5. DEPOSIT-REFUND SYSTEMS

5.1. INTRODUCTION

Deposit-refund systems (hereafter referred to as "deposit systems") are similar to the advance disposal fees described in the previous section except that the payer of the fee can obtain a partial or complete refund by returning the used product for recycling or proper disposal. Such a system could be looked upon as a combination of a product charge and a recycling subsidy. Manufacturers or vendors of products subject to deposits incur additional costs in handling returned products, but these costs are often partially offset by interest earned on deposits, unclaimed deposits, and sales of collected used products.

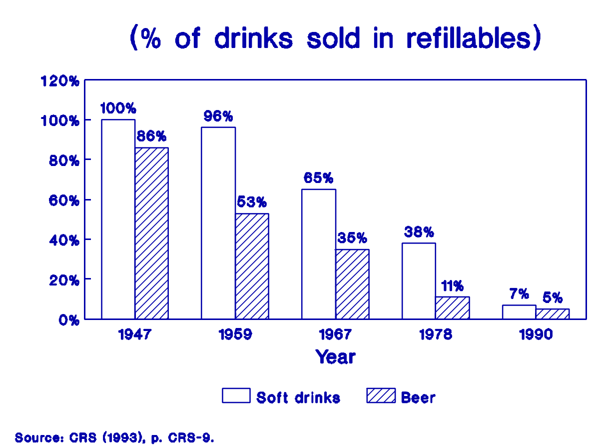
As noted below, deposit systems are used most commonly for beverage containers but have also been used for other products such as pesticide containers, lead-acid batteries, and tires. Some of these systems are voluntarily implemented by industry whereas others are required by government. As with most other incentive mechanisms discussed in this report, deposits have been required not by federal government but rather by state or local authorities, although federal legislation on deposits has been considered.

Several studies have concluded that deposit systems are more cost-effective than other methods of waste disposal reduction such as command-and-control regulations, recycling subsidies, and advance disposal fees. A recent study by Resources for the Future concluded that a 10% reduction in waste disposal would cost $45 per ton of waste reduced under a deposit system compared to $85 per ton under advance disposal fees and $98 per ton under recycling subsidies. However, the study noted that the relatively high administrative costs of a deposit system could outweigh these cost savings.[1]

(RFF study: www.rff.org/dpapers/abstract/9533.htm)

Fullerton and Kinnaman (1995) concluded that waste collection should be priced positively if disposal and recycling are the only two disposal options, but that if illicit burning or dumping is also an option, the optimal policy is "a tax on output plus a rebate on proper disposal," i.e., a deposit system. While waste collection fees give waste generators an incentive to dispose of waste in an uncontrolled manner, deposit schemes give them an incentive to recycle.

Figure 5-1: U.S. MARKET SHARE OF REFILLABLE BOTTLES



As noted below, studies have found that deposit systems result in higher recovery rates and less contamination of recyclables than curbside recycling programs. However, deposit schemes are also believed to cost more than curbside programs.

5.2. BEVERAGE CONTAINERS

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

As shown in Table 5-1, ten states have passed "bottle bills" mandating beverage container deposits ranging in magnitude from 2.5¢ to 15¢, the most common amount being 5¢. Beer and soft drinks are subject to deposits in all ten states, mineral water in six states, malt in four states, and wine coolers, liquor, and carbonated mineral water in three states. Michigan includes canned cocktails, New York includes soda water, and Maine includes juices and tea. In most states, deposit requirements apply to the full range of container types, including glass, plastic, aluminum, and steel, but Delaware has exempted aluminum from its requirement.

Most states require retailers to take back containers that are in their product line, even if the container was purchased elsewhere. In Maine, however, retailers located within a certain distance of a certified redemption center are not obliged to take back containers. In addition to retail outlets, "redemption centers" accept containers in most states. Any organization may operate such centers, although certification of the center may be required. Some redemption centers and retailers could earn profits from mandatory handling fees of 1.5¢ to 3¢ per container paid by distributors. As shown in table 5-1, in most states unclaimed deposits are kept by the distributor.

Not included in table 5-1 is a deposit system in effect in Columbia, Missouri since 1982. Under this system, consumers pay deposits of 5¢ on beer, soft drinks, malt, and carbonated mineral water containers. Although retail stores are required to take back containers, no handling fees are mandated. The overall redemption rate is estimated at 85-95%.[2]

Although it is beyond the scope of this report to describe in detail every deposit system in table 5-1, systems in Maine and California are discussed below as illustrative examples.

5.2.1. Maine Bottle Bill

Maine introduced a deposit system for beer and soft drink containers on January 1, 1978. In distributing beer and soft drinks to retailers, distributors (or manufacturers) levy a 5¢ deposit as well as a 3¢ handling fee. Retailers in turn include these amounts in their sales prices. The customer can obtain a 5¢ refund by returning the container to any retailer selling the product or to a redemption center. Demand for containers is sometimes sufficiently high that customers can obtain refunds 10-20% higher than the deposit amount.[3] In some places, reverse vending machines also offer refunds for returned containers.

Table 5-1: STATE BEVERAGE CONTAINER DEPOSIT SYSTEMS

State	Since	Containers Covered	Refund Amount	% Returned	Redemption Sites	Unclaimed Deposits	Handling Fees
California	1987	Beer, soft drinks, wine coolers, mineral water	2.5¢ < 24 oz 5¢ > 24 oz	Aluminum 88% Glass 76% PET 50% Overall 84%	State-certified centers	Program administration grants	Per container processing fee
Connecticut	1980	Beer, malt, soft drinks, mineral water	Minimum 5¢	Cans 88% Bottles 94% Plastic 70-90%	Retail stores, redemption centers	Kept by distributor or bottler	Beer 1.5¢. soft drinks 2¢
Delaware	1982	Non-aluminum beer, malt, soft drink, mineral water<2qt	5¢	Insufficient data	Retail stores, redemption centers	Kept by distributor or bottler	20% of deposit
Iowa	1979	Beer, soft drinks, wine, liquor	5¢	Aluminum 95% Glass 85% Plastic 70-90%	Retail stores, redemption centers	Kept by distributor or bottler	1¢
Maine	1978	Beer, soft drink, wine, wine cooler, liquor, juice, water, tea	Beer, soft drink, juice 5¢. Wine, liquor 15¢	Beer, soft drink 92% Spirits 80% Wine 80% Juices, non-car-bonated 75%	Retail stores and redemption centers	Kept by distributor or bottler	3¢
Massachusetts	1983	Beer, soft drink, carbonated water	5¢	Overall 85%	Retail stores and redemption centers	State	2.25¢
Michigan	1978	Beer, soft drink, canned cocktails, carbonated and mineral water	Refillables 5¢, nonrefillables 10¢	Overall 93%	Retail stores	75% environ-mental programs, 25% handling fees	25% of unclaimed deposits
New York	1983	Beer, soft drink, wine cooler, carbonated mineral water, soda water	5¢	Wine cooler 63% Soft drink 72% Beer 81%	Retail stores and redemption centers	Kept by distributor or bottler	1.5¢
Oregon	1972	Beer, malt, soft drink, carbonated mineral water	Standard refillables 3¢. Others 5¢	Overall 85%	Retail stores	Kept by distributor or bottler	None
Vermont	1973	Soft drink, beer, malt, mineral water, liquor	Soft drink, beer 5¢. Liquor 15¢.	Overall 85%	Certified redemption centers. Retail stores.	Kept by distributor or bottler	3¢

Retailers and redemption centers then redeem the used containers to distributors (or manufacturers) in exchange for 8¢ refunds. Distributors typically pick up used containers while distributing new products. Retailers and redemption centers keep the 3¢ handling fees. Distributors (or manufacturers) have at least three sources of revenue to offset the costs of handling containers. They can sell the collected containers to processors and keep unclaimed refunds and handling fees. Half of unclaimed refunds formerly went to the State, but as a result of distributor complaints about costs, deposit initiators are now (effective January 1, 1996) allowed to retain all unclaimed refunds.[4] A third source of revenue is interest earned on deposits and handling fees before redemption.

The expansion of the deposit scheme to liquor and wine on September 1, 1990 and to bottled water, iced tea, and juice on December 31, 1990 resulted in new (and perhaps less efficient) types of deposit-refund arrangements. Unlike soft drinks and beer, juice is often distributed by several companies in the same geographic area. If several distributors operate in the same area, each one often has difficulty determining which containers it is responsible for collecting. As a result, some distributors may pay more in refunds than they charge in deposits, while for others, deposits may exceed refunds. Because distributors fear that they will lose money in charging deposits and paying refunds, manufacturers have had to charge deposits themselves and contract independent collectors to redeem containers. This collection method may be less efficient than collection by distributors who already travel to collection sites while distributing new products.

Another problem with juice containers has been misredemptions caused by in-state distribution without imposing deposits and in-state redemption of containers originally purchased outside the state. Such misredemptions have resulted in redemption rates in excess of 100% for certain products. For example, Coca-Cola reported redemption rates for Minute Maid Juices and Hi-C of 142% in 1993, 281% in 1994, and 126% in the first six months of 1995.[5]

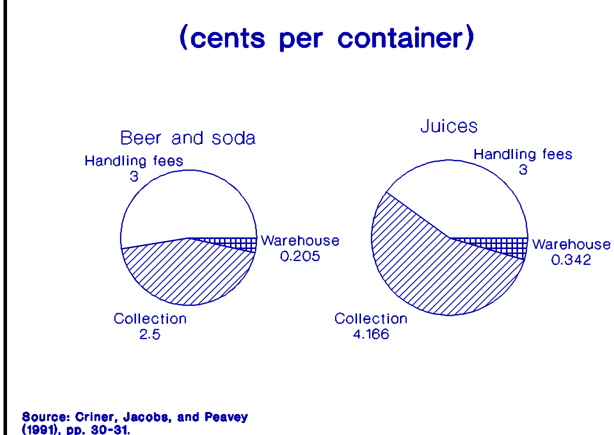
Retailers have complained that the deposit system (especially the expanded one) requires more storage space and more time for recordkeeping and bottle reception and sorting. In addition, traces of beverages in containers have attracted pests. The administrative burden has probably become more severe since the expansion of the system, as significant variations in juice containers make them more difficult to sort and store.[6]

The deposit in Maine is reported to have significantly reduced litter. A Maine Department of Transportation study (1979) found that total litter was reduced by 10% and that container litter was reduced by 56%.[7] Since the redemption rate has risen since 1979, it is likely that litter has decreased further. One reason for the decline in litter is that people sometimes collect bottle and can litter to obtain refunds. The deposit has also been credited with increasing recycling by creating a reliable supply of recyclable materials. Three container processing facilities were created as a result of the system. These facilities can in turn stimulate demand for recyclables collected outside the deposit system.[8]

Criner, Jacobs, and Peavey (1991) estimated that the costs of Maine's deposit system exceed those of curbside collection programs but also result in higher collection rates. They surveyed retailers, redemption centers, distributors, and manufacturers to develop cost estimates for the deposit system. Their comparison of the deposit system and curbside collection programs relied on the Waste Plan computerized waste management modeling system.[9] Readers should be aware of at least three potential shortcomings of the data used in the estimates that follow: 1) Survey responses were often incomplete. (For example, no beer distributors answered the survey, and soda distributors submitted only "weighted average" data.) 2) Although manufacturers, distributors, retailers, and redemption centers might have the best access to cost information, they might also have an incentive to overstate their costs associated with container handling. 3) The report was published in April 1991, probably too early to incorporate a full range of experiences under the expanded deposit system, which was not in effect until December 30, 1990.

Criner, Jacobs, and Peavey estimated that retailers incurred costs of 2.4¢ to 3.1¢ per container under the original deposit system and virtually the same costs under the expanded system. The high end of this range applies to smaller retailers. Based on these estimates, the 3¢ per container handling fees appear to be set at a level that covers retailers' costs. The handling fee was originally 1¢ but rose to 2¢ in 1980 and again to 3¢ in 1990.[10]

Figure 5-2: ESTIMATED DISTRIBUTOR COSTS OF MAINE DEPOSIT SCHEMES



As shown in Figure 5-2, Criner, Jacobs, and Peavey estimate the costs incurred by distributors at 5.7¢ per container for beer and soda and 7.5¢ for juice products. (These estimates do not include the costs incurred by consumers in returning containers for refunds.) Two reasons why collection costs, storage facilities, and labor could be more expensive for juices are that larger variations in juice containers make them more expensive to sort and store and that manufacturers hire companies specifically to collect used juice containers.

Table 5-2 presents estimates of the costs of collecting recyclables under curbside programs and deposit systems for a community of 25,000 inhabitants in Maine.[11] The estimates suggest that the costs of deposit systems are not only significantly higher than curbside programs but also raise the costs of curbside collection when the two are implemented at the same time. This last effect could be caused by diversion of recyclables from curbside programs, thereby reducing economies of scale.

Table 5-2: ESTIMATED COLLECTION AMOUNTS AND COSTS OF CURBSIDE AND DEPOSIT PROGRAMS IN MAINE COMMUNITY OF 25,000 INHABITANTS

	No deposit	Original deposit	Expanded deposit
Curbside tons recycled, cost per ton	2,538 ($41)	1,917 ($80)	1,378 ($100)
Deposit scheme tons recycled, cost per ton	0	1,138 ($567)	2,037 ($402)
Total tons recycled, weighted average cost per ton	2,538 ($41)	3,055 ($261)	3,413 ($280)

Source: Criner, Jacobs, and Peavey, p. 50.

A significant portion of the costs of Maine's deposit system appear to be passed on to consumers. In 1990, Criner et al. compared beverage prices in Maine with those of neighboring New Hampshire, Rhode Island, and Massachusetts. Prices were very similar for juices, which were not subject to deposits at the time, but were higher in Maine for soda and beer. As noted above, Massachusetts has a 5¢ deposit like Maine. Criner et al. speculate that the deposit system in Massachusetts has not resulted in beverage prices higher than those of New Hampshire and Rhode Island because distributors in the state face more competition than in Maine and because the state's density limits the cost of handling used containers.

Criner et al. also found that prices of most orange and non-orange juices sold at two Maine supermarkets increased during the period from the fall of 1990 to late February 1991, although prices of orange juice in large plastic containers (64-96 oz.) subject to deposit requirements fell significantly during the same period. Although these findings suggest that the expansion of the deposit to juices had an impact on prices, the price increases at the two stores were not compared with price changes elsewhere.

5.2.2. California Beverage Container Recycling Program[12]

The 1986 California Beverage Container Recycling and Litter Reduction Act (AB2020) led to the creation of the Beverage Container Recycling Program (BCRP) in 1987. The program was originally intended to achieve an overall beverage container recycling rate of 80%.

California's deposit system differs significantly from that of other states in that retailers generally are not responsible for collecting deposits and offering refunds to consumers and used containers are not returned to their original distributors. Instead, manufacturers of most beverage containers pay a fee of 2¢ per container to a State recycling fund. When containers are returned, the fund pays 2.5¢ per container to the individual or organization that collected it. For containers of more than 24 ounces, the fee is 4¢ and the payment 5¢. The payment may be passed on to consumers to entice them to return containers.

This scheme resembles an advance disposal fee, with fee revenues used to provide collection incentives. It is the result of compromise between various interests, including grocers, who did not want to manage used containers in their stores, and environmentalists, who wanted incentives to stimulate recycling.

Retailers with annual revenues of less than $2 million are not required to accept used containers, and larger retailers can be exempted if there is a recycling center located with a 1/2 mile radius of their store. In areas where there are no centers, retailers generally contract a recycling business to establish a collection site or reverse vending machine.

The State also assesses handling fees annually for each type of container. Manufacturers are required to either pay these fees or guarantee a scrap recyclable price equal to the cost of collection. These requirements have increased scrap prices in the State to the point of providing incentives to import scrap from other states. By law, such imports may not be redeemed.

In 1994/95, the BCRP received about $333 million in revenues. However, this figure is expected fall in the next few years as a result of reductions in processing fees required by 1995 legislation and increases in container redemption.[13] Unclaimed deposits and fees not paid out as subsidies finance grants for non-profit and government organizations for activities such as litter reduction and recycling.

($333 revenue figure: www.lao.ca.gov/a96b2.html)

Like all other states with deposit systems, California has specific beverage container labelling requirements. All containers must bear the label "CA Redemption Value" or "California Redemption Value." To increase awareness of the deposit system, the CRV must be posted separately on store shelves, in advertising, and on retailer invoices.[14]

The BCRP required the creation of a government structure to manage the program and initially generated relatively low return rates. By the early 1990s, however, after the initial 1¢ fee had been more than doubled, the program had achieved return rates comparable to those of other states with deposit systems. As shown in table 1, the overall beverage container recycling rate has risen to 84%.

Ackerman et al. (1995) stated that California's redemption system results in lower costs per redeemed container than systems in which redemption is managed through vendors. Containers are not sorted by brand and returned to their distributors as in other states. As a result, administrative costs are estimated at 0.2¢ in California and 2.3¢ in other bottle bill states.[15]

Although data are incomplete, anecdotal evidence suggests that beverage container deposit laws have significantly reduced litter in several states. As noted above, Maine reported decreases in litter following the introduction of its deposit scheme. Oregon reported a 75-85% decrease in roadside litter just two years after enacting deposit legislation.[16]

Another probable impact has been an increase in the percentage of containers recycled, although this is difficult to confirm due to a lack of historical data on recycling. One study estimated that the percentage of PET containers recycled in 1993 was about 80% in states with deposit systems (excluding California), 70% in California, but only 53% nationally.[17] A 1990 study found that almost 2/3 of the glass recycled in the U.S. came from the deposit states excluding California, even though these states made up only 18% of the U.S. population. If California is included, the ten states accounted for over 80% of recycled glass. All deposit states also report aluminum can return rates in excess of the national average.[18]

A related phenomenon is the relatively high share of refillable containers in states with deposit schemes. In the case of beer containers, for example, all nine deposit states (excluding California) exceed the national average for market share of refillables. The unweighted average for these nine states was 15% in 1990, three times the national average.[19]

A 1993 Congressional Research Service comparison of deposit systems and curbside recycling programs found that deposits generally resulted in higher percentages of materials returned and less contamination of collected materials. None of the states with large curbside programs but lacking deposits, the study found, had attained a recovery rate equal to that of states with deposit schemes. Moreover, glass collected through curbside programs is much more likely to break before it can be sorted by color. Such breakage makes it difficult to recycle not only glass bottles but also other recyclables that may be contaminated with glass. The largest user of recycled PET reported that because of concerns over contamination, more than 90% of the PET it purchased came from states with deposit schemes.[20]

The costs of deposit systems may be substantial for manufacturers, distributors, vendors, consumers, and regulatory authorities, and one study found California's system to be more cost-effective than those in which retailers accept redeemed containers. Deposit systems could also divert revenues from and lower the cost-effectiveness of curbside recycling programs, but at least one study found evidence suggesting that "local governments would achieve a greater diversion of solid waste from disposal at a lower cost per ton if both a bottle bill and a curbside collection program were in place."[21] One difference between the two approaches is that the costs of deposits are borne by manufacturers and distributors, who in turn pass on some costs to consumers, whereas the curbside programs are often funded by general revenues or waste tipping fees. Lack of information on the costs and benefits of litter reductions and recycling and on the costs incurred by consumers in returning containers makes it difficult to thoroughly evaluate beverage container deposit systems.

5.3. LEAD-ACID BATTERIES

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

Despite the presence of numerous voluntary schemes, 11 states have required deposit systems. As shown in Table 5-3, state laws have addressed such questions as the refund period and what portion of unclaimed refunds goes to different parties.[22]

Table 5-3: MANDATORY LEAD-ACID BATTERY DEPOSIT SYSTEMS

State	Amount	Unclaimed Refunds	Refund Period
Arizona	$5	Retailer	30 days
Arkansas	$10	Retailer	30 days
Connecticut	$5	Retailer	30 days
Idaho	$5	Retailer	30 days
Maine	$10	Retailer	30 days
Minnesota	$5	Retailer	30 days
New York	$5	Retailer	30 days
Rhode Island	$5	80% State 20% Retailer	7 days
South Carolina	$5	Retailer	30 days
Washington	Mini- mum $5	Retailer	30 days

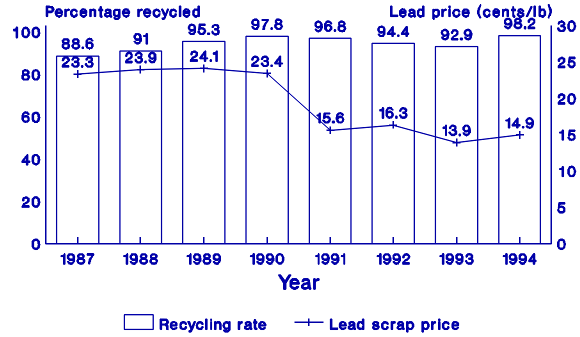
Source: Weinberg, Bergeson & Neuman.

As with beverage containers, deposit systems for lead batteries appear likely to have a significant incentive effect by offering motorists payments in return for a used product. As shown in Figure 5-3, the percentage of battery lead recycled has been estimated at over 90% since 1988.[23]

Figure 5-3 also suggests that recycling rates may be positively related to the price of lead. The fall in lead prices beginning in 1991 coincided with a fall in the percentage of battery lead recycled.[24]

(lead price data: www.mlinet.com/bci/pages/lsm023.htm)

Figure 5-3: BATTERY LEAD RECYCLING AND LEAD SCRAP PRICES IN THE U.S.



Sources: Smith, Bucklin, and Associates; Business Cycle Indicators.

5.4. MAINE PESTICIDE CONTAINER DEPOSIT SYSTEM

The discovery of over 400 uncontrolled disposal sites in Maine led the state's authorities to initiate a deposit system for pesticide containers in 1985. The rule applies to all limited and restricted use pesticides sold in glass, metal, or plastic containers, a category consisting mainly of conventional agricultural and forestry applications. Deposit amounts are $5 for containers of less than 30 gallon capacity and $10 for larger containers.

Farmers must rinse containers three times before returning them for refunds. Containers found to have significant traces of pesticides are not accepted for refunds. Collections are made at designated points once a year according to publicized schedules. Pesticide dealers arrange for container shredding equipment at the collection sites. According to the Director of the Maine Board of Pesticides Control, the deposit system has played a significant role in the reduction of improper container disposal.[25]

In 1985, the first year of operation of the deposit system, Board of Pesticides Control staff inspected 7,055 containers. Had these containers simply been drained rather than properly rinsed, 429 pounds of active ingredient would have been deposited into landfills. By guaranteeing that the containers were triple rinsed and therefore 99.998% clean, only 0.05 pounds of active ingredient was landfilled.[26]

One problem with the deposit system is that it does not apply to general use pesticide containers, which are far more numerous than restricted and limited use pesticides. One reason why general use products are not included in the system is that inspecting them would require significantly more resources. For a similar reason, a few larger states have considered a program similar to Maine's but concluded they would not be able to inspect the large number of containers in their states.[27]

5.5. OTHER PRODUCTS

Rhode Island has required $5 deposits on all types of replacement vehicle tires since 1988. Customers can recover their deposits by returning old tires within 10-14 days of the date of purchase of the new tires. Their refund payments are limited to one tire for every tire purchased, and the refunds can be obtained only at the point of sale of the new tire. In addition to the deposit, Rhode Island imposes product charges of $0.75 on tires to finance the cleanup of old tire piles.[28]

Outside the United States, deposit systems have been applied to car hulks, light bulbs, lubricating oil, and other products. These systems are described in Section 11.

5.6. VOLUNTARY DEPOSIT SCHEMES

In addition to lead-acid batteries, a few other products are subject to deposit schemes voluntarily operated by industry. Among such products are large paper drums, beer kegs, propane gas containers, and, in some areas, beer bottles and pesticide containers. As noted in Section 11, voluntary deposit schemes appear to be much more common outside the United States.

5.7. PERFORMANCE BONDS

Performance bonds are deposit payments for which the payer can obtain a refund by fulfilling certain obligations. In that sense, a performance bond acts like a deposit-refund system.

As an example of an environmental issue addressed with performance bonds, the Surface Mining Control and Reclamation Act (SMCRA) of 1977 requires performance bonds for surface coal mining and reclamation permits. The amounts are determined by the regulatory authority (either the State or the Department of the Interior) and depend on reclamation requirements specified in the permit and anticipated difficulty of reclamation due to factors such as topography, geology, hydrology, and revegetation potential of the site. SMCRA requires that the amount be sufficient to finance reclamation by the regulatory authority in case of forfeiture. The minimum amount is $10,000 per permit area. Deposit amounts are adjusted as mined areas increase or decrease and as reclamation cost estimates change.

(SMCRA complete text: www.osmre.gov/smcra/smcra.html)

Although such performance bonds give companies an economic incentive to reclaim mining sites, they are backed up by a command-and-control requirement specified in a permit. The reclamation requirement may have more of an incentive effect than the deposit.

Notes for Section 5

1. Palmer et al. (1995), Abstract. www.rff.org/dpapers/abstract/9533.htm

2. The information in the last two paragraphs and in table 1 was supplied by the Container Recycling Institute.

3. Criner, Jacobs, and Peavey (1991), p. 20.

4. Lucinda White, Maine Department of the Attorney General, personal communication, July 1996.

5. For more information on redemption problems in Maine, see Maine Legislature Office of Policy and Legal Analysis (1996). Coca-Cola's over-redemption figures are stated on p. 20 of this source.

6. Criner, Jacobs, and Peavey, pp. 25-26.

7. Cited in Criner, Jacobs, and Peavey (April 1991), p. 41.

8. Criner, Jacobs, and Peavey, p. 44.

9. Tellus Insitute (1990), *WastePlan: The integrated solid waste planning model*, Boston, MA, as cited in Criner, Jacobs, and Peavey, p. 48.

10. Information on changes in handling fees provided by Lucinda White, Maine Department of the Attorney General, personal communication, July 1996.

11. In this table, the original deposit scenario assumes that no beer or soda containers are collected in the curbside program, and the expanded deposit scenario assumes that no beer, soda, juice, wine, or liquor containers are collected in the curbside program. Under the expanded deposit scenario, the curbside program collects only newspaper and ferrous, glass, aluminum, and HDPE containers or packaging for products other than beverages.

12. Unless otherwise stated, the information on California's deposit scheme is provided by McCarthy (1993).

13. California LAO internet site, "LAO Analysis of the 1995-96 Budget Bill, Resources, Part II." www.lao.ca.gov/a96b2.html

14. *Beverage World 1994-1995 Databank*, p. 275.

15. Ackerman, Frank, Dmitri Cavander, John Stutz, and Brian Zuckerman, *Preliminary Analysis: The Cost & Benefits of Bottle Bills*, Boston: Tellus Institute, January 1995, as cited in Palmer et al. (1995), p. 31.

16. EPA (July 1992), p. 4-1.

17. Wellman Inc. (1994), pp. 66-67.

18. The 1990 glass recycling study was cited by McCarthy (1993).

19. McCarthy (1993).

20. Ibid.

21. Ibid, summary.

22. The information on state lead battery deposits was supplied by Saskia Mooney and Weinberg Bergeson & Neuman, April 8, 1996, "Summary of State Lead-Acid Battery Recycling Law."

23. Smith, Bucklin and Associates (1995), p. 1.

24. Lead scrap price data were obtained from Business Cycle Indicators (BCI): www.mlinet.com / bci / pages / lsm023.htm. BCI monthly prices were averaged to determine annual price.

25. Bob Batteese, Director of Maine Board of Pesticides Control, personal communication, 1996.

26. Batteese (1988).

27. Bob Batteese, personal communication, June 1996.

28. *Scrap Tire News Legislative Report*, January 1996, "Scrap Tire Laws and Regulations," and Paul Dudra, Rhode Island Department of Environmental Management, personal communication, 1996.

6. TRADING SYSTEMS

Emission trading systems came into use in the U.S. in the mid-1970s as a means for new sources to locate in nonattainment areas without causing air quality to worsen. From this important but modest beginning, pollution trading systems now come in a wide variety of forms, apply to a large and growing number of sources of pollution that impact air, water and land.

The general principle of pollutant trading systems is that sources may satisfy their obligations by one of two means: (1) limiting their releases of pollution to no more than the permitted amount, and (2) releasing more (or less) than the permitted amount and exchanging credits representing any deficiency (or surplus) in the quantity of emissions controlled with other sources. Sources with marginal costs of pollution control that are about average are likely to meet their obligations without trading. Sources with relatively high marginal control costs are likely buyers of pollution reduction credits and sources with relatively low marginal costs of control are likely sellers of excess credits.

Trading systems have evolved to include far more than the exchange of pollution reduction credits. For example, the well-known acid rain trading system is based on allowances for future 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 for use as an additive in gasoline. Heavy-duty truck manufacturers can meet engine emission standards by averaging together the emissions performance of all engines they produce. Programs to trade water effluents are operating in selected locations. 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 below. 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 US is involved.

A few basic parameters may be used to characterize trading systems: (1) whether trading is restricted to averaging within single facility, allowed among facilities owned by the same firm, or allowed among firms or facilities under different ownership; (2) whether there is a cap on overall emissions or effluents; (3) whether tradable certificates are obtained as allowances for future pollution or as a credit for previous pollution control actions; (4) the required trading ratio (one to one or some greater ratio); (5) whether tradable certificates can be banked or stored for future use; and (6) how credit generation and trading is monitored. The success of the trading systems described in this Section do not appear to depend upon any particular formulation; however, trading probably would not function to lower compliance costs and protect environmental quality if one or more of these parameters is not defined.

6.1. TRADING OF AIR EMISSIONS

6.1.1. EPA's Air Emission Trading Program

6.1.1.1. Offset Program

EPA's air emission trading program had its origins in the mid-1970s as a solution to the problem of locating new sources of air pollution in nonattainment areas.[1] To accommodate new sources and expansion of existing sources of air pollution, the EPA proposed the "offset" policy that permitted growth in nonattainment areas provided new sources install pollution control equipment meeting Lowest Achievable Emission Rate (LAER) standards and offset any excess by acquiring greater emission reductions from other sources in the area. Through this process, growth could be accommodated while maintaining progress toward attainment of national ambient air quality standards.

Of more than 10,000 offset trades (a few of which are described later in this Section), over 90 percent have been in California. Nationwide, about 10 percent 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 closure of all or part of a facility.

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), generated when sources reduce emissions below the lower of actual or allowable emissions and apply for the state for certification of the reduction. To be certified as an ERC, the state must determine that the reduction is (1) surplus in the sense of not being required by current regulations in the State Implementation Plan (SIP); (2) enforceable; (3) permanent; and (4) quantifiable. ERCs are normally denominated in terms of the quantity of pollutant in tons released over one 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.[2] States have approved a variety of activities that sources may use to generate offset credits. California, for example, accepts the scrapping of older vehicles and lawn mowers as means of generating credits and applies a formula to determine the magnitude of air pollution credits for each old car that is scrapped.

The four emission trading programs were subject to numerous revisions, before being incorporated into EPA's Final Emission Trading Policy Statement, issued in 1986 and addressing trading of ERCs for criteria pollutants such as sulfur dioxide, nitrogen oxides, particulate matter carbon monoxide, and volatile organic compounds that contribute to the formation of ground-level ozone.[3] 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 unity and air quality modeling for some cases).

6.1.1.2. Bubble Program

The bubble program, 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. A bubble can include more than one facility owned by one firm, or 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. An additional 34 bubbles were approved 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. No estimates are reported for the number or savings from post-1986 bubbles. Bubbles are designed to be neutral in terms of environmental impact.

6.1.1.3. Banking

EPA's initial offset policy did not allow 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 willing to create and supply credits.

The offset policy in the 1977 amendments to the Clean Air Act included provisions for banking of emission reduction credits for future use or sale. Although the EPA has approved several banks, there has been limited use of the provision, most likely because of the uncertain nature of the banked ERC. EPA determined in 1980 that an ERC cannot be 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 banked ERCs.[4] A 1994 report identified 24 emission banks; some limited ERCs to a life of as little as five years.[5] 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.

6.1.1.4. Netting

Netting, the final component of EPA's emission trading policy, dates from 1980 and 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 the emission trading programs; one source estimates that between 5,000 and 12,000 sources have used netting.[6]

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 which 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).[7] 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 caused by the permitting process.

EPA's Office of Air and Radiation announced on April 3, 1996 a series of proposed revisions to new source regulations expected to reduce by more than one-half the number of permitting actions new sources and sources undergoing changes must take. Because the proposal shares many of the features of netting, it is described here. The proposed regulations would allow sources to use plantwide limits and 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 plantwide emissions cap (generally this would be the source's maximum potential emissions). Process changes could be made so long as the changes did not result in an increase in emissions beyond the cap.

6.1.1.5. Evaluation of Emissions Trading Program

Foster and Hahn provide the most comprehensive evaluation of the emissions trading program, using data for offset transactions in the Los Angeles area.[8] They obtained data on trading activity from the South Coast Air Quality Management District, reported 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.

During the period 1985-1992, over 10,000 tons of pollutants were traded in the offset program, with total expenditure on ERCs estimated to be on the order of $2 billion (indicating an average price for traded pollutants of about $200 per ton. Nearly three quarters of the trades involved reactive organic gases (SCAQMD terminology for a subset of volatile organic compounds), but there also were trades in CO, 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.[9] 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 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 transactions costs to the seller (thought to be a minimum of $10,000 per transaction). In a few cases, transactions costs apparently exceeded the market value of the credits that were exchanged.

Though the highest and average prices increased over the period, most of the change in 1991 can be attributed to a change in SCAQMD rules the prior year. None of the observed prices remotely approach the typical incremental control costs for ROG and 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.

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 the area could offer to attract new firms. Offset ratios greater than unity further depressed the value of ERCs. In many areas it appears that ERCs had an economic value less than the transactions costs of completing a sale to another party.

In other respects, the emission trading program revealed the myriad possibilities for emission trading and many of the features that would be necessary to make trading viable. It served as the foundation for the enormously successful lead credit trading program and the many emission trading features of the 1990 Clean Air Act Amendments. In some respects, however, the 1990 Amendments reduced the scope of trading programs. For example, Section 173(b) restricts the use of growth allowances in State Implementation Plans, limiting the use of offsets. A number of states have redesigned their offset programs as trading programs without emission caps (examples include Delaware, Massachusetts, Michigan, New Jersey, Texas, and Wisconsin as described below). The Los Angeles area has developed a much more significant trading initiative known as RECLAIM with an emissions cap and phased reductions in allowable emissions of SO_2 and NO_x. Illinois expects to have a similar program with an emissions cap in place soon.

Regional trading programs that involve several states also are under development, as described below. In June 1993 NESCAUM (Northeast States for Coordinated Air Use Management) launched a Demonstration Project to trade *discrete emission reductions*

(DERs). The Ozone Transport Commission (OTC) received approval from EPA for "cap and trade" system in NO_x emission allowances. The Ozone Transport Assessment Group (OTAG) is working on a regional trading program for NO_x and perhaps also VOC that would cover the eastern one-half of the U.S.

Table 6-1: EMISSION TRADING ACTIVITY IN THE LOS ANGELES AREA
(all trades reported to SCAQMD)

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

Source: Foster and Hahn

6.1.2. RECLAIM

The highest ozone levels in the nation are recorded in the Los Angeles area, with readings often exceeding twice the national ambient air quality standard of 0.12 ppm.[10] The South Coast Air Quality Management District (SCAQMD or District) also fails to meet the particulate and CO standards, though not by such a large margin. Historically, the SCAQMD has relied on command and control rules to limit emissions of ozone precursors (as well as other pollutants).

Despite making substantial progress over the past three decades in improving air quality in the Los Angeles Basin, it was apparent to SCAQMD officials that further progress toward attaining federal standards would be prohibitively expensive using traditional regulatory approaches.[11] By 1990 the marginal costs of NO_x control in the District had reached $25,000 per ton at electric power plants, versus $5,000 (or less) nationally. Proposed SO_2 controls on catalytic cracking units at refineries would have cost $32,000 per ton, versus national costs of perhaps $500 per ton (see the section describing the Acid Rain allowance trading program). Consequently, the District began to investigate the feasibility of creating a marketable permit in the ozone precursors VOC and NO_x as well as SO_2 (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) that would include about 2,000 sources of reactive organic gases (representing about 85 percent of permitted stationary source emissions), 700 sources (representing 95 percent of permitted NO_x emissions), and about 50 sources of SO_2 (representing about two-thirds of permitted stationary source emissions). Each market would start with an allocation of emissions equal to the 1994 emissions target in the District's Air Quality Management Plan (AQMP). Each marketable permit program would reduce emissions annually by amounts necessary to achieve the AQMP targets: attainment of air quality standards by 2003 for SO_2 and NO_x and VOC emissions goals by 2010.

For the NO_x and SO_2 programs, emissions originated at combustion sources with well-defined exit points to the environment. Emission monitoring would be based on stack gas measurement, a relatively simple task that increasingly is accomplished with remote sensing devices. For VOC the market was based largely on evaporative emissions, which are inherently more difficult to measure. Prospective VOC trading also was complicated by the fact that ROG are not homogeneous; some react much more readily than others to form ozone. Further, some ROG also are classified as toxic pollutants and regulated separately. After about one year of analysis and discussion, RECLAIM officials decided to defer including ROG and concentrate on program design for NO_x and SO_2.

A basic issue for both programs was which facilities would be included. Despite the prospect for lower control costs that would accompany participation in a marketable permit program, a number of sources argued for exemptions due to concerns about the future price and availability of marketable permits. District officials eventually exempted sewage treatment plants, landfills, and three small municipally-owned power plants.

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

Monitoring and reporting issues also proved controversial, with lengthy debates over how emissions would be measured and how often reports would be filed. Industry sought to file one report per year, while public health agencies and environmentalists wanted daily or weekly reporting. The EPA sought assurance that the hourly 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 participating facilities in RECLAIM. Sources installed continuous emission monitors (costing $100,000 to $150,000 each) on every boiler emitting 10 tons annually or more. The CEM recorded pollutant readings minute by minute and sent the readings to a remote terminal that averaged the readings over fifteen minute periods and forwarded the number to the AQMD central computer. An artificial intelligence system analyzed the data and verified compliance by each boiler. When the system detected a potential problem, inspectors were dispatched to investigate further.

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 command and control regulations would be an average of $58 million annually for each of the next ten years, muting industry 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.[12] After 2003 the balance remains constant. The RTC are denominated in pounds: one RTC equals one pound of emissions. Sources are free to trade RTCs for the current year or for future years; however, all RTCs are good only for the year for which they are issued. Trades in RTCs are limited by geographical factors; for a potential buyer, the number of credits required to offset a pound of emissions varies with the location of the seller. The District maintains records of all transactions in RTCs and shares that information with market participants. The RTC bulletin board can be reached via modem at 909-396-3499.

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

In 1994, the NO_x and SO_2 markets began with 370 sources and 40 sources, respectively. Both markets represented approximately 70 percent of stationary source emissions. Analysis shows that the program should reduce NO_x emissions by an average of 8.3 percent per year (amounting to a cumulative reduction of 80 tons per day by 2003) and SO_2 emissions by 6.8 percent per year (a cumulative 15 tons per day by 2003). The District projects that RECLAIM will lower compliance costs by 42 percent compared to a command and control approach: $80.8 million versus $138.7 million.

As a means of jump starting the market, the SCAQMD held an auction of RTCs on July 29, 1994. Utilities, which had by then installed new emission control equipment and did not need their full allocation, were large sellers of NO_x credits. A total of 114,676 NO_x credits and 9,400 SO_2 credits changed hands at the auction. Prices for RTC were low for near years and much higher for more distant years (See Table 6-3). In all cases, though, the cost for a ton of credits was far lower than the marginal control costs from recently enacted or proposed command and control regulations. In a privately negotiated transaction in August 1995, Unocal reported paying Anchor Hocking $3.65 million for 8.6 million pounds of NO_x emission credits. The per ton price ranged from less than $20 to $2000, depending upon the credit's year of validity, prices that are very much in line with the 1994 auction.

Table 6-2: RECLAIM TRADING CREDIT PRICES
(July 1994 auction)

Year	NO_x	SO_2
1994	2	
1995	334	1,500
1996	574	1,900
1997		
1998		
1999	1,480	
2000	1,580	
2001	1,700	
2002	1,830	
2003	2,090	

Source: BNA *Daily Environment Report*, August 10, 1994, p. A-1

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 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 met with fierce opposition from environmentalists who charged that the 1989 baseline selected for emissions could result in a huge increase in emissions over 1993 levels when the program starts.[13] Regulators sought the 1989 baseline to avoid locking industry into emission levels associated with recessionary conditions in 1991 through 1993. Industry representatives note that the AQMP has a schedule for orderly reductions over time toward the 2010 goals. In their view, emissions increases from 1993 to 1996 as the economy pulls out of a recession are not relevant so long as emissions remain below the target levels in the AQMP.

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

RECLAIM officials hope to launch by the fall of 1996 an expansion of the program to 30,000 companies, from the 400 at present. And in the latest of its innovations for reducing ozone precursor emissions, the SCAQMD announced on May 13, 1996 that it will offer tradable "smog credits" to lawn mower retailers for accepting and scrapping the 1.7 million gasoline-powered mowers in the District.[14] SCAQMD estimates that a single mower used for 20 hours a year emits as much VOC emissions as a new car driven 26,000 miles. Credits for scrapping lawn mowers would complement other means available to firms for earning credits, such as scrapping older cars and increasing employee use of car pools.

RECLAIM has won praise for its progress to date. A state-mandated performance review found that the District has a state-of-the-art air quality program that is performing efficiently and effectively.[15] According to the report, RECLAIM, demonstration projects to stimulate technological development, and outreach and compliance programs have helped save or create over 10,000 jobs while achieving air quality improvement.

6.1.3. Other State Air Emission Trading Programs

6.1.3.1. Illinois

Unveiled in March 1995 and expected to begin operations in 1997, the Illinois Clean Air Market will allow the trading of VOC emission credits between firms in the Chicago nonattainment area. Like RECLAIM, the program is 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. If all eligible sources of 10 tons of VOC per year choose to participate, the program would have 283 participants. The Illinois EPA estimated that companies would have the potential to save $160 million annually in compliance costs.[16]

An earlier program in Chicago was aimed at trading NO_x allowances; however, the *Lake Michigan Ozone Study* released in 1994 showed that reducing NO_x emissions substantially could have the effect of increasing ground level ozone. Consequently, efforts to reduce NO_x levels in the immediate Chicago area have been put on hold.

6.1.3.2. Delaware

In December 1995, the state Department of Natural Resources and Environmental Control proposed a trading program in VOC and NO_x emissions. The program would stationary sources and mobile sources, through such features as vehicle scrapping and employee trip reduction efforts. The program is expected to become operational in early 1996.

Delaware also was one of the first states to approve facility-wide permitting. In October 1995 Chrysler obtained permission to set a facility-wide limit on air emissions from its Newark Delaware auto assembly plant.[17]

6.1.3.3. Massachusetts

In September 1993, Massachusetts officials announced a trading program involving new and existing stationary source and mobile source emissions of three pollutants: VOC, NO_x, and CO. The program allows sources to bank emission reduction credits (ERC) obtained for reducing emissions below permitted levels. On February 22, 1995 the US EPA gave tentative approval to the program. In June 1995, Massachusetts officials announced the first trade under the program, as Montaup Electric bought NO_x credits from New England Power Company. Montaup Electric also announced that it would donate to the state 5 percent of the 65 tons of ERCs it purchased and retire any credits it does not use.

6.1.3.4. Michigan

The Michigan Department of Environmental Quality designed a voluntary statewide air emissions trading program in VOC and all criteria pollutants except ozone that took effect on March 16, 1996. The Michigan program is voluntary, allowing all stationary and mobile sources to participate. Sources earn ERCs for emission reductions beyond what is required by an emission standard or limitation. Sources may bank ERCs for future use, trade emission reduction credits, or engage in emission averaging. To ensure an environmental benefit, the DEQ will retire 10 percent of all ERCs.

6.1.3.5. New Jersey

Under the 1991 Pollution Prevention Act, the State's Department of Environmental Protection is testing the use of facility-wide permits that would incorporate pollution prevention into the permitting process and improve the overall administrative efficiency of permitting by consolidating the air, water and waste permits into a single, facility-wide permit.[18] This meant that as many as 150 separate permits at a facility were rewritten as a single permit. As an inducement for firms to participate in the pilot test, New Jersey allows operations with facility-wide permits to change processes without prior approval provided the facility continues to meet existing emission standards and the process changes do not increase hazardous air emissions or wastes. Firms that apply for the pilot program must agree to expand the number of pollutants in their pollution prevention plans. As of December 1995, New Jersey had accepted three firms (out of 18 applicants) into the program.

In mid-June 1995, New Jersey officials proposed an air pollution trading system that would allow companies to meet permit limits by acquiring credits earned by other companies for reducing emissions below permitted amounts. The US EPA indicated the proposal would be accepted.[19]

6.1.3.6. Texas

With a grant in 1992 from the EPA, the Texas Air Control Board began to evaluate and design a marketable permit program for air pollutants with special emphasis on the Houston nonattianment area. Using an incremental approach, the State first created an emission reduction credit bank in 1993 and later adopted rules for community-wide trading. One of the means by which ERCs may be generated is scrapping polluting motor vehicles. The Texas scrappage provisions require actual measurement of vehicle emissions to determine the number of credits earned. This differs from the approach in California which relies on a formula to determine credits.

The first trade under the trading program took place in July 1995 and involved Anchor Glass Container, which sold 125 tons of NO_x ERCs to Rollins Environmental Services. Rollins plans to use only 96 tons of ERCs with the remainder to be retired to improve air quality in Houston. A broker involved in the transaction indicated terms of the sale are confidential, but that if Anchor has more credits for sale they could be sold for between $5,000 and $15,000 per ton in the Houston area.[20]

The Texas ERC bank had 370 tons of VOC in inventory as of July 1995 waiting for a buyer. Demand for VOC credits has been slow because sources have been able to achieve required reductions internally, partly as a consequence of new "flexible" permitting rules.

Texas implemented "flexible" air permit rules effective December 1994 that allow a company to make equipment and process changes at a facility provided that total emissions remain below a permitted maximum level. Emission caps under this program are set at levels that reflect use of state of the art equipment and are generally lower than what is allowed under traditional permitting. Historically, the State required the approval of individual pieces of pollution control equipment and the modification of a source's permit every time there was a process change. The "flexible" permitting approach allows sources to engage in intra-plant trades within the emission cap. In the 14 months to March 11, 1996, the State had issued 11 "flexible" air permits.

6.1.3.7. Wisconsin

In 1996 the Wisconsin Air Bureau expects to have EPA approval for a trading program in VOC and NO_x emissions. The chief remaining point of contention in developing the program is the credits to offer in instances of facility shutdown and production rollback. To discourage the long-term banking of emission credits, the State proposed to subject banked shutdown credits to a "banking" fee of $35 per ton in the first year the credit is certified, with the fee doubling every year thereafter until the credit is used or sold.[21] Like the four other state programs described above, the Wisconsin proposal was developed largely in response to provisions of the Clean Air Act Amendments of 1990 regarding the use of offsets for new sources.

6.1.4. NESCAUM/MARAMA Demonstration Project

The NESCAUM/MARAMA Demonstration Project, initiated in June 1993, joins regulators, environmentalists and members of the business community to resolve the issues surrounding emission trading in the states from North Carolina to Maine.[22] The first phase in 1993 developed principles for creating discrete emission reductions (DERs). The second phase, completed in 1995, developed portocols to promote an environmentally sound trading system by reviewing actual and proposed trades. The third phase assisted the EPA in developing its Open Market Trading Rule, enacted on July 26, 1995 (see below).

Phase two reviewed twelve proposed DER trades. Several trades were completed, including a June 1 1995 transaction in which Merck purchased 10 tons of NO_x credits valid for one year from Public Service Electric and Gas Co. for $16,000, or $1,600 per ton, to meet requirements in its operating permit.

6.1.5. OTC/OTAG Regional NO_x Reduction Program

Title I of the Clean Air Act Amendments establish a northeast transport region consisting of 12 states and the District of Columbia, which runs from northern Virginia to New England. This region in effect is treated as one Moderate ozone nonattainment area requiring RACT controls. Title I also called upon EPA to establish an Ozone Transport Commission (OTC) as a consensus building organization with representation from each affected jurisdiction to recommend additional control measures. By September 1994, the OTC had obtained agreement among all participants except for Massachusetts and Virginia that its model rule for controlling NO_x should be implemented.[23] Massachusetts signed recently, leaving Virginia as the only non-signatory. Virginia has declined to sign the agreement before ozone modeling is done (possibly a reflection of the fact that northern Virginia, the only part of the state in the OTR, has few large NO_x sources.

The agreement divides the region into three zones with different magnitudes of NO_x reduction. Within the Inner Zone, which includes the northeastern corridor from northern

Virginia to southern New Hampshire, large stationary NO_x sources (utilities and industrial boilers) must achieve the less stringent of a 65 percent reduction relative to 1990 baseline emissions or an emissions rate no greater than 0.2 pounds of NO_x per million Btu by May 1, 1999. By 2003 these requirements become a 75 percent reduction and 0.15 lb / MBtu for Inner Zone facilities. Facilities in two other zones, designated the Outer Zone and the Northern Zone, are required to achieve lesser reductions.

The agreement establishes a program for trading NO_x reduction credits that closely parallels the acid rain allowance trading program. Both programs create allowances and provide for trading of allowances under a cap that decreases over time and both programs encourage banking of excess allowances. The OTG has worked out the total NO_x budget for 1999 and 2003, as well as allocations to each state. Under the OTC plan, states would be responsible for the further division of allocations to individual sources within the state. OTC estimates that the trading feature of its proposal will save approximately 30 percent in compliance costs (nearly $80 million on an annualized basis) relative to uniform reductions at each source. The OTC NO_x trading program is scheduled to begin in May, 1999.

The issue of expanding the control of NO_x emissions (and perhaps also VOC emissions) outside the ozone transport region is being addressed by the Ozone Transport Assessment Group, which was organized through a March 1995 EPA policy memorandum that asked each of the 37 states east of the Mississippi River and the District of Columbia to look at the problem of ozone formation and transport within that entire region.[24] OTAG is at a much earlier stage of development than its OTC counterpart. Its primary activity to date is modeling the effects of different ratios of NO_x and VOC throughout the OTAG region. NO_x has been the primary focus of the modeling efforts since it is transported over greater distances than are VOC. If OTAG determines that controls on NO_x or VOC beyond those called for the Clean Air Act Amendments of 1990 are required, OTAG is expected to propose a trading option.[25]

6.1.6. Open Market Trading

On March 16, 1995, President Clinton announced 25 initiatives for regulatory reinvention at EPA, the first one of which was an "open market" air emissions trading rule to help achieve the national ambient air quality standard (NAAQS) for ozone in nonattainment cities faster and at lower cost. The announcement read in part:

> EPA will issue an emissions trading rule for smog-creating pollutants that will allow States to obtain automatic approval for open market trading of emissions credits with accountability for quantified results. Expanding use of market trading on a local and regional level will give companies broad flexibility to find lowest cost approaches to emissions reductions. The rule will encourage experimentation with new trading options, while enabling States to pursue more quickly allowance-

based cap systems, which are already under development in some areas.[26]

In August 1995, EPA published a proposed open market trading rule, demonstrating the Agency's strong support for innovative, market-based approaches that would produce less expensive and faster progress toward meeting the NAAQS for ozone.[27] The term "open market" was used to distinguish the approach from programs with an emissions budget or cap, the so-called "closed market" system. Offered as a model of what states could adopt within their State Implementation Plan (SIP), the proposed rule would allow sources to legally substitute discrete emission reductions (DER) for on-site compliance with pollution control equipment. DERs could be offered on the market by sources that control more than required, much like the earlier offset program. The open market trading rule placed responsibility for the quality of DERs on firms that used them for compliance.

The Agency received numerous comments on the proposal, not all of them favorable. One of the most common complaints was that the seller of DERs should bear some (or all) of the responsibility for assuring their quality. Otherwise, the market could be flooded with offers, many of them of dubious quality, and sources seeking to use the DERs for compliance would have great difficulty determining the quality of what they were acquiring. The market in DERs could flounder unless this problem is resolved, according to potential DER users. Whether (and in what form) the Agency reproposes the open market trading rule remains under consideration as of the writing of this Section.

Many of the programs developed by states and local areas in response to (or are at least compatible with) EPA's open market trading initiative are summarized in the EPA Directory of Air Quality Economic Incentive Programs: On-line Database, which can be accessed from the following Web address: http://www.epa.gov/omswww/market.htm.

6.1.7. Acid Rain Allowance Trading

An early solution to the problem posed by SO_2 and nitrogen oxide emissions from power plants was to build tall stacks to disperse the pollutant away from populated areas. By the 1980s, though, this strategy fell into disfavor as studies began to demonstrate probable harm to lakes and forests, agricultural crops, materials, and other valuable resources from acidic precipitation. Studies also revealed that acidification of soils and waters could release heavy metals and aluminum previously bound in the soils, posing a risk to human health and to ecosystems.[28]

Though great scientific uncertainty surrounded almost every aspect of the acid rain issue, legislators in states affected by acid rain were understandably interested in implementing some form of control program. In Title IV of the Clean Air Act Amendments of 1990, Congress created a program for the control of SO_2 emissions from utility sources that would cut total national emissions by approximately one-half at an estimated cost of $4 to $5 billion per year. The program sets a cap of 8.95 million tons of SO_2 per year, to be achieved in two phases. During the Phase I, which began in 1995 and ends in 2000, the 110 highest emitting coal-fired power plants (with a total of 256 coal burning "units") must reduce emissions to meet a tonnage cap equal to 2.5 lbs. of SO_2 per million Btu multiplied by each unit's average 1985-1987 Btu consumption.[29] The tonnage cap is expressed in terms of "allowances," with each allowance good for one ton of SO_2. Phase I will yield a nationwide reduction in emissions of 3.5 million tons of SO_2. Sources that fail to meet these limits are subject to a penalty of $2,000 per ton of "excess" emissions. In the second phase, which begins in 2000, all power plants producing more than 25 megawatts and all new facilities must meet an emission cap computed as 1.2 lbs. of SO_2 per million Btu times each unit's 1985-1987 Btu consumption.[30] Phase II reductions will total an additional 5 million tons and will reach the overall 8.95 million ton cap.

Utilities must install continuous emission monitoring systems (each one costing approximately $250,000) to verify compliance with the emission limits, and file quarterly reports of their hourly emissions data with EPA. Initially sources mailed these data to EPA on floppy disks, but EPA is now encouraging electronic transmission. Continuous emission monitoring systems (CEMS), the accepted industry standard for measuring SO_2, NO_x, and CO_2, provide an accurate accounting of emissions, assuring both buyers and sellers that the commodity they are trading is real.

Prior to the drafting of this title of the Clean Air Act, a number of studies had identified potential cost savings of up to $1 billion per year through emission trading due to significant differences among utility sources in the marginal cost of abatement.[31] Title IV created a market-based trading system in SO_2 under which utilities may buy or sell allowances for future production of SO_2. Title IV also sets allowable limits on NO_x emissions from utility boilers. Though these emissions are not subject to the same type of market-based trading system as SO_2, an owner of two or more power plants may comply with the NO_x requirement by averaging emissions across all of its power plants.

SO_2 allowances may be used for 30 years, giving utilities the flexibility to develop compliance approaches during their regular planning cycles. Utilities may satisfy their emission limits by controlling emissions to the required extent or through participation in the allowance market. Under the authority of Title IV, EPA developed an allowance tracking system that serves as the official record of ownership and transfers. In addition to private transactions in allowances, Title IV directed EPA to offer at an annual auction beginning in 1993 allowances equivalent to about 2.8 percent of total allowances to assure that some allowances would be available for utilities that planned on complying with their emission limits by purchasing allowances. EPA also was authorized to make a small quantity of allowances available at the price of $1500 per ton to guarantee the availability of allowances if utilities found themselves out of compliance and had no other recourse.

Beginning January 1, 1995 the EPA can allocate up to 300,000 bonus allowances from its Conservation and Renewable Energy Reserve to utilities that undertake energy efficiency and renewable energy measures. In December 1995, the EPA announced awards to ten utilities totalling 8,635 allowances under this program.[32]

In March 1995, EPA expanded the acid rain program to include industrial facilities that burn fossil fuels. The rule establishes an "opt-in" program that allows industrial and other sources to participate in the existing SO_2 program that previously included only utilities.[33] Industrial sources that participate in the program will have an allocation of allowances that they can use for compliance or sell or trade to other sources.

Results from 1995 and 1996 show that the Acid Rain Program has been very successful, with firms over-achieving the reductions target at less than one-half the forecasted cost. These results appear to derive more from the emissions cap and flexible technological requirements, rather than trading, per se. By early 1997 utilities had exchanged over 7.2 million allowances and purchased an additional 300,000 allowances through the annual auction. Intra-firm transfers, which are believed to be significant, are not included in this total. While this activity is not negligible, most utilities were not relying on trading allowances to achieve compliance. The price of allowances has been far below what had initially been forecast, an issue that has attracted considerable attention (see Table 6-3). Before the Clean Air Act Amendments of 1990 were passed, industry estimates of abatement costs were as high as $1500 per ton, leading Congress to use that figure for the price of direct allowance sales by the EPA.

In searching for explanations for the relatively low level of activity, analysts have cited transactions costs that could reduce realized gains from trading allowances, the behavior of public utility commissions, and state legislation that promotes the use of locally-produced coal.[34] Another factor is that utilities have traded between facilities owned by the same company (so-called "intra-utility" trading) rather than between facilities owned by different parent companies ("inter-utility" trading). Only the latter trades are included in the totals reported above.

Low allowance prices appear to have their explanations too, as detailed by Burtraw. Prices for virtually every form of compliance have declined well below what had been anticipated before 1990. The price of low-sulfur western coal delivered to midwest and eastern markets has declined due to productivity improvements in extraction and transport. Engineers have found ways to blend low-sulfur coal with high sulfur coal to reliably meet emission limits. Innovations in the scrubber market have cut the cost of scrubbing by approximately one-half. Apparently the decline in allowance prices over time is largely a consequence of improvements in productivity and technology, encouraged by the flexibility of the Acid Rain Program.

Economists have criticized the mechanics of the auction, suggesting that it may also contribute to lower prices than otherwise would occur.[35] The Act requires what is termed a discriminating price auction, which ranks bids from highest to lowest.[36] EPA has interpreted this as requiring that each seller receive the bid price of a specific buyer. The auction awards allowances offered by the seller with the lowest asking price to the bidder with the highest bid price first and moves up the supply list and down the bid list until no bidder is willing to offer what a seller demands. This unusual auction mechanism apparently causes sellers to misrepresent and under-reveal their true costs of emission control.[37] EPA may consider using a single price auction, which in theory should elicit higher bids

Table 6-3: ESTIMATED AND AVERAGE REALIZED ALLOWANCE PRICES
(nominal dollars per ton)

Pre-1989 industry esti-mates	1990 EPA esti-mate	Early trades	1993 CBOT auction	1994 CBOT auction	1995 CBOT auction	1996 CBOT auction	1997 CBOT auction
$1,500	$750	$250	$122	$140	$126	$66	$110

. The role that allowance trading is playing in stimulating cost-effectiveness in SO_2 control at coal-fired power plants will continue to be debated. There is no doubt that SO_2 control has experienced tremendous technological and productivity improvements over a very short period of time, leading to much lower allowance prices than had been anticipated. The issue is the extent to which these gains could have been achieved without allowance trading. One analyst concluded that it is the flexible, performance-based design of the acid rain control program, rather than allowance trading *per se* that has stimulated the development of low cost compliance measures seen in Phase I, and that allowances trading had played a positive but lesser role.[38]

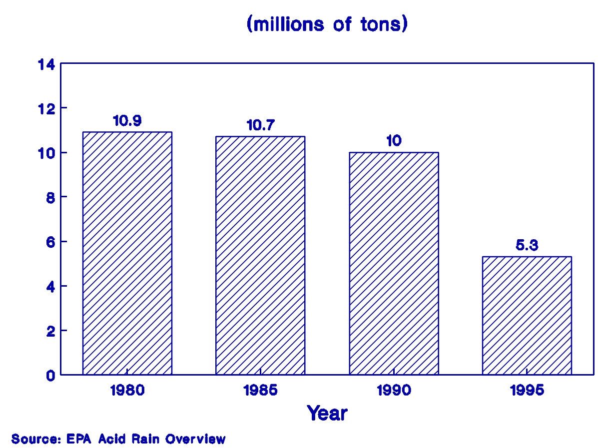
A question, then, is what effect trading actually has had - and what effect it is likely to have in the future. A few utilities clearly are buying allowances as part of their compliance plan. At the March 29, 1993 auction, Carolina Power and Light bought approximately two-thirds of the allowances offered. At the March 27, 1995 auction Duke Power bought over one-half of the allowances offered. More broadly, however, allowance transactions and especially auctions provide a very visible price benchmark against which utilities and regulators can gauge performance.

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

A recent 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.[39] Early estimates of the costs of acid rain control put the costs at $4.5 to $6 billion annually if a command and control approach were adopted.[40] The same report estimated the mean value of annual health benefits at $10.6 billion in Phase I and $40 billion in Phase II. Benefits to the environment and to materials previously had been placed at approximately $2 billion annually.[41] Interestingly, health benefits were not a major concern in the design of acid rain control legislation, yet they now appear to be the dominant benefit component, dwarfing earlier estimates for the environmental effects.

Phase I, which began in 1995, affects 263 separate combustion units at 110 coal-fired power plants. An additional 182 combustion units joined Phase I as compensation or substitution units, raising the total of Phase I units to 445. Preliminary emissions data compiled by EPA show that SO_2 emissions control is far ahead of schedule; during 1995, emissions from all Phase I sources amounted to 5.3 million tons, approximately 40 percent below the required level of 8.7 million tons and only about one-half of what these units had emitted during the 1980s (see Figure 6-1).[42]

Figure 6-1: PHASE I SO_2 EMISSIONS



6.1.8. Chlorofluorocarbon Production Allowance Trading

The Montreal Protocol on Substances that Deplete the Ozone Layer called for a cap on chlorofluorocarbon and halon consumption at 1986 levels, with reductions scheduled for 1993 and 1998.[43] 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.

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 command and control approach to end uses would cost more than $300 million for record keeping and reporting, versus only $2.4 million for the allowance trading approach.[44]

Title VI of the Clean Air Act Amendments of 1990 modified the trading system to allow producers and importers to trade allowances within groups of regulated chemicals segregated by their ozone depleting potential.[45] 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 use of these substances, while CFC-12 users maintained their demand. By 1994, the quantity of CFC-11 and CFC-113 swapped for CFC-12 grew to 26 million kilograms. EPA rules implementing Title VI specify that each time a production allowance is traded, one percent of the allocation is "retired" to assure further improvement in the environment.

EPA coupled the marketable allowance trading system with excise taxes on CFC production, which are discussed in the section on fees, taxes, and charges. The rationale for the excise taxes was that the restrictions on the quantity of CFCs and halons offered on the market would lead to rapidly escalating prices. The excise taxes were designed to capture "windfall profits;" whereas the allowance trading system was designed to assure that production and import of the substances was efficient (concentrated at the lowest cost producers, who then produced the most valued CFCs).

6.1.9. Lead Credit Trading

As early as the 1920s tetra-ethyl lead was added to gasoline by refiners to increase octane and reduce premature combustion in engines, allowing more powerful engines to be built. Lead additives in gasoline were the least expensive of several ways of raising octane. The additives also prevented premature recession of valve seats.

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. New production vehicles by 1975 were equipped with catalysts to meet tailpipe emission standards for hydrocarbons, carbon monoxide and nitrogen oxides 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 run on leaded gasoline. As catalyst-equipped vehicles began to dominate the fleet, sales of unleaded gasoline reached about 80 percent of all gasoline sales by the mid 1980s.

Concerns about the role of airborne lead in adult hypertension and cognitive development in children motivated EPA to also 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 mounted concerning the magnitude and severity of the health effects attributable to lead.

EPA acted to curtail sharply the remaining use of lead in gasoline, initially setting as a limit 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 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, in effect extending 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 at 1.0 gm/gal, a refiner producing 1 million gallons of gasoline with average lead content 0.5 gm/gal would earn 500,000 lead credits. EPA enforcement relied on reporting requirements and random testing of gasoline samples. Reporting rules were simple; each refiner or importer was obligated to provide 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 percent of all transactions were reported accurately; however several dozen fraudulent transactions occurred.[46] 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, the lead credit trading program was quite successful. Lead credit trading as a percentage of lead use rose above 40 percent by 1987. Some 20 percent of refineries participated in trading early in the program, rising to 60 percent by the end of the program.[47] Early in the program 60 percent of refineries participated in banking, rising to 90 percent 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 when lead credits were traded, the price increased from about 3/4 cents/gm to 4 cents/gm.[48] Nearly one-half of all lead traded was between refineries owned by the same firm.[49] With external transactions, refiners revealed a preference to deal with normal trading partners even though they could obtain a better price elsewhere.

This indicates that even though there was an active market in lead credits, trading did not produce least cost outcomes.

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. The lead trading program 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, though, as noted above, refiners did not maximize gains from trade. Also, despite seemingly foolproof procedures for catching fraudulent trades, some small refiners and ethanol blenders nonetheless sold more credits than they had earned.

6.1.10. 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 refiners to develop reformulated fuels. The Amendments require tailpipe emission reductions of 35 percent for hydrocarbons and 60 percent for NO_x, starting with 40 percent 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 a further cut of 50 percent below these standards by 2003 unless it finds such reductions are not necessary, technologically feasible or cost-effective.

Title II requires that states with CO nonattainment areas with design values of 9.5 or higher must implement a program to supply oxygenated fuels in winter months. Gasoline sold in the 41 cities affected by this requirement must have an oxygen content of 2.7 percent 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 suppliers.

Title II requires that the 9 worst ozone nonattainment areas offer reformulated gasoline during the summer months and specifies several performance characteristics for reformulated gasoline, as well as certain fuel properties including a minimum oxygen content of 2 percent by weight beginning in 1995. Under so called "opt in" provisions, an additional 31 areas applied to be included in the RFG program. Title II allows states to 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 that collectively the standards were satisfied.

In October 1992, EPA issued rules for trading programs in oxygenates; however, participation is optional for the affected states.[50] 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, 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 percent 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 percent requirement.

While trading in oxygenates (and other fuel constituents) theoretically offers a cost-effective means of meeting RFG requirements, in fact the trading programs have been moribund. Only the Pennsylvania part of the Philadelphia ozone nonattainment area adopted trading rules and within that area no trades have been reported. Other areas have declined to allow trading, citing as prohibitive the costs of monitoring such a program.

6.1.11. Heavy Duty Truck Engine Emissions

Title II of the Clean Air Act Amendments of 1990 directs EPA to set standards for particulate and NO_x emissions from heavy duty truck engines. The standards must represent the maximum degree of reductions achievable, with the objective to accomplish a 75 percent reduction in the "average of actually measured emissions." EPA interpreted this language to allow engine manufacturers to average together the emission performance from all heavy duty truck engines they produce.

Averaging of emissions facilitates compliance, since not every class of engines has to meet the 75 percent reduction standard. How much engine manufacturers actually save is unknown; however, a recent paper that examined a similar type of engine performance averaging program for light-duty trucks proposed in California found that the cost savings were likely to be modest.[51]

6.1.12. Hazardous Air Pollutants

6.1.12.1. Early Reduction Program

In December 1992, EPA issued final rules for the early reduction of hazardous air pollutants.[52] If a facility qualifies by reducing hazardous air pollutants by 90 percent (95 percent in the case of hazardous particulate emissions) prior to EPA proposing MACT regulations on the source category, the facility may defer compliance with the new maximum available control technology standards (MACT) for up to six years. Because participation in the program is voluntary, a source must anticipate cost savings or it would not have an incentive to participate. Once a source is accepted into the program it becomes legally obligated to meet the 90 (or 95) percent emission limitation. Trading exists intertemporally in that sources exchange their early reductions for their later reductions.

EPA has shown how 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. Table 6-4 illustrates the time profile of emissions. The source has reduced emissions by 360 tons in years 1-4 in exchange for 48 tons of emissions in years 5-10. Total emissions are reduced by 312 tons.

Table 6-4: EXAMPLE OF EMISSION BENEFITS OF EARLY REDUCTION PROGRAM

Year	MACT Emissions	Early Reduction Emissions
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

By mid-1993 over 60 chemical plants had asked to participate so as to avoid for 6 years the synthetic organic chemical MACT standard. Other types of facilities also had applied to join the program.[53]

6.1.12.2. Petroleum Industry NESHAPS

This NESHAP rule, promulgated on August 18, 1995, establishes MACT requirements for process vents, storage vessels, wastewater streams and equipment leaks tanks at refineries. The rule specifically includes marine tank vessel loading activities and gasoline loading racks. The rule excludes distillation units at pipeline pumping stations and certain process vents that EPA determined to be subject to future NESHAP rules: catalyst regeneration on cracking units, vents on sulfur recovery units, and vents on catalytic reforming units.

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

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

6.1.12.3. Hazardous Organic Chemical NESHAP

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

6.1.13. Corporate Average Fuel Economy Standards (CAFE)

The Energy Policy and Conservation Act set standards for domestic automobile manufacturers, beginning at 18 miles per gallon (mpg) in 1978 and rising to 27.5 mpg by 1985. The original standards were modified on two occasions, now standing at 27.5 mpg for 1990 and later production vehicles.

Corporate average fuel economy and compliance with the CAFE standard is determined as the harmonic average of the fuel economy of automobiles produced by each manufacturer. Harmonic average fuel economy is more difficult to achieve than would be 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 per automobile for every 0.1 mpg shortfall. There are carry back and carry forward provisions akin to banking that allow shortfalls in one year to be met with credits from another year.

While CAFE standards are directed at fuel economy, they do have a pollution consequence. CO_2 emissions rise and fall inversely with fuel economy ($R^2 = .99$), while emissions of CO, NO_x and hydrocarbons are largely unrelated to fuel economy.[54] Thus, the CAFE standard can be viewed as an intra-firm trading system to meet a *de facto* CO_2 reduction goal. It is only fair to point out that higher gasoline taxes would be a less costly means of reducing fuel use (and, implicitly, CO_2 reductions) since fuel taxes do not distort the selection of vehicles available to consumers as does a CAFE standard (under which smaller, less safe vehicles tend to replace larger, safer vehicles).[55] Further, a gasoline tax affects vehicle use as well as which vehicle is purchased, whereas higher CAFE standards have the perverse effect of stimulating more use of a vehicle (the so-called "rebound effect").

6.1.14. Wood Stove and Fireplace Permit Trading

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 command and control regulations. In 1977 the city passed an ordinance limiting new residential construction to one stove or fireplace per unit. While this might have slowed the deterioration in air quality, continued new construction virtually guaranteed that air quality would continue to worsen, which it did into the 1980s.

In 1987, the city adopted a program, part command and control and part modeled on air pollution offsets, that would guarantee improvements in air quality. Existing wood stove and fireplace owners were grandfathered with operating permits, but required to meet stringent performance standards within 3 years: 6 grams of particulate matter and 200 grams of CO per hour. During the first two years of the program these individuals converting their fireplaces and wood stoves to natural gas could earn a rebate of $750, partially defraying their costs. For new construction, no new permits would be issued for wood-burning stoves or fireplaces. To install such an appliance in new construction, the owner must produce permits to operate two fireplaces or stoves. The only place these permits could be acquired was 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 transaction prices for permits 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 that combined performance-based standards that encouraged the retirement of older inefficient fireplaces and wood stoves. The programs all aimed at reducing the burning of wood, but some offered no rebate for conversion 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.

6.1.15. Grass Burning Permit Trading

The City of Spokane, Washington nestled in the Spokane River basin about 400 feet below the surrounding Columbia River Plateau, forming a natural trap for air pollution during temperature inversions. The area exceeds the federal 24 hour PM10 standard several times each year, due to a combination of unpaved roads, wind-blown dust, grass burning and wood 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, Spokane County air pollution authorities implemented an innovative program to reduce grass burning as a source of PM.[56]

Grass burning had been subject to permit for years. The program superimposes on the permit process a County-wide cap of 35,000 acres that may be burned each year. Growers are allocated permits to burn 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 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 percent of the burnable acreage is deducted from the buyers 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 quantity offered was not all 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.

6.2. TRADING OF WATER EFFLUENTS

6.2.1. Effluent Bubble

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

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.[57] The reasons include the fact that most industrial facilities already have centralized wastewater treatment plants with a single point of discharge, trades between outfalls may be circumscribed due to water quality concerns, and some facilities already operated under permits that allowed all technologically feasible tradeoffs to be made.

Despite the acknowledged limitations, a subsequent study identified 4 plants in the iron and steel industry that potentially would benefit from water bubbling as they went from BPT (best practicable control technology currently available) to BAT (best available technology economically achievable).[58] The iron and steel industry offered what might be unique opportunities for bubbling inasmuch as many plants had yet to consolidate their water treatment at a single processing facility. The projected savings from effluent bubbles were modest as a percent of control costs, though, as shown in Table 6-5.

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

Since the bubble became available to the industry, 7 iron and steel plants in the midwest have used the provision.[59] Three of the mills no longer use the bubble: one facility closed and two have changed ownership, a cause for termination of bubbling rights. The steel effluent bubble undoubtedly has produced some compliance cost savings for the industry, but according to a former EPA employee who is now a consultant to the industry the bubble has not resulted in any pollution control innovations.[60]

6.2.2. Effluent Trading (point-point)

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

Table 6-5: PROJECTED COST SAVINGS FROM EFFLUENT BUBBLE
(in thousands of 1978 dollars)

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

Source: TBS, p.9.

Analysis showed that the potential from trading was significant: $7 million annually or roughly one-half of anticipated compliance costs for BOD (biological oxygen demand) regulations.[61] The program that was implemented allows trading between point sources of rights to discharge wastes that increase BOD. Sources that control more than required under their discharge permit may sell those incremental right to sources that control less than is required. Strict conditions are imposed on would-be buyers of rights: trading of rights is allowed only if the buyer is a new facility, is increasing production, or is unable to meet required discharge limits despite optimal operation of its treatment facilities. Traded rights must have a life of at least one year, but may not run past the expiration date of the seller's discharge permit, at most a five year period. Since effluent discharge limits may change with each permit renewal, there can be no guarantee that rights that were traded in during one permit period would be available during subsequent permit periods.

The State initiated BOD trading programs on two rivers: a 35-mile stretch of the Fox River and 500 miles of the Wisconsin River. For administrative reasons, the Fox River was divided into three segments, the Wisconsin River 5 segments. The Fox River program includes 21 parties: five mills and two towns in each of the three administrative segments. Twenty-six parties are included in the Wisconsin River program. To date, trading under these programs has been disappointing, involving a single trade on the Fox River between a municipal wastewater plant and a paper mill.[62] One reason for the limited activity is that dischargers developed a variety of compliance alternatives not contemplated when the regulations were drafted. Second, there were and remain questions about the vulnerability of the program to legal challenge, since the Clean Water Act does not explicitly authorize trading and the standards set by the State do not conform fully to the national policy of uniformity established in the CWA. Finally, as noted above, the State imposed severe restrictions on the ability of sources to trade.

Currently, the EPA is investigating the feasibility of extending point-point trading to San Francisco Bay, where copper discharges would be traded, and Tampa Bay, where nitrogen and suspended solids would be traded.[63]

6.2.3. Effluent Trading (Point-nonpoint)

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

6.2.3.1. 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 nonpoint sources.

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

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

6.2.3.2. Cherry Creek

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

6.2.3.3. 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. North Carolina law requires that upon designating an area as nutrient sensitive, the Division of Environmental Management (DEM) must identify the nutrient sources, set nutrient limitation objectives, and develop a nutrient control plan.

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

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

6.2.3.4. Other Point-Nonpoint Trading Proposals

The EPA is actively involved in a number of other projects that are likely to lead to effluent trading between point and nonpoint sources. These projects include: Chehalis Basin, Washington (BOD); Boone Reservoir, Tennessee (nutrients); Wicomico River, Maryland (phosphorus); Long Island Sound, New York (dissolved oxygen); Tampa Bay, Florida (nitrogen and suspended solids); and Chatfield Basin, Colorado (phosphorus). (EPA's May 1996 report *Draft Framework for Watershed-Based Trading*, appendix C, contains about 20 examples that will be put in a table as an update).

6.3. LAND PROTECTION TRADING

6.3.1. 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 date of the original colonization, the United States has lost over one-half of its original wetland acreage.

In recent years, as scientists pointed out the ecological importance of wetlands, government policies at the federal, state and local level have 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 the section on fees, charges 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 among federal and state officials and a bank administrator. Generally 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. Typically, 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 existing wetland mitigation banks, most MOUs allow the bank operator to sell credits only after the bank has actually accomplished wetland enhancement or preservation. A minority of states allow the manager 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 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. Nearly one-half of existing wetland mitigation banks were established by state highway departments to provide a means of mitigating losses due to highway construction. Other mitigation banks are operated by conservation organizations and for-profit entities that offer 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; and with banking there can be greater assurance of long-term management of the protected area.

Some 60 wetland mitigation banks in at least 15 states are currently in operation and about 40 more are in advanced stages of planning.[64] Wetland mitigation banking was featured in the 1996 Farm Bill as part of the Wetland Reserve Program. Wetland mitigation banking has been endorsed by the 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 this suggests that wetland mitigation banking will grow in importance as a means of protecting and enhancing the nation's wetlands.

6.3.2. Transferable Development Rights

To achieve the goal of restricting development in environmentally sensitive areas, many communities have sought to zone large tracts of agricultural land to preclude or severely limit development. Compensation to property owners in exchange for their accepting restrictive zoning in perpetuity typically takes one of two forms: transferable development rights (TDR) and purchase of development rights (PDR). PDR payments typically are established as the difference between appraisals of land value in agricultural use and for development.

No appraisals are needed with a TDR system. Rather, transferable development rights are allocated to property owners on the basis of acreage (e.g., one right per acre). TDRs are available for sale to urban areas designated by the community for further growth. Property owners in the designated growth areas are allowed to exceed normal building density limits provided they acquire sufficient TDRs. Thus the market mechanism provides a means of compensating rural property owners whose land holdings are restricted in terms of development; no government funding is needed. However, inasmuch as the price of TDRs is determined by the availability of TDRs and the demand for more intensive development in designated growth areas, there is no necessary connection between the payment and the decrease in value of rural land whose development is restricted.

A comprehensive treatment of all applications of TDRs is beyond the scope of this paper. Many of the earliest programs were poorly conceived and little used. A 1981 review of 23 separate TDR programs was able to identify only 6 trades that had taken place.[65] Instead of attempting to review all TDR programs, a small sample of cases are described that highlight some of the most successful programs to convey to the reader a sense of how such programs can operate in practice, the typical range of transaction prices, and some of the problems that have been encountered. Case studies reported here include Montgomery County, Maryland; Talbot County, Maryland; The Pinelands, New Jersey; and Palm Beach County, Florida (the latter to give a sense of why many programs have failed to live up to expectations). The TDR programs in Maryland are compared with the State's PDR program.

6.3.2.1. Montgomery County, Maryland

While both programs are directed at preserving agricultural land, Montgomery County's program differs from Palm Beach County's in one important respect: landowner participation is compulsory in the designated agricultural portion of Montgomery County. When Montgomery County downzoned about 90,000 acres in the western portion of the county from zoning of one dwelling per 5 acres to one dwelling per 25 acres in 1980 and 1981, it distributed TDRs to affected landowners at the rate of one TDR for every five acres, some 18,000 TDRs in all. Landowners who so elected could receive PDRs; however, few chose that option. The County designated other areas closer to Washington D.C. as "receiving" areas in which higher density development would be allowed if TDRs were submitted with the development application. Over 12,000 units of receiving capacity have been authorized to date and more than 5,500 TDRs used, at prices ranging from $3,000 to $7,000 each.

6.3.2.2. Talbot County, Maryland

Talbot County initiated two TDR programs in 1989. One program, designed to protect the shoreline of Chesapeake Bay and selected interior areas, allows landowners in the designated interior areas to earn one development credit for each 20 acres permanently set aside for agricultural use. The credits may be used to increase the density of shoreline development from one dwelling for every 20 acres to one for every 5 acres, provided measures are implemented to protect the shoreline from erosion. Under this program TDRs have changed hands for $40,000 to $50,000, a reflection of the high value of water-front property.

The second program attempts to protect undeveloped rural areas as farms and to concentrate future development in areas where land is most valuable. In the designated "Rural Agricultural Zone" the County distributed TDRs at the rate of one for each ten acres, the base development rate. The maximum allowed density was increased to one dwelling for every five acres; however, an extra TDR would have to accompany any proposal to subdivide a 10 acre parcel and build two dwellings. The result is that the least valuable lands are preserved in agricultural use while the most valuable areas are developed residentially.

6.3.2.3. Maryland PDR Program

Though not a trading system, the purchase of development right (PDR) program in the State offers a point of comparison with the TDR program. The State purchases development easements to protect farmland through a program that requires 40 percent cost sharing by the county. In the 1980s, the State spent some $26 million, of which the county shares totaled $11 million, to protect 23,500 acres, or about $1,100 per acre. In Montgomery County, landowners who chose to receive compensation in the form of PDRs instead of TDRs received an average of about $950 per acre.[66] The compensation as PDRs is quite similar to what has been received for TDRs (transaction prices were equivalent to $600 to $1400 per acre). More details on the Maryland PDR program are provided in the next section of the report, which deals with subsidy approaches to environmental management.

6.3.2.4. The Pinelands, New Jersey

The New Jersey Pinelands is a largely undeveloped, marshy area in the south eastern part of the State encompassing approximately one million acres that provides habitat for several endangered species. In an effort to direct development to the least environmentally sensitive areas, the Pinelands Development Commission established a system of TDRs known as Pineland Development Credits. Landowners in environmentally sensitive areas receive PDCs in exchange for limiting development at the rate of 1 PDC for every 39 acres of existing farmland, 1 PDC for every 39 acres of preserved upland, and 0.2 PDCs for every 39 acres of wetlands. One PDC could be used by a developer within designated growth areas to exceed the base density by four units.

While simple in concept, the program was actually complex in that it sought to include 52 local governments located within the Pinelands, several of which failed to see the advantages of participation at first. While the program was slow to gain acceptance, and suffered for years from a glut of already-approved development projects, more recently there are definite signs of success.

The Commission established a Pinelands Development Credit Bank to act as a purchaser of last resort for PDCs at the statutory price of $10,000 per credit. In 1990 the Bank auctioned its inventory at the price of $20,200 per PDC. To date, developers have used well over 100 PDCs.

6.3.2.5. Palm Beach County, Florida

In 1980, Palm Beach County adopted a plan directed at controlling growth and alleviating a chronic deficiency in public facilities. Future growth would be managed to encourage higher density development in built up areas of the County and 25,000 acres were earmarked for an Agricultural Reserve in which future development would be restricted. The County's plan for the agricultural area was ambiguous in that it continued to allow development on five acre lots throughout the entire 25,000 acres and more intensive 1 acre developments on planned unit developments of 40 acres on which farmers had based their borrowing. Investors who control about two-thirds of the 25,000 acres have held off selling TDRs since they expected the future value of the land for residential development to exceed what they could receive for TDRs and land restricted solely to agricultural uses.

Meanwhile, demand from developers has not materialized to the extent once anticipated. A large supply of permitted construction remains in the pipeline; for this no TDRs are needed. Also, developers can build more densely by obtaining the status of planned unit districts for which no TDRs are required. While the program eventually may succeed in protecting parts of the intended 25,000 acre Agricultural Reserve, to date very little has been accomplished.

6.4. INTERNATIONAL TRADING ACTIVITIES INVOLVING US GOVERNMENT

6.4.1. Joint Implementation

The concept of "Joint implementation" (JI) stems from the United Nations Framework Convention on Climate Change (FCCC) signed during the 1992 Earth Summit in Rio. By agreeing to the terms of the FCCC, over 100 countries committed themselves to reducing their greenhouse gas emissions. Under JI, businesses, non-governmental organizations, and government entities in one country jointly undertake mitigation and sequestration with similar interests in another. Projects that diminish, sequester, or avoid global greenhouse gas emissions may be considered JI projects if the source of emissions being offset and the site of the emission abatement are located in two different countries.

JI is in effect an incentive mechanism applied to countries by the FCCC, giving them an "offset" option to meet their greenhouse gas reduction commitments by implementing reduction activities abroad. Since reduction costs may vary among countries, JI provides industrialized countries with opportunities to reduce emissions at a lower cost abroad than they could within their borders. The possibility that such offsets eventually may become marketable reduction credits provides an added incentive. It should be noted, however, that the 1995 Conference of the Parties to the FCCC in Berlin decided that no Parties could earn credits through JI activities during the pilot phase of the project, which the Conference decided would end on December 31, 1999, at the latest. This decision has led some industry officials in the United States to ask why they should participate in JI activities.[67]

The United States Initiative on Joint Implementation was the first national JI program to adopt a formal set of criteria and evaluation process for JI proposals. An Evaluation Panel of representatives of U.S. government agencies determines the acceptability of proposed projects. The first seven United States JI projects were accepted in January 1995, and another eight projects were accepted in December 1995. Central America has hosted most of the projects, but Russia and the Czech Republic have each hosted one as well. Projects have involved biomass, geothermal, hydroelectric, and wind energy technologies and forestry management. Investments in the second round of projects could exceed $200 million.[68]

Japan is also asking businesses to participate in joint implementation projects. It plans to set up an " APEC environment technology exchange virtual center" to promote the transfer of Japanese carbon dioxide emission containment technologies to members of the Asia-Pacific Economic Cooperation Forum.[69]

6.4.2. Proposed Cross-Border Trading Program: El Paso Region

The El Paso, Texas region is a nonattainment area for the federal ozone, PM10 and carbon monoxide standards. Much of the pollution problem can be traced to sources in Ciudad Juarez, Chihuahua, directly across the Mexican border.[70] Because of the very different levels of economic development and pollution control in the two cities, there appear to be opportunities for cost-effective control of air pollution in the region through cross border trading.

On March 29 1996, U.S. and Mexican representatives created a binational committee to develop recommendations for the prevention and control of air pollution in the international air quality management basin (IAQMB). Work of the committee is expected to include the integration of air quality monitoring networks, exchange of information, development of outreach programs, evaluation of specific abatement strategies, and the development and implementation of economic instruments such as emission trading programs with emission budgets, allowances, and/or caps.

Endnotes for Section 6

1. See Tietenberg (1985) for a comprehensive review of emission trading policy.

2. For example, Unocal earned ERCs to apply against obligations at its Los Angeles refinery by scrapping old cars.

3. U.S. EPA December 4, 1986.

4. EPA (1980).

5. Crookshank (1994).

6. Hahn and Hester (1989).

7. Hahn and Hester (1989).

8. Foster and Hahn (1995).

9. All price data are expressed in 1992 dollars.

10. This is a one hour standard, not to be exceeded more than once a year (averaged over three years).

11. Background papers on RECLAIM include: Selmi (1994) and Lentz and Leyden, 1996.

12. The District originally planned to have a single expiration date of December 31 each year for all allocations. Concern that there could be a "logjam" of trading near the expiration date led District officials to randomly divide facilities into two categories of equal size: Cycle One sources with calendar year compliance dates, whose credits would expire on December 31 of each year; and Cycle Two sources with a July 1 to June 30 compliance calendar, whose credits would expire on June 30. Sources in Cycle One are free to trade with those in Cycle Two, but the expiration dates on the credits do not change.

13. The Natural Resources Defense Council contended that basing emissions allocations on 1989 emission levels could result in an increase in emissions of up to 71 percent over 1993 levels. See: "TRADING PROGRAM FOR VOLATILE ORGANICS STALLS OVER INITIAL EMISSION ALLOCATION," BNA *Daily Environment Report*, August 15, 1995, p. B-1.

14. "LA smog cops seek clean cut in dirty mowers," *Financial Times*, May 14, 1996, 14.

15. Review conducted by KPMG Peat Marwick and cited in BNA *Daily Environment Report*, March 3, 1995, p. B-2.

16. Illinois EPA, 1995. *Design for VOC Emissions Trading System*.

17. BNA *Daily Environment Report*, Nov. 11, 1995, B-1.

18. GAO (1996).

19. BNA *Daily Environment Report*, June 5, 1995, pAA-1

20. BNA *Daily Environment Reporter*, July 25, 1995, B-5.

21. BNA *Daily Environment Report*, August 29, 1995, B-1.

22. NESCAUM, which stands for Northeast States for Co-ordinated Air Use Management, is an association of the state air quality directors of each of the New England states, plus New York and New Jersey. MARAMA, which stands for the Mid-Atalntic Regional Air Management Association, is an association of the state air quality directors from Pennsylvania, New Jersey, Delaware, Maryland, Virginia, North Carolina and the District of Columbia.

23. The model rule was developed as a template for states to create their own individual state rules. The model rule may be accessed at www.dep.state.pa.us.

24. Information on OTAG is available on an electronic bulletin board EPA has set up as part of the Technology Transfer Network and accessible by modem at 919-541-5742.

25. According to Robert Shinn, commissioner of the New Jersey Department of Environmental Protection (www.thompson.com / tpg / enviro / airr / airrapril.html).

26. President Bill Clinton and Vice President Al Gore (1995).

27. 60 FR 39668.

28. Five years after the Act was passed, EPA analysis indicated that reduction of sulfates could have large health benefits, perhaps as much as $40 billion per year for Phase I of the Acid Rain program. See EPA, Office of Air and Radiation (November, 1995).

29. The 2.5 pounds of SO_2 per million Btu is adjusted, if necessary, so that aggregate emissions meet the overall reduction targets.

30. This will add over 700 additional sources to the program, mostly cleaner and/or smaller plants.

31. ICF Resources Inc. (1989a).

32. BNA *Daily Environment Report*, December 11, 1995, p. A-3.

33. U.S. EPA, *Federal Register*, March 29, 1995.

34. Burtraw (1995).

35. Cason (1995).

36. Section 416(d)(2) of the Act states "allowances shall be sold on the basis of bid price, starting with the highest bid and continuing until all allowances for sale at such auction have been allocated."

37. Cason (1995), p. 905.

38. Burtraw.

39. U.S. EPA 1995. *op cit*.

40. ICF Resources (1989).

41. Portney (1990).

42. http://www.epa.gov/acidrain/overview.html.

43. This agreement was ratified by the United States and 22 other countries in September, 1987.

44. EPA, *CFC Regulatory Impact Analysis*, 1988, vol 2.

45. Canada, Mexico and Singapore also implemented trading programs in CFCs.

46. Loeb (1996).

47. Hahn and Hester (1989).

48. Anderson, Rusin and Hoffman.

49. Kerr (1993).

50. EPA (1992).

51. Rubin and Kling (1993).

52. 57 FR 61970 (December 29, 1992).

53. Novello and Martineau (1993).

54. Khazzoom (1995).

55. See, for example, Crandall *et al.* (1986).

56. Skelton (1994).

57. Putnam, Hayes & Bartlett, Inc. (1981).

58. Temple, Barker & Sloane (1981).

59. Memorandum from Robert Graff and Brian Morrison, Industrial Economics, Inc., to Richard Kashmanian, Regulatory Innovations Staff, EPA, September 16, 1993.

60. Memo, *op cit*. p.12., citing conversation with Gary Amendola.

61. O'Neil (1983).

62. In return for a cash payment, the paper mill was able to close its wastewater treatment facility and send its effluent to the wastewater treatment plant.

63. "Effluent Trading in Watersheds Policy Statement" at http://www.epa.gov/OW/watershed/tradetbl.html

64. See Environmental Law Institute (1993) and Crookshank (1995).

65. Maabs-Zeno (1981).

66. Schiff.

67. Bureau of National Affairs, *Daily Environment Report*, June 1, 1995, p. A4.

68. Bureau of National Affairs, *Daily Environment Report*, December 20, 1995, pp. A5-6.

69. Bureau of National Affairs, *Daily Environment*, December 1, 1995, p. A4.

70. Texas Natural Resource Conservation Commission (1994).