6. Trading Programs

Crocker and Dales generally are credited with first proposing that marketable emission permits be used as an incentive mechanism for achieving environmental goals.[89] The basic approach outlined by Crocker and Dales and later refined by Dewees and Harrison is that the environmental authority can issue a fixed number of marketable permits to release emissions.[90] Through trading, low-cost sources will sell some of their permits and abate more than they would under a traditional regulatory approach, while high-cost sources will buy permits and abate less. The end result, according to the academic design, is the same amount of pollution reduction that would be achieved through traditional regulatory approaches, but it is achieved at lower cost.

EPA first applied the concept of marketable emission permits in the mid-1970s as a means for new sources of emissions to locate in non-attainment areas without causing air quality to worsen. New sources and existing sources that wanted to expand their facilities were required to offset their emissions by acquiring emission reduction credits from existing sources. This important but modest beginning was based on an interpretation of the Clean Air Act, rather than on a specific statutory authority. EPA's Offset Policy was included in the 1977 amendments to the Clean Air Act statute. In 1980, then-Administrator Hawkins signed a memo that allowed emission averaging between can-coating lines.[91]

On August 7, 1980, EPA promulgated New Source Review (NSR) and Prevention of Significant Deterioration (PSD) rules that allowed netting, a means for sources to avoid PSD and NSR requirements for emission increases due to facility expansion, if emissions were decreased contemporaneously elsewhere at the facility.[92] Under the PSD mandate, this rule included facilities within a plant as a source of emissions as well as an entire plant as a source of emissions, in what was termed a "dual-source definition." Chevron and others challenged this rule, claiming it made modernization too difficult. Eventually the U.S. Supreme Court agreed that states did not need to include the dual-source definition in their non-attainment rules. This opened the door to many of the emission trading programs that exist today.

The 1990 Clean Air Act Amendments authorized a variety of emission trading systems. While similar statutory authority to establish effluent permit trading systems does not exist, EPA believes that the Clean Water Act allows effluent trading. Programs of this sort have been operational for several years without legal controversy. Pollution permit trading systems now come in a wide variety of forms, and they apply to a large and growing number of sources of pollution that affect the quality of air, water, and land.

Insofar as trading between economic entities is concerned, two main forms of trading systems are observed: (1) uncapped emission (or effluent) reductions credit (ERC) systems, and (2) capped allowance systems (also referred to as cap-and-trade systems). In the case of uncapped systems, pollution limits are rate-based (e.g., grams per mile for motor vehicles), and sources earn credits by releasing less pollution than their legal limit or other defined baseline. Under these systems,


Pollution Charges, Fees, Taxes


Deposit-Refund Systems


Trading Programs


Subsidies for Pollution Control


Liability Approaches


Information Disclosure


Voluntary Programs

emissions can increase with economic growth. By contrast, with capped systems, total emissions are limited by an overall ceiling that is designed to achieve health or environmental goals, and allowances are allocated to sources in quantities consistent with this ceiling. The formula for making such allocations will vary from one situation to the next.

A number of the programs described in this chapter involve the right to average emission characteristics of a slate of similar products that are manufactured by one economic entity. Emission averaging is an important mechanism for improving the cost effectiveness of environmental regulation. It can be characterized as intra-firm trading across the product lines where it is allowed.

Trading systems, properly designed and applied in appropriate circumstances, can cut compliance costs, encourage technological development, and create incentives for achieving environmental benefits beyond minimum requirements. For trading systems to function well, a number of requirements must be satisfied. There should be several potential participants in trades if a functioning market is to be created. Exactly how small a universe of potential participants there can be and still have a functioning market is difficult to say, but simulation experiments suggest that 8–10 participants is a reasonable estimate.[93] If sources are dispersed geographically, trading ratios other than one-to-one might have to be imposed to account for wind direction or the distance between sources to ensure no degradation in environmental quality.

Some pollutants are seasonal in their impact, implying that trades might be allowed only during a portion of the year. Trading might be limited because of a desire to avoid “hot spots” where pollution concentrations increase. Trading requires that pollution control agencies have the ability to monitor emissions (or measure a surrogate to those emissions) reasonably well. The need to ensure accountability of trades must not pose unacceptably high transaction costs. The commodity to be traded needs to be defined. In general, a well-defined commodity requires a baseline from which to calculate the emission reduction credits (or allowances) that may be traded. Establishing baselines is likely to require good historic data on emissions, input use, etc. In the case of allowance systems, the political will must exist to achieve an allocation of allowances among competing interests.

Cap-and-trade systems to date have allocated most or all of the allowable emissions under the cap to existing sources, providing allowance set-asides for new sources or using auctions as a safeguard to ensure access to allowances. Initially, environmentalists opposed marketable permit trading because the existence of trading was evidence that sources could make greater reductions in pollution than were being achieved. In addition, there has been a lingering concern that trading could result in localized “hot spots” that had undesirably high levels of pollution. With the success of the Regional Clean Air Incentives Market (RECLAIM) and the Acid Rain Program described later in this chapter, marketable permit trading has become more accepted as a cost-effective means of achieving many environmental goals.

On the other hand, attempts to establish new trading programs often encounter controversy. For example, some citizen groups have opposed trading programs for ozone-forming volatile organic compounds (VOCs). They based their opposition on two basic concerns: (1) the possibility of localized toxic pollution “hot spots,” or (2) the ability of the source (or EPA for that matter) to reliably measure emissions to ensure that participants would be held accountable. EPA, in consultation with environmental justice groups and other stakeholders, is working on guidance for addressing these environmental justice concerns with trading.

The scope of trading systems is considerable. An emission trading proposal is a centerpiece of the Kyoto Protocol for controlling greenhouse gas emissions. Certain Colorado communities have created programs to trade the right to own and operate a wood burning stove or fireplace. For a number of years, there was an active program under which refiners could trade lead that was used as an additive in gasoline. Heavy-duty truck manufacturers can meet engine emission standards by averaging together the emissions performance of all the engines they produce. Programs to trade effluents are operating in selected locations. These particular programs are likely to be expanded significantly in coming years as a result of a new EPA initiative to improve water quality in polluted rivers and lakes. Developers whose activities would cause the loss of wetlands can satisfy mitigation requirements in some areas by purchasing credits from a wetland mitigation bank.

These and other trading systems for air, water, and land are described in this chapter. The discussion begins with a review of trading programs in air emissions, followed by sections on water effluent trading, land development, and, finally, international trading programs in which the United States is involved.

A few basic parameters may be used to characterize trading systems:

1. *Scope.* Is trading restricted to averaging within a single facility, allowed among facilities owned by the same firm, or allowed among firms or facilities under different ownership?
2. *Cap.* Is there a limit on total emissions or on effluents?
3. *Commodity Being Traded.* How will the commodity be defined: As allowances for future pollution, as credits for quantifiable reductions in pollution, as emission characteristics of products, as rights to own and operate products themselves, or as some other definition?
4. *Distribution of Tradable Permits.* Are the tradable certificates auctioned to the highest bidder, or are they grandfathered to existing sources?
5. *Trading Ratio.* Is the required trading ratio 1:1 or some greater ratio? Does the trading ratio depend on the respective location of the sources, season of the year, or other factors?
6. *Banking.* Can tradable certificates be banked or otherwise reserved for future use?
7. *Monitoring.* How is credit generation and trading monitored?
8. *Environmental Benefit.* Is a "set-aside" for the benefit of the environment built into the trading system? For example, each trade could be debited by 10% to yield an environmental benefit.

6.1 Trading in Clean Air Act Programs: An Overview

Since 1990, EPA has significantly expanded the use of trading in Clean Air Act programs. Today, emissions trading is a standard tool of EPA's air quality program. Although not a panacea for every situation, trading is being used by EPA and states to help solve a variety of air pollution problems. A broad overview of these programs follows. (Some of these programs are discussed in detail later in this chapter.)

Acid Rain: Perhaps the best-known example of trading is the Acid Rain Program's system of marketable pollution allowances for sulfur dioxide emissions for electric utilities. Enacted as part of the Clean Air Act Amendments of 1990, this cap-and-trade program has been highly successful at achieving cost-effective emissions reductions. The first phase of the program, which took effect in 1995, reduced annual emissions by 4 million tons. Since then, measurements have shown that rainfall in the eastern United States is as much as 25% less acidic, some ecosystems in New England are showing signs of recovery, and ambient sulfate concentrations have been reduced, thus benefiting public health. The second phase of the program, beginning in 2000, will more than double the annual emissions reductions achieved by the first phase over time. The annual cost of the program, once it is fully implemented, is expected now to be approximately $2 billion, which is about one-half the cost that EPA had originally estimated.

Smog and Other Common Pollutants: EPA is working with states to promote trading and other market-based approaches to help achieve national air quality standards for smog, particulates, and other common pollutants that are regulated through national air quality standards. In addition, EPA has provided trading opportunities in virtually all federal rules that are aimed at cutting emissions from motor vehicles and fuels. These federal measures are essential to helping states meet federal air quality goals.

Under the Clean Air Act, states have primary responsibility for devising pollution control strategies for local areas, so states can meet national air quality standards. EPA has issued guidance to assist states in designing trading and other economic incentive programs, including economic incentives rules and guidance in 1994 (which, at present, are being revised); general guidance on State Implementation Plans (SIPs) in 1992; and the 1986 emissions trading policy statement. EPA also has assisted states in setting up trading programs, such as California's RECLAIM cap-and-trade program for sulfur dioxide and nitrogen oxides and the Ozone Transport Commission's (OTC) program for controlling nitrogen oxide emissions among states in the Northeast. Through a unique partnership, EPA and the OTC states are jointly implementing this NO_x budget system for the Northeast, which draws on the experience of the acid rain program.

In 1998, EPA issued a rule that established NO_x budgets for many states (the "NO_x SIP call") to combat the problem of transported ozone pollution in the eastern United States on a broader scale. To encourage an efficient market-based approach to reducing NO_x on a regional basis, EPA simultaneously provided states with a model cap-and-trade rule for utilities and large industrial sources. The experiences of the acid rain program and the OTC effort show that this approach holds the potential to achieve regional NO_x reductions in an efficient and highly cost-effective manner.

In the 1990 Clean Air Act Amendments, Congress called for EPA to help states meet their air quality goals by issuing federal standards to cut emissions from cars, trucks, buses, many types of non-road engines, and fuels. These rules cut toxic air pollution as well as reduced the amount of air pollutants, which were regulated through air quality standards.

EPA has provided trading opportunities in virtually all of these new standards, building on the early success of trading in the phased reduction of lead in leaded gasoline during the 1980s. These standards include rules for cleaner burning reformulated gasoline, which now accounts for approximately 30% of the nation's gasoline, and the national low-emission vehicle standards for cars and light-duty trucks that will be met nationwide by 2001. Opportunities for averaging, trading, and banking also are provided by new national emissions standards for heavy-duty trucks and buses, locomotives, heavy-duty off-road engines such as bulldozers, and small gasoline engines (e.g., those used in lawn and garden equipment).

Another recent example is the landmark Tier II/gasoline sulfur rule that President Clinton announced in December 1999. This rule would provide compliance flexibility to both vehicle manufacturers and fuel refiners by allowing them to use averaging, banking, and trading. to In the case of automakers, EPA created different "bins" of emissions levels, rather than require a single NO_x emissions standard for each vehicle model. EPA required automakers to achieve a fleet average emissions rate of 0.07 grams of NO_x per mile (gpm). Automakers whose fleet average is below 0.07 gpm could generate credits that they could either use in a later model year or sell to another auto manufacturer. This rule does allow the production of certain higher polluting vehicles that consumers desire. However, it also provides a strong incentive for the industry to develop technology well beyond the 0.07 gpm standard, since any higher polluting vehicle will have to be offset by a lower polluting one.

Industrial Air Toxics: The 1990 Clean Air Act Amendments called on EPA to establish national emissions standards to control major industrial sources of toxic air pollution. EPA has used emissions averaging as one of several ways to provide compliance flexibility in these industry-by-industry standards. For example, emissions averaging is permitted by national air toxics emissions standards for petroleum refining, synthetic organic chemical manufacturing, polymers and resins manufacturing, aluminum production, wood furniture manufacturing, printing and publishing, and a number of other sectors. To avoid shifting risks from one area to another, toxics averaging is allowed only within individual facilities. With appropriate safeguards, EPA also has used other methods, including multiple compliance options, to help provide flexibility in complying with air toxics rules.

Ozone Layer Depletion: In gradually phasing out the production of chemicals that harm the stratospheric ozone layer, EPA is giving producers and importers the flexibility to trade allowances. Under the Montreal Protocol, the United States and other developed countries agreed to stop producing and importing CFCs (chlorofluorocarbons) and other chemicals that are destructive to the ozone layer. By 1996, production of the most harmful ozone-depleting chemicals, including CFCs, virtually ceased in the United States and other developed countries. Additional chemicals are to be phased out in the future. Provided the United States and the world community maintain their commitment to planned protection efforts, the stratospheric ozone layer is projected to recover by the middle of the 21st century.

The phase-out of these chemicals is being achieved by using trading rules developed by EPA, rules that have served as a model for programs in other countries. In part because of the flexible market-based approach, the phase-out of CFCs was much less expensive than predicted. In 1988, EPA estimated that a 50% reduction of CFCs by 1998 would cost $3.55 per kilogram. In 1993, the cost for a 100% phase-out by 1996 was reduced to $2.45 per kilogram.

6.2 Foundations of Air Emissions Trading

The first trading of permitted rights to release any type of pollutant in the United States began in the 1970s as a mechanism to allow economic development in areas that failed to meet ambient air quality standards. EPA gradually broadened the offset policy to include emission bubbles, banking, and netting. These programs are described in the following paragraphs. While many of the achievements are modest, EPA's early efforts in emissions trading are important because they provided a foundation and valuable practical experience for the development of more effective and cost-effective trading programs such as the Acid Rain Program.

6.2.1 Offset Program

In the mid-1970s, the EPA proposed the "offset" policy that permitted growth in non-attainment areas, provided that new sources install air pollution control equipment which met Lowest Achievable Emission Rate (LAER) standards. These sources also had to offset any excess emissions by acquiring greater emission reductions from other sources in the area. Through this process, growth could be accommodated while maintaining progress toward attaining national ambient air quality standards.

Of more than 10,000 offset trades (a few of which are described later in this section), over 90% have been in California. Nationwide, about 10% of offset trades are between firms; the remainder are between sources owned by the same firm. Most offset credits are created as a result of all or part of a facility being closed.

The offset policy, which was included in the 1977 amendments to the Clean Air Act, spawned three related programs: bubbles, banking, and netting. The common element in these programs is the Emission Reduction Credit (ERC), which is generated when sources reduce actual emissions below their permitted emissions and apply to the state for certification of the reduction. To be certified as an ERC, the state must determine that the reduction meets the following criteria: (1) that the reduction is surplus in the sense of not being required by current regulations in the State Implementation Plan (SIP); (2) that it is enforceable; (3) that it is permanent; and (4) that it is quantifiable. ERCs are normally denominated in terms of the quantity of pollutant in tons released over 1 year. By far the most common method of generating ERCs is closing the source or reducing its production. However, ERCs also can be earned by modifying production processes and installing pollution control equipment. Trades of ERCs most often involve stationary sources, although trades involving mobile sources are permitted. States have approved a variety of activities that sources may use to generate offset credits. The South Coast Air Quality Management District (SCAQMD) in California, for example, accepts the scrapping of older vehicles and lawn mowers as a means of generating credits. It then applies a formula to determine the magnitude of air pollution credits for each old car that is scrapped.[94]

The offset, banking, and netting programs and bubble policy were subject to numerous revisions before being incorporated into EPA's Final Emission Trading Policy Statement, which was issued in 1986.[95] The Policy Statement addresses trading of ERCs for criteria pollutants such as sulfur dioxide, nitrogen oxides, particulate matter, carbon monoxide, and volatile organic compounds (VOCs) that contribute to the formation of ground-level ozone. The final policy statement responded to public comments that pollutant trading could cause environmental damage unless accompanied by safeguards, such as trading ratios greater than 1:1and the use of air quality modeling in some cases).

6.2.2 Bubble Policy

The bubble policy, established in 1979, allows sources to meet emission limits by treating multiple emission points within a facility as if they face a single aggregate emission limit. The term *bubble* was used to connote an imaginary bubble over a source such as a refinery or a steel mill that had several emission points, each with its own emission limit. Within the "bubble," a source could propose to meet all of its emission control requirements for a criteria pollutant with a mix of controls that is different from those mandated by regulations—as long as total emissions within the bubble met the limit for all sources within the bubble. A bubble can include more than one facility owned by one firm, or it can include facilities owned by different firms. However, all of the emission points must be within the same attainment or non-attainment area.

Bubbles must be approved as a revision to an applicable State Implementation Plan (SIP), a factor that has discouraged their use. Prior to the 1986 final policy, EPA approved or proposed to approve approximately 50 source-specific bubbles. EPA approved 34 additional bubbles under EPA-authorized generic bubble rules. The EPA-approved, pre-1986 bubbles were estimated to save $300 million over conventional control approaches. State-approved, pre-1986 bubbles saved an estimated $135 million.[96] No estimates are reported for the number of, or savings from, post-1986 bubbles. By design, bubbles are neutral in terms of environmental impact.

6.2.3 Banking

EPA's initial offset policy did not allow the banking of emission reduction credits for future use or sale. EPA contended that banking would be inconsistent with the basic policy of the Clean Air Act. But without a provision for storing or banking ERCs, the policy encouraged sources to continue operating dirty facilities until they needed credits for internal use. New and expanding firms without internal sources of ERCs had to engage in lengthy searches for other firms that were willing to create and supply credits.

The offset policy in the 1977 amendments to the Clean Air Act included provisions for the banking of emission reduction credits for future use or sale. Although the EPA approved several banks, there was limited use of the provision, most likely because of the uncertain nature of the banked ERC. In 1980, EPA determined that an ERC is not an absolute property right and that communities must have the option of modifying the use of ERCs, including the debiting of part or all of the banked ERCs.[97] A 1994 report identified 24 emission banks; some limited ERCs to a life of as little as 5 years.[98] Since that date, the number of banks has remained stable. Most of the banks provided a registry to help buyers of ERCs find potential sellers. Some states debit a percentage of each ERC deposit for use by the state to attract new industry or to meet anticipated SIP requirements.

6.2.4 Netting

Netting, the final component of EPA's 1986 emission trading policy statement, dates from 1980. Netting allows sources undergoing modification to avoid new source review if they can demonstrate that plant-wide emissions do not increase significantly. Netting is the most widely used of these early emission trading programs. Hahn and Hester (1989) estimate that between 5,000 and 12,000 sources have used netting.

In each application, netting is designed to have no significant impacts on environmental quality. However, with a large number of netting transactions, a modest adverse impact might ensue. The total savings in control costs from netting are difficult to estimate because the number of transactions is not known precisely, and the cost savings from individual transactions can be highly variable.

Cost savings can arise in three ways. First, netting may allow a firm to avoid being classified as a major source, under which it would be subject to more stringent emission limits. Reductions in control costs in such a case would depend upon the control costs and emission limits that the firm must satisfy after netting. One source estimated that netting typically results in savings between $100,000 and $1 million per application (indicating aggregate savings of $500 million to as much as $12 billion).[99] Second, the aggregate cost savings from avoiding the cost of going through the major source permitting process could range from $25 million to $300 million. Third, additional savings could arise from avoiding construction delays that are caused by the permitting process.

On April 3, 1996, EPA's Office of Air and Radiation announced a series of proposed revisions to new source regulations. These revisions were expected to reduce the number of permitting actions that new sources and sources undergoing changes must take by more than one-half. Because the proposal shares many of the features of netting, it is described here. The proposed regulations would allow sources to use plant-wide limits. They would also provide exemptions for pollution prevention activities and so-called "clean" emission sources in a facility.

Under the proposal, sources making changes could avoid new source review requirements by establishing a plant-wide cap on emissions. (In general, this cap would be the source's maximum potential emissions.) Process changes could be made as long as the changes did not result in an increase in emissions beyond the cap.

6.2.5 Evaluation of Early Emission Trading Activities

With data from offset transactions in the Los Angeles area, Foster and Hahn (1995) provide the most comprehensive evaluation of the original emissions trading program. The South Coast Air Quality Management District (SCAQMD) provided data on trading activity, some of which are reproduced in Table 6-1. 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.

Table 6-1. Emission Trading Activity in the Los Angeles Area

YEAR	OFFSETS	NETTING	TOTAL
pre-1977	...	5	5
1977	...	30	30
1978	...	34	34
1979	...	72	72
1980	...	129	129
1981	...	238	238
1982	...	210	210
1983	...	258	258
1984	...	256	256
1985	7	235	242
1986	27	432	459
1987	24	329	353
1988	55	358	413
1989	30	352	382
1990	53	394	447
1991	2,208	155	2,363
1992	3,678	77	3,755

Note: Trading activity is based on the number of trades reported to SCAQMD.
Source: Foster and Hahn (1995).

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. (This figure indicates 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, NO_x, PM, and SO_2.

AER*X, a broker in the Los Angeles offset market, supplied data for prices for over 40 of the trades from 1985 to 1992. 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 NO_x trades was about $120 per ton. High prices for ROG increased steadily over the period, from $135 per ton to $711 per ton; and high NO_x 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 NO_x 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 transaction costs to the seller (thought to be a minimum of $10,000 per transaction). In a few cases, transaction costs apparently exceeded the market value of the credits that were exchanged. Although the highest and average prices increased over the period, most of the change in 1991 can be attributed to a change in SCAQMD rules in the prior year. None of the observed prices remotely approach the typical incremental control costs for ROG and NO_x in the Los Angeles area over that period: on the order of $5,000 per ton for ROG and $8,000 per ton for NO_x.

ERC 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 environmental 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 that 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 transaction 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 for many of the emission trading features of the 1990 Clean Air Act Amendments. States also have learned from the experience.

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.) The Los Angeles area has developed a much more significant trading initiative known as "RECLAIM," with an emissions cap and phased reductions in the allowable emissions of SO_2 and NO_x. (The RECLAIM initiative is described in more detail later in this chapter.) Illinois recently developed a similar program with an emissions cap.

6.3 Acid Rain Allowance Trading[100]

An early solution to mitigate local air pollution that was caused by sulfur dioxide (SO_2) and nitrogen oxide (NO_x) 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 SO_2 per million Btu (British Thermal Units). 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 SO_2 per million Btus—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 sulfates and nitrates formed from SO_2 and nitrogen oxide emissions. Studies also revealed that the acidification of soils and waters could release heavy metals and aluminum that were previously bound in soils. Further, increased atmospheric levels of sulfate and nitrate pose a risk to human health.

In Title IV of the Clean Air Act Amendments of 1990, Congress created the Acid Rain Program to address both wet and dry acidic deposition by cutting national SO_2 emissions from power plants by approximately 50%. Costs of compliance were estimated in the range of $5 billion per year. At that time, quantifiable economic benefits were believed to be lower—in the range of $1 billion per year.[101] Actual costs have been far less and associated benefits have been far greater, as further explained in this last paragraph of this subsection.

Title IV also sets allowable limits on NO_x emissions from utility boilers by placing limits on emission rates. An owner of two or more power plants may comply with the NO_x requirement by averaging emissions across all its power plants, a rudimentary form of emissions trading.

The Acid Rain Program set a cap of 8.95 million tons of SO_2 per year, to be achieved in two phases. During Phase I, which ran from 1995 through 1999, the 110 highest emitting coal-fired power plants (with a total of 263 coal-burning units) were required to reduce emissions to satisfy a tonnage cap. These so-called "Table 1" units were targeted for the first phase because their emissions exceeded 2.5 pounds of SO_2 per million Btu, and their capacity exceeded 100 megawatts. Between 125 and 182 additional units each year joined Phase I as substitution or compensating units. Although not required to participate until Phase II, these units elected to participate early to help fulfill the compliance obligations of a Table 1 unit. Furthermore, several units not required to participate in the Acid Rain Program opted to join the program during these years. In the second phase, which began 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 Title IV of the Clean Air Act, a number of studies had identified potential cost savings of as much as $1 billion per year through emissions trading due to significant differences among utility sources in the marginal cost of abatement.[102] Actual experiences with emission trading have exceeded expectations. A recent study estimates that emissions trading reduces the cost of complying with Title IV by 50%, or $2.5 billion annually.[103]

6.3.1 Allowances

Emission caps are enforced through a system of tradable emission allowances. Title IV specifies fixed numbers of allowances, each of which represents a limited authorization to emit one ton of SO_2, to be given each year to each of the affected units. Political considerations dictated that allowances be given rather than auctioned. SO_2 allowances issued in any particular year do not expire, meaning allowances issued in 1 year may be "banked" for use in subsequent years. The banking provision has been widely utilized in the Acid Rain Program. Emissions each year have been well below allocated levels, resulting in an increasing amount of banked allowances that can be used for compliance in later years. For example, 1999 emissions were almost 30% below the level allowed. Sources benefit from the flexibility that allows them to conserve allowances for use in later years.

The basic formula for computing Phase I allowances is 2.5 pounds of SO_2 per million Btu, multiplied by each unit's average 1985−1987 Btu consumption. For Phase II, 1.2 pounds of SO_2 per million Btu are 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 hold sufficient allowances to cover their emissions following a compliance period 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 is currently more than $2,600 per ton. The Acid Rain Program has reported 100% compliance for its first 5 years, primarily because noncompliance carries such a high price.

As in Table 6-2, Table 1 units received 6.9 million allowances in 1999. Several other provisions of Title IV also create allowances, and the number of allowances created under these other provisions can vary from year to year. These other provisions varied from year to year during

Table 6-2. Origin of 1999 Allowable Emissions

TYPE OF ALLOWANCE	NUMBER OF ALLOWANCES	EXPLANATION OF ALLOCATION
Initial allocation	5,550,820	Granted to units based on baseline Btu output and emission rates, as specified in the Clean Air Act Amendments of 1990
Phase I extension	171,710	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	909,455	These are the initial allocations of Phase II units that enter Phase I as substitution units
Auctions	150,000	Provided in the Clean Air Act Amendments in a Special Allowance Reserve when initial allocations were made
Compensation allocation	85,138	These are the initial allocations of Phase II units that enter Phase I as compensating units
Opt-in allowances	97,392	Provided to units that enter the program voluntarily
Small diesel allowances	25,617	Allocated to small diesel refineries that produced desulfurized diesel fuel in the previous year
Total (1997)	**6,990,132**	

Source: Exhibit 2 at http://www.epa.gov/airmarkets/cmprpt/arp99/index.html#so2compliance

Phase I. 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 units to substitute cheaper reductions from other units for the reductions required of Table 1 units. The compensation provision lets a utility reduce electricity generation of a Table 1 unit below its baseline level, provided the source of any compensating generation is designated. If the compensating unit emits SO_2, EPA provides an allocation of allowances to that unit, so the compensating unit in essence becomes part of Table 1. Phase I initially included 263 units. An additional 125–182 combustion units joined Phase I as compensation or substitution units (the totals varied by year). Several opt-in sources joined as well, raising the total of Phase I units to between 398 and 445 units.

Beginning January 1, 1995, EPA 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 1999 allowances are identified in Table 6-2 to illustrate the many sources of allowances.

In order to maintain the emissions cap, new sources receive no allowances. Instead, they must buy them from existing allowance holders or in EPA auctions. New sources are also required to satisfy New Source Performance Standards.

In March 1995, EPA expanded the Acid Rain Program to include industrial facilities that burn fossil fuels.[104] The rule establishes an "opt-in" program that allows industrial sources and other sources to participate in the existing SO_2 program, which previously included only utilities. Industrial sources that participate in the program will have an allocation of allowances that they can use for compliance or for selling or trading to other sources. These provisions allowing industrial sources to opt-in have been little used, partially due to high transaction costs and lower-than-expected allowance prices.[105] Ten units had joined the program as opt-in units by 1999.

6.3.2 Monitoring and Compliance

Utilities whose units are included in Phase I and Phase II must install continuous emission monitoring (CEM) systems to verify compliance with emission limits, and they must file quarterly reports of their hourly emissions data with EPA. Initially, sources mailed these data to EPA on computer disks, but most sources now transmit the information over the Internet. Continuous emission monitoring systems—the accepted industry standard for measuring SO_2, NO_x, and CO_2—provide an accurate accounting of emissions, assuring those buying and selling allowances that the commodity they are trading is real and assuring EPA that emission limits have been met.

CEMs for coal-fired electric power plants 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 amount is equivalent to about $0.16 per kilowatt of installed capacity.[106]

The cost of monitoring with CEMS represents approximately 7% of the observed cost of compliance. More than 2,100 units are now required to have CEMS for Phase II of the program. This requirement helps ensure low transaction costs and confidence that each allowance represents one ton of SO_2 emissions, regardless of where or when it is generated. That confidence is an important underpinning of trading.

At the end of each quarter, EPA receives more than 1,700 reports containing hourly emissions data and heat input for affected units. More than 90% of this data is received electronically.

Using these data and the allowance record for each unit, EPA tracks compliance. CEMS provide some of the most accurate and complete data ever collected by EPA. In 1999, SO_2 monitors on sources in the Acid Rain Program achieved a median relative accuracy of 3% and a median availability of 99.5%.

Under the authority of Title IV, EPA developed an allowance tracking system that serves as the official record of ownership and transfers. The system currently requires a paper form with the signature of the seller, but it will allow transactions to be completed on the Internet by the end of this year. With just two staff members, EPA processes most allowance transactions within one day of receipt.

6.3.3 Allowance Auction

In addition to private transactions in allowances, Title IV directed EPA to offer allowances at an annual auction, beginning in 1993. This auction offers the equivalent of roughly 2.8% of total allowances. Private parties may also offer allowances at the auction. Each offer includes the quantity for sale and a minimum acceptable price. The auctions helped to provide a price signal to the allowance market in the early stages of the program and currently provide an additional source of allowances for utilities. The auctions have only involved allowances that can be used in the current year and 6 and 7 years into the future. From now on, each auction will involve current-year and 7-year allowances.

Before discussing the specifics of the auction, it is worth noting that it has largely served its purpose now that (1) the market under the Acid Rain Program is flourishing and (2) the auction activity is dwarfed by the allowance exchanges occurring every day all over the country. Economists have criticized the mechanics of the auction, suggesting that it may also contribute to lower prices than otherwise would occur.[107] The Act requires a discriminating price auction, which ranks bids from highest to lowest. EPA has interpreted this statement 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 staff members of the U.S. House of Representatives, who were convinced that such an auction maximized revenue to sellers.[108]

This unusual auction mechanism may cause sellers to misrepresent and under-reveal their true costs of emission control.[109] 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 (1998) concludes that EPA auctions became a sideshow to the much larger private market, after just the first two auctions. (These two auctions provided useful indications early in the process that allowance prices would be lower than first anticipated.)–The evidence from a detailed analysis of the auction records is that private sellers in the EPA auction have tended to set prices above market-clearing levels rather than too low, as initially hypothesized by Cason and others.

6.3.4 Transaction Costs

Many observers of the Acid Rain Program have noted the low transaction costs of the allowance market. The allowance market operates on a very narrow bid—to-ask spread. Recently, this spread has been less than $2 per ton, or about 1% of allowance prices. Most allowance transfers are processed within 24 hours of receipt, as program requirements eliminate the need for review of submissions beyond electronic verification that the allowances being transferred are indeed in the seller's account. In addition, program design eliminates the need for source-specific emission limits or reviews of compliance strategies, causing the costs of oversight to drop dramatically.

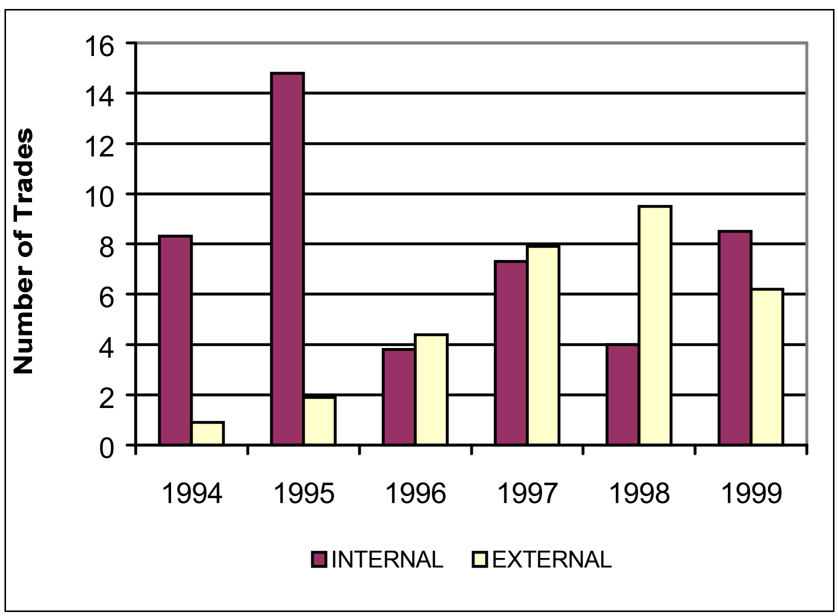
During the 5 years following the Clean Air Act Amendments, EPA spent $44 million to implement the Acid Rain Program and allocated an additional $18.9 million to state and local governments to implement the program. These costs may be compared with the $1.09 billion that EPA spent to implement the Clean Air Act in the same period and the $833 million EPA distributed to state and local governments for this purpose.[110]

6.3.5 Results

From 1995 through 1999, the Acid Rain Program has exceeded expectations, with firms exceeding the reduction target at less than one-half the forecast cost. These results follow from the very flexible structure of the program, one key component of which was the trading provision.[111]

While there was considerable trading activity from the start, little of that activity initially was between economically distinct entities. (See Figure 6-1.) In searching for explanations for the relatively low level of trading between economically distinct entities (labeled "external" in Figure 6-1), analysts have cited relatively high transaction costs at first, the behavior of public utility commissions, and legislation in some states that promoted the use of locally produced coal.

Figure 6-1. Internal and External Trading



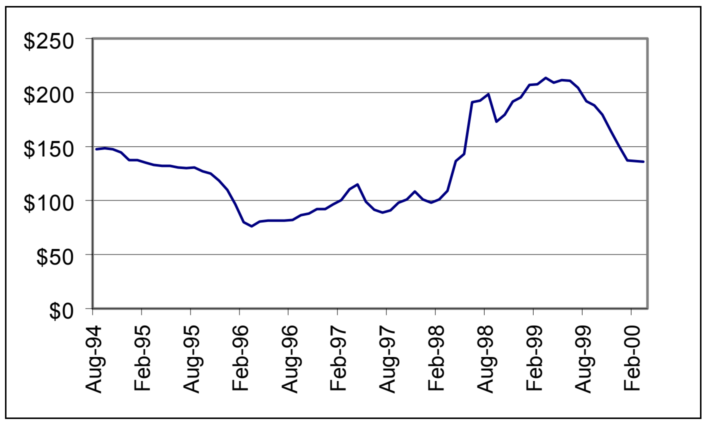
Source: Exhibit 6 at http://www.epa.gov/airmarkets/cmprpt/arp99/index.html#so2compliance

Emissions data compiled by EPA show at least 9,300 transfers involving 81.5 million allowances through the end of 1999. About 62% of the allowances or 50.4 million tons were transferred within organizations, and 38% or 31 million tons were transferred between organizations. Another 40 million tons reflect movements of allowances from EPA to the market through auctions, Phase I extension allowances, substitution allowances, and other mechanisms. SO_2 emissions control is ahead of schedule. The excess emissions reductions—unused allowances—in Phase I are being banked by utilities for use during Phase II, when the performance standard tightens significantly.

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 EPA forecast allowance prices were in the $750-per-ton range. As an ultimate backstop for compliance, Congress authorized direct allowance sales by EPA at a price of $1,500 per ton. The direct sale provisions were eliminated several years ago when it became clear that allowance prices were far lower than anticipated, and the direct sale option would not be utilized.

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 per ton to $200 per ton. Allowance prices—from EPA auctions, transactions through the Emissions Exchange, and through brokers—gradually fell to a low of $66 per ton through mid-1995 and, in general, remained below $120 per ton through 1997. (See Figure 6-2.) In 1998, allowance prices began to increase and exceeded $200 per ton by early 1999, peaking at $217 per ton in March. Prices then declined to about $130 ton by March 2000.[112]

Figure 6-2. Acid Rain Allowance Prices



Source: Exhibit 5 at http://www.epa.gov/airmarkets/cmprpt/arp99/index.html#so2compliance

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 Western coal with high-sulfur Eastern coal to meet emission limits in boilers that had been designed to burn high-sulfur coal. In addition, 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 utilities had anticipated SO_2 control costs better, fewer scrubbers would have been placed in service. The consequence of greater-than- expected compliance is downward pressure on allowance prices in Phase I.

Analysts debate the role that allowance trading plays in stimulating cost effectiveness in SO_2 control from power plants. There is no doubt that SO_2 control has experienced tremendous technological and productivity improvement over a very short period of time, leading to approximately 50% lower costs for controlling emissions than had been anticipated. The issue is the extent to which allowance trading should be credited with these gains. Burtraw (1995) reached two conclusions. First, it is the flexible, performance-based design of the program that has stimulated the development of low-cost compliance measures seen in Phase I. Second, within that framework, allowance trading played an important, positive role. Ellerman (2000) attributes all of the cost savings to trading provisions. The difference in the two points of view is considerable. Ellerman gives credit to emissions trading for a dramatic fall in the cost of scrubbing emissions and for the growing use of low-sulfur Western coal. In contrast, Burtraw credits performance standards and flexible program design, not emissions trading directly, for much of the cost savings.

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. More scrubbing should result in greater variation in the marginal costs of control across sources. Consequently, there should be greater incentives to trade allowances to achieve compliance in Phase II.

A 1995 EPA 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.[113] The same EPA report estimated the mean value of annual health benefits at $10.6 billion in Phase I and $40 billion in Phase II. These health benefits are limited to benefits from reduced sulfates; total health benefits would be even higher. Interestingly, health benefits were not a major concern in the legislative decision to control acid rain, yet they now appear to be the dominant benefit component, dwarfing earlier estimates of environmental effects. Recall that early estimates of the costs of controlling acid rain put the costs at $4.5 billion to $6 billion annually with a traditional regulatory approach and benefits at $1 billion to $2 billion. An independent assessment reached a similar conclusion: Benefits will be much greater than costs.[114] More recent studies have estimated Phase II costs at $1.0 billion (Carlson et al., 2000) and $1.4 billion (Ellerman, 2000, p. 282).

To estimate the savings attributable to tradable allowances, Carlson et al. (2000) estimated marginal abatement cost functions for thermal power plants that were 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 million to $800 million per year, relative to an "enlightened" regulatory approach with a uniform emission standard.

6.4 NO_x Regional Ozone Programs

The federal SO_2 control program shows that acid rain poses a number of difficult problems for policy makers, regulators, environmentalists, and industry. Experiences with the SO_2 program were instrumental in designing and implementing the recent NO_x control program.

Along with SO_2, NO_x contributes to the acid rain problem nationwide. NO_x also contributes to ground-level ozone and fine particulate problems in the East and in certain densely populated areas elsewhere. With respect to acid rain, both SO_2 and NO_x have cumulative and long-range impacts on the environment. With respect to ground-level ozone and fine particulate matter, the primary concern is ambient concentrations over short periods of time during the summer months.

NO_x trading is designed to account for these complex time and space dimensions in the need to control NO_x. Electric power generation peaks in summer months in the Northeast to meet air conditioning demands. Periods of peak power production are periods of peak NO_x emissions and tend to be periods of time when ambient ground-level ozone concentrations are most likely to exceed federal standards.

6.4.1 OTC NO_x Budget Program

In the 1990 Clean Air Act Amendments, Congress established the Ozone Transport Commission (OTC), a working group consisting of 12 Northeast states and the District of Columbia. OTC's mandate was to develop plans to meet national ambient air quality goals for ozone in the Eastern United States. With the help of EPA, the OTC developed a NO_x Budget Program to address regional ozone problems. Critical program elements, such as monitoring and reporting provisions, compliance determination, and penalties, were required to be uniform across states. A 1994 memorandum of understanding with EPA was signed by all of the OTC states, except Virginia. It put in place a NO_x cap-and-trade system within the OTC states. The intent of the agreement is to institute a cooperative effort to solve a common problem.

The agreement caps NO_x emissions at 219,000 tons during the May through September compliance period for the years 1999–2000 and at 143,000 tons starting in 2003. Both amounts are less than one-half the 1990 baseline of 490,000 tons. The cap affects 465 sources of NO_x in the participating OTC states, including utilities, industrial plants, and independent power producers.

The OTC NO_x trading program is implemented by states, as are many programs under Title I of the Clean Air Act. States are free to establish rules of their own choosing, including allocation provisions. (See Table 6-3.) The OTC made efforts to ensure that the rules were compatible across states to facilitate regional emissions trading. Some provisions, such as initial emission allocation formulas, differ across participating states. The program establishes that one allowance is good for one ton of NO_x emissions emitted during the compliance months. EPA administers the Allowance Tracking System and the Emissions Tracking System, but the states maintain all responsibility for compliance and enforcement.

Table 6-3. OTC's NO_x Budget Program Allocations and Emissions (1999)

STATE	BASELINE EMISSIONS (in tons)	1999 ALLOCATIONS[115] (in tons)	1999 EMISSIONS (in tons)
Connecticut	11,130	6,312	5,830
Delaware	13,510	6,142	6,160
Massachusetts	41,331	19,680	17,293
New Hampshire	14,589	6,788	3,463
New Jersey	46,963	21,292	15,390
New York	85,632	54,276	47,267
Pennsylvania	203,181	103,668	79,166
Rhode Island	1,099	580	274
TOTAL	**417,435**	**218,738**	**174,843**

Source: 1999 OTC NO_x Budget Program Compliance Report.

Unlimited banking of allowances is allowed, but sources are restricted in how they may use them for compliance. The constraints on banking address seasonal and spatial concerns regarding ozone formation. Eight states participated in the 1999 OTC NO_x Budget Program: Connecticut, Delaware, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Rhode Island. A total of 912 affected combustion units underwent reconciliation for 1999 to determine whether they held sufficient allowances to cover their emissions. The affected sources released emissions at a level nearly 20% below their allocations for 1999, banking the remainder for future use when emission limits will be stricter.[116]

The market is showing signs of maturing. Trades for future year allowances have higher prices, which reflect the anticipated difficulty of meeting a shrinking cap on emissions. Similar price spreads also exist in the SO_2 allowance market.

6.4.2 NO_x Budget Trading Program

EPA promulgated the call for State Implementation Plans (SIPs) on NO_x, (the NO_x SIP call) pursuant to the requirements of Section 110 of the Clean Air Act (CAA). Section 110 requires a SIP to contain adequate provisions that prohibit any source or type of source or other types of emissions within a state from emitting any air pollutants in amounts that will contribute significantly to non-attainment in, or interfere with maintenance of attainment of a standard by, any other State with respect to any National Ambient Air Quality Standard (NAAQS). Section 110 authorizes EPA to find that a SIP is substantially inadequate to meet any CAA requirement when appropriate, and, based on such finding, to then require the state to submit a SIP revision within a specified time to correct such inadequacies.

The final rule required 22 states and the District of Columbia to submit State Implementation Plans that address the regional transport of ground-level ozone. The rule will reduce total summertime emissions of nitrogen oxides by about 28% (1.2 million tons) in the affected states and the District of Columbia. The final rule includes a model NO_x Budget Trading Program that will allow states to achieve over 90% of the required emissions reductions from large electric generating sources and large industrial boilers in a highly cost-effective way.

The NO_x SIP call was challenged by representatives of both industry and affected states. In May 1999, the U.S. Court of Appeals for the District of Columbia Circuit stayed the submittal deadline of the NO_x SIP call indefinitely. In November 1999, oral arguments were heard and, in March 2000, the Appeals Court ruled in favor of EPA on all major issues, remanding to EPA only a few minor issues.

As a result of its ruling, three states were no longer required to comply with the NO_x SIP call (Wisconsin, Georgia, and Missouri), and EPA was required to take further notice and comment on a portion of its electric generation unit (EGU) definition. Sources in several states will be subject to this action: Alabama, Connecticut, District of Columbia, Delaware, Illinois, Indiana, Kentucky, Massachusetts, Maryland, Michigan, North Carolina, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, and West Virginia. In June 2000, the Appeals Court lifted the stay and ruled that affected states must submit SIPs to EPA by the end of October 2000. In August 2000, the court made another ruling. This ruling moved the compliance date to submit SIPs to May 31, 2004, from its original date of May 1, 2003. As of September 2000, EPA had not yet decided whether to appeal this ruling.

The petitioners have asked the Supreme Court to review the Appeals Court's decision. As of August 2000, the Supreme Court had not decided to hear the case.

Section 126 of the Clean Air Act allows states that are adversely affected by interstate transport of pollution to petition EPA to set pollution limits on specific sources of pollution in other states. In a December 17, 1999 rule, EPA granted petitions filed by Connecticut, Massachusetts, New York, and Pennsylvania that sought to reduce ozone in these states through the control of NO_x

emissions from other states.[117] These states had petitioned that they could not attain the federal 1-hour ozone standard because of the interstate transport of ozone and its precursors.

Under its Section 126 authority, EPA published a final rule that affects 392 electric utilities and industrial boilers with rated output greater than 25 megawatts or a maximum heat input capacity greater than 250 MMBtu/hr. The Federal NO_x Budget Trading Program establishes emission limits for affected sources in the form of tradable NO_x allowances. One allowance authorizes the emission of one ton of NO_x. Sources in the program are located in Delaware, the District of Columbia, Indiana, Kentucky, Maryland, Michigan, North Carolina, New Jersey, New York, Ohio, Pennsylvania, Virginia, and West Virginia. Collectively, they must reduce NO_x emissions by nearly 530,000 tons per year by 2007 from levels had been allowed that year.

Both the NO_x SIP call and the Section 126 action require sources to reduce emissions of NO_x. However, the SIP call allows states the flexibility to choose how reductions will be made; under the 126 action, EPA directly regulates sources. Furthermore, the SIP call covers a larger geographic area. EPA is continuing to work with the states to determine how to integrate these two programs.

6.5 Chlorofluorocarbon (CFC) Production Allowance Trading

The Montreal Protocol on Substances that Deplete the Ozone Layer called for a cap on chlorofluorocarbon (CFC) and halon consumption at 1986 levels, with reductions in the cap scheduled for 1993 and 1998. 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.[118]

The Montreal Protocol defined consumption as production plus imports, minus exports. Consequently, in implementing the agreement, EPA distributed allowances to companies that produced or imported CFCs and halons. Based on 1986 market shares, EPA 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 traditional regulatory approach to end uses would cost more than $300 million for recordkeeping and reporting, versus only $2.4 million for the allowance trading approach.

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 that were segregated by their ozone-depleting potential. As an example, 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 their use of these substances. At the same time, 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, 1% of the allocation is "retired" to assure further improvement in the environment.

Congress coupled the marketable allowance trading system with excise taxes on CFC production, which are discussed in Chapter 4, Pollution Charges, Fees, and Taxes. The rationale for the excise taxes was that the restrictions on the quantity of CFCs and halons could be sold would lead to rapidly escalating prices. The excise taxes were designed to capture "windfall profits." In contrast, the allowance trading system was designed to assure that the production and import of the CFCs was cost-effective. The excise tax has the effect of making CFCs much more expensive in the United States than they are in developing countries where production is still allowed. Smuggling of these chemicals has become a serious problem.

6.6 Lead Credit Trading

As early as the 1920s, tetra-ethyl lead was added to gasoline by refiners to increase octane levels and reduce premature combustion in engines, which allowed more powerful engines to be built. Lead additives in gasoline were the least expensive of several ways of raising octane levels. The additives also prevented premature recession of soft-valve seats, a feature of most automobile engines that were manufactured prior to 1975 (but not after).

By the 1970s, virtually all gasoline contained lead at an average of almost 2.4 grams per gallon. EPA acted to curtail lead use in gasoline for two reasons. One, by 1975 new production vehicles were equipped with exhaust system catalysts, so these vehicles could meet the tailpipe emission standards for hydrocarbons, carbon monoxide, and nitrogen oxides that were mandated by the 1970 Clean Air Act. Unleaded fuel was required for vehicles manufactured after model year 1975, since exhaust system catalysts would be fouled and not function properly if vehicles were run on leaded gasoline. As catalyst-equipped vehicles began to dominate the fleet, sales of unleaded gasoline reached about 80% of all gasoline sales by the mid-1980s.

Two, concerns about the role of airborne lead in adult hypertension and cognitive development in children motivated EPA to limit the overall use of lead in gasoline. EPA required that the average lead content of all gasoline sold be reduced from 1.7 grams per gallon after January 1, 1975, to 0.5 grams per gallon by January 1, 1979. Initially, these limits were applicable as quarterly averages for the production of individual refineries, implicitly allowing trading across batches of gasoline at individual refineries. Later, EPA broadened definition of averaging to allow refiners who owned more than one refinery to average or "trade" among refineries to satisfy their lead limits each quarter.

During the late 1970s, the demand for unleaded gasoline grew steadily as more catalyst-equipped vehicles were sold. By the early 1980s, the market share of leaded gasoline had shrunk to the point that EPA's limits on the average lead content of all gasoline ceased to have an impact on the lead content in leaded gasoline. Meanwhile, evidence on the magnitude and severity of the health effects attributable to lead mounted.

EPA acted to curtail sharply the remaining use of lead in gasoline, initially setting a limit of an average level of 1.1 gm/gal beginning on November 1, 1982. EPA lowered the average to 0.5 gm/gal by July 1, 1985, and then to 0.1 gm/gal by January 1, 1986. To facilitate the phasedown, EPA allowed two forms of trading: inter-refinery averaging during each quarter and banking for future use or sale.

Inter-refinery averaging, which operated from November 1, 1982, to December 31, 1985, allowed refineries to "constructively allocate" lead. To take an example, suppose refiner A produced 200 million gallons of gasoline in the first quarter of 1983 with an average lead content of 1.4 gm/gal. Refiner A could buy 60 million grams of lead credits from Refiner B, who produced an equal quantity of gasoline with lead content of 0.8 gm/gal. In 1985, EPA permitted refiners to bank credits for use until the end of 1987, which in effect extended the life of lead credits to that date.

Lead credits were created by refiners, importers, and ethanol blenders (who reduced the lead content of gasoline by adding ethanol). For example, when the average lead content was limited to 1.0 gm/gal, a refiner producing 1 million gallons of gasoline with an average lead content 0.5 gm/gal would earn 500,000 lead credits. EPA enforcement relied on reporting requirements and the random testing of gasoline samples. Reporting rules were simple. Each refiner or importer was obligated to provide the names of entities with whom it traded, the volumes for each trade, and the physical transfer of lead additives. The data allowed EPA to compare reported lead additive purchases and sales for each transaction to assure compliance. Discrepancies in reported figures could trigger investigations and enforcement actions. Well over 99% of all transactions were reported accurately; however, several dozen fraudulent transactions occurred.[119] In one quarter alone, the now-defunct Good Hope refinery in Louisiana accounted for over one-half of all reported lead credits sold during one quarter. Subsequent investigation uncovered the fraud.

Judged by market activity, lead credit trading was quite successful. Lead credit trading as a percentage of lead use rose above 40% by 1987. Some 20% of refineries participated in trading early in the program; by the end of the program, 60% participated.[120] Early in the program, 60% of refineries participated in banking, rising to 90% by the end. Trading allowed the EPA to phase out the use of lead in gasoline much more rapidly than otherwise would have been feasible. Given that refiners faced very different opportunities for reducing the lead content of gasoline, a rapid phase-down without trading would have rewarded refiners collectively, since the market price of gasoline would have been determined by the high-cost producers.

During the period of time when lead credits were traded, the price increased from about 3/4 cent/gm to 4 cents/gm.[121] Nearly one-half of all lead traded was between refineries owned by the same firm.[122] With external transactions, refiners revealed a preference to deal with normal trading partners, even though they could obtain a better price elsewhere. This preference indicates that trading did not produce the least cost outcomes, even though there was an active market in lead credits. In part, this result occurred because internal trades have lower transaction and information costs than inter-refinery trades. However, it also reflects strong preferences in the industry to avoid revealing potentially valuable information to competitors.

EPA estimated that the banking provisions alone would involve 9.1 billion grams of lead credits and save refiners $226 million. Subsequently, the amount of lead banked was placed at just over 10 billion grams. Lead credit trading may be viewed in retrospect as a considerable success. The use of lead in leaded gasoline was sharply reduced over a short period of time, without spikes in the price of gasoline that otherwise might have occurred. The market in lead credits was quite active, although, as noted in the previous paragraph, refiners did not maximize their gains from trade. In addition, some small refiners and ethanol blenders nonetheless sold many more credits than they had earned, despite seemingly foolproof procedures for catching fraudulent trades.

6.7 Gasoline Constituents

Title II of the Clean Air Act Amendments of 1990 imposes substantially tightened mobile source emission standards by requiring automobile manufacturers to reduce tailpipe emissions and by requiring refiners to develop reformulated fuels. The Amendments require reductions in tailpipe emissions of 35% for hydrocarbons and 60% for NO_x, starting with 40% of the vehicles sold in 1994 and increasing to all vehicles sold in 1996. Light-duty trucks are subject to similar requirements. EPA is required to impose further reductions of 50% below these standards by 2003 if it finds such reductions are necessary, technologically feasible, and cost-effective. EPA recently issued Tier 2 gasoline sulfur standards that implement this further reduction.

Title II requires that states having CO non-attainment areas with design values of 9.5 parts per million (ppm) or higher must implement a program to supply oxygenated fuels to motorists in winter months. (The term "design values" is defined as the second highest ambient reading measured over the most recent two years.) Gasoline sold in the 41 cities affected by this requirement must have an oxygen content of 2.7% starting in 1992. To meet the percent oxygen requirement, states are "strongly encouraged" to create a program for marketable oxygen credits to provide flexibility to gasoline suppliers.

In October 1992, EPA issued guidance for trading programs in oxygenates under the wintertime oxygenated gasoline program; however, participation is optional for the affected states.[123] In areas where trading is permitted, credits in oxygenates can be exchanged between parties that the state has designated as responsible for satisfying fuel requirements, also known as the Control Area Responsible Party or CAR. Normally the CAR is the party who owns gasoline at a terminal. The CAR receives data on the volume and oxygen content of all gasoline shipped to the terminal and assures that the average oxygen content is 2.7% by weight. Where trading is allowed, the CAR would be free to sell excess oxygenate credits to other CARs or buy oxygenate credits from a CAR to meet the 2.7% requirement. While trading in oxygenates theoretically offers a cost-effective means of meeting wintertime oxygenate requirements, in fact, the trading programs have been moribund. Only the Pennsylvania part of the Philadelphia ozone non-attainment area (which also includes parts of New Jersey) adopted trading rules. Within that area, no trades have been reported. Other areas have declined to allow trading, citing the costs of monitoring such a program as prohibitive.

Title II also requires that the 9 worst ozone non-attainment areas offer reformulated gasoline during the summer months. It also specifies several performance characteristics for reformulated gasoline as well as certain fuel properties, including a minimum oxygen content of 2% by weight beginning in 1995. Under so-called "opt in" provisions, an additional 31 areas applied to EPA, so they could participate in the reformulated gasoline program.

Title II requires that EPA establish trading systems for three constituents of reformulated fuels: oxygen, aromatics, and benzene. Under a trading system, refiners could meet reformulated content requirements by producing gasoline that met the specifications or by trading credits in these constituents with other refiners, so collectively the standards were satisfied. EPA's rules for reformulated gasoline set up an averaging-and-trading system as well as an averaging-and-trading system for meeting EPA's performance standards for VOCs and toxic air chemicals.

There has been considerable trading and averaging of reformulated gasoline requirements, mainly from the Midwest to the East Coast. That trading has led to some regional failures to meet oxygenate retail averages, and it has resulted in a tightening of the oxygenate standards for reformulated gasoline.

6.8 Tier 2 Emission Standards

On February 10, 2000, EPA promulgated new standards for tailpipe emissions of NO_x from passenger cars and light-duty trucks and for the sulfur content of gasoline.[124] The tailpipe emission action was taken under EPA's authority to set tailpipe emission standards for new vehicles (Section 202 of the Clean Air Act). The fuel standard action was based on EPA's determination that motor vehicle fuels contribute to air pollution and adversely affect the performance of emission control systems (an authority under Section 211 (c)(1) of the Clean Air Act).

Manufacturers will be able to average their Tier 2 vehicles to comply with the corporate average NO_x tailpipe standard of 0.07 grams per mile (gpm), which is more than a 75% reduction from the current 0.30 gpm. standard.[125] When a manufacturer's corporate average NO_x emissions fall below the standard, it will earn credits that may be banked for later use or sold to another manufacturer. These credits will be very similar to those currently in place for non-methane organic gas (NMOG) emissions under California and the federal National Low Emission Vehicle (NLEV) regulations. The NO_x credits will have unlimited life. Manufacturers would be permitted to run a credit deficit for 1 year and carry forward that deficit. If the manufacturer has a credit deficit in the second year, the manufacturer would be subject to an enforcement action.

Refiners and gasoline importers must satisfy a corporate average gasoline standard of 120 ppm and a cap of 300 ppm sulfur beginning in 2004. In 2005, this corporate average standard drops to 90 ppm sulfur, with the cap remaining at 300 ppm. The format of the program changes in 2006 from a corporate average to a per-refinery requirement. At that time, the cap will be 80 ppm sulfur, and most refiners will have to produce gasoline that averages no more than 30 ppm sulfur. Refiners who produce gasoline with a corporate average sulfur content lower than the standard will be allowed to bank credits for future use or for sale to other refiners that are unable to meet the standard. Credits produced under the phase-in years have a limited life. Those credits produced beginning in 2006 have an unlimited life. The program runs until 2010. However, refiners will be able to carry forward a deficit for 1 additional year, providing that the average is below 80 ppm sulfur.

The standards concern hydrocarbon emissions, which was termed "NMOG" in the rulemaking. Manufacturers would have to satisfy a corporate average standard, but they could meet this standard through the trading of credits earned by manufacturers that exceeded the corporate average standard. Banking also would be allowed. Banked credits, however, would be subject to discounting over time.

6.9 Heavy-Duty Truck Engine Emission Averaging

Title II of the Clean Air Act Amendments of 1990 authorizes EPA to set standards for particulate matter, NO_x, and other emissions from heavy-duty truck engines. The standards must represent the maximum degree of reductions achievable, taking cost and other factors into consideration. EPA has interpreted this provision to authorize the use of averaging, banking, and trading as part of the process of realizing the maximum degree of reductions achievable.

Under this program, there has been a great deal of averaging and banking but only one trade between firms, a 1996 exchange of rights to 5 tons of particulate matter from Navistar to Detroit Diesel. The averaging of emissions facilitates compliance, since not every class of engines has to meet the 75% reduction standard. How much engine manufacturers actually save is unknown. However, a recent paper examined a similar type of engine performance averaging program that was proposed in California for light-duty trucks. It concluded that the cost savings of the program were likely to be modest.[126]

6.10 Corporate Average Fuel Economy (CAFE) Standards

The Energy Policy and Conservation Act of 1975 established corporate average fuel economy (CAFE) standards for all manufacturers that sell vehicles in the United States. The standards were first imposed in 1978 and are now 27.5 miles per gallon (mpg) for production passenger cars and 20.7 mpg for production light-duty vehicles. (Light-duty vehicles include sport utility vehicles, minivans, and pickup trucks with gross vehicle weight ratings less than 8500 pounds.)

Corporate average fuel economy and compliance with the CAFE standard is determined as the harmonic mean of the fuel economy of automobiles produced by each manufacturer.[127] Harmonic average fuel economy is more difficult to achieve than is simple averaging. For example, to achieve a CAFE standard of 27.5 mpg, two 35-mpg vehicles must be sold for every 20-mpg vehicle sold. The penalty for failing to meet the CAFE standard is $5.50 per automobile for every 0.1-mpg shortfall. Carry back and carry forward provisions akin to banking do exist, and they allow shortfalls in one year to be met with credits from another year.

CAFE standards have been the primary national policy instrument for improving personal vehicle fuel economy and for reducing gasoline and oil consumption in the transportation sector. From the late 1970s through the mid-1980s, CAFE standards—working in concert with higher gasoline prices through most of that period—nearly doubled the average fuel economy of new personal vehicles. Throughout the 1990s, with oil and gasoline prices recording historic lows on an inflation-adjusted basis, CAFE standards provided a floor for automotive fuel economy. Fuel economy was higher than it would have been absent the standards. Therefore, compliance with these standards reduced gasoline consumption.

Since fuel economy is inversely proportional to carbon dioxide emissions, the primary greenhouse gas from motor vehicles, CAFE has yielded reductions in carbon dioxide emissions and overall greenhouse gas emissions. (Fuel economy is largely unrelated to emissions of criteria pollutants such as particulate matter, CO, and NO_x). In this regard, CAFE can be viewed as an intra-firm trading system to meet a de facto standard to reduce the carbon dioxide emissions from personal vehicles.

As a policy instrument, CAFE has both advantages and disadvantages. Some of CAFE's advantages follow.

- CAFE is in place, it has proven to be a workable program, and lessons have been learned about how it could be improved.
- CAFE has yielded significant reductions in gasoline consumption and carbon dioxide emissions, which would not have been the case without these standards.
- The general public strongly supports CAFE relative to other alternatives to increase fuel economy and reduce carbon dioxide emissions, such as higher gasoline taxes.
- CAFE includes many market elements, such as

- sales-weighted averaging (as opposed to a floor that every vehicle must meet),
- a 7-year rolling average for compliance (and credits can be carried back or forward for 3 years), and
- the option of paying monetary fines in lieu of meeting the standard, a choice that is left to the discretion of the manufacturer. (Several non-U.S. firms pay these fines. All U.S. automakers have chosen to meet CAFE standards in the past.)

Like any policy instrument, CAFE also has disadvantages. Some of them follow.

- CAFE is inconsistent with low fuel prices. That is, when gasoline prices are relatively low, there is less demand for high-fuel economy cars, and manufacturers must sell higher fuel economy than the market demands.[128]
- CAFE does nothing to reduce vehicle miles traveled (VMT). (Some analysts argue that CAFE increases VMT and emissions by lowering the cost of driving, i.e., raising the fuel economy of vehicles means, in theory, that less gasoline is needed to travel a certain number of miles. Other analysts assert that these effects are negligible.)
- CAFE does have a cost, either in terms of the higher prices of vehicles or the tradeoffs that must be made with other vehicle attributes such as utility, weight, or acceleration.
- CAFE is strongly opposed by automakers, whose objections include higher vehicle cost and the potential reduction in safety for passengers in these lighter weight vehicles.

Alternatives to CAFE standards would include higher gasoline taxes and "feebates," which would assess fees to the sale of vehicles with low-fuel economy and rebates for the purchase of high-fuel economy vehicles. Like CAFE, each of these options has advantages and disadvantages. The relative merits of these options relative to CAFE are debated, as is the magnitude required for such policies to provide the same benefits as CAFE.

6.11 Hazardous Air Pollutant (HAP) Early Reduction

In December 1992, EPA issued final rules for the early reduction of hazardous air pollutants.[129] If a facility qualifies for inclusion in the program by reducing hazardous air pollutants by 90%—95% in the case of hazardous particulate emissions—prior to EPA proposing maximum available control technology (MACT) regulations on the source category, the facility may defer compliance with the new MACT for as long as 6 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%) reduction in emissions. Trading exists intertemporally across time in that sources exchange their early reductions for their later reductions. (The example in the next paragraph illustrates how this program works.)

EPA has shown that such a program can benefit the environment. Assume a source emits 100 tons per year. Under the early reduction program, it would emit 10 tons per year. Further assume that MACT would have the source reduce emissions to 2 tons per year in year 5 and thereafter. The source has reduced emissions by 360 tons in years 1 through—4 in exchange for 48 tons of emissions in years 5 through10. Total emissions are reduced by 312 tons. Table 6-4 illustrates the time profile of emissions.

By mid-1993, over 60 chemical plants had asked to participate in the program, so they could avoid the synthetic organic chemical MACT standard for 6 years. Other types of facilities also had applied to join the program.[130]

Table 6-4. Benefits of Achieving Early Emission Reductions

YEAR	MACT EMISSIONS (in tons)	EARLY REDUCTION EMISSIONS (in tons)
1	100	10
2	100	10
3	100	10
4	100	10
5	2	10
6	2	10
7	2	10
8	2	10
9	2	10
10	2	10
TOTAL	**412**	**100**

Source: 57 FR 61970

6.11.1 The Petroleum Industry NESHAP

EPA's National Emission Standard for Hazardous Air Pollutants (NESHAP) rule, promulgated on August 18, 1995, establishes Maximum Available Control Technology (MACT) requirements for process vents, storage vessels, wastewater streams, and equipment leaks 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 would be subject to future NESHAP rules: catalyst regeneration on cracking units, vents on sulfur recovery units, and vents on catalytic reforming units.

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

Both of these NESHAP 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 a particular situation. The owner may over-control at some emission points and under-control at others to achieve the overall level of emissions control that is required.

6.11.2 Hazardous Organic Chemical NESHAP

The Hazardous Organic Chemical NESHAP (or "HON") affects more than 400 facilities of the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The final rule requires sources to limit emissions of organic hazardous air pollutants (HAPs) and to apply "reference control" or equivalent maximum available control technology (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 emissions credits that can be used to offset the debits they accrue when measures under-control at other points.

6.12 Regional Clean Air Incentives Market (RECLAIM)

Some of the highest ozone levels in the nation are recorded in the Los Angeles area. The South Coast Air Quality Management District (SCAQMD or District) also fails to meet the particulate matter and CO NAAQS, although not by such a large margin. Historically, the SCAQMD has relied on source-specific emissions regulations to limit the emissions of ground-level ozone precursors (as well as other pollutants).

Substantial progress has been made over the past three decades in improving the air quality in the Los Angeles Basin. However, it was apparent to SCAQMD officials that further progress toward attaining federal standards would be prohibitively expensive if they used traditional regulatory methods. By 1990, the marginal costs of NO_x control in the District had reached $10,000 per ton to $25,000 per ton at electric power plants, versus $500 per ton to $2000 per ton elsewhere in the United States. Proposed SO_x controls on catalytic cracking units at refineries would have cost $32,000 per ton, versus the national costs of less than $500 per ton for other methods of controlling SO_2 emissions. (See Section 6.3, Acid Rain Allowance Trading. Consequently, the District began to investigate the feasibility of creating a marketable permit in reactive organic gases (ROG) and NO_x as well as SO_x—the latter for its role in the formation of small particulate matter—as a means of accomplishing air quality goals at lower cost.

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

For the NO_x and SO_x programs, emissions originated at combustion sources with well-defined exit points to the environment. Emission monitoring would be based on stack gas measurement using continuous emission monitors (CEM). 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 to form ozone than others do. Furthermore, some ROG are classified as toxic pollutants and regulated separately. After about 1 year of analysis and discussion, RECLAIM officials decided to defer including ROG in its program and to concentrate on the program's design for NO_x and SO_x.

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. These sources were concerned about the future price and availability of marketable permits. District officials eventually exempted sewage treatment plants, landfills, and three small municipally owned power plants.

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 target was computed in the AQMP by taking reported 1987 emissions and deducting projected reductions that were 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, not the AQMP. 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 that were 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 NO_x 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 facilities participating in RECLAIM. Sources installed continuous emission monitors, or CEMS, which cost $100,000 to $150,000 each, on every boiler emitting 10 tons annually or more. These CEMs recorded pollutant readings minute by minute and sent the readings to a remote terminal that averaged the readings over 15-minute periods. The remote terminal then 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.

The District projected that the one-time costs of installing monitoring equipment would be approximately $13 million, with negligible annual operating costs. The District projected that annual savings in compliance costs relative to traditional forms of regulation would be an average of $58 million annually for each of the next 10 years. These calculations effectively muted the industry's complaints about the costs of monitoring equipment.

The actual trading works as follows. Each source has a declining allocation of RECLAIM Trading Credits (RTC) for each year from 1994 to 2003. After 2003, the balance remains constant. The RTC are denominated in pounds: one RTC equals one pound of emissions. Sources are free to trade RTC for the current year or for future years; however, all RTC are good only for the year for which they are issued. Trades in RTC 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 RTC and shares that information with market participants.

Under RECLAIM rules, the District may impose penalties for net emissions (including trades) in excess of the permitted amounts. One such penalty would reduce next year's emission allocation by the amount that emissions exceeded the allowable limit. Other possible actions include civil penalties and the loss of the facility's operating permit.

In 1994, the NO_x and SO_x markets began with 370 sources and 40 sources, respectively. Both markets represented approximately 70% of stationary source emissions. Analysis shows that the program should reduce NO_x emissions by an average of 8.3% per year, which amounts to a cumulative reduction of 80 tons per day by 2003. It should also reduce SO_x emissions by 6.8% per year, which amounts to a cumulative reduction of 15 tons per day by 2003. The District projects that RECLAIM will lower compliance costs by $57.9 million a year when compared to a traditional regulatory approach: $80.8 million versus $138.7 million.

As a means of jump-starting the market, the SCAQMD held an auction of RTC 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 NO_x credits. A total of 114,676 NO_x credits and 9,400 SO_x 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 incurred from recently enacted or proposed regulations. 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. (See Table 6-5 for the prices of these credits.)

Table 6-5. Reclaim Trading Credit Prices

VINTAGE*	NO_x ($ per ton)**		SO_x ($ per ton)**	
	1994	1997	1994	1997
1994	2			
1995	334		1,500	
1996	574		1,900	
1997		227		64
1998				
1999	1,480			
2000	1,580			
2001	1,700			
2002	1,830			
2003	2,090			2,393
2010		1,880		2,385

Notes: * The term "Vintage" refers to the year in which the credit could be used. ** These figures are based on prices at a July 1994 auction and 1997 market prices.

Source: *BNA Daily Environment Report,* Aug. 10, 1994; SCAQMD 1998.

In June 1995, the SCAQMD proposed adding VOC emissions to RECLAIM; the initiative included almost 1,000 facilities in 14 industrial categories that generated 4 tons or more of VOC annually. In contrast to the NO_x and SO_2 programs that were scheduled to last for 7 years, the VOC 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 to include the trading of VOCs within RECLAIM met with fierce opposition from environmentalists. They charged that the 1989 baseline selected for emissions by SCAQMD could result in a huge increase in emissions over 1993 levels when the program is fully implemented. Regulators sought the 1989 baseline to avoid locking industry into emission levels that were associated with the recessionary conditions that occurred in 1991, 1992, and 1993. Industry representatives note that the AQMP has a schedule for orderly reductions over time toward the 2010 goals. In their view, emissions increases that occur 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 governing board of SCAQMD set aside the proposed rule to include trading of VOCs within RECLAIM in January 1996. The board then directed its staff to develop a program to trade VOC emissions separately. Due to strong opposition in some quarters and to difficulties in accurately measuring these emissions, a subsequent VOC initiative ultimately was shelved.

RECLAIM has won praise for its progress to date. A state-mandated performance review found that the District has a state-of-the-art air quality program that is performing efficiently and effectively. According to the report, RECLAIM demonstration projects have helped stimulate technological development. Furthermore, its outreach and compliance programs have helped save or create more than 10,000 jobs, while, at the same time, these programs have improved air quality.

Trading in the program has been active, expanding from $2.1 million worth of credits in 1994 to $21 million worth of credits in 1997.[131] The largest buyers of credits have been large refineries and utilities, while the sellers were smaller refiners, glass container manufacturers and facilities that ceased operations. Of the sources that went out of business or left the area, only a handful cited environmental regulations as a factor in their decision.

RECLAIM credit prices have remained far below the prices that were projected at the time of program adoption. The average price in 1997 for NO_x credits of the same vintage was just $227 per ton, while 2010 vintage credits were $1,880 per ton. Average 1997 prices for SO_x credits were as low as $64 for 1997 vintage credits and as much as $2,393 per ton for 2003 vintage credits. According to Cantor Fitzgerald, a broker in emission reduction credits, the average price for SO_x RTC in early 2000 was about $1500 per ton for 2000 vintage credits and $2,300 per ton for 2005 to 2010 vintage credits.[132]

6.13 Other State Programs

In addition to RECLAIM, emission-trading programs are in various stages of development in several states. This section reviews activities in Illinois, Michigan, New Jersey, Texas, Pennsylvania, Colorado, and Washington. The state programs are an outgrowth of EPA's proposed 1995 Open Market Trading Rule.[133] While the 1995 proposal was never finalized, it was incorporated into Draft Economic Incentive Program (EIP) Guidelines in September 1999. The Open Market Trading Rule and the subsequent EIP Guidelines provided guidance for states that wish to institute emissions trading as part of their State Implementation Plans (SIP). As is the case with all draft guidance documents, the guidelines are subject to change. The advantage of EPA's generic emission trading rules over offsets, bubbles, netting, and banking is that individual trades do not require a SIP revision or EPA review. By following the generic rules, the transaction costs of emission trading can be reduced substantially.

6.13.1 Illinois Emission Reduction Market System

The Illinois Emission Reduction Market System (ERMS) allows the trading of VOC emission credits between firms in the Chicago non-attainment area. Like RECLAIM and the Acid Rain Program, the Illinois ERMS is an allowance program designed with an overall emissions cap and phased reductions to meet air quality goals. By 2007, when the market is scheduled to end, the

Chicago area must be in attainment for the national ambient air quality standard for ozone. Air quality modeling revealed that controlling emissions of volatile organic matter would be far more effective in reducing ozone than controlling NO_x emissions.

The ERMS is applicable to sources in the Chicago ozone non-attainment area that emit more than 10 tons per year of volatile organic matter (VOM) during the ozone season and that are subject to the Clean Air Act Permit Program. Sources receive an allocation of allotment trading units (ATU), each of which represents the right to release 200 pounds of VOM during the May 1-to-September 30 allotment period. Sources may receive a program exemption if they accept a 15-ton per season cap on emissions or if they agree to limit emissions to 82% of baseline emissions. Sources in the program receive an allocation that is 12% lower than their baseline emissions, defined as the two highest emission years during the 1994–1996 period.

6.13.2 Michigan Emissions Trading Program

The Michigan Air Emission Trading Program began in 1996.[134] It provides for the banking and trading of emission reduction credits (ERCs) in NO_x, VOCs, and all criteria pollutants except ozone. ERCs, which are denominated in tons per year, may be generated in the following ways: (1) through a facility shutdown; (2) through a permanent reduction in operations that results in reduced emissions; (3) through the use of new technologies, equipment, or inputs that result in reduced emissions; and (4) through the installation of pollution control equipment that decreases actual emissions. Various methods may be used to measure emissions: CEM; stack gas sampling; measuring surrogates (e.g., some VOC, but not all VOC); inputs; process conditions; etc. In general, credits obtained through a facility shutdown cannot be traded within a non-attainment area to satisfy a source's obligations.

6.13.3 New Jersey Emission Trading Program

The New Jersey Emission Trading Program is similar to Michigan's program, except that it applies only to NO_x and VOC.[135] The New Jersey Department of Environmental Protection maintains a registry of discrete emission reduction (DER) credits that are transferred. Average prices for 2000 are reported in Table 6-6.

Table 6-6. Open Market Emissions Trading Registry Report (2000)

POLLUTANT	OZONE SEASON	YEAR-TO-DATE AVERAGE PRICE PER DER
NO_x	No	$43.91
NO_x	Yes	48.40
VOC	No	127.50
VOC	Yes	127.50

Source: http://www.omet.com/scripts/omet/OMET_Report_Month_Selector.idc

6.13.4 Texas Emissions Trading Program

The Texas Natural Resource Conservation Commission (TNRCC) Emission Credit Banking and Trading Program provides a market-based framework for trading emission reductions of volatile organic compounds (VOC), nitrogen oxides (NO_x), and certain other criteria pollutants from stationary, area, and mobile sources. The program was designed to provide additional flexibility for complying with the Texas Clean Air Act while creating a net reduction in total air emissions with each transaction. At present, the TNRCC is developing a NO_x cap-and-trade for certain ozone non-attainment areas.

6.13.5 Pennsylvania Emission Trading Program

The Pennsylvania program is similar to the Michigan program, with some exceptions. ERCs may be generated only for VOCs and NO_x. ERCs can be transferred from dirtier areas—the five Philadelphia counties—to cleaner areas, but not from the cleaner areas to the dirtier ones.[136] ERCs may be transferred within the five-county Philadelphia area with some limitations. The Pennsylvania Department of Environmental Protection (DEP) maintains a registry of ERCs that are available for trade or future use. Buyers and sellers of ERCs are encouraged to contact DEP for assistance.

6.13.6 Wood Stove and Fireplace Permit Trading (Colorado)

During the 1970s and 1980s, a number of mountain communities in Colorado experienced unacceptably high levels of particulate pollution during winter months due to the use of wood-burning stoves and fireplaces. The growing popularity of skiing and other winter activities has exacerbated the problem in some of these areas.

Telluride tried to combat the problem through traditional forms of regulation. In 1977, the city passed an ordinance limiting new residential construction to one stove or fireplace per unit. This rule might have slowed the deterioration in air quality. However, new construction continued, which virtually guaranteed that air quality would continue to worsen, which it did into the 1980s.

In 1987, the city adopted a program that was part traditional and part modeled on air pollution offsets that would guarantee improvements in air quality. Owners of existing wood stoves and fireplaces were grandfathered with operating permits, but they were required to meet stringent performance standards within 3 years: 6 grams of particulate matter and 200 grams of CO per hour. During the first 2 years of the program, those individuals who converted their fireplaces and wood stoves to natural gas could earn a rebate of $750, which would partially defray their costs. For new construction, no new permits would be issued for wood-burning stoves or fireplaces. To install such an appliance in a newly constructed building, the owner must produce permits to operate two fireplaces or stoves. These permits could only be acquired from existing permit owners.

In a matter of months, a lively market in second-hand permits developed, with potential buyers and sellers making contact through classified advertisements. By the mid-1990s, permit prices were in the $2,000 range. In the years after Telluride adopted the program, it has reported no violations of the ambient air quality standard for particulate matter.

Other communities in Colorado soon implemented similar programs, which combined performance-based standards that encouraged the retirement of older inefficient fireplaces and wood stoves. All these programs focused on reducing the burning of wood, but some offered no rebates for converting these fireplaces and stoves to natural gas. From the available evidence, the programs appear to have been a success, achieving air quality goals quickly and at a relatively modest cost. A project for future research would compare and contrast the approaches taken by different communities in limiting the use of heavily polluting wood stoves and fireplaces, as well as assess the effectiveness of the programs.

6.13.7 Grass-Burning Permit Trading (Washington)

The City of Spokane, Washington, is nestled in the Spokane River Basin about 400 feet below the surrounding Columbia River Plateau. The basin forms a natural trap for air pollution during temperature inversions. The area exceeds the federal 24-hour standard for particulate matter several times each year, due to a combination of unpaved roads, wind-blown dust, grass burning, and wood-burning stoves.

Spokane is a major growing region for turf grass seed, with between 15,000 and 30,000 acres planted for seed production each year. After harvest each year, the fields are burned in August or September to control weeds and pests and to stimulate the grass to produce seed rather than concentrate its energy on vegetative growth. In 1990, air pollution authorities in Spokane County implemented an innovative program to reduce grass burning as a source of particulate matter.[137]

Grass burning had been subject to permitting for years. The program superimposes a countywide cap of 35,000 acres that may be burned each year onto the existing permit process. Growers are allocated permits to burn grass based on burning permits they held during the base period, 1985 to 1989. The overall cap does not appear to be binding; it exceeds the actual acreage burned in every year since 1971. However, some grass growers found themselves short of desired permits because they had planted other crops during the base period or because they had rented their land to tenants (who held the permits) during the base period.

The program allows transfers of grass-burning permits in three situations: permanent land transfers; temporary land transfers by lease; and transfer through an auction held by the Air Pollution District. When permits are transferred through the auction, 10% of the burnable acreage is deducted from the buyer's account, resulting in a small decrease over time in the total number of burnable acres. The auction mechanism is patterned after the acid rain allowance auction. Parties submit sealed bids and offers prior to the auction. The party with the highest bid is matched with the party with the lowest offer, with the actual transaction occurring at a price midway between the bid and offer. If the entire quantity offered was not purchased by that bidder, the bidder with the next lower price is then matched with the remaining offer. The process continues until all potential transactions are completed.

6.14 Effluent Trading

Despite many academic studies showing the potential benefit of effluent trading and considerable effort by EPA and the states to implement the concept, effluent trading has yet to live up to its full promise. While conceptually very similar to emission trading (which deals with emissions to the air), effluent discharge and its regulation also differ significantly from emission trading because effluent trading deals with emissions to the water.

Water pollution is caused by both point and non-point sources. *Point sources* discharge pollutants into surface waters through a conveyance such as a pipe or ditch. Primary point sources include publicly owned treatment works (POTWs) and industries. *Non-point sources* add pollutants from diffuse locations such as surface agricultural runoff or unchannelized urban runoff. The most important non-point source of water pollution is agriculture. The differences between emission trading and effluent trading have made it difficult to design practical programs that can capture the potential benefits of effluent trading. New efforts by EPA to implement its Total Maximum Daily Load (TMDL) program in areas with impaired water quality are expected to vastly increase the use of effluent trading. For current EPA efforts to promote effluent trading, see http://www.epa.gov/owow/watershed/trading.htm.

6.14.1 Effluent Bubble

In concept, a water effluent bubble operates identically to the air emission bubble described in Section 6.2.2, Bubble Policy. 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 in the following paragraphs.

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.[138] 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 four plants in the iron and steel industry that would, potentially, benefit from water bubbling as they went from BPT (best practicable control technology currently available) to BAT (best available technology economically achievable).[139] The projected savings were less than $1 million annually. A retrospective study estimated the savings from effluent bubbles in the iron and steel industry were far larger: in excess of $122 million, as shown in Table 6-7.

Table 6-7. Estimated Cost Savings from Iron and Steel Intraplant Trades

FACILITY	OUTFALLS IN TRADE	TRADING PERIOD FOR ANALYSIS	PRESENT VALUE OF REDUCED CAPITAL COSTS (in millions of 1993 dollars)	PRESENT VALUE OF REDUCED OPERATING & MAINTENANCE COSTS (in millions of 1993 dollars)	PRESENT VALUE OF ALL REDUCED COSTS (in millions of 1993 dollars
A	5	1987–1993	$3.9	$2.4	$6.3
B	2	1983–1986	No Data	No Data	No Data
C	2	1985–1993	2.4	2.5	4.9
D	3	1984–1993	2.1	1.2	3.3
E	4	1986–1993	No Data	No Data	No Data
F	2	1983–1988	10.3	3.9	14.2
G	2	1984–1993	5.5	3.1	8.6
H	2	1984–1989	8.9	6.8	15.7
I	3	1983–1985	57.7	12.1	69.8
J	3	1984–mid-1980s	No Data	No Data	No Data
TOTALS			**$90.8**	**$32.0**	**$122.8**

Source: Kashmanian et al. 1995.

EPA's implementation of the effluent bubble for the iron and steel industry was dictated by a 1983 settlement agreement among EPA, the Natural Resources Defense Council (NRDC), and the American Iron and Steel Institute. The agreement supports the use of bubbling under the

Clean Water Act, but it imposes constraints on the approach. Bubbling of effluents from iron and steel plants is acceptable, provided that net reductions are achieved in each pollutant that is bubbled. Relative to the BAT limits that are in effect, bubbling must involve a reduction of at least 15% of the amount of both suspended solids and oil and grease and 10% of the amount of other pollutants. The NRDC reserved the right to challenge bubbles that might be proposed for other industries.

Complying with the steel effluent bubble has produced considerable cost savings for the industry. According to a former EPA employee who is now a consultant to the industry, however, the bubble has not resulted in any pollution control innovations.[140] EPA will soon propose revisions to the iron and steel regulations that would make the effluent bubble unnecessary.

6.14.2 Effluent Trading: Point-to-Point

Effluent trading dates to the early 1980s. At that time, 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 the state's water quality standards through the trading of effluent rights. The first application of this authority was on the heavily industrialized lower Fox River.

The Fox River program applies to the last 35miles of the river, allowing trading between point sources with permits to discharge wastes that increase biochemical oxygen demand (BOD). Sources that control more waste than their discharge permit requires can sell those incremental rights to sources that control less waste 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 1 year, but they may not run past the expiration date of the seller's discharge permit, which is, at most, a 5-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. Analysis predicted that the potential gains from effluent trading among sources on the lower Fox River was significant: $7 million annually or roughly one-half of anticipated compliance costs for BOD regulations.[141]

Later, the state initiated BOD trading programs on 500 miles of the Wisconsin River. For administrative reasons, the Fox River was divided into three segments and the Wisconsin River into five segments. The Fox River program included 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. 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 questions about the vulnerability of the program to legal challenge, and these questions remain since the Clean Water Act does not explicitly authorize trading. Furthermore, there is a requirement that all facilities meet minimum technology-based effluent limits. Finally, as noted in a previous paragraph, the state imposed severe restrictions on the ability of sources to trade.

6.14.3 Effluent Trading: Point-to-Non-point Sources

A number of programs allow the trading of nutrient discharges between point and non-point sources. Three such programs are described here; others are included in Table 6-8.

6.14.3.1 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 non-point 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 non-point loadings. Discharges from new non-point sources are restricted through regulations that require developers to show a 50% reduction of phosphorus from pre-1984 norms. New non-point sources must offset all of their discharges by using a trading ratio of 1:1 with existing non-point sources. For point sources, the plan established a trading ratio of 2:1, whereby point sources that are above their allocation must obtain credits from point or non-point sources for twice the amount of the excess from sources that are below their allocation. The system would be monitored through existing NPDES (National Pollution Discharge Elimination System) permits for point sources.

Trading has been very slow. Not only has the region experienced a recession for a number of years that limited 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. Population growth is once again evident, leading to the conclusion that more trading activity is likely.

6.14.3.2 Cherry Creek Reservoir

Like the Dillon Reservoir, Cherry Creek Reservoir also is a source of water for the Denver region and an important recreation area. The 800-acre reservoir attracts more than 1.5 million visitors annually. To protect recreational and water supply uses, the Cherry Creek Basin Authority developed a total phosphorus standard to limit algae concentrations and assigned wasteload allocations to the 12 wastewater treatment facilities in the watershed (a total maximum daily load for the reservoir). Source trading between point sources and non-point sources is authorized as an option for addressing the fact that 80% of the phosphorus load originates with non-point sources. To date, there has been no compelling need to trade at Cherry Creek since phosphorus effluent at municipal wastewater treatment facilities remain below the limits set by the Colorado Water Quality Commission. The Cherry Creek Basin Authority has designed a number of non-point pollution control projects that will generate phosphorus reduction credits. When regional economic growth compels wastewater treatment facilities to achieve greater phosphorus reductions, the credits will be available.

6.14.3.3 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. Upon designating an area as nutrient-sensitive, North Carolina law requires that 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 non-point 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 discharge from wastewater treatment plants: nitrogen at 4 mg/l in the summer and 8 mg/l in the winter and 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 with cropland managers on a 3:1 basis. To date, point source dischargers have found ways to meet new and stricter discharge limits without resorting to trading. In the future, trading may become more attractive as a compliance option. Hoag and Hughes-Popp (1997) provide a useful discussion of the program.

6.14.3.4 Other Effluent Trading Initiatives

EPA and the states are actively involved in a number of other effluent trading projects. These projects are summarized in Table 6-8 and in more detail in a recent EPA report entitled “A Summary of U.S. Effluent Trading and Offset Projects.”[142] Many of these projects also are discussed on the Nutrientnet web site: http://www.nutrientnet.org.

6.14.4 Future Prospects for Effluent Trading

The Federal Water Pollution Control Act (FWPCA) of 1972 developed the basic framework for federal water pollution control. After amendments in 1977, the FWPCA has been known as the Clean Water Act (CWA). The FWPCA controls water pollution by regulating discharges of pollutants from point sources—such as industrial facilities, sewage treatment plants, and concentrated animal feeding operations—with a system of national effluent standards and permits for each class of point source discharge (the NPDES system). EPA sets effluent discharge standards based on the cost of control and the availability of control technology. By using this basic approach, many of the nation’s streams and rivers are demonstrably cleaner than they were in 1972.

Table 6-8. Effluent Trading Projects

PROJECT	WATER BODY	STATE	ACTIVITY DESCRIPTION	STAGE	TRADES/ OFFSETS APPROVED?	SAVINGS ESTIMATE AVAILABLE?
Grassland Area Tradable Loads	San Joaquin River	CA	Watershed trading program	Implementation	Y	N
San Francisco Bay Mercury Offset	San Francisco Bay	CA	Regional offset program	Under development	N	N
Bear Creek Trading Program	Bear Creek Reservoir	CO	Watershed trading program	Approved	N	N
Boulder Creek Trading Program	Boulder Creek	CO	Watershed trading program	Implementation	Y	Y
Chatfield Reservoir Trading Program	Chatfield Reservoir	CO	Watershed trading program	Approved	N	N
Cherry Creek Basin Trading Program	Cherry Creek Reservoir	CO	Watershed trading program	Implementation	Y	N
Dillon Reservoir Trading Program	Dillon Reservoir	CO	Watershed trading program	Implementation	Y	N
Long Island Sound Trading Program	Long Island Sound	CT	Large watershed trading program	Under development	N	Y
Blue Plains WWTP Credit Creation	Chesapeake Bay	DC	Single trade	Under development	N	N
Tampa Bay Cooperative Nitrogen Management	Tampa Bay	FL	Regional cooperation	Implementation	Y	N
Cargill and Ajinomoto Plants Permit Flexibility	Des Moines	IA	NPDES permit flexibility	Implementation	Y	N
Lower Boise River Effluent Trading Demonstration Project	Boise River	ID	Watershed trading program	Under development	N	Y
Specialty Minerals Inc.	Hoosic River	MA	Offset for one discharger	Implementation	N	Some
Town of Acton POTW	Assabet River	MA	Offset for one discharger	Under development	N	Some
Wayland Business Center Treatment Plant Permit	Sudbury River	MA	Offset for one discharger	Implementation	Y	Y
Maryland Nutrient Trading Policy	Chesapeake Bay, other MD waters	MD	Statewide trading program	Under development	N	N
Kalamazoo River Water Quality Trading Demonstration	Kalamazoo River, Lake Allegan	MI	Watershed pilot program	Implementation	Y	N
Michigan Water Quality Trade Rule Development	MI Waters	MI	Statewide trading program	Nearing completion	N	Y

PROJECT	WATER BODY	STATE	ACTIVITY DESCRIPTION	STAGE	TRADES/ OFFSETS APPROVED?	SAVINGS ESTIMATE AVAILABLE?
Minnesota River Nutrient Trading Study	Minnesota River	MN	Watershed trading study	Completed	N/A	Y
Rahr Malting Plant	Minnesota River	MN	Offset for one discharger	Implementation	Y	N
Southern Minnesota Beet Sugar Plant	Minnesota River	MN	Offset for one discharger	Implementation	Y	N
Chesapeake Bay Nutrient Trading	Chesapeake Bay	multi	Large watershed trading program	Under development	N	N
Neuse River Nutrient Strategy	Neuse River Estuary	NC	Watershed trading program	Approved	N	Y
Tar Pamlico Nutrient Program	Pamlico River Estuary	NC	Watershed trading program	Implementation	Y	Y
Passaic Valley Sewerage Com. Effluent Trading	Hudson River	NJ	Pretreatment program	Implementation	Y	N
Truckee River Water Rights and Offset Program	Truckee River	NV	Offset for one discharger	Implementation	Y	N
New York Watershed Phosphorus Offset Pilot Programs	Hudson River	NY	Offset pilot programs	Implementation	Y	N
Claremont County Project	Little Miami River, Harsha Reservoir	OH	Potential regional trading project	Under development	N	N
Delaware River Basin Trading Simulation	Delaware River	PA	Watershed pilot program	Early discussion	N	N
Henry Co. Public Service Auth. and City of Martinsville	Smith River	VA	Single trade	Implementation	Y	N
Virginia Water Quality Improvement Act and Tributary Strategy	Chesapeake Bay, other VA waters	VA	Statewide trading program	Approved	N	N
Wisconsin Effluent Trading Rule Development	WI waters	WI	Statewide trading program	Pilots active	N	N
Fox-Wolf Basin Watershed Pilot	Green Bay	WI	Watershed pilot program	Approved	N	Y
Red Cedar River Pilot Trading Program	Tainter Lake	WI	Watershed pilot program	Approved	N	Y
Rock River Basin Pilot Trading Program	Rock River Basin	WI	Watershed pilot program	Under development	N	N

Source: EPA. Reinvention Activity Fact Sheets. Effluent Trading in Watersheds

According to data submitted by states in 1998, about 40% of the nation's streams and rivers do not meet the water quality goals set forth by states, Indian tribes, and territories.[143] For these water bodies, a little-known provision in Section 303 of the Clean Water Act will soon be used to achieve further improvements in water quality. Recently, EPA published final rules, which have not yet taken effect, concerning the Total Maximum Daily Load (TMDL) Program.

A TMDL is a calculation of the maximum quantity of pollution that a water body can accept and still meet designated water quality standards. The TMDL is then allocated to point and non-point sources. Effluent trading will be encouraged as a means of lowering compliance costs for affected sources.

Of concern is the CWA requirement that existing, expanding, and new facilities—including publicly owned treatment works, industrial dischargers, stormwater programs, and coastal zone measures—meet all applicable technology-based requirements. This requirement appears to represent a severe obstacle to trading.

The potential cost savings from effluent trading are impressive. Analysis by EPA suggests that trading among indirect dischargers could produce compliance cost savings of $658 million to $7.5 billion. Trading just among point sources could achieve cost savings of $8.4 million to $1.9 billion, while trading among point and non-point sources could yield compliance cost savings of $611 million to $5.6 billion.[144]

6.15 Wetland Mitigation Banking

Wetlands (also sometimes termed "swamps," "bogs," or "floodplain") were long considered unproductive wastelands. Over time, hundreds of thousands of acres of wetlands were drained by farmers, filled by developers, and otherwise converted to "productive" uses. From the 1780 to 1980, the contiguous 48 states lost over one-half of their original wetland acreage. [145]

In recent years, scientists pointed out the ecological importance of wetlands. Government policies at the federal, state, and local level have since come to emphasize wetland preservation, not development. Developers whose proposed actions would destroy wetlands are increasingly being forced to minimize damage to wetlands and to offset what damage occurs through wetland protection or enhancement offsite. Sometimes, the offset takes the form of compensation. That approach is described more fully in Chapter 4, Pollution Charges, Fees, and Taxes. This section describes wetland mitigation banking, a procedure for offsetting the adverse impacts of development on wetlands.

Wetland mitigation banks are created through a memorandum of understanding (MOU) among federal and state officials and a bank administrator. In most cases, the MOU would describe the responsibilities of each party, the physical boundaries of the bank, how mitigation credits will be calculated, and who is responsible for long-term management of the bank. Credits, which are usually denominated in terms of acres of habitat values, may only be used to mitigate development within the same watershed. State regulations would cover issues such as where mitigation credits can be used (e.g., statewide or within a watershed) and the compensation ratios that would be required for various types of development. Existing banks vary from a few acres to over 7,000 acres.

Among established wetland mitigation banks, most MOUs allow the bank operator to sell credits only after the bank has actually accomplished wetland enhancement or preservation. A few states allow the bank operator to sell credits concurrently as preservation or enhancement actions are undertaken.

The land for a mitigation bank could have any number of origins. Some of the more common sources of mitigation bank lands include existing natural wetland areas, enhanced natural wetland areas, pits created by the removal of landfill material, and lands that previously had been drained for agricultural use. State highway departments established approximately one-half of existing wetland mitigation banks to provide a means for mitigating losses due to highway construction. Conservation organizations and for-profit entities have set up mitigation banks that offer mitigation credits for sale.

Mitigation banking offers several advantages over more traditional on-site mitigation activities.

- Environmental values are better protected in large-scale developments.
- Economies of scale in wetland preservation and enhancement can be realized.
- The cost of wetland mitigation actions can be made known to developers very early in the development process.
- Mitigation banking offers greater assurance of long-term management of the protected area.

About 100 wetland mitigation banks in at least 34 states are currently in operation, and more are in advanced stages of planning. Wetland mitigation banking was featured in the 1996 Farm Bill as part of the Wetlands Reserve Program. Wetland mitigation banking has been endorsed by EPA, the Army Corps of Engineers (which oversees most development in wetlands under Section 404 of the Clean Water Act), and by the authors of leading legislative initiatives to reauthorize the Clean Water Act. All of these facts suggest that wetland mitigation banking will grow in importance as a means of protecting and enhancing the nation's wetlands.

6.16 Greenhouse Gas Emissions

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) establishes quantified emission limitations and reduction targets for greenhouse gases (GHG) that are to be achieved by the end of the first commitment period (2008–2012). On average, these commitments call for a 5.2% reduction from 1990 emission levels. (However, these commitments vary from one Party to the Convention to another.) To date, the Protocol has been signed by 38 industrialized countries and the European Community—the so-called Annex I Parties—but it has not been ratified by a sufficient number of Parties to come into effect.

Among other things, the Protocol includes basic provisions for the monitoring, reporting, and verification of greenhouse gas emissions (Articles 5, 7, and 8), and it outlines the need for effective procedures and mechanisms to address non-compliance (Article 18). Most remarkably, the Kyoto Protocol allows for the use of economic-incentive mechanisms, the so-called "flexible mechanisms," that enable the emission reduction targets to be met at least cost. These mechanisms, described in the following paragraphs, consist of Joint Implementation (Art. 6); the Clean Development Mechanism (Art. 12); and International Emissions Trading (Art. 17). They also include the use of Article 4 (the "bubble") by a group of Parties to fulfill their commitments jointly. At present, many of the rules and guidelines related to these provisions are in the process of being negotiated. How the issues are resolved will have an effect on the number of countries that will ratify the Kyoto Protocol and the cost of achieving these emission reduction targets. In November 2000, delegates met in The Hague, The Netherlands but were unable to resolve many of the issues concerning GHG trading. They have scheduled a resumed session for May 2001 in Bonn.[146]

Joint Implementation (JI): JI allows Annex I Parties to transfer and acquire "Emission Reduction Units" that are generated from project-level activities that reduce emissions by sources or that enhance removals by sinks in other Annex I countries. That is, a country or designated legal entity within a country can invest in a greenhouse gas (GHG) reduction project in another Annex I country and receive credits for the emissions reductions that the project generates. Project participants must show that the emissions reductions or removals are real, measurable, and additional to what would have occurred in the absence of the project activity.

Clean Development Mechanism (CDM): The CDM enables Annex I Parties or legal entities within these countries to invest in GHG emission reduction or removal projects in non-Annex I countries (i.e., developing countries), in exchange for "certified emissions reduction" units. The CDM would promote sustainable development in developing countries and help Annex I countries meet their GHG targets. Similar to JI, project participants must show that the emissions reductions or removals are real, long-term, measurable, and additional to what would have occurred in the absence of the project activity.

International Emissions Trading (IET): Under Article 17, Annex I Parties are able to participate in international emissions trading to meet their GHG targets. That is, countries with high costs of emissions abatement can provide funding for additional reductions in other Annex I countries that have low costs of emissions abatement, in exchange for the acquisition of assigned amount units. This ruling, in effect, enables Annex I Parties to reach their emission reduction targets at minimum cost.

The Article 4 Joint Fulfillment: Article 4 would allow a group of Parties in Annex I to choose to satisfy their emission reduction commitments jointly and to reallocate the commitments among the Parties within the group. The provision was designed to allow the European Union (EU) to change the distribution of reduction and limitation commitments set out in Annex B of the Kyoto Protocol for its members, with the absolute EU target remaining unchanged. The provision also enables other groups of Annex I Parties to enter into such an agreement, if they choose.

Activities Implemented Jointly (AIJ): At the first conference of the Parties to the UN Framework Convention on Climate Change, which was held at the 1990 Rio Earth Summit, the Parties agreed to a pilot program called "Activities Implemented Jointly." Under this program, government entities in one country could jointly undertake projects with similar entities in another country.

The United States Initiative on Joint Implementation (USIJI) was the first national program to adopt a formal set of criteria and an evaluation process for activities that could be implemented jointly (AIJ). An Evaluation Panel with representatives from U.S. government agencies determined the acceptability of proposed projects. The first United States AIJ projects were accepted in January 1995, and others followed soon thereafter. Central America hosted most of the early U.S. projects, but Russia and other nations also hosted AIJ 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 6-9.) The other projects were withdrawn or rejected.

Table 6-9. Accepted USIJI Projects

(As of October 25, 2000)

PROJECT NAME	COUNTRY	PROJECT TYPE
CAPEX, SA Electric Generation Project	Argentina	Energy production
Landfill Gas Management in Greater Buenos Aires	Argentina	Energy production
Rio Bermejo Carbon Sequestration Project	Argentina	GHG sink
Bel/Maya Biomass Power Generation Project	Belize	Energy production
Rio Bravo Conservation and Forest Management	Belize	GHG sink
Noel Kempff M. Climate Action Project	Bolivia	GHG sink
Rural Solar Electrification Project	Bolivia	Energy production
The Taquesi River Hydroelectric Power Project	Bolivia	Energy production
SIF Carbon Sequestration Project	Chile	GHG sink
The Rio Condor Carbon Sequestration Project	Chile	GHG sink
Wind Energy Project	Chile	Energy production
La Sierra Electricity Efficiency in Colombia	Colombia	Energy end use
Aeroenergia S.A. Wind Facility	Costa Rica	Energy production
Consolidation of National Parks & Biological Reserves as Carbon Deposit	Costa Rica	GHG sink
Dona Julia Hydroelectric Project	Costa Rica	Energy production
ECOLOAND: Piedras Blancas National Park	Costa Rica	GHG sink
Esquinas National Park	Costa Rica	GHG sink
Klinki Forestry Project	Costa Rica	GHG sink
Plantas Eolicas S.R.L. Wind Facility	Costa Rica	Energy production
Territorial and Financial Consolidation of Costa Rican National Parks and Biological Reserves	Costa Rica	GHG sink
Tierras Morenas Windfarm Project	Costa Rica	Energy production
City of Cecin: Fuel Switching, District Heating System	Czech Rep.	Energy end use
Bilsa Biological Reserve	Ecuador	GHG sink
Cemento de El Salvador, S.A. de C.V.	El Salvador	Energy end use
Matanzas Hydroelectric Project	Guatemala	Energy production
Rio Hondo II Hydroelectric Project	Guatemala	Energy production
Santa Teresa Hydroelectric Project	Guatemala	Energy production
Bio-Gen Biomass Power Generation Project, Phase I	Honduras	Energy production
Bio-Gen Biomass Power Generation Project, Phase II	Honduras	Energy production
Solar-Based Rural Electrification	Honduras	Energy production
The Bagepalli Project: Community-Based Fruit Tree Orchards for CO_2 Sequestration	India	GHG sink
Reduced Impact Logging for Carbon Sequestration in East Kalimantan	Indonesia	GHG sink
Energy Centers for Mali	Mali	Energy production
Solar Electric Generation for the Island of Rodrigues	Mauritius	Energy production
APS/CRD Renewable Energy Mini-Grid Project	Mexico	Energy production
Community Silviculture in the Siera Norte of Oaxaca	Mexico	GHG sink
Project Salicornia: Halophyte Cultivation in Sonora	Mexico	GHG sink
Scolel Té: Carbon Sequestration and Sustainable Forest Management in Chiapas	Mexico	GHG sink
El Hoyo-Monte Galan Geothermal Project	Nicaragua	Energy production

Continued on the next page

PROJECT NAME	COUNTRY	PROJECT TYPE
Commercial Reforestation in the Chiriqui Province	Panama	GHG sink
The Central Selva Climate Action Project	Peru	GHG sink
Energy Efficient Street Lighting Project in the Philippines	Philippines	Energy end use
District Heating Renovation in Lytkarino	Russian Fed.	Energy end use
Improving District Heating Efficiency in Metallurguichesky District of Cheliabinsk	Russian Fed.	Energy end use
Reforestation in Vologda	Russian Fed.	GHG sink
RUSAFOR--Saratov Afforestation Project	Russian Fed.	GHG sink
RUSAGAS: Fugitive Gas Capture Project	Russian Fed.	Energy end use
Zelenagrad District Heating System Improvements	Russian Fed.	Energy end use
Guguletu Eco-Homes Project	South Africa	Energy end use
SELCO—Sri Lanka Rural Solar Electrification Project	Sri Lanka	Energy production
Energy Center for Uganda	Uganda	Energy end use
Solar Light for the Churches of Africa	Uganda	Energy end use

Source: USIJI Secretariat, 2000.

Financing remains a major obstacle; just 13 of the 32 projects that were approved through July 1998 had obtained funding by sponsors. Participants in these projects assert that they faced large transaction costs in dealing with host governments and experienced significant delays in getting project approvals from the USIJI Evaluation Board and from host governments. Sponsors identified development of new contacts in the host country, early entry into a potentially profitable business, the possibility of influencing future AIJ criteria, and favorable publicity as motivating factors.

The record of the early AIJ projects offers important lessons regarding the CDM and how it should be structured. After-the-fact assessments of a large number of U.S. AIJ projects reveal difficulties in determining whether project activities truly are additional to activities that would have been undertaken without the AIJ program. Furthermore, 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 AIJ 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.

Implementation of the Kyoto Protocol will have major financial implications. EPA-sponsored studies by Koomey et al. (1998) and Laitner et al. (1999) suggest that market-based policies, including expanding EPA's own voluntary programs, could reduce domestic energy-related carbon emissions by as much as 300 million metric tons at a net positive benefit to the economy by 2010. Estimates of the potential savings from the use of trading to satisfy U.S. obligations, versus traditional alternatives, are as high as $100 billion per year.[147] Clearly, details regarding how the program will be designed and implemented are likely to have considerable financial implications.