial Classification (SIC) codes 20 through 39 that manufacture, process, or otherwise use one or more of the listed chemicals above certain threshold amounts. Thresholds are 25,000 pounds per year for manufacturing and processing and 10,000 pounds per year for otherwise using. Federal facilities were also required to submit their first TRI reports by July 1, 1995 for the 1994 calendar year.

The number of listed chemicals was originally set at 320 but has since been increased. (A few chemicals have also been deleted from the list.) The most significant expansion took place in 1994, when EPA added 286 new chemicals to the list effective for the 1995 calendar year, bringing the number to 654. Individuals and organizations can petition EPA to add or remove chemicals from the list.

Also in 1994, EPA streamlined reporting requirements for small businesses. Facilities that have a total annual reportable amount of 500 pounds or less of a TRI chemical, and that manufacture, process, or use 1 million pounds or less of a TRI chemical can now submit a shorter, annual certification statement in lieu of the longer Form R. These streamlined requirements became effective for the 1995 calendar year. "EPA believes that this rule strikes a positive balance between maintaining the community's right-to-know about toxic chemical releases, and the economic costs (both to EPA and industry) of collecting the information." Ibid, p. 5. EPA estimates that the streamlining will result in annual cost savings of about $17.3 million for industry and $700 thousand for EPA. *1994 Toxics Release Inventory*, p. A11.

After expanding the number of listed chemicals in what it referred to as phase 1 expansion, EPA turned to phase 2, intended to expand TRI requirements to other industries that have significant releases of listed chemicals and which are related to facilities currently subject to reporting. The proposed expansion for 1998 would extend reporting requirements to the following seven industries: metal mining, coal mining, electric utilities, commercial hazardous waste treatment, petroleum bulk terminals, chemical wholesalers, and solvent recovery services.

A third phase will focus on expanding the types of data to be collected for the TRI. New data could include chemical use and materials accounting information. This third phase is intended to provide more information on topics such as the results of companies' source reduction efforts and the amounts of chemicals in companies' finished products.

EPA has sought to make TRI information available to industry, environmental groups, and the general public so that they can know about facilities' toxic releases and transfers off-site. This information is available via several media, including printed reports, CD-ROM, and the Internet.

The emergency planning component of EPCRA calls for the creation of state and local emergency response bodies to plan for toxic releases. It also requires facilities to inform these bodies of the existence of certain hazardous substances on their premises, give immediate notice of accidental releases, and develop response plans to be implemented in the event of such accidents. Information provided by facilities is available to the public.

Trends in TRI Data:

Reported TRI releases have decreased 44.1% since 1988. Decreases are observed in most industry SIC codes. Although the data suggest significant reductions in toxic releases, there are several reasons why they may not be equal to actual decreases in releases. EPA points out that TRI increases and decreases can be "real changes" or "paper changes." *1994 Toxic Releases Inventory*, p. 201. The latter result from errors, changes in facilities' estimation or calculation techniques, changes in reporting guidance and facilities' interpretation of that guidance, and facilities' use of exemptions. Companies generally determine their TRI release amounts through estimation rather than monitoring. EPA guidance has not been issued for all aspects of TRI reporting, and companies can sometimes lower reported releases by using different estimation techniques.

EPA says that estimation errors are more likely for releases such as fugitive air emissions and complex wastewater for which little monitoring data are available. However, EPA audits have found companies' estimation techniques to be reasonably accurate. An audit of 1987 data at selected facilities led to the conclusion that releases had been underreported by 2%, but a 1988 audit found that companies reported about the same amount as the auditor's own estimate. (Ibid, pp. C2-C3.)

Another potential problem is that most chemicals have not been subject to TRI requirements. A 1994 GAO study stated that over 70,000 chemicals are used commercially in the United States, of which only 320 had been included in the TRI. "Consequently," the study added, "the companies may maintain or even increase their usage of toxic chemicals while concurrently reducing the chemicals that are reported to EPA." GAO (September 1994), p. 14. The original list focused on the most important toxics, and, as noted above, EPA included another 286 chemicals in TRI requirements effective 1995. However, some highly toxic chemicals have not been included because they are generated in amounts that are too small to meet criteria for inclusion.

In addition, a number of small sources in SIC codes 20-39 and all sources outside that code range are currently excluded from the TRI. It is not known what percentage of releases are currently exempt from reporting. As noted above, however, EPA intends to include other SIC codes in the system.

Releases are not weighted according to toxicity or the dangers posed by various methods of disposing of various types of chemicals and do not indicate exposure or potential effects on human health and the environment. Moreover, the TRI does not include information on the quantity of toxic chemicals in products leaving the facility. Such products themselves can eventually be released into the environment.

Incentive Effect of the TRI:

The incentive effect of the TRI on polluters cannot be assessed solely on the basis of reported decreases in releases. A number of factors, including command-and- control regulations and other economic incentive mechanisms discussed in this report, have affected releases. Pollution prevention is also influenced by a number of factors unrelated to the TRI.

Nonetheless, the TRI is widely believed to have a significant impact on polluters. EPA has called it "one of the most powerful tools in this country for environmental protection" EPA (March 1995), p. 3. and "one of the most successful policy instruments ever created for improving environmental performance." *DEN*, October 10, 1995, p. E1. Vice-President Gore called the annual TRI publication "the single most effective common-sense tool" to promote environmental protection. *Wall Street Journal*, June 27, 1996, p. B12. Shortly after the first TRI was released in 1989, citizen groups placed a full-page advertisement in the *New York Times* listing "the corporate top ten" land, water, and air polluters. Several of these polluters subsequently promised the EPA that they would improve their environmental performance, effectively beginning the 33/50 voluntary releases reduction program described in the next Section. Arora and Cason (1995), p. 9. Monsanto, for example, promised 90% reductions of 1987 air emission levels by 1992. "The Nation's Polluters - Who Emits What, and Where," *New York Times*, October 31, 1991, as reprinted in ELI (June 1993). AT&T said it would halt all TRI air emissions by the end of the century. "For Communities, Knowledge of Polluters is Power," *New York Times*, March 24, 1991. Dow said it planned to reduce overall emissions by 50% by 1995, and Dupont promised to cut air emissions by 60% by 1993 and cancer-causing components by 90% by the year 2000. In Minnesota, public outcry over revelations that an electronic circuits manufacturer was emitting methylene chloride led the facility to promise 90% reductions in emissions by 1993. "Right to Know: A U.S. Report Spurs Community Action By Revealing Polluters," *Wall Street Journal*, January 2, 1991. After 1987 TRI data found an IBM facility in California to be the state's largest emitter of CFCs, a public interest group organized a campaign and IBM subsequently promised to end the use of CFCs at the plant by 1993. *1994 Toxics Release Inventory*, p. D-2.

TRI data also appear to influence investors. Some of the investor interest may be attributed not so much to socially responsible investing but rather to the belief that companies with relatively high emissions might face mounting environmental costs in the future.

Hamilton (1995) found that companies' 1988 TRI performance (as reported in June 1989) was of interest to journalists and investors. The higher a firm's TRI pollution figures, the study found, the more likely journalists were to write about the firm's toxic releases, especially for firms previously less associated with pollution. Those companies that reported TRI releases underperformed the market during the five days after the data were released. The more chemicals for which a company submitted data, the greater its underperformance. The underperformance was less signficant, however, for companies previously associated with pollution.

The Investor Responsibility Research Center has analyzed TRI data to provide clients with environmental profiles of companies. The Clean Yield investment portfolio management group compares companies' TRI data with industry-wide averages of releases per unit of sales. *Fortune* magazine has used TRI data in its "green index" of American manufacturers, assigning scores of zero to 10 in 20 performance categories, including toxic emissions per unit of sales. Ibid, pp. D7-D8.

Although EPCRA's emergency planning element briefly described above has received less attention than the TRI as an incentive mechanism, it could also have a significant effect on polluters' behavior. Firms might reduce the amounts of hazardous substances on their premises if forced to disclose these amounts to local emergency response bodies and (indirectly) to the public. They might also manage hazardous substances more safely if required to plan for and give immediate notice of accidental releases.

Reporting requirements afford industry flexibility in how (or whether) a firm responds. Many firms want to show progress in lowering reported emissions and to avoid being compared unfavorable with other firms in their industry. Several accounts describe these firms as actively seeking to identify control measures that can be adopted relatively inexpensively. Because firms effectively have infinite choice in which measures are adopted, the cost-effectiveness of options selected is likely to be quite good. Thus, it appears reasonable to assume that incremental control costs for releases to air eliminated as a consequence of SARA Title III would average $2,000 per ton ($1 per pound) less than command and control regulations that accomplished the same reductions.

It is possible to project emission reductions attributable to SARA Title III from recent reporting trends. From 1988 to 1994 reportable air emissions were reduced from 2.595 billion pounds to 1.556 billion pounds, a compound annual rate of decrease of just over 8 percent, saving an estimated $1.04 billion in compliance costs, based on the assumed savings of $1 per pound. Projecting impacts to the year 2000 at the same rate of 8 percent per year, one obtains a cumulative reduction of about 64 percent relative to 1988 levels. Assuming average savings of $1 per pound, annual savings by the year 2000 would be about $1.66 billion.

3.2.6. Regional NOx Trading Program

In November 1997 and May 1998 Federal Register notices, the USEPA proposed creating a regional NOX trading program involving most of the eastern one-half of the US. The program, in part, is based on a Demonstration Project to trade "discrete emission reductions" (DERs) that was developed by the Northeast States for Coordinated Air Use Management (NESCAUM) in 1993. Other important contributors to the design of USEPA's regional NOX program include the Ozone Transport Commission (OTC) and the Ozone Transport Assessment Group (OTAG), both of which worked to design regional trading programs for NOX for the eastern part of the US.

NOx emissions along with volatile organic compounds (VOC) are precursors of ozone. Ozone has long been recognized in clinical and epidemiological studies as affecting public health, ornamental vegetation, agricultural crops and forests. The effects of ozone on health, which are the concern of most recent regulatory efforts, include decreased lung function (mainly in children exercising outdoors), increased respiratory symptoms (particularly in highly sensitive individuals such as asthmatics), increased hospital admissions and emergency room visits for respiratory effects, increased inflammation of the lungs, and possible chronic (long-term) effects on the lungs.

EPA's proposal recognizes that regional NOx controls would have comparable ambient impacts on ozone as would local NOx and VOC controls, but at significantly lower cost. Sources of NOx emissions include power generation, other point sources, area sources, and mobile sources. The trading regime that EPA proposed would involve only large point sources (sources serving electric generators with capacity greater than 25 MWe and boilers with a designed heat input greater than 250 mmBTu/hr. The large point sources have various means of reducing emissions: combustion modifications, post-combustion technologies, and fuel switching. If the state in which they were located decided to participate in the trading program, the sources could add emission trading to the list of possible compliance options. To participate in trading, EPA would insist that sources install continuous emission monitors (CEM).

EPA analysis indicates that the savings from trading would be substantial. The projected additional cost of the most enlightened form of command and control regime, a performance standard for point sources, would cost $500 million a year more to achieve the same environmental results. A number of details remain to be worked out, including whether trading would occur throughout the entire region or would restricted to different sub-regions. Another issue is what trading ratio to apply to trades and whether the ratio should vary with distance between parties to the trade, season, weather, or other variables. EPA recognizes the fact that there will be tradeoffs between cost savings from trading and potential adverse environmental impacts in certain areas.

3.2.7. Other Incentives for Air Pollution Control

There are literally hundreds of economic instruments in use at the federal, state and local level for managing air quality. The aggregate savings from these instruments is difficult to assess without performing an evaluation of a large number of such instruments. This section examines five instruments believed to have the potential for producing large dollar savings:

1. State Air Emission Fees
2. Federal Nonattainment Area Fees
3. Vehicle Scrapping
4. Oxygenated Fuels Requirement.
5. Hazardous Air Pollutants Early Reduction

Of these instruments, vehicle scrapping could achieve savings on the order of $100 million annually relative to a command and control alternative such as more vigorous inspection and maintenance policies. Although the other instruments can be characterized well, it is very difficult to project cost savings.

3.2.7.1. State Air Emission Fees

The 1990 Clean Air Act Amendments require states to impose permit fees to recover the administrative costs of their EPA-approved operating permit programs. The Amendments set the minimum presumptive level for such fees at $25 per ton of emissions of criteria air pollutants (excluding carbon monoxide) and air toxics and specified that this amount should be adjusted for inflation. Each state is required to set fees to completely cover operating permit program costs. If the fees are greater than or equal to $25 per ton adjusted for inflation (currently about $30 per ton), EPA assumes that they are adequate. States with lower fees must present detailed evidence that fee revenues are sufficient to cover their operating permit program costs. Several state permit programs have been denied EPA full approval because of insufficient information on fee adequacy. These states have received interim approval pending submission of better evidence.

Although states can meet the revenue-raising requirement through flat fees, most have chosen volume-based fees of approximately $20-30 per ton. Some states base fees on the pollutant's potential harm to the environment. New Mexico, for example, charges fees of $150 per ton for air toxics but only $10 per ton for criteria pollutants. Fee structures in Maine and Southern California are discussed here for illustrative purposes.

Air emission permit fees in Maine

In November 1993, Maine set its air emission permit fees at $5.28 per ton for emissions up to 1,000 tons, $10.57 per ton for emissions between 1,001 and 4,000 tons, and $15.85 per ton for emissions in excess of 4,000 tons. The minimum charge is $250, and the maximum charge $150,000. The fees cover sulfur oxides, NOx, VOCs, and particulate matter. The fees apply to all permit holders, of which there are approximately 500.

Maine has also imposed an air quality surcharge based on toxicity of emissions. The magnitude of the surcharge is determined on the basis of several criteria. Approximately 85 facilities are subject to the tax, which is capped at $50,000. Before the adoption of the surcharge, the Director of Maine's Air Quality Bureau said it would give polluters an incentive to identify methods of reducing their emissions of the most toxic substances. An Air Quality Bureau official says that surcharge revenues have fallen and that the surcharge has had a slight incentive effect, but the impact is difficult to isolate from other potential factors such as the Toxic Release Inventory. Annual revenues are approximately $1.8 million from permit fees and $0.6 million from toxicity surcharges. Revenues are used for the air permit program and other air quality activities. (*DEN*, June 22, 1993, p. B-6 and Limouze.

Air emission permit fees in the South Coast Air Quality Management District

The South Coast Air Quality Management District (SCAQMD, located in Southern California) levies the highest unit air emissions fees in the United States. In 1997, the fees ranged from $281 to $682.70 per ton of organic gases, and from $214.90 to $521.20 per ton of particulate matter, depending upon the magnitude of emissions. For annual carbon monoxide emissions in excess of 100 tons, the fee is $3.50 per ton.

AIR EMISSION FEES IN SOUTH COAST BASIN
(1997, in $/ton)

Emissions in tons per year	Organic gases	Specific organics	Nitrogen oxides	Sulfur oxides	Particulate matter
4 - 25	281.00	50.30	116.40	195.00	214.90
25-75	456.10	79.70	261.10	315.60	348.10
over 75	682.70	119.50	393.20	472.90	521.20

source SCAQMD Rule 301

Through provisions of Rule 301, the SCAQMD also levies fees on a variety of air toxics and ozone-depleting substances. The fees for 1997-1998 vary from a low of $0.05 per pound to a high of $5.00 per pound.

Facilities that temporarily exceed their allowable emissions levels must pay excess emissions fees. For most pollutants, the excess emissions fees are about the same as the regular fees. For carbon monoxide, however, they are approximately twice as high. In addition, SCAQMD imposes fees for visible emissions and various administrative procedures. SCAQMD, Rules 303, 304, 306, 307.

Given the presence of command-and-control regulations and other factors that might influence air pollutant emissions, the incentive effect of the SCAQMD emissions fees would be difficult to determine. In most cases, these fees are lower than marginal pollution abatement costs. The main purpose of the fees is to recover the administrative costs of SCAQMD's activities.

3.2.7.2. Federal Nonattaniment Area Fees

The 1990 Clean Air Act Amendments provide for fees on "excess" emissions of volatile organic compounds in certain ozone nonattainment areas. To give these areas time to reduce their ozone levels, the fees will not enter into effect until the next century. Areas with ozone design values of 0.18 to 0.19 ppm have 15 years to comply with ozone standards; areas with values of 0.19 to 0.28 ppm have 17 years; and areas with values over 0.28 ppm, referred to as extreme ozone non-attainment areas, have 20 years. (California's South Coast Air Quality Management District is currently the only extreme non-attainment area.) Failure to attain specified levels by the deadlines will subject major stationary sources to VOC emissions fees of $5,000 (adjusted for inflation) for each ton emitted in excess of 80% of a baseline quantity. The baseline amount is the lower of actual or allowable VOC emissions. For details, see Title I, Section 185 of Clean Air Act.

At $5,000 per ton, such fees equal or exceed incremental control costs in all but the Los Angeles area. Consequently, they could have a significant impact and should be more cost-effective than command and control alternatives. Any cost savings, however, would be well in future, since the fees would be unlikely to affect compliance decisions until well after the turn of the century.

3.2.7.3. Vehicle Scrapping

With Rule 1610 the SCAQMD established the first program in the country that allows stationary sources to obtain credit for emission reductions from scrapping vehicles. Subsequently, the EPA developed a similar vehicle scrapping program that states can include in State Implementation Plans. Many states have followed up with specific programs of their own.

SCAQMD's Rule 1610 allows sources with AQMD-approved scrapping programs to buy and scrap 1982 or earlier automobiles. The sources can obtain credits for 26 to 91 pounds of reactive organic gases and 16 to 19 pounds of nitrogen oxides, depending on the model year. The credits are good for three years and may be applied toward compliance with stationary source emission requirements. The credits earned under Rule 1610 also are tradable.

In their anlaysis, AQMD officials estimated that at least 10,000 cars would be retired each year for an average cost of $800. Assuming an average cost of $800 per vehicle, the cost per ton of removing reactive organic gases or nitrogen oxides would be about $8,000. This cost compares favorably with incremental control costs faced by many stationary sources in the basin. For example, in the early 1990's Unocal officials claimed that they faced incremental control costs for these pollutants of approximately $160,000 per ton at a refinery located in the basin.

The potential cost savings from nationwide application of automobile scrapping programs may be estimated as follows. Approximately 30 million vehicles still in use could qualify; however, scrapping programs would operate only in serious ozone nonattainment areas, limiting the number of candidate vehicles to about 15 million. About 20 percent of the candidate vehicles would be retired each year without a scrapping program. The air quality gains for these vehicles would be zero, even though they might earn credits if bought and scrapped. An additional 5 percent of candidate vehicles might be scrapped each year due to the existence of a scrapping program. By the year 2000, only about 3.5 million candidate vehicles remain in serous ozone nonattainment areas; 5 percent of these could be scrapped each year; some 175,000 vehicles in the year 2000 and fewer in subsequent years. Assuming that scrapping produces savings averaging $5,000 per ton relative to alternative control costs for stationary sources, in the year 2000 a vehicle scrapping program would reduce pollution by about 20,000 tons and produce savings of some $100 million.

3.2.7.4. Oxygenated Fuels Requirement

The 1990 Clean Air Amendments require that gasoline with a 2.8 percent oxygen content be marketed in 39 cities during the winter months beginning in 1992 and reformulated gasoline with an oxygen content of 2 percent be marketed by 1995 during the summer months in 9 cities. Additional cities decided to "opt in" to the reformulated gasoline requirements, increasing to nearly one-third of the gasoline supply the amount that must be reformulated. As part of the oxygenate requirement, the 1990 Amendments allow refiners and blenders to trade oxygen credits (assuming that the applicable regions adopt EPA rules for trading). Potentially, this trading provision could save refiners up to $150 million per year, calculated as follows. The oxygenated fuel requirements apply to as much as 30 billion gallons of fuel annually; the cost of adding oxygen is approximately 3 cents per gallon; and trading might save as much as one-half cent per gallon.

Of all regions where trading could take place, only a portion of the Philadelphia area has approved the EPA oxygenate trading rules. And in that region no trades have taken place. While there are undeniable potential gains from trading, refiners have not pressured administrators of the RFG program to adopt trading rules. One could speculate on the reason. Trading would lower the cost of producing RFG for high cost producers whose costs in turn are the primary determinant of market prices according to standard economic theory. Consequently, while consumers of gasoline would benefit from lower market prices, trading of oxygenate credits would lower refining profits.

3.2.7.5. Hazardous Air Pollutants Early Reduction

In December 1992, EPA issued final rules for the early reduction of hazardous air pollutants. If a facility qualifies by reducing hazardous air pollutants by 90 percent (95 percent in the case of hazardous particulate emissions) prior to EPA proposing MACT regulations on the source category, the facility may defer compliance with the new maximum available control technology standards (MACT) for up to six years. Because participation in the program is voluntary, a source must anticipate cost savings or it would not have an incentive to participate. Once a source is accepted into the program it becomes legally obligated to meet the 90 (or 95) percent emission limitation. Trading exists intertemporally in that sources exchange their early reductions for their later reductions. Two NESHAP rules are discussed here.

Petroleum Industry NESHAP

The petroleum industry NESHAP rule, promulgated on August 18, 1995, establishes MACT requirements for process vents, storage vessels, wastewater streams and equipment leaks tanks at refineries. The rule specifically includes marine tank vessel loading activities and gasoline loading racks. The rule excludes distillation units at pipeline pumping stations and certain process vents that EPA determined to be subject to future NESHAP rules: catalyst regeneration on cracking units, vents on sulfur recovery units, and vents on catalytic reforming units. The rule achieves VOC reductions at a modest cost of less than $600 per ton; however, without the VOC credits the rule would fail a stand-alone benefit-cost test on the air toxics component.

On September 19, 1995 EPA issued a final NESHAP rule for marine vessel tank loading operations that affects new and existing marine bulk loading and unloading facilities that emit 10 tons or more of a hazardous air pollutant (HAP) or 25 tons of any aggregate HAPs. Affected facilities must install a vapor collection system to collect VOC displaced from marine tank vessels during loading. The vapor recovery system must achieve a 95 percent reduction in emissions (98 percent if combustion is used).

Both rules permit the use of emissions averaging among marine tank vessel loading operations, bulk gasoline terminal or pipeline breakout station storage vessels and bulk gasoline loading racks, and petroleum refineries. Emissions averaging gives the owner the opportunity to find the most cost-effective control strategies for its situation. The owner may over-control at some emission points and under-control at others to achieve the overall required level of emissions control.

Hazardous Organic Chemical NESHAP

The Hazardous Organic Chemical NESHAP (or "HON") affects more than 400 facilities of the Synthetic Organic Chemical Manufacturing Industry (SOCII). The final rule requires sources to limit emissions of organic HAPs to apply "reference control" or equivalent technology at MACT. In recognition of the high costs of some MACT controls in this industry, the rule allows emissions averaging. Under this alternative method of compliance, sources engaging in pollution prevention measures that over-control at some points earn credits that can be used to offset debits for under-control at other points.

By mid-1993 over 60 chemical plants had asked to participate so as to avoid for 6 years the synthetic organic chemical MACT standard. Other types of facilities also had applied to join the program. (Novello and Martineau)

3.2.8. Summary of Cost Savings from Existing Incentives to Reduce Air Pollution

Air emissions trading constitutes the largest source of currently-achieved incentive based savings, an estimated $150 million to $2.1 billion in annual savings (midpoint $1.1 billion). Allowance trading of Phase I acid rain control requirements add another $200 to $300 million in current savings. CFC trading, now over, may have constituted the third largest source of savings during the mid-1990s according to these calculations, accounting for up to $500 million annually in savings. SARA Title III reporting is another significant source of cost savings, accounting for an estimated $170 million annually. RECLAIM might save an additional $50 to $100 million annually. The total current savings from existing incentives to reduce air pollution are estimated at $1.7 billion, nearly all of which concerns stationary sources. Corporate Average Fuel Economy requirements may be viewed as an incentive mechanism for air pollution control, since emissions of hydrocarbons tend ot fall as fuel economy rises. Careful analysis might reveal CAFE provisions to save considerable sums on mobile source pollution control relative to a hypothetical command and control alternative.

By the year 2000 or shortly thereafter, a number of additional incentive programs for stationary sources will begin to have an effect: Phase II acid rain trading will save an estimated $700 to $800 million annually (an increase of $500 million over Phase I); SARA Title III some $1.3 billion annually, RECLAIM perhaps $300 million annually and scrapping older vehicles $100 million annually. Air emissions trading other than RECLAIM, such as the regional NOx program, could yield additional savings comparable to current savings from air emission trading, or $1.1 billion annually. The total cost savings for existing stationary source programs in the year 2000 is thus about $3.5 billion. Potential mobile source savings in the year 2000 include oxygenated fuels, heavy duty truck engines and clean fuel vehicle trading programs; collectively these provisions could produce cost savings as large as $300 million annually.

3.3. Water Pollution Control

Anderson and Lohof (1997) describe several incentive-based mechanisms that are being used to influence either the cost or magnitude of water pollution activities. The report describes five programs including effluent charge systems, reporting requirements, liability rules, and trading of effluent discharge credits between point and nonpoint sources or among point sources. These programs, along with the likely magnitude of compliance cost savings are described in this section. Point source programs dominate this list; the only nonpoint incentive programs involve trading with point sources. Currently there are no incentive-based programs under the Safe Drinking Water Act, nor are any known under state authorities.

Liability rules as an economic incentive are described in this section. While impacts on water resources are the main focus of several of the liability provisions of federal law, some provisions also would apply to releases of pollution to air or land that cause harm.

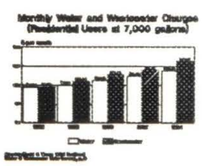
3.3.1. Effluent Charge Systems

Effluent charges are common in the United States and elsewhere. Dischargers to publicly owned treatment plants face charges that are based on volume or volume multiplied by toxicity weights. In 28 of the states, NPDES permit fees for industrial dischargers to surface waters are based on volume or volume and toxicity. Duhl

Indirect discharge and user fees

Fees are imposed on households and businesses for discharges into Publicly Owned Treatment Works (POTWs). Some larger businesses' fees are based not only on water use but also on discharge toxicity. To the extent that discharge fees are included in water consumption bills, they can be difficult to distinguish from water user fees.

Periodic surveys of selected water utilities indicate that water fees are almost always based at least in part on water consumption. The declining block rate structure is becoming less common, the main reason for the shift being the desire to promote water conservation.



This figure indicates that water and wastewater fees have risen significantly during every 2 year period since 1986. These price rises have exceeded inflation.

In addition to water and wastewater charges, stormwater charges have been imposed in a number of areas. Ernst and Young found that the number of utilities with such charges increased significantly from 1992 to 1994. Their use varies significantly across regions: They are used by over half of all utilities surveyed in the West but by none surveyed in the Northeast. In some areas, reduced stormwater fees are assessed in return for measures to promote stormwater management. For more information on such stormwater credits, see Reese (1996).

In some states, water user fees generate revenues for drinking water programs. New Jersey, for example, raises $2.8 million annually (out of a total drinking water program budget of $5 million) from a water use tax of $0.01 per 1,000 gallons. Morandi,et al. (1995), p. 10.

Sims (1977) found that pollutant-based charges provided an incentive for large industrial facilities to reduce discharges. Some studies have found that household water demand elasticity is low in winter but significant in summer, and others have found industrial and agricultural water demand to be sensitive to price. EPA (March 1991) p. 4-6.

Direct Discharge Fees

The Federal Water Pollution Control Act of 1972 provides for the regulation of point source discharges through a system of national effluent standards promulgated by EPA. All point sources must obtain National Pollution Discharge Elimination System (NPDES) permits in order to discharge effluent. EPA has authorized 40 states to issue NPDES permits. In the other ten states, EPA regional offices issue the permits. As of July 1995, about 59,000 municipal and industrial facilities in the United States had received NPDES permits. GAO (January 1996), pp. 1-4.

As shown in the following table, 39 states assessed NPDES permit fees as of December 1993. In 18 of these states, fees varied according to discharge volume, and in an additional 10, fees varied according to discharge volume and toxicity. Unless otherwise stated, the rest of the information in this sub-section on state effluent fees is provided by Duhl (1993). Other criteria sometimes used in setting fees include the purpose of the water use, the receiving water, and the type of discharger. Some states use point or class systems with various criteria to determine different dischargers' fee levels. Fees for POTWs are sometimes based on the size of the population presumed to be connected to the local sewage system.

STATE EFFLUENT FEES AS OF DECEMBER 1993

States with effluent fees that are flat or vary only according to industry or size of permittee.	Alabama, Alaska, Delaware, Hawaii, Kentucky, Maine, Massachusetts, Pennsylvania, Rhode Island, Utah, Virginia
States with effluent fees varying according to discharge volume	Arizona, Arkansas, Colorado, Connecticut, Florida, Kansas, Minnesota, Missouri, Nevada, New York, North Carolina, Ohio, Oregon, South Carolina, South Dakota, Tennessee, Vermont, Washington
States with effluent fees varying according to discharge volume and toxicity	California, Indiana, Louisiana, Maryland, Montana, New Jersey, Oklahoma, Texas, West Virginia, Wisconsin
Source: Duhl, p. 10.	

Examples of state effluent fees: Louisiana, California, and Wisconsin

Although it is beyond the scope of this report to describe all state water effluent fees, examples from Louisiana, California, and Wisconsin should illustrate their characteristics. Louisiana uses water permit fees to fund not only the state permit program but also the activities of the Office of Water Resources of the Department of Environmental Quality. (The legislature no longer provides general revenues to the Office.) The annual permit fee is determined by a worksheet assigning points on the basis of 1) facility complexity, 2) flow volume and type, 3) pollutants released, 4) heat load, 5) potential public health threat, and 6) major/minor facility designation. The points are multiplied by a rate factor of $97.50 per point for municipal facilities and $170.63 per point for industrial facilities to determine total annual fees. The minimum annual fee is $227.50, and the maximum annual fee is $90,000. In addition to annual fees, Louisiana imposes application fees for new, modified, or reissued permits. In most cases, these fees are 20% of the annual fee.

In California, NPDES annual fees are based on the threat to water quality and the complexity of the permit. There are three categories for each characteristic: I, II, and III for water quality threat and a, b, and c for permit complexity. Permittees with a I-a rating, with the greatest threat to water quality and the most complex permits, pay the highest fees, $10,000 a year. III-c permittees pay the lowest fees, $400 a year. These fees fund State Water Board programs.

In addition to the NPDES permit fees, California charges Bay Protection and Toxic Cleanup fees. This fee structure is similar to that of the NPDES permits except that it is also applied to other sources such as storm drains, boat construction and repair facilities, marinas, dredging operations, and beach replenishment activities. Another difference is that its revenues fund the Bay Protection and Toxic Cleanup Program designed to identify hot spots, develop a water quality database, and help coordinate water policy. Bay Protection and Toxic Cleanup fees range from $300 for III-c permittees to $11,000 for I-a permittees. Dredging operations are charged an annual fee of up to $15,000. The fee schedule is posted on the Internet by the California Water Resources Control Board.

The Wisconsin effluent fee system is believed to have potential incentive effects. Since the fee rate per pound of pollutant is inversely related to the permit limit for the pollutant, the most harmful pollutants are taxed at the highest rate. Pollutant loadings are calculated on the basis of flow and concentration information contained in wastewater monitoring reports. Polluters are thereby encouraged to reduce both the quantity and the toxicity of pollutant releases.

The primary purpose of NPDES permit fees is to raise revenue, especially for the permitting program, which explains why fees are often based on permit complexity. In a number of states, fees are set to attain revenue targets.

A secondary purpose is to discourage water pollution. Although the incentive effect of water effluent fees in the United States has not been comprehensively studied, several factors limit the likelihood of a strong impact. In some cases, fees are based not on actual discharge characteristics but rather on proxies for discharge data. Moreover, some fee structures place dischargers into classes for the purposes of discharge volume and/or toxicity and charge the same fees for all volume and toxicity levels within given classes. In such cases, polluters have no incentive to limit discharges unless they can move from one class to another. Finally, the charges are often modest relative to control costs. As of 1993, the largest effluent fees in the United States, paid by two facilities in New Jersey, amounted to $702,812, and most states had maximum fee levels of less than $100,000. For large facilities, annual effluent control costs typically exceed $5 million.

Very limited information is available concerning the impact of these fee systems on the volume or toxicity of industrial discharges. Simms found that pollutant-based charges provide an incentive for large industrial facilities to reduce effluents. Several studies cited earlier in this report have modeled the potential savings from effluent charge systems, finding possible savings of 20 percent to 50 percent or more.

Cost savings from existing state NPDES permit charge systems are likely to be small because the charge levels are low relative to incremental control costs. Nonetheless there could be small but measurable impacts. State NPDES charge systems apply in 28 states, with an emphasis on states with greater than average industrial activity. Thus of the $40 billion spent annually on water pollution control in the mid-1990s ($50 billion by 2000), about $30 billion takes place in states with NPDES charge systems. The NPDES charge systems might affect as much as 20% of those expenditures and result in savings of 25% of that 20%. Thus a plausible estimate of the savings attrributable to the state NPDES charge systems is $1.5 billion By the year 2000, assuming no change in policy, savings would approximate $2 billion annually.

3.3.2. Liability Provisions

Two federal environmental statutes, CERCLA and OPA, provide liability for harm caused by releases of hazardous substances and petroleum, respectively, to the environment. Both CERCLA and the Clean Water Act hold parties responsible for the costs of cleanup. The incentive effects are clear, since environmental values in effect become part of the overall cost of doing business. Avoiding harm to the environment is good practice when it reduces the overall cost of doing business.

Several of the federal environmental statutes provide for civil and criminal liability for failure to comply with the law and implementing regulations. The incentive effect of this form of liability is to encourage individuals to comply with what are largely command and control regulations. Such an incentive is qualitatively different from the subject matter for this report: incentives that put a price on pollution that harms health, the environment, or natural resources. No study has attempted to address whether the existing level of penalties and enforcement produce the correct incentive effect (an optimal level of investment in pollution control). Excessive investment in pollution control is possible if entities seek to avoid penalties that are too harsh. Also possibility is too little effort at pollution if penalties are low and enforcement is lax.

Tort law is a third means through which liability encourages behavior that improves the state of the environment. Under tort law, individuals may seek compensation from polluters for harm to their property or person. The difficulty of proving harm caused by pollution, particularly chronic health effects, creates a severe barrier to such cases, meaning that many environmental costs will not be internalized through a liability mechanism. In fact, it is largely the failure of tort law to address many types of environmental harm that led to the passage of the principal environmental statutes.

Cleanup Liability

Enacted by Congress during the change-over from a Democratic to a Republican administration in 1980, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) responded to an issue with no precedent: the legacy of contaminated sites containing hazardous wastes. CERCLA established a trust fund (the Superfund) which is financed primarily by a tax on corporate income, crude oil and certain chemicals. EPA uses the fund to pay for cleanup and restoration activities at sites where no solvent responsible party can be identified or where immediate response is deemed necessary. The most important feature of CERCLA centers on the cleanup of hazardous waste sites posing a threat to human health and the environment.

CERCLA is unique among the principal environmental statutes in that it is backward looking, seeking to remedy problems stemming from past actions, rather than forward looking and trying to prevent damage from current or future activities. The incentive effects of CERCLA cleanup responsibility must lie outside of the actual costs of cleanup, since the actions that precipitated the need for cleanup are historical not contem- poraneous. But the mere prospect of CERCLA cleanup liability can affect current and future decisions regarding the disposal of hazardous wastes. Section 107(a) of CERCLA provides for liability for anyone who is did something from which there is a release (of a hazardous substance), or threatened release.

The courts have interpreted this to require strict, joint and several liability for parties deemed responsible for disposing of hazardous wastes that pose risks to human health and the environment. Joint and several liability means that if the government can identify just one party out of many that contributed wastes to a site, potentially the one party can be held responsible for all cleanup costs. In turn any potentially responsible parties identified by the government may seek to involve other potentially responsible parties. Joint and several liability appears to some to be a recipe to ensure litigation over who is responsible for what. Strict liability is a standard that holds parties responsible regardless of the circumstances of their action.

Private sector cleanup costs under CERCLA certainly have run into the tens of billions of dollars already and eventually may amount to several hundred billion dollars. Cleanup of defense wastes, particularly radioactive wastes, could cost at least $500 billion. Transactions costs associated with determining liability run high under this program.

The Clean Water Act holds parties responsible for the costs of cleanup following a release of petroleum or hazardous substances into the nation's waters. While future oil spill cleanup expenditures are more difficult to predict, these costs have ranged from a few tens of millions of dollars in years with few large incidents to more than $2 billion in particulary difficult years.

Liability for Damage to Natural Resources

By 1996, under provisions of CERCLA, OPA, and the Clean Water Act, federal agencies had settled more than 100 natural resource damage cases for a total of well over $700 million. million. By that date state agencies acting as trustees also had settled several cases on their own for a total of at least another $20 million. In comparison, cleanup settlements by that date under CERCLA alone totaled at least $10 billion, or approximately 100 times the magnitude of the natural resource damage settlements. A number of large NRDA cases are still pending, at least three of which could amount to at least $500 million. Several important cases involving the federal government as a responsible party also are outstanding.

The specter of paying large claims for natural resource damages already is affecting industry behavior. Some firms have decided to use only double-hulled vessels, despite a several year period during which they could continue to transport oil in single-hulled vessels. Other firms have altered the routes that vessels follow to reduce the chances of accidental groundings and collisions. In certain harbors, firms are adding additional tug escorts. All of these voluntary actions are taken by firms in the belief that they are cost-effective. These measures appear to be having an impact on volumes spilled. Apart from 1989, when the *Exxon Valdez* ran aground, the volume of oil spilled in recent years has been about one-half of comparable periods in the 1970's or early 1980's, despite increases in volumes shipped.

In theory, the same level of care that results from OPA liability rules could be achieved through a set of operating protocols specified by a regulatory agency. Since industry is likely to be better able than a regulatory agency to identify which measures are cost-effective, the liability approach is likely to be less expensive for the same level of pollution avoidance.

Over the past five years, liability rules have resulted in damage assessments and cleanup costs that averaged about two-tenths of a cent per gallon of petroleum products consumed in the U.S. ($.5 billion annually). The possibility that nonuse values could be included in future, as endorsed by a "blue ribbon" National Oceanic and Atmospheric Administration advisory panel, could result in larger damage awards in the future. A direct regulatory approach would be almost certain to cost more, since petroleum shippers are in a far better position to understand relative risks than are regulators. While the exact savings from the liability approach is largely unknowable, it appears reasonable to assume that a direct regulatory approach could cost at least one cent per gallon to achieve comparable effectiveness, or an additional $2.0 billion annually.

Civil and Criminal Liability

Congress first decreed pollution of the environment to be a federal crime in the Refuse Act of 1899, which made it a misdemeanor to "throw, discharge, or deposit" into navigable waters of the United States refuse of any kind other than runoff from streets and discharge from sewers. Violators convicted of violating the act could be punished by fines not less than $500 nor more than $2,500, or by imprisonment for not less than 30 days nor more than one year. The court had the discretion to reward persons who provided information leading to conviction with one-half of the fine.

More recently, the 1970 Amendments to the Clean Air Act punished violations of the Act as a misdemeanor. The 1970 Amendments to the Federal Water Pollution Control Act established misdemeanor penalties for "negligent or willful" release of pollutants into navigable waters without a permit or in violation of a permit. The Resource Conservation and Recovery Act of 1976, as amended by the Solid Waste Disposal Act Amendments of 1980, provides felony penalties for treatment, storage or disposal of hazardous waste without a permit.

Continuing through the 1980s, Congress further refined the scope of environmental crimes, as well as the maximum fines and terms of imprisonment, in the Hazardous and Solid Waste Amendments of 1984, the Superfund Amendments and Reauthorization Act of 1986, and the Water Quality Act of 1990. In the Clean Air Act Amendments of 1990, Congress increased the penalty provisions to felonies.

By 1995 the Justice Department had indictments against 443 corporations and 1,068 individuals, and had recovered $297 million in criminal penalties. Sentences for individuals totaled 561 person-years of prison for those convicted. Cooney

State and local prosecutors also can pursue environmental crimes, since they are required to demonstrate such a capacity in order to obtain EPA authorization to administer locally programs of the Clean Air Act, the Clean Water Act and RCRA. While most states were not active in pursuit of environmental crimes, there are a number of important exceptions. New Jersey, Ohio, Pennsylvania and California are active in the prosecution of environmental crimes. Los Angeles maintains its own team of investigators and prosecutes cases.

An important sanction in addition to fines and sentences is mandatory "blacklisting" of contractors under the CAA and the CWA. Both statutes prohibit the federal government from entering into new contracts with or issuing grants to any organization convicted of environmental crimes under these laws. Federal agencies and all states also have the authority to temporarily disqualify contractors from new work pending receipt of further information, when a contractor is violates a permit and is suspected of harming the environment. Consequently, environmental violations can adversely affect a firm or individual even if no criminal conviction is imposed.

Do liability rules create incentives to avoid harm to the enviornment? Unquestionably. The petroleum industry invested voluntarily several hundred million dollars in oil spill prevention following the *Exxon Valdez* incident. Did this expenditure result in cost savings? And measured how? Economic theory suggests the industry invests voluntarily in pollution prevention only when it anticipates that the investment produces positive returns comparable to alternative investment opportunities. That is one form of cost savings -- cleanup and environmental damage costs averted above and beyond the costs of pollution prevention. If traditional command and control measures were taken to encourage oil spill prevention they are unlikley to be as cost-effective as what the industry can design on its own. That is a second avenue for cost savings. Neither of these sources of potential cost savings is easily measured and no estimate can be provided at this time.

3.3.3. Reporting Requirements

The 1986 Emergency Planning and Community Right-to-Know Act (SARA Title III) requires firms that manufacture or process in excess of 25,000 pounds of some 302 chemicals (currently) to report all quantities released to air, water, and public sewage facilities, deposited on land and injected underground. While not a water pollution control statute, per se, SARA Title III requirements may influence the quantity of effluents released to the nation's waters. SARA Title III reporting requirements were viewed by Congress as a powerful stimulus, through their effect on public attitudes, shaping firm behavior. By now a considerable body of evidence demonstrates that disclosure requirements provide a strong incentive to identify and act upon opportunities to reduce accidental and routine releases of listed chemicals.

EPA data support this view. In 1994, 66 million pounds of toxic chemicals were discharged to surface water, down 78% from the 310 million pounds released in 1988. Transfers to POTWs were 255 million pounds in 1994, down 55% from the 570 million pounds transferred in 1988.

To project the potential reduction in annual compliance costs for controlling water discharges to the year 2000, assume as was done for air that the same trends continue. Quantities discharged directly would be reduced to just 13 million pounds and quantities transferred to POTWs to 115 million pounds. This would represent a cumulative reduction of about 750 million pounds in the annual rate of release, relative to a 1988 baseline. Per-pound control cost savings are not likely to be as large as for air. The principal chemicals discharged to surface water are ammonium sulfate, phosphoric acid, methanol, and sulfuric acid. The three largest categories of chemicals discharged to public sewers are ammonium sulfate, methanol and sulfuric acid. Control costs for several of these substances are likely to be relatively modest; for example, acids can be neutralized with limestone at low cost. Consequently, projected savings from Title III reporting requirements relative to a command and control approach for water discharges could amount to $0.50 per pound, or about $400 million annually in the year 2000.

3.3.4. Effluent Trading Programs

Until very recently, water effluent trading in the United States was confined to five separate programs. Certain plants in the iron and steel industry are allowed to treat discharges from different points within the facility as if they originated at a single point, a so-called "water effluent bubble". Wisconsin has a program that allows trading of effluent discharge credits between point sources and savings from this program should be credited to point source programs. Three water effluent trading programs are designed to gain efficiencies in controlling nutrient discharges among point and nonpoint sources: Dillon and Cherry Creek Reservoirs in Colorado and the Tar-Pamlico Basin in North Carolina. In a recent policy statement, the EPA proposed expanding significantly the scope of water point-nonpoint effluent trading to include many more water bodies.

Effluent Bubble

In concept, a water effluent bubble operates identically to the air emission bubble described earlier. A facility with multiple discharge points is wrapped in an imaginary bubble, with a facility-wide discharge limit rather than separate limits at the individual points of discharge. In contrast to the 100-some bubbles approved under the air emission trading program, only a handful of facilities within the iron and steel industry have received the authority to bubble effluents. The historical development of that program is described below.

It should be noted at the outset that opportunities to apply effluent bubbles outside the steel industry are very limited. When asked by EPA to evaluate the potential for water effluent bubbling, a contractor ventured in 1981 that bubbling would not produce cost savings for most industrial facilities.Putnam, Hayes & Bartlett, Inc., 1981. The reasons include the fact that most industrial facilities already have centralized wastewater treatment plants with a single point of discharge, trades between outfalls may be circumscribed due to water quality concerns, and some facilities already operated under permits that allowed all technologically feasible tradeoffs to be made.

Despite the acknowledged limitations, a subsequent study identified 4 plants in the iron and steel industry that potentially would benefit from water bubbling as they went from BPT (best practicable control technology currently available) to BAT (best available technology economically achievable). Temple, Barker and Sloane, 1981. The iron and steel industry offered what might be unique opportunities for bubbling inasmuch as many plants had yet to consolidate their water treatment at a single processing facility. The projected savings from effluent bubbles were modest as a percent of control costs, though, as shown in the table below.

EPA's implementation of the effluent bubble for the iron and steel industry was dictated by a 1983 settlement agreement among the EPA, the Natural Resources Defense Council, and the American Iron and Steel Institute. The agreement supports the use of bubbling under the Clean Water Act, but imposes constraints on the approach. Bubbling of effluents from iron and steel plants is acceptable provided that net reductions are achieved in total effluents. Relative to BAT limits that are in effect, bubbling must involve an average reduction of at least 15 percent in the mass of suspended solids and 10 percent in the mass of other pollutants. The NRDC reserved the right to challenge bubbles that might be proposed for other industries.

Since the bubble became available to the industry, 7 iron and steel plants in the midwest have used the provision. Industrial Economics. Three of the mills no longer use the bubble: one facility closed and two have changed ownership, a cause for termination of bubbling rights. The steel effluent bubble undoubtedly has produced some compliance cost savings for the industry, but according to a former EPA employee who is now a consultant to the industry the bubble has not resulted in any pollution control innovations. (Gary Amendola, cited in Industrial Economics memorandum).

Projected Cost Savings from Effluent Bubble
(in thousands of 1978 dollars)

Facility	One-Time Savings in Capital Costs	Percent of BAT Capital Costs	Annual Savings in O&M Costs	Percent of Annual BAT O&M Costs
Republic Steel, Cleveland	328	5.7	15	3.6
Republic Steel, Warren	200	3.3	10	2.5
U.S. Steel, Gary	1,103	4.7	55	2.1
Wheeling Pittsburgh, Steubenville	800	6.2	32	2.7

source: Temple, Barker and Sloane

Effluent Trading (point-point)

Effluent trading dates to the early 1980s, when the State of Wisconsin created a State-wide program to give sources such as wastewater treatment plants and pulp and paper mills added flexibility to meet state water quality standards through the trading of effluent rights. The first and only application of this authority is on the heavily industrialized lower Fox River.

Analysis showed that the potential from trading was significant: $7 million annually or roughly one-half of anticipated compliance costs for BOD (biological oxygen demand) regulations. O'Neil. The program that was implemented allows trading between point sources of rights to discharge wastes that increase BOD. Sources that control more than required under their discharge permit may sell those incremental right to sources that control less than is required. Strict conditions are imposed on would-be buyers of rights: trading of rights is allowed only if the buyer is a new facility, is increasing production, or is unable to meet required discharge limits despite optimal operation of its treatment facilities. Traded rights must have a life of at least one year, but may not run past the expiration date of the seller's discharge permit, at most a five year period. Since effluent discharge limits may change with each permit renewal, there can be no guarantee that rights that were traded in during one permit period would be available during subsequent permit periods.

The State initiated BOD trading programs on two rivers: a 35-mile stretch of the Fox River and 500 miles of the Wisconsin River. For administrative reasons, the Fox River was divided into three segments, the Wisconsin River 5 segments. The Fox River program includes 21 parties: five mills and two towns in each of the three administrative segments. Twenty-six parties are included in the Wisconsin River program. To date, trading under these programs has been disappointing, involving a single trade on the Fox River between a municipal wastewater plant and a paper mill. In return for a cash payment, the paper mill was able to close its wastewater treatment facility and send its effluent to the wastewater treatment plant. One reason for the limited activity is that dischargers developed a variety of compliance alternatives not contemplated when the regulations were drafted. Second, there were and remain questions about the vulnerability of the program to legal challenge, since the Clean Water Act does not explicitly authorize trading and the standards set by the State do not conform fully to the national policy of uniformity established in the CWA. Finally, as noted above, the State imposed severe restrictions on the ability of sources to trade.

Currently, the EPA is investigating the feasibility of extending point-point trading to San Francisco Bay, where copper discharges would be traded, and Tampa Bay, where nitrogen and suspended solids would be traded. "Effluent Trading in Watersheds Policy Statement"

EFFLUENT TRADING (point-nonpoint)

Three programs allow the trading of nutrient discharges between point and nonpoint sources: Dillon Reservoir, Cherry Creek Reservoir, and the Tar-Pamlico Basin. These programs are discussed in turn.

Dillon Reservoir

Dillon Reservoir, which supplies Denver with more than one-half of its water supply, is situated in the midst of a popular recreational area. Four municipal wastewater treatment plants discharge into the reservoir: the Frisco Sanitation District, Copper Mountain, the Breckenridge Sanitation District, and the Snake River treatment plant of the Keystone area.

Due to concerns that future population growth in the region could lead to eutrophic conditions in Dillon Reservoir, as well as the discovery that Copper Mountain was exceeding its discharge limits, EPA launched a study of the Dillon Reservoir in 1982 under its Clean Lakes program. The study indicated that phosphorus discharges would have to be reduced to maintain water quality and accommodate future growth. Point source controls alone were unlikely to be sufficient; runoff from lawns and streets and seepage from septic tanks also would have to be reduced.

A coalition of government and private interests developed a plan to reduce phosphorus releases to the reservoir. The plan established a cap on total phosphorus loadings, allocated loadings to the four wastewater treatment plants, and provided for the first-ever trading of phosphorus loadings with nonpoint sources.

The plan relies on 1982 phosphorus discharges as the baseline; that year represented a near worst-case scenario due to high rainfall and water levels that led to high nonpoint loadings. Discharges from new nonpoint sources are restricted through regulations requiring developers to show a 50 percent reduction from pre-1984 norms. The plan established a trading ratio of 2:1, whereby point sources that are above their allocation must obtain credits for twice the amount of the excess from sources that are below their allocation. New nonpoint sources must offset all of their discharges using a trading ratio of 1:1 with existing nonpoint sources. The system would be monitored through existing NPDES permits for point sources.

Trading has been very slow. Not only has the region experienced a recession for a number of years limiting population growth but the wastewater treatment plants have found cheaper means of controlling phosphorus than were previously envisioned. In the future, though, opportunities for further control at the wastewater treatment plants are thought to be limited and population growth is once again evident, leading to the conclusion that more trading activity is likely.

Cherry Creek

Like the Dillon Reservoir, Cherry Creek Reservoir also is a source of water for the Denver region and an important recreation area. The Denver Regional Council of Governments established an effluent trading program for Cherry Creek very similar to that at Dillon. One difference is that trading at Cherry Creek has been nonexistent to date, reflecting the fact that phosphorus loadings at municipal wastewater treatment facilities remain below limits set by the Colorado Water Quality Commission.

Tar-Pamlico Basin

The North Carolina Environmental Management Commission designated the Tar Pamlico Basin as nutrient sensitive waters in 1989, in response to findings that algae blooms and low dissolved oxygen threatened fisheries in the estuary. North Carolina law requires that upon designating an area as nutrient sensitive, the Division of Environmental Management (DEM) must identify the nutrient sources, set nutrient limitation objectives, and develop a nutrient control plan.

DEM prepared analysis showing that most of the nutrient loadings (nitrogen as the limiting factor but also phosphorus) came from nonpoint sources, principally agricultural runoff. Other identified sources included municipal wastewater treatment plants and industrial and mining operations. DEM proposed a solution to control both nitrogen and phosphorus discharges from wastewater treatment plants: nitrogen at 4 mg/l in the summer and 8 mg/l in the winter; phosphorus at 2 mg/l year-round.

Concerned about the potential costs of this regulation, municipal wastewater dischargers worked with state agencies and the North Carolina Environmental Defense Fund to design an alternative approach. Ultimately accepted by the DEM, the plan requires the parties to the accord to develop a model of the estuary, identify engineering control options, and implement a trading program for nutrient reductions. The trading program allows each of the 12 point source dischargers the opportunity to offset any discharges above their permitted limits. They may trade with feedlot operators on a 2:1 basis or cropland managers on a 3:1 basis. To date point source dischargers have found means of meeting new and stricter discharge limits without resorting to trading. In the future trading may become more attractiv as a compliance option. EPA provides more details of the program in its TMDL analysis.

Other Point-Nonpoint Trading Proposals

The EPA is actively involved in a number of other projects that are likely to lead to effluent trading between point and nonpoint sources. These projects include: Chehalis Basin, Washington (BOD); Boone Reservoir, Tennessee (nutrients); Wicomico River, Maryland (phosphorus); Long Island Sound, New York (dissolved oxygen); Tampa Bay, Florida (nitrogen and suspended solids); and Chatfield Basin, Colorado (phosphorus). *(EPA)*

3.3.5. Summary of Cost Savings from Existing Incentives to Reduce Water Pollution

Effluent charges in the form of sewerage fees and fees for state NPDES permits are likely the most important source of savings from existing incentives for water pollution control, accounting for an estimated $1.5 billion in savings in the mid-1990s rising to $2.0 billion by the year 2000. Liability rules also likely are producing major cost savings, since this particular regulatory mechanism leaves industry free to select the nature and amount of care. The alternative, dictating in detail how oil and other materials must be transported is notoriously inefficient. Oil pollution liability rules may save $2 billion annually (less than one-half of one cent per gallon for all crude oil and petroleum products transported) relative to a command and control system that has an equal impact on pollution. Reporting requirements already have had a significant impact on quantities of hazardous wastes discharged to water and likely produced cost savings during the mid-1990s on the order of $200 million annually through voluntary efforts to reduce toxic effluent discharges. These voluntary actions reduced the need for expenditures to satisfy command and control regulatory requirements, placing some dischargers below regulatory thresholds, allowing others to discharge to POTWs and in other ways reducing compliance costs. By 2000 or shortly thereafter, cost savings of $400 annually may result from pollution reductions made as a result of reporting requirements. Effluent trading provisions may save $10 to $100 million annually by the year 2000 (take $50 million as mid-range estimate), particularly if these mechanisms are more widely implemented.

3.4. Solid and Hazardous Waste Management

This section reviews some of the more important economic instruments already in place for solid and hazardous waste management. Over 3,000 communities have instituted per-bag or per-can charge systems for household solid waste disposal.This experience is reviewed in the first subsection Marginal Cost Pricing for Solid Waste. The second subsection describes experiences with beverage container deposit systems that were first enacted in Oregon in 1972 and now are found in ten states..A third subsection characterizes experiences with deposit legislation affecting lead acid automotive batteries. A number of states have imposed or are considering recycled content standards for newsprint as an incentive to stimulate newsprint recycling but experiences with this approach are too few from which to form an assessment. SARA Title III reporting, described in the fourth subsection, appears to be influencing the reported quantities of hazardous waste disposed of on land and injected underground. Private disposal charges for hazardous waste vary with quantity, providing an incentive to reduce wastes; however, little in the way of quantitative analysis points to the magnitude of potential cost savings from such charges.

3.4.1. Marginal Cost Pricing for Household Waste

Communities throughout the United States have traditionally levied fixed collection fees for household waste or included the collection costs in property taxes. Such pricing practices are inefficient in that the marginal price for the household is zero, whereas the marginal collection cost is positive.

However, a growing number of communities are now charging for solid waste collection based on the volume generated by the household. Such variable rate (or "pay-as-you-throw") programs have been implemented in over 3,200 communities in 37 states, reaching an estimated 12% of the U.S. population. Four states have mandated the use of variable rate programs in some or all of their municipalities. Washington's law applies mostly to private collectors operating in unincorporated areas of the state, but virtually all municipalities in the state use variable rates. Iowa and Wisconsin require variable rates only in communities that fail to attain a 25% waste recycling/diversion goal by certain deadlines. In Minnesota, variable rates are required in all communities. Skumatz, 1996, p.1. EPA is also encouraging variable rates and has held a series of workshops to explain their advantages and disadvantages and provide information on how to implement them.

Variable rate programs can take several forms. Pre-paid garbage bags or stickers to affix to bags can be required for collection, or collection fees can be based on the number and/or size of cans. Some areas have weight-based systems. Others have mixed systems combining a fixed rate up to a certain amount of garbage and incremental rates for amounts in excess of the minimum covered by the flat rate. Such mixed systems are becoming increasingly common, perhaps because they are relatively easy and inexpensive to implement, provide a stable source of revenue for collection services, have the potential to reduce illegal dumping, and offer a minimum level of free service to many customers. Skumatz, 1996, p.2. According to one source, collection systems that require periodic billing of customers are likely to be administratively more expensive than bag or sticker systems. Miranda and Aldy, 1996, p. 16. One disadvantage of bags is that they can tear, especially if handled improperly or penetrated by animals. Many U.S. communities rely on variable rate structures; a few of them are characterized below.

VARIABLE RATE STRUCTURES IN SELECTED COMMUNITIES

Community	Fee structure
Glendale, CA	65-gallon cart: $6.45/month, 2¢/gallon 100-gallon cart: $10.10/month, 2¢/gallon
Pasadena, CA	60-gallon cart: $10.41/month, 4¢/gallon 100-gallon cart: $16.23/month, 4¢/gallon 2 60g carts: $19.01/month, 4¢/gallon 60g & 100g cart: $22.40/month, 4¢/gallon 2 100g carts: $28.62/month, 3¢/gallon

San Jose, CA	32-gallon cart: $13.95/month, 10¢/gallon 64-gallon cart: $24.95/month, 10¢/gallon 96-gallon cart: $37.50/month, 10¢/gallon 128-gallon cart: $55.80/month, 10¢/gallon
Santa Monica, CA	40-gallon cart: $14.85/month, 9¢/gallon 68-gallon cart: $17.76/month, 7¢/gallon 95-gallon cart: $21.07/month, 6¢/gallon 68g & 95g cart: $37.28/month, 5¢/gallon
Oakland, CA	20-gallon can: $10.08/month, 13¢/gallon 1st 32-gallon can: $13.74/month, 11¢/gallon Each extra 32g can: $16.49/month, 13¢/g
Portland, OR	20 gallon can: $14.60/month, 18¢/gallon 32 gallon can: $17.60/month, 14¢/gallon 35 gallon cart: $19.30/month, 14¢/gallon 60 gallon cart: $24.05/month, 10¢/gallon 90 gallon cart: $27.10/month, 8¢/gallon
Takoma, WA	60 gallon can: $17/month, 7¢/gallon 90 gallon can: $25.50/month, 7¢/gallon
Spokane, WA	20 gallon can: $8.56/month, 11¢/gallon 1st 30 gallon can: $11.07/month, 9¢/gallon Each extra 30g can: $6.01/month, 5¢/gallon
Colorado Springs, CO The city of Colorado Springs neither collects garbage nor licenses haulers. Fees here are charged by Waste Management when it supplies cans and bags. Customers supplying their own cans and bags pay other rates.	1 34g can + 1 30g bag: $9.50/month, 4¢/g 2 cans and 2 bags: $11/month, 2¢/gallon 3 cans and 3 bags: $13/month, 2¢/gallon
Downers Grove, IL	30-gallon bag: $1.50, 5¢/gallon
Grand Rapids, MI (City)	30-gallon bag: $0.85, 3¢/gallon 30-gallon can: $44.20/year, 3¢/gallon
Grand Rapids, MI (Waste Management)	64-gallon cart: $15/month, 6¢/gallon 104-gallon cart: $17/month, 4¢/gallon
Grand Rapids, MI (Able)	90-gallon cart: $17.35/month, 5¢/gallon
Hoffman Estates, IL	30-gallon bag: $1.45, 5¢/gallon
Lansing, MI (City)	30-gallon bag: $1.50, 5¢/gallon
Lansing, MI (Waste Management)	63-gallon cart: $12/month, 5¢/gallon 104-gallon cart: $15/month, 4¢/gallon
Lansing, MI (Granger)	60g cart: $11/month, 5¢/gallon 90g cart + 3 30g bags: $13.40/month, 2¢/g

Woodstock, IL	30-gallon bag: $1.56, 5¢/gallon
Sources: Miranda and Aldy; Bauer and Miranda	

The table shows that communities vary as to whether the city and/or private haulers collect waste. Waste collection systems can be open systems or exclusive franchises. In open systems, the city may provide optional waste collection (eg. Grand Rapids, Lansing) or it may leave collection completely in the hands of private firms (eg. Colorado Springs). In exclusive franchises, collection can be done either by the city (eg. Spokane, Takoma) or by one or more contracted haulers (eg. Oakland). In both open and franchise systems, communities can set rules regarding collection fees. In St. Paul, Minnesota, for example, the city operates no collection program but requires that collectors charge variable rates, and Portland's open system has no city program but sets collection fees charged by private haulers.

Many communities with variable rates implement public education, curbside recycling, yard waste, white goods, and holiday greenery programs as well. Education has been found to be an important element in the success of variable rate programs. The collection frequency, fees, materials collected, and participation requirements for curbside recycling, yard waste, white goods, and holiday greenery collection programs vary across communities. These complementary activities can have an important impact on the success of variable rate programs.

Cities that have adopted per-can or per-bag charge (often called "unit pricing") systems for household solid waste report significant decreases in the volume of waste collected. In most areas where variable rate programs have been introduced, amounts of waste collected have decreased significantly. A 1992 survey of 14 cities with variable rate programs found that the amount of waste destined for disposal decreased by an average of 44%. Skumatz, 1983, pp 283-84. A study in Maine found that municipalities with variable rate systems disposed of less than half as much waste per capita as municipalities without such systems. *Warmer Bulletin* 1996. Surveys in Tompkins County, New York and Dover, New Hampshire found that variable rates led consumers to think of ways to reduce waste generation, including altering their purchasing habits. A 1996 study of four communities in California and five in the Midwest found that they achieved reductions in waste disposal of 6% to 50% after introducing variable rate systems. The higher the unit prices, the greater the reductions. Moreover, reductions were greater in those communities with relatively small minimum container sizes. (Some variable rate structures are more variable than others.) If the minimum container size is too large, consumers often have little incentive to alter their behavior. Miranda and Aldy 1996, p. 19.

As shown in the following table, another study found reductions in tons of waste landfilled ranging from 17% to 74% following the adoption of variable rates in 21 northern cities. The study found the magnitude of the unit prices to be positively correlated with the change in the amount of waste recycled and negatively correlated with the change in the amount of waste landfilled. Seattle's 30 percent reduction might be taken as representative.

CHANGES IN WASTE DISPOSAL IN RESPONSE TO VARIABLE RATE PRICING PROGRAMS

Municipality	% Reduction in tons of waste landfilled	% Increase in tons of waste recycled
Antigo, WI	50	145

Charlemont, MA	37	N/A
Downers Grove, IL	52	N/A
Grundy Center, IA	32	N/A
Hancock, VT	33	N/A
Hartford, VT	17	29
Harvard, IL	33	113
High Bridge, NJ	18	N/A
Huntingburg, IN	74	N/A
Illion, NY	51	141
Ithaca, NY	31	63
Lisle, IL	53	N/A
Mt. Pleasant, IA	49	N/A
Mt. Pleasant, MI	44	141
Perkasie, PA	54	157
Plains, PA	49	88
Quincy, IL	41	45
River Forest, IL	19	N/A
St. Charles, IL	41	456
Weathersfield, VT	36	150
Woodstock, IL	31	N/A
Source: Miranda, reprinted in Arner and Davis, p. 4.		

The recycling increases shown in the table were achieved in areas that did not simultaneously implement recycling programs. In places where the adoption of variable rate programs has coincided with new public recycling activities, however, it may be difficult to determine how much of the decline in waste disposal is due to the variable rates and how much is due to the new recycling alternatives. The Dover survey found that curbside recycling programs alone encouraged recycling but that variable rates provided additional incentive.Skumatz 1994, p 284. Another study estimates that a variable rate program will increase the percentage of waste diverted under existing recycling programs by 4-13%. Skumatz 1996.

Despite the evidence cited above, variable rate programs are not without problems. Data on decreases in collection can be misleading if the programs result in significant illegal disposal or diversion to cheaper disposal services. Illegal dumping includes direct discharge to the environment as well as placing waste in someone else's container or donating unrepairable items to charitable organizations. Direct discharge to the environment is likely to be of more concern than other types of illegal disposal. The Maine study found that an increase in backyard burning and a slight increase in roadside dumping and illegal disposal in commercial containers coincided with variable rate systems. Of the cities surveyed in the 14-city study mentioned above, "six cities reported no problem with dumping, four reported minor problems, and four reported notable problems." Among the measures cited to limit illegal disposal are creation of viable recycling alternatives, public education, the locking of commercial dumpsters, high dumping fines, and minimum flat collection fees. Repetto et al., p.18-19.

Other problems that need to be addressed in designing and managing variable rate programs are that they can be difficult to implement in multi-family housing such as apartments and that they can have a regressive effect on the poor and large families. In addition, the programs can lead to significant decreases in revenue for municipal waste collectors. The magnitude of these decreases can be difficult to predict.

Variable rate programs may not be appropriate for all communities. Analysts assert that variable rate pricing is unlikely to be successful in areas with affordable and environmentally acceptable landfill disposal options, lack of nearby recycling possibilities, nearby open spaces for easy illegal dumping, and lack of consumer willingness to pay variable rates. Skumatz (1994), p. 286. In some areas, however, they appear to be beneficial. According to a World Resources Institute study Repetto, et al., "Where landfill costs are high, disposal charges would generate net economic savings of $0.17 for every dollar of revenue collected, even after the gross costs of curbside recycling programs were paid."

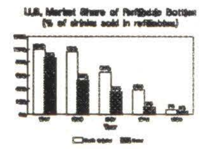
Based on the data in the above table, a representative figure is the 30 percent reduction observed in Seattle, where per can fees were coupled with increased opportunities for households to recycle. The entire 30 percent does not represent a cost saving, though, since recycling does not provide a competitive financial return to labor and capital inputs (particularly those of the household). Thus, the net savings are less than 30 percent, perhaps in the 20 percent range.

Unit pricing for solid wastes is likely to be cost-effective for up to one-half of the nation's households. In heavily urbanized areas, deterring littering through flat fees may be more important than the incentive effect of unit pricing. In some contexts, such as large apartment buildings, unit pricing for waste may be infeasible altogether. Also, in many rural areas, solid waste disposal remains quite inexpensive, bringing into question the ability to recover administrative costs of unit pricing.

Current EPA estimates are that some form of unit pricing currently affects about 5 million households (12% of the population). Some of these households pay per-can fees only in the form of surcharges for exceeding a weekly or monthly limit, while others pay explicit per-can fees on each can. In the absence of such incentives each of these households would generate more wastes and experience disposal costs about 25 percent higher than a current average of $200 annually (about one-third higher than the national average). Savings of $50 per household for 5 million households indicates that unit pricing may currently produce savings of $250 million annually. Repetto *et al.* estimate that if unit pricing is adopted in all regions with high disposal costs, the savings would be $650 million annually.

3.4.2. Beverage Container Deposits

Like certain other products, beverage containers have been subject to both voluntary and mandatory deposit schemes. The beverage industry formerly made extensive use of voluntary schemes to recover refillable bottles but this practice fell out of favor with the introduction of cheaper "disposable" containers. Predictably, the share of beverage containers sold in refillable bottles fell.



As shown in the table below, ten states have passed "bottle bills" mandating beverage container deposits ranging in magnitude from 2.5¢ to 15¢, the most common amount being 5¢. Beer and soft drinks are subject to deposits in all ten states, mineral water in six states, malt in four states, and wine coolers, liquor, and carbonated mineral water in three states. Michigan includes canned cocktails, New York includes soda water, and Maine includes juices and tea. In most states, deposit requirements apply to the full range of container types, including glass, plastic, aluminum, and steel, but Delaware has exempted aluminum from its requirement.

Most states require retailers to take back containers that are in their product line, even if the container was purchased elsewhere. In Maine, however, retailers located within a certain distance of a certified redemption center are not obliged to take back containers. In addition to retail outlets, "redemption centers" accept containers in most states. Any organization may operate such centers, although certification of the center may be required. Some redemption centers and retailers could earn profits from mandatory handling fees of 1.5¢ to 3¢ per container paid by distributors. In most states unclaimed deposits are kept by the distributor.

Not included in the table is a deposit system in effect in Columbia, Missouri since 1982. Under that system, consumers pay deposits of 5¢ on beer, soft drinks, malt, and carbonated mineral water containers. Although retail stores are required to take back containers, no handling fees are mandated. The overall redemption rate is estimated at 85-95%.

STATE BEVERAGE CONTAINER DEPOSIT SYSTEMS

State	Year	Containers Covered	Refund Amount	% Returned	Sites	Unclaimed Deposits	Handling Fees
CA	1987	Beer, soft drinks, wine coolers, mineral water	2.5¢ < 24 oz 5¢ > 24 oz	Aluminum 88% Glass 76% PET 50% Overall 84%	State certified centers	Program admin. grants	Per container processing fee
CT	1980	Beer, malt, soft drinks, mineral water	Minimum 5¢	Cans 88% Bottles 94% Plastic 70-90%	Retail stores, redemption centers	Kept by distributor or bottler	Beer 1.5¢. soft drinks 2¢
DE	1982	Non-aluminum beer, malt, soft drink, mineral water<2qt	5¢	Insufficient data	Retail stores, redemption centers	Kept by distributor or bottler	20% of deposit
IA	1979	Beer, soft drinks, wine, liquor	5¢	Aluminum 95% Glass 85% Plastic 70-90%	Retail stores, redemption centers	Kept by distributor or bottler	1¢
ME	1978	Beer, soft drink, wine, wine cooler, liquor, juice, water, tea	Beer, soft drink, juice 5¢. Wine, liquor 15¢	Beer, soft drink 92% Spirits 80% Wine 80% Juices, non carbonated 75%	Retail stores and redemption centers	Kept by distributor or bottler	3¢
MA	1983	Beer, soft drink, carbonated water	5¢	Overall 85%	Retail stores and redemption centers	State	2.25¢
MI	1978	Beer, soft drink, canned cocktails, carbonated and mineral water	Refillables 5¢, nonrefillables 10¢	Overall 93%	Retail stores	75% environmental programs, 25% handling fees	25% of unclaimed deposits
NY	1983	Beer, soft drink, wine cooler, carbonated mineral water, soda water	5¢	Wine cooler 63% Soft drink 72% Beer 81%	Retail stores and redemption centers	Kept by distributor or bottler	1.5¢
OR	1972	Beer, malt, soft drink, carbonated mineral water	Standard refillables 3¢. Others 5¢	Overall 85%	Retail stores	Kept by distributor or bottler	None
VT	1973	Soft drink, beer, malt, mineral water, liquor	Soft drink, beer 5¢. liquor 15¢.	Overall 85%	Redemption centers. Retail stores.	Kept by distributor or bottler	3¢

source: Container Recycling Institute

Beverage container deposits produce both benefits and costs. Littering is reduced, and valuable commodities are recycled, but such systems impose costs on users and on those who must accept returned containers. Porter's cost-benefit analysis of deposit systems suggests that any cost savings from deposit systems are likely to be small.

3.4.3. Lead-Acid Battery Deposits

The objective of lead battery deposit systems is to avoid having batteries included in municipal landfills. Deposit legislation is likely to be more effective than command and control regulations, since batteries are small enough to conceal in one's household solid waste or to dump surreptitiously. Thus one would best measure the impact of battery deposit legislation not so much by cost savings but by much increased effectiveness. To produce comparable effectiveness, however, a command and control approach would likely involve substantially higher costs.

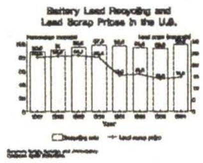
Unlike beverage containers, lead-acid batteries are still subject to voluntary deposit systems in most areas. The lead in used batteries has positive economic value for battery makers. Deposit amounts are typically $5-$10. Consumers can obtain rebates by returning a used battery soon, usually 7 to 30 days, after the purchase of a new one.

Despite the presence of numerous voluntary schemes, 11 states have required deposit systems. As shown below, state laws have addressed such questions as the refund period and what portion of unclaimed refunds goes to different parties. The information on state lead battery deposits was supplied by Saskia Mooney and Weinberg Bergeson & Neuman, April 8, 1996, "Summary of State Lead-Acid Battery Recycling Law."

MANDATORY LEAD-ACID BATTERY DEPOSIT SYSTEMS

State	Amount	Unclaimed Refunds	Refund Period
Arizona	$5	Retailer	30 days
Arkansas	$10	Retailer	30 days
Connecticut	$5	Retailer	30 days
Idaho	$5	Retailer	30 days
Maine	$10	Retailer	30 days
Minnesota	$5	Retailer	30 days
New York	$5	80% State, 20% ret.	7 days
Rhode Island	$5	Retailer	30 days
South Carolina	$5	Retailer	30 days
Washington	minimum of $5	Retailer	30 days

source: Weinberg, Bergeson and Neuberg



As with beverage containers, deposit systems for lead batteries appear likely to have a significant incentive effect by offering motorists payments in return for a used product. As shown in the above figure, the percentage of battery lead recycled has been over 90% since 1988. Smith, Bucklin and Associates

The figure suggests that recycling rates may be positively related to the price of lead. The fall in lead prices beginning in 1991 coincided with a fall in the percentage of battery lead recycled. Lead scrap price data were obtained from Business Cycle Indicators (BCI). BCI monthly prices were averaged to determine annual price.

3.4.4. Reporting Requirements

In response to SARA Title III requirements, firms reported on-site land disposal of 535 million pounds of hazardous waste in 1988 but just 289 million pounds in 1994, a reduction of nearly 50%. The compound annual rate of decrease is 9% per year. Reported underground injection of hazardous waste also fell from 1,334 million pounds in 1988 to 349 million pounds in 1994, a cumulative reduction of 74% or 20% per year.

The magnitude of cost savings depends largely on the magnitude of present and future disposal costs. Land disposal of hazardous waste presently costs from about $50 to $200 per cubic yard, or about $0.10-0.25 per pound. Underground injection is believed to be less expensive, perhaps one-half as much. Control costs must be higher for the substances that are released to land and undergound; otherwise control measures would have been implemented. That the controls were made voluntarily suggests that actual control costs at the time they were selected probably cost an amount comparable to disposal costs. It seems reasonable to assume that a command and control approach that accomplished the same result would have cost at least twice as much. Thus, we estimate that in 1994 reporting requirements saved industry about $50 million in land disposal costs and $100 million in injection costs. Given the approximate doubling in the number of substances subject to reporting in the mid 1990s, those amounts that could rise, respectivley, to the neighborhood of $100 million and $150 annually by the year 2000.

3.4.5. Summary of Cost Savings from Existing Incentives to Reduce Land Pollution

Two solid waste incentive mechanisms have the potential for producing significant cost savings under existing incentives: deposit systems for bottles and batteries and unit pricing for household wastes. While deposit systems do encourage greater recycling, evidence is inconclusive concerning any net savings Porter, 1978. Unit pricing apparently produces savings for the communities where it is used. Seattle's Solid Waste Authority estimated that unit pricing yielded a 30 percent reduction in volumes collected when coupled with recycling alternatives. According to earlier calculations, total national savings from solid waste unit pricing probably were on the order of $100 million annually in the early 1990s, about $250 million annually by the mid-1990s, and have the potential to achieve savings of at least $650 million annually.

Disposers of hazardous waste (other than small generators) must comply with Resource Conservation and Recovery Act (RCRA) requirements. These requirements impose substantial costs on generators, costs that vary directly with the volumes of hazardous wastes produced. There is very limited information concerning the response of generators to increased disposal costs, though analysts are beginning to address this issue.Sigman, 1993.

Hazardous waste pricing incentives almost certainly are having an impact on the volume of waste generated. Because generators are able to choose between paying for disposal or reducing their waste stream, pricing incentives will be more cost-effective than direct regulation and will result in cost savings for generators. To date this subject has not been studied closely, though the cost savings could be large given the approximate $40 billion in RCRA compliance outlays each year.

Reporting requirements for land disposal of hazardous wastes are having a significant effect on volumes generated. As presented earlier in this section, by the mid-1990s cost savings attributable to reporting requirements likely were on the order of $150 million annually, with projected savings by 2000 amounting to $250 million annually.

4. Potential Future Savings from New MBI Programs

This section examines the potential for new environmental management programs based on economic instruments. Four new approaches to managing local and regional air quality are described in section 4.1. Section 4.2 describes the potential for using market-based instruments to reduce emissions of the greenhouse gas CO2 in the context of the Kyoto Protocol. Section 4.3 considers potential new instruments for controlling water pollution, while section 4.4 examines new market-based approaches for managing solid and hazardous waste. Section 4.5 summarizes these proposals.

4.1. Cost Savings from New Incentive Systems for Air Pollution Control

This section uses two different methods for making a lower bound estimate of the potential additional savings that would be possible through a wider use of economic incentive mechanisms for the control of air emissions. The first approach is to review studies that model incentive applications. Of the some 25 studies summarized earlier in this report, the *average* ratio of CAC costs to incentive-based costs is 5.2, indicating that on average an incentive approach would cost about 20 percent as much as a command and control approach. It would be far too optimistic to assume that savings of this magnitude could be achieved unless improvements are incorporated into new and existing economic instruments. Indeed retrospective studies show that the actual savings from incentive applications have fallen well short of the theoretically predicted magnitudes due to higher transactions costs and greater regulatory hurdles than were anticipated. Consequently, one might more realistically assume that incentive-based mechanisms could save 50 percent over command and control approaches for stationary source air pollution control. Mobile source programs might realistically achieve one-half that percentage saving, primarily from greater reliance on incentives to reduce pollution from existing vehicles rather than new vehicles.

Table 3-2A of EPA (1990) estimates that air regulations will result in $42.8 billion expenditures by non-regulatory groups by the year 2000, $28.7 for stationary sources and $14.1 for mobile sources. Using the assumption of average savings of 50 percent in compliance costs for stationary sources and 25 percent for mobile sources, widespread use of incentive-based programs might reduce compliance costs by $14.4 billion for stationary sources and $3.5 billion for mobile sources in the year 2000. Some of these savings could be achieved through aggressive use of incentive provisions in the 1990 Clear Air Act Amendments. More realistically, new amendments that actively promote incentives rather than simply allow their use would be required to achieve these levels of savings.

An alternative method that can be used to check whether these estimates are reasonable is to identify some major areas where incentive-based mechanisms could be applied and calculate the potential savings for these applications. Of necessity, such an approach will neglect a host of relative minor applications whose cumulative impact on costs could nonetheless be quite large. Also, the discussion should not be taken as advocacy of any particular application, rather merely a rough indication of the magnitude of savings in compliance costs that may be achieved. Savings from incentives are estimated to be in the range of about $1.7 billion (possibly somewhat higher due to failure to calculate a few items), rising to a range of $4.1 billion by the year 2000. The following possible new applications could increase the annual savings by the year 2000 by an additional $10 billion:

- Allow trading between mobile and stationary sources. Evidence accumulated by the Congressional Budget Office (1982), Freeman (1982), and others suggests that, measured in terms of cost-effectiveness, mobile sources have been controlled more stringently than stationary sources. White (1982) estimated that a reallocation of control costs could have saved the equivalent of $240 per vehicle, or about $2.5 billion annually.

- The 1977 Clean Air Act Amendments effectively require all new power plants to scrub their stack emissions of sulfur dioxide. The Congressional Budget Office (CBO) estimates that if utilities were allowed to meet New Source Performance Standards (NSPS) requirements through the least cost approach (such as trading with other sources and use of low sulfur coal) the annual savings would be $4.2 billion per year.

- The Northeast states, Chicago, Houston, and other areas have considered creating trading regimes similar to RECLAIM. The USEPA recently proposed a NOx trading program for the Northeast states. The SCAQMD projected that RECLAIM would produce savings in compliance costs for stationary sources on the order of 65 percent in the early years of the program. Assume a 50 percent saving and apply that to EPA's estimate in *Environmental Investments* of the cost of controlling stationary source emissions of VOC and NOx. Controls for these pollutants comprise about 35 percent of all air pollution control outlays for stationary sources, or a projected $3 billion in 1992 and $4.5 billion in the year 2000. Savings of 50 percent of this would indicate potential savings in the range of $1.5 billion in 1992, rising to $2.2 billion in the year 2000 including $300 million estimated for RECLAIM in that year. EPA projected that about $500 million of these savings will be achieved with the recently proposed regional NOx trading program.

- Inspection and maintenance programs are less effective than they otherwise could be due to errors in detecting and repairing high emitting vehicles. Some of these "errors" are intentional, which is to say compliance with I&M requirements is poor in several programs. While EPA's new enhanced I/M requirements make improvements in the detection process and in dealing with evaporative system leaks, an incentive system based on taxing a vehicle's actual in-use emissions would have a number of advantages. For example, high-emitting vehicles might be scrapped if the owner had to pay for emissions. Under current and proposed EPA policy, the owner of such a vehicle could receive a waiver if an expensive repair would be required. The Oregon legislature has considered such an emissions tax. The potential savings might be estimated as follows: assume that vehicle hydrocarbon emissions, presently some 6.5 million tons annually, [OTA (1989).] could be reduced by 20 percent at a cost of $2,000 per ton, rather than the $5,000 per ton of a direct regulatory approach (the cost of basic I/M programs, estimated by EPA). The savings associated with an emissions tax could approximate $2 billion annually.

4.2. Greenhouse Gases

Global warming is shaping up as one of the great challenges of the 21st Century. The UNEP provides a helpful guide to the basic issues, as does a CNN special report. The USEPA, the Department of Energy and other federal agencies are playing active roles in this issue.

The United Nations Framework Convention on Climate Change signed in Rio de Janeiro in 1992 committed signatory governments to address the issue of climate change, though it did not require specific actions. Most of the industrialized nations subsequently made commitments to reduce carbon dioxide emissions to levels estimated to have occurred in 1990 by some nearby but unspecified date. In December 1997, representatives from industrialized nations met in Kyoto, Japan and made specific commitments that were lacking in the 1992 Framework Convention.

Cooperative Implementation under the Kyoto Protocol

In the Kyoto Protocol, 38 industrialized nations plus the European Community committed to reduce their emissions of greenhouse gas (GHG) emissions in the period 2008-2012 relative to baseline emissions in 1990. The nations and their respective commitments are listed in Annex B to the Kyoto Protocol. These nations also are referred to as Annex I parties since all but three of them were identified in Annex I of the UN Framework Convention on Climate Change. The percent reductions vary from one nation to another but the aim is to achieve an average reduction of 5.2 percent, representing a reduction of more than 30% relative to a business as usual scenario with growth in incomes, population, and energy use over that 20 year interval. Australia's commitment represents a small increase, reflecting its heavy dependence on coal and coal exports.

Among the Kyoto Protocol's important features is the use of market-based mechanisms for achieving required emissions reductions at least cost. Termed "cooperative implementation," the market-based instruments include: joint implementation (JI), the Clean Development Mechanism (CDM), and international emissions trading (IET). Joint fulfillment, another provision of the Kyoto Protocol, might also be viewed as a market-based approach.

The negotiators in Kyoto postponed for future deliberations many important and contentious decisions. International emissions trading is not well defined, in terms of how it would function, whether only parties could participate or also designated private sector entities, and other important features. Many important details regarding the CDM were left unresolved including the criteria to judge whether projects involve net reductions in emissions. Finally there is no mention of interim measures that can be undertaken prior to 2008 nor any opportunity to earn credits against future commitments for activities undertaken before 2008. How these and other issues are resolved will have a great bearing on whether the Kyoto Protocol is ratified by many nations and whether it is capable of meeting its stated objectives.

What is now termed the CDM was termed joint implementation (or international joint implementation) prior to the Kyoto Protocol. The experiences with joint implementation prior to Kyoto are of great relevance to future CDM activities. Consequently, this section reviews these activities in some detail for lessons to be learned.

Article 4: Joint Fulfillment. Joint Fulfillment lets countries with emission reduction commitments satisfy the commitments jointly by reallocating the total reductions among the parties. This provision was designed to allow the European Union (EU) as a regional economic integration organization to make a different distribution among its members from the requirements of the Kyoto Protocol. During the negotiations, the provision was defined to include any group of countries in Annex I that enter into such an agreement.

Article 6: Joint Implementation. Joint Implementation lets Annex I countries sell to or buy from other Annex I countries emission reductions associated with specific projects that reduce emissions or enhance greenhouse gas sinks. That is, countries, or designated legal entities within a country, may support of finance GHG reduction projects in another country and receive part or all of the GHG reductions that result from the project. Such JI projects must be approved by both nations, must produce GHG reductions beyond those that would otherwise occur, must be supplemental to GHG reduction activities by the acquiring country, and are banned if the acquiring country is not in compliance with its reporting and accounting obligations under the Protocol. Sales (transfers) reduce the assigned amounts of GHG that a country may release and purchases add to assigned amounts.

Article 12: Clean Development Mechanism. The Clean Development Mechanism (CDM) creates a means through which Annex I countries, or designated legal entities in Annex I countries, finance or sponsor GHG reductions in non-Annex I (developing) countries. The CDM would promote sustainable development in developing countries and help Annex I countries meet their GHG reduction requirements. Emission reductions resulting from CDM projects must be real and measurable and provide benefits in addition to those that would occur in the absence of the project. Emission reductions resulting from CDM projects will be subject to a certification procedure by 'independent auditors' that has yet to be elaborated.

Article 17: Emissions Trading. Under Article 17, international emissions trading is authorized between Annex I countries. Participants in ET potentially could include designated legal entities in addition to the countries themselves. Most of the details of ET remain to be elaborated. Among these details are: would liability rest with the buyer or the seller of emission reduction units? Who would certify the units? Would there be an international clearinghouse for the units? What reporting would be required? To prepare for ET, several countries, including Australia, Canada, and Norway have begun to establish national trading programs in GHG (so far, principally carbon dioxide).

November 1998 Meeting in Buenos Aires

At the 4th Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC) in Buenos Aires, delegates met to discuss implementation issues related to the Kyoto Protocol. The Kyoto Protocol will enter into force only after being signed by governments and ratification by national congresses by 55 parties representing at least 55 percent of 1990 CO_2 emissions from Annex I countries. To obtain that level of support, it will be important to have the US with a 36.1 percent share and Russia with a 17.4 percent share ratify the agreement. But the US Congress is on record insisting that developing countries participate and that there be no costs to the US economy (GNP loss or unemployment increase).

To obtain greater support from developing countries, Argentina proposed that developing countries accept GHG targets based on expected growth and that reductions be measured relative to that projection. The PRC and several other nations had very negative reactions so the proposal was dropped. During the conference, Argentina and Kazakstan announced their intention of joining Annex I. While the US representative signed the Kyoto Protocol on behalf of the government, ratification by the US Congress remains problematic.

By the end of the conference there was no agreement over the modalities for achieving the Kyoto Protocol targets. Operation of the Clean Development Mechanism and how emissions could be capped outside of Annex I nations remained contentious. The principal result of the conference was an agreement on a work plan to determine within two years specific modalities for implementing the Kyoto Protocol.

Pre-Kyoto Joint Implementation

At the first conference of the parties to the Framework Convention on Climate Change, held at the 1990 Rio Earth Summit, the parties agreed to a Joint Implementation pilot program. Under JI businesses, non-governmental organizations, and government entities in one country could jointly undertake mitigation and sequestration projects with similar entities in another country. Projects that diminish, sequester, or avoid global greenhouse gas emissions could be considered JI projects if the source of emissions being offset and the site of the emission abatement are located in two different countries.

The United States Initiative on Joint Implementation (USIJI) was the first national JI program to adopt a formal set of criteria and an evaluation process for JI proposals. An Evaluation Panel with representatives from US government agencies determined the acceptability of proposed projects. The first United States JI projects were accepted in January 1995 and others followed soon thereafter. Central America hosted most of the early US projects, but Russia and other nations also hosted JI projects. Projects involved energy end uses; energy production; biomass, geothermal, hydroelectric, and wind energy technologies; and forestry management. Through the end of July, 1998, the USIJI panel had approved 32 projects out of 110 that had been submitted (see Table). The other projects were withdrawn or rejected.

The USIJI conducts two rounds of review each year. For those projects that were accepted, most acceptances came during the round in which they were proposed or in the next round. Of the 32 projects accepted through July 1998, 6 involved end uses of energy, 12 provided improvements in the efficiency of energy production, and 14 promoted land use changes to enhanced greenhouse gas sinks.

Table 4.1 Accepted USIJI Projects
(July 31, 1998)

Project Name	Country	Project Type	RS	RA	PF
Fuel Switching, District Heating System	Czech Rep.	Energy end use	1	1	yes
District heating (Zelenagrad)	Russia	Energy end use	1	3	no
Rusagas Fugitive Gas Capture	Russia	Energy end use	2	2	yes
District Heating Renovation (Lytkarino)	Russia	Energy end use	5	5	yes
District Heating Renovation (Metallurguichesky, Chellabinsk District)	Russia	Energy end use	5	6	yes
Energy efficient housing (Izindlu Ezigcinayo Ubushushu)	South Africa	Energy end use	5	5	no
Plantas Eolicas S.A. Wind Facility	Costa Rica	Energy production	1	1	yes
Enersol Rural Solar Electrification	Honduras	Energy production	1	1	no

El Hoyo-Monte Galan Geothermal Project	Nicaragua	Energy production	2	2	no
Bio-Gen Biomass Power Generation Project	Honduras	Energy production	2	2	no
Dona Julia Hydroelectric Project	Costa Rica	Energy production	2	2	no
Aeroenergia Wind Facility	Costa Rica	Energy production	2	2	yes
Tierras Morenas Windfarm Project	Costa Rica	Energy production	2	2	yes
Bel/Maya Biomass Power Generation Project	Belize	Energy production	3	3	no
Phase II, Sava Site	Honduras	Energy production	3	3	no
Rural Solar Electrification Project	Bolivia	Energy production	3	3	yes
Rural Photovoltaic Electrification	Sri Lanka	Energy production	5	5	yes
Renewable Energy Mini-Grid Project	Mexico	Energy production	5	6	yes
Forest Conservation (Bilsa Reserve)	Ecuador	GHG sink	1	3	no
Saratov Afforestation Project	Russia	GHG sink	1	1	yes
Rio Bravo Conservation and Forest Management	Belize	GHG sink	1	1	yes
Esquinas National Park	Costa Rica	GHG sink	1	1	yes
Klinki Forestry Project	Costa Rica	GHG sink	2	2	no
Silviculture in Siera Norte (Oaxaca)	Mexico	GHG sink	2	6	no
Scolel Té—Sustainable Land Management	Mexico	GHG sink	2	3	yes
Carbon Sequestration	Mexico	GHG sink	2	3	yes
Reforestation in Vologda	Russia	GHG sink	3	3	no
Project Salicornia: Carbon Sequestration and Halophyte-based Industries in Sonora	Mexico	GHG sink	3	3	no
Noel Kempff M. Climate Action Project	Bolivia	GHG sink	3	3	yes
Reforestation of Chiriqui Province	Panama	GHG sink	3	3	yes
Reduced Impact Logging	Indonesia	GHG sink	3	3	no
Consolidation of National Parks & Biological Reserves as Carbon Deposit	Costa Rica	GHG sink	4	4	yes

Source: Lile, Powell, and Toman, 1998

Financing remains a major obstacle; just 13 of the 32 projects approved through July 1998 had obtained funding by sponsors. Participants in these projects assert that they faced large transactions costs in dealing with host governments and experienced significant delays in getting project approvals from the USIJI Evaluation Board and from host governments. Because project sponsors could not sell any carbon reduction credits from these projects (this was prohibited prior to the Kyoto Protocol), there must have been other motivations for participation. Sponsors identified development of new contacts in the host country, early entry into a potentially profitable business, the possibility of influencing future JI criteria, and favorable publicity as motivating factors.

The record of the early JI projects offers important lessons regarding the CDM and how it should be structured. After-the-fact assessments of a large number of US JI projects reveal difficulties in determining whether project activities truly are additional to activities that would have been undertaken without the JI program. Further, monitoring progress and measuring the success of JI activities in reducing GHG emissions have proven to be a challenge, particularly for projects designed to create or enhance carbon sinks. Since pre-Kyoto JI was largely an experimental activity, the consequences of a shortfall were not large. If credits had been sold or traded to other parties, the consequences would have been more serious.

Evaluating whether projects are "additional" to baseline activity and projections of baselines will be a major challenge in implementing the CDM of the Kyoto Protocol. Further, projects may reduce GHG emissions in one sector or region only to result in increases elsewhere, so-called " leakage."

A number of methods potentially could be used to develop baselines. Historical emissions in a base year could be used, though this would restrict economic development severely in DMCs. For DMCs, the baseline could allow for economic growth by projecting emissions based on historical trends in emissions or based on projected GNP and emission/GNP factors. Finally, a baseline might be developed from the bottom up using project-by-project emissions, and adding these to obtain a baseline and reference projected level. The Kyoto Protocol uses 1990 emissions as the baseline for Annex I parties. Baselines for non-Annex I parties, which are necessary to determine whether CDM projects are additional, are not defined.

Determining whether a project is additional to what would have been done without the Kyoto Protocol is a particularly thorny issue. As the CDM is described in the Kyoto Protocol, it does not explicitly provide for the creation of GHG sinks. Eventually, activities such as planting forests to create carbon sinks might be accepted as part of the CDM; however, it could be difficult to demonstrate that tree planting is additional to what would have occurred in the baseline set of activities. Fuel switching from coal to natural gas reduces GHG emissions, yet the choice of fuels might be dictated by concerns regarding local air quality or cost considerations. Which activities yield GHG reduction credits and which ones are not additional to baseline activities will surely be debated into the future.

The Global Environment Facility (GEF), which is active in financing projects that offer climate change benefits, has developed an approach for dealing with a related, but distinct, concept of additionality. Normally GEF funded projects maintain domestic benefits at constant level while increasing global benefits. If a GEF-supported activity delivers *additional* domestic benefits, the GEF has devised an approach to treat the incremental costs of these additional domestic benefits.

Ensuring Compliance

The Kyoto Protocol does not describe the means that will be used to ensure compliance with targets and timetables. This section explores some of the issues that must be addressed. Much of the discussion applies to obligations, such as reporting, adoption of mitigation policies and measures, and financing. The discussion provides an overview of main compliance approaches that might be used in connection with the CDM.

Individual compliance mechanisms in international environmental agreements involves three interrelated elements:

- Monitoring and Reporting;
- Review and Verification;
- Non-compliance Responses and Enforcement.

Monitoring and reporting seeks to obtain data with which to determine compliance. Review and verification uses the information reported to ascertain compliance. Non-compliance responses and enforcement are triggered by the verification process and address violations of treaty obligations. Various parties bear responsibility for different stages of the compliance system.

Monitoring and reporting is generally the obligation of participants in the agreement, though these obligations could be delegated to others. Review and verification usually is performed by an independent appointed body, the secretariat to the agreement or some other neutral party. To have reasonable expectations that parties will comply, non-compliance responses and enforcement measures need to be authorized in the agreement.

Experience with other international agreements demonstrates that effectiveness and compliance are enhanced through clear and specific treaty language, transparent procedures and widespread dissemination of information, informal communication channels with stakeholders and non-governmental organizations, enforcement responses that can be tailored to address problems of varying severity, and provisions that encourage new parties to join.

Incorporating compliance procedures early in the development of an international agreement helps assure that the agreement will be effective and fair. Compliance procedures strengthen an international agreement by demonstrating that parties want to satisfy its requirements. Compliance procedures encourage parties to consider the binding nature of new commitments and their ability to comply before accepting new obligations. Consequently, thoughtful design of the compliance system should be a priority task in developing the provisions and obligations of an international agreement.

Monitoring and Reporting

Reporting by countries is required under both the UN Framework Convention on Climate Change and the Kyoto Protocol. Countries bear the primary reporting responsibility but they may delegate to legal entities the right to buy and sell certificates for GHG reductions. These legally-designated entities then incur a responsibility for reporting to their national government. National reporting facilitates efficient monitoring and transparency.

Concerns regarding data quality, which greenhouse gases to include and which sources and sinks to specify, were important issues in the negotiations. The Protocol covers the most significant direct greenhouse gases and incorporates known sources and sinks of greenhouse gases.

Uncertainty in inventories varies with different greenhouse gases and with various sources and sinks. Among GHG, the sources of methane are particularly uncertain but CFC sources are well known. Data quality also varies among countries. Unless addressed as monitoring procedures are developed, poor data quality could undermine the agreement.

Because the CDM and other cooperative implementation measures would give GHG emission reductions an explicit market value, trading should create incentives for national enforcement and international compliance. Because of this, countries or firms that want to buy or sell carbon equivalent units, would have a strong incentive to help ensure that other participants were dealing in verifiable emission reductions. These incentives should provide nations the impetus to deliver unbiased data and seek low-cost means of improving data quality.

In order to assess compliance with emission targets, complete accuracy of inventory data is not necessary, but removing systematic biases is important. Inventory data are estimates, at best, based on fieldwork, engineering calculations, and statistical sampling of diverse economic activities.

A number of approaches could be used to deal with uncertainty in emission inventory data:

- adjust for uncertainty (e.g., adjust estimates to reflect data quality, with greater percentage deductions made for projects and countries with greater uncertainty);
- begin with carbon dioxide and CFCs, subsequently adding other greenhouse gases and their sources and sinks when they are sufficiently well understood; and
- agree to follow detailed standards for estimating inventories.

Several observations follow. Rules to adjust for uncertainty could be difficult to design and to implement. Adjustment factors would have to be arbitrary in many cases due to limited understanding of several components of GHG inventories and sinks. Progressively including greenhouse gases as data improve could delay the inclusion of important gases. However, the Kyoto Protocol relies on this approach by including only a subset of possible land use change and forestry activities as sinks. Detailed standards could be attractive and would provide a basis for independent auditing and certification. Developing such standards could prove to be a formidable challenge. Who would pay for the necessary background work is an open issue.

Review and Verification

The purpose of verification is to assess compliance by parties with targets and other commitments. National reports provide the basic information for the verification process. In international agreements verification involves two steps: technical review of the data and an assessment of whether obligations have been satisfied by the party. The review process under the UNFCCC has not been tested with respect to the verification of national data. The Secretariat is tasked with detailed review responsibilities that could be augmented by assistance from NGOs and international organizations.

Non-compliance Responses and Enforcement

While there are a large number of possible responses to compliance problems, few examples exist of successful international enforcement procedures in international environmental agreements. Consultation and negotiation is a well-recognized (but potentially weak) enforcement process in international agreements. The UNFCCC recognizes the potential utility of consultation and negotiation in provisions of Article 13. Mediation and conciliation, the next logical step if consultation and negotiation fails, is featured in many international environmental agreements but is not explicit in the UNFCCC. Financial assistance and the prospect of withholding financial assistance in cases of noncompliance is featured in the Montreal Protocol and the UNFCCC. Suspending rights and privileges, such as the right to participate in the CDM, are a next logical step in progressively more stringent enforcement actions. Trade sanctions represent a further and more stringent step. While not explicitly authorized in the Kyoto Protocol, some international disputes have been taken to the International Court of Justice.

Financing

CDM projects are likely to follow much the same pattern of past joint implementation pilot projects. A project donor or sponsor provides some or all of the technology and funding for host country projects that reduce GHG emissions and provide other outputs. The donor receives some or all of the GHG credits while the host country receives the other valuable outputs. While donor countries are the nominal sponsor, it is really private sector enterprises within the donor countries that provided much of the financing for past JI projects. Commercial banks, host as well as donor central banks, and international financial organizations such as the World Bank and regional development banks could also play an active role in arranging financing for CDM projects.

Potential Savings from Market-Based Instruments

The potential savings from trading greenhouse gas emission reduction requirements among nations result from the marked differences in incremental control costs that different nations face. In testimony before the House Commerce Committee on March 4, 1998, Janet Yellen, chair of the Council of Economic Advisers, presented the administration's estimates (Council of Economic Advisors, 1998) of the cost of controlling carbon dioxide emissions under several scenarios.

It is important to recognize that the administration's estimates are based on the assumption that the US will not have to drastically reduce greenhouse gas emissions by anything approaching the 30 percent from the present trend amount that the Kyoto Protocol would seem to imply. Rather, the administration assumes that some form of international trading in greenhouse gas emission reductions will be authorized, requiring the US to reduce its annual emissions by about 3 percent from the trend amounts.

The so-called "Second Generation Model" developed by Battelle Laboratories predicts that if the US could not trade emissions permits with any other nation, the cost of reducing emissions would be equivalent to $108 per ton of carbon. If the US could trade with counterpart developed nations, the cost would fall to $72 per ton of carbon. If trading were to take place throughout the world, so that only the most cost-effective reductions worldwide took place, the cost per ton would be between $26 per ton. The administration's estimates are slightly more favorable, a range of $14 to $23 per ton of carbon.

How large are the potential savings from worldwide trading relative to go-it-alone program by the US? The reductions called for in the Kyoto Protocol, relative to trend amounts, would be 552 million metric tons of carbon. At a cost of $14 to $23 per ton of carbon, the administration estimates the cost to the US economy would be between $7 billion and $12 billion in the year 2010. With emission permit trading allowed only within nations and not between nations, the cost to the US would rise to $60 billion. Thus, trading carbon emission permits among nations to meet the Kyoto limits is predicted to save the US $48-$53 billion per year by the year 2010.

Carbon taxes are an alternative means of reducing carbon dioxide emissions. This approach would necessitate large increases in energy prices and generate substantial revenues for the government. The Second Generation Model predicts that a tax of $193 per ton of carbon would be required to reduce emissions by 550 million metric tons in 2010, assuming that no trading is allowed, even within the US. The difference between $193 and $108, or $85 per ton, is the estimated saving to the US economy from internal US trading. That amount is $47 billion. The total gains from worldwide trading are the internal gains of $47 billion plus the gains from trades with other nations of $48-$53 billion, for a total saving to the US economy of $100 billion.

4.3. Cost Savings from New Incentive Applications for Water Pollution Control

Eight published studies listed in Table 2-2 show potential savings from using incentive mechanisms to control water pollution. Some of the studies consider hypothetical effluent fees, while other studies considered the potential impact of effluent credit trading systems. The ratio of command and control costs to those that would be incurred with an incentive approach ranged from a low of 1.12 to a high of 3.13.

For a variety of reasons, effluent trading systems are unlikely to be implemented widely unless trading of unlike pollutants is allowed. The most important constraint appears to be the limited number of water bodies for which there are several dischargers of the same pollutant. [U.S. EPA (May 1992) and U.S. General Accounting Office (1992).] Trading between municipal wastewater treatment plants and nonpoint agricultural sources does appear to have the potential for relatively large cost savings, perhaps on the order of one-third to one-half of projected municipal wastewater expenditures of about $6 billion annually through the 1990s.

If there are to be further major savings in compliance costs from an incentive mechanism for water pollution, the most efficient mechanism probably is an effluent discharge fee. If one assumes average savings of one-third of normal command and control costs, somewhat less than the 40 to 50 percent average savings shown in quantitative studies, and applies this to *total* forecast pollution control costs for all point source dischargers of $50.7 billion in the year 2000, there exists a potential for reducing environmental compliance costs by some $17 billion per year. Some of this saving could be achieved from more widespread and energetic application of state NPDES fees.

Nonpoint source incentives could produce major savings; however, under present law, nonpoint control costs will remain modest through the year 2000. Several analysts (*e.g.*, Freeman, 1990) have concluded that marginal control costs for conventional pollutants are far lower for nonpoint sources than for point sources, leading them to recommend that any new efforts to control conventional pollutants be focused on nonpoint sources. A number of incentive-based mechanisms potentially are available for nonpoint sources: subsidies for creating wildlife buffer zones along watercourses, fertilizer and pesticide taxes, and trading of nutrient reduction requirements among point and nonpoint sources. Drinking water regulations might be amenable to incentive-based mechanisms but the specifics remain unclear. Consequently no savings are projected for this cost category.

4.4. Cost Savings from New Incentive Systems for Solid and Hazardous Waste Management

Analysts have offered a number of incentive-based proposals for improving waste management policy. [See, for example, Wirth and Heinz (1991).] Many of the suggestions involve more widespread application of incentives in current use: marginal cost pricing of household solid waste disposal, and container and battery deposits. Other suggestions are more novel: for example, virgin material content taxes, product tax/recycling subsidy systems, and recycling credits combined with recycled content standards.

For solid waste disposal, Repetto *et al*. project that widespread use of unit pricing incentive mechanisms in earea with high disposal costs could achieve a cost savings of $650 million annually, if not by the year 2000 then shortly thereafter. That full potential is unlikely to be achieved without some form of encouragement at the federal level. Some proposed approaches such as packaging requirements, virgin material taxes, and recycled content standards would require additional federal actions, but could increase the magnitude of savings to as much as 30 percent of the annual solid waste disposal bill for the nation as a whole, producing savings shortly after the year 2000 of as much as $6.7 billion annually.

Greater use of deposit-refund systems is a possibility; however where they would be applied is not clear. Evidence suggests that the net savings from bottle deposit systems are negligible once one considers all transactions costs. Lead-acid batteries are already recycled at a rate approaching 100%. Car hulk deposits to encourage recycling of junked automobiles appear to be a success in Sweden and are being adopted elsewhere.

Hazardous waste regulations include those involving leaking underground storage tanks (LUST), Superfund, and most RCRA activity. These statutes impose substantial liabilities on generators, transporters, and disposers of hazardous wastes, especially in the event of a leak into the environment. The liability provisions act as powerful incentives to engage in due care. It may be possible to fine tune the liability rules to produce incentives that closely match marginal costs and marginal benefits, a feature that some feel is missing in some current rules. At this point it is premature to attempt to estimate any potential cost savings from such charges.

4.5. Summary of Cost Savings

The cost savings discussed in this section are summarized in Table 4-1. Compliance costs are used as the basis for the estimates. Market-based instruments are unlikely to produce significant savings in government environmental regulatory costs, as agencies would still have to promulgate regulations and monitor and enforce the programs. As shown in column (3), 1992 projected savings are estimated to be $5.7 billion in 1986 dollars (not counting an additional $2 billion from liability rules of the Oil Pollution Act) and are projected to increase to $9.7 billion by the year 2000 (again not counting $2 billion from liability rules under OPA). Potential savings from the full the use of additional incentives are estimated to be about $35 billion. If the Kyoto Protocol is ratified and becomes binding on the U.S., savings from trading greenhouse gas emission reduction obligations both internationally and domestically could produce savings to the U.S. economy of $100 billion annually relative to a command and control alternative.

Table 4-1. ESTIMATED COST SAVINGS FROM USE OF ECONOMIC INCENTIVES
(billions of 1986 dollars annualized at seven percent)

1 Media/ Program	2 Pollution Control Costs in 1992	3 Savings Due to Existing Incentive Mechanisms	4 Pollution Control Costs in 2000	5 Projected Savings in 2000 from Existing Incentives	6 Potential Savings with Full Incentives	7 Additional Savings Possible
3. Air	28.9	1.7	43.5	3.9	17.9	14.0
3.1.1 Stationary	20.2	1.7	28.7	3.8	14.4	10.9
3.1.2 Mobile	8.2	.0	14.1	.1	3.5	3.4
3.2 Radiation	0.5		.7			
4. Water	45.1	1.6	57.4	2.3	17.3	15.0
4.1.1 Point Source	40.7	1.6	50.7	2.2	17.2	15.0
4.1.2 Non-point	.3		.4	.05	.05	0
4.3 Drinking	4.1		6.3			
5. Land	32.6	25	45.6	0.5	9	4

5.1 Solid Waste	18.7	.1	22.3	.25	.65	.4
5.2Hazardous	7.0	.15	11.7	.25	.25	0
5.3 LUST	4.1		3.5			
5.4Superfund	2.8		8.1			
8. Total	106.6	3.5	146.5	6.7	36.1	29.74

Footnotes to Table 4-1

All columns:

Line 3: Total of lines 3.1.1 through 3.2
Line 4: Total of lines 4.1.1 through 4.3.
Line 5: Sum of lines 5.1 through 5.4.
Line 8. Sum of lines 3, 4, and 5.

Column (1): Media and program names used in EPA (1990), line numbering and report sections correspond to those used in most tables of EPA (1990).

Column (2) and (4): Excludes those costs which are predominantly regulatory in nature since regulatory costs are not likely to be reduced using more economic incentives.

Lines 3.1.1, 3.1.2, and 3.2: Total costs minus state and local and EPA costs found in corresponding lines of U.S. EPA (1990), Tables 3-3A and 3-3B. Includes full implementation costs.
Line 4.1.1: Total costs found in corresponding line of U.S. EPA (1990), Table 4-3A, minus full implementation costs.
Line 4.1.2: Total costs found in corresponding line of U.S. EPA (1990) minus state and local government expenditures.
Line 4.3: Total costs found in corresponding line of U.S. EPA (1990) minus EPA and state government expenditures.
Lines 5.1 through 5.3: Total costs found on corresponding lines of U.S. EPA (1990), Tables 5-3A, minus EPA costs.
Line 5.4: Total costs found on corresponding lines of U.S. EPA (1990), Table 5-3B.

Column (3):

Line 3.1.1: Midpoint of range for air emissions trading provided by Hahn and Hester ($1.1 billion), plus $200-$300 million from Phase I Acid Rain controls, plus $170 million from SARA Title III requirements, plus $50-$100 million from RECLAIM, as explained in text.
Line 3.1.2: No current savings.
Line 4.1.1: Three and one-half percent of column (3), plus $100 million for savings attributable to reporting requirements. Based on a ten percent saving on one-half of current effluent discharge control costs due to effluent permit charge systems imposed in about two-thirds of the states. Omits several incentives with potentially significant current impact: effluent charges, effluent discharge permit fees and liability rules under CERCLA and the Oil Pollution Act of 1990.
Line 5.1: Assumes a 25 percent saving or $50 from 2 million households from marginal cost pricing for solid waste disposal, as explained in text.
Line 5.2: Reporting requirements for hazardous wastes reduce volumes at lower cost than comparable command and control approach, saving an estimated $150 million annually.
Lines 5.3 and 5.4: Incentive effect on current behavior may affect future costs.

Column (5):

Line 3.1.1: Assumes continued $1.1 billion annual savings from air emissions trading, $.8 billion from Acid Rain trading program, $1.3 billion from SARA Title III, $300 million from RECLAIM, and $100 million from scrapping older vehicles.
Line 3.1.2: Assumes total saving of $100 million from oxygenates trading, clean fuel vehicle trading program and heavy duty truck emission averaging.
Line 4.1.1: Five percent of column (5), as explained under column (4).
Line 4.1.2: $20 million savings from full use of existing point-nonpoint trading programs.
Line 5.1: Assumes unit disposal pricing is extended to twice as many households (4 million) and saves 20 percent more ($60) for each household because of the increasing real cost of disposal.
Line 5.2: Disposal charges for RCRA wastes reduce volumes and overall costs by an estimated 20 percent, as explained in text.

Column (6):

Line 3.1.1: Potential savings of 50 percent of $28.7 billion, or $14.4 billion, as explained in text.
Line 3.1.2: Potential savings of 25 percent of 14.1 billion, or $3.5 billion, as explained in text.
Line 4.1.1: Potential savings of one-third of year 2000 costs, or $17.2 billion, as explained in text.
Line 4.1.2: No change in projected nonpoint control cost savings, unless additional incentive-based programs are adopted.
Line 5.1: Assumes adoption of per-can pricing in one-half of the U.S., saving 20 percent in costs where it is adopted, or 10 percent of national solid waste disposal costs, plus additional savings of 20 percent due to the adoption of tradeable permits in the recycled content of products, tradable permits in packaging requirements and/or virgin materials taxes.
Line 5.2: Assumes no additional incentives are adopted.
Line 5.4: Assumes no change in current Superfund program; transactions costs could be reduced if a formula for responsible party shares were adopted in legislation.

Column (7): Column (6) minus column (5)

Table 4-2 puts these savings into perspective relative to the total national costs of pollution control in the air, water, and land media. Since the costs shown in column (4) of Table 4-1 and line 1 of Table 2-3 are the actual projected non-regulatory costs in the year 2000, it is necessary to add the projected regulatory costs (shown in line 2 of Table 4-2) and the projected savings from existing incentives in that year (shown in column (5) of Table 4-2 and line 3 of Table 4-2), to obtain the total costs without incentives (line 4). The projected savings, additional savings, and total potential savings can then be compared with these totals (lines 5, 6, and 7). As shown on line 6, the greatest percentage additional savings are to be found in air. These relationships are illustrated in Figures 2-1 through 2-3. As shown in Figure 2-1, an additional 19 percent of projected pollution costs could be saved in the year 2000 through full use of useful and available economic incentives. In 1992 dollars, that comes to about $29 billion. Although there are some difficulties in doing so, it may be useful to place this number in perspective by pointing out that these additional possible savings come to about one-half of one percent of gross domestic product.

Table 4.2. SUMMARY OF ESTIMATED COST SAVINGS IN 2000 FROM USE OF ECONOMIC INCENTIVES

(billions of 1986 dollars annualized at seven percent except as otherwise noted)

Medium	Air	Water	Land	Total
1. Projected Non-regulatory Costs	43.5	57.4	45.6	146.5
2. Projected Regulatory Costs	1.4	0.8	0.6	2.8
3. Projected Savings from Existing Incentives	3.9	2.3	0.5	6.7
4. Total Costs without Savings	48.8	60.5	46.7	156.0
5. Projected Savings as a Percentage of Total Costs without Savings	8.0	3.8	1.0	4.3
6. Additional Savings Possible as a Percentage of Total Costs without Savings	28.6	24.8	0.8	18.8

7. Total Potential Savings as a Percentage of Total Costs without Savings	36.6	28.6	1.8	23.1

Footnotes for Table 4-2 by Line

1. From column (4) of Table 4-2.
2. Regulatory costs for EPA, state, and local government subtracted from the totals given in EPA (1990) in deriving the non-regulatory costs shown in column (4) of Table 4-1.
3. From column (5) of Table 4-1.
4. Sum of lines 1, 2, and 3 of this Table.
5. Column (5) of Table 4-1 as a percentage of line 4 of this table.
6. Column (6) of Table 4-1 as a percentage of line 4 of this table.
7. Sum of lines 5 and 6.

Figure 2-1: INCENTIVE SAVINGS IN 2000 AS A PERCENTAGE OF TOTAL COSTS WITHOUT SAVINGS

(billions of 1986 dollars annualized at seven percent)

Source: Tables 4-1 and 4-2

Figure 2-2: MEDIA DISTRIBUTION OF PROJECTED SAVINGS IN 2000

(billions of 1986 dollars annualized at seven percent)

Source: Table 4-1

Figure 2-3: MEDIA DISTRIBUTION OF ADDITIONAL POSSIBLE SAVINGS IN 2000

(billions of 1986 dollars annualized at seven percent)

Source: Table 4-1

5. Conclusions: Opportunities for Cost Savings

Economic incentives have long been advocated by environmental economists as a more efficient means to achieve environmental goals than the present predominantly command and control approach. The following savings are projected to occur in air, water, and land pollution control in the year 2000 under **existing** Federal, state, and local laws, regulations, and programs and the continuation of recent trends in their implementation:

Medium	Air	Water	Land	Total
Projected Savings (billions of 1986 dollars annualized at seven percent)	3.9	2.3	0.5	6.7
Projected Savings (billions of 1992 dollars annualized at seven percent)	4.9	2.9	0.6	8.4
Projected Savings as a Percentage of Total Costs without Savings	8.0	3.8	1.0	4.3

Although in some cases appropriate changes in the relevant legislation would be required, the following **additional savings are estimated to be possible by the year 2000** if the most economically efficient incentive programs were instituted:

Medium	Air	Water	Land	Total
Additional Possible Savings (billions of 1986 dollars annualized at seven percent)	14.0	15.0	0.4	29.4
Additional Possible Savings (billions of 1992 dollars annualized at seven percent)	17.4	18.6	0.5	36.5
Additional Possible Savings as a Percentage of Total Costs without Savings	28.6	24.8	0.8	18.8

The total additional possible savings of about $29 billion can be placed in perspective by pointing out that they come to about one-half of one percent of gross domestic product. If the projected and the possible additional savings are added together, then the **total potential savings** would be as follows:

Medium	Air	Water	Land	Total
Total Potential Savings (billions of 1986 dollars annualized at seven percent)	17.9	17.3	0.9	29.4
Total Potential Savings (billions of 1992 dollars annualized at seven percent)	22.2	21.5	1.1	36.5
Total Potential Savings as a Percentage of Total Costs without Savings	36.6	28.6	1.8	23.1

If the incentives were carefully designed, these savings could be achieved with no change in environmental objectives. The relative size of the projected savings, additional possible savings, and remaining costs are compared to total costs without savings graphically in terms of both percentages and billions of 1986 dollars annualized at seven percent. The total costs without savings are projected to be $156 billion in 1986 dollars or about $194 billion in 1992 dollars.

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