MARKET-BASED ENVIRONMENTAL POLICIES

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ABSTRACT

Some eighty years ago, economists first proposed the use of corrective taxes to internalize environmental and other externalities. Fifty years later, the portfolio of potential economic-incentive instruments was expanded to include quantity-based mechanisms — tradeable permits. Thus, economic-incentive approaches to environmental protection are clearly not a new policy idea, and over the past two decades, they have held varying degrees of prominence in environmental policy discussions. This paper summarizes U.S. experiences with such market-based policy instruments, including: pollution charges; deposit-refund systems; tradeable permits; market barrier reductions; and government subsidy reductions.

No particular form of government intervention, no individual policy instrument — whether market-based or conventional — is appropriate for all environmental problems. Which instrument is best in any given situation depends upon a variety of characteristics of the environmental problem, and the social, political, and economic context in which it is being regulated. There is no policy panacea. Indeed, the real challenge for bureaucrats, elected officials, and other participants in the environmental policy process comes in analyzing and then selecting the best instrument for each situation that arises.

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Robert Stavins*

1. WHAT ARE MARKET-BASED POLICY INSTRUMENTS?

Nearly all environmental policies consist of two components, either explicitly or implicitly: the identification of an overall goal (either general or specific, such as a degree of air quality or an upper limit on emission rates) and some means to achieve that goal. In practice, these two components are often linked within the political process, because both the choice of a goal, and the mechanism for achieving that goal, have important political ramifications.[1] This chapter focuses exclusively on the second component, the means — the "instruments" — of environmental policy, and considers, in particular, economic-incentive or market-based policy instruments.

1.1 A Definition

Market-based instruments are regulations that encourage behavior through market signals rather than through explicit directives regarding pollution control levels or methods.[2] These policy instruments, such as tradable permits or pollution charges, are often described as "harnessing market forces"[3] because

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[1]While discussion of goals typically precedes examination of alternative means for achieving goals, this is not necessarily the case. For example, both the Bush and Clinton administrations endorsed market-based methods for addressing global climate change before either had committed itself to specific greenhouse policy goals.

[2]This section draws, in part, on: Hockenstein, Jeremy B., Robert N. Stavins, and Bradley W. Whitehead. "Creating the Next Generation of Market-Based Environmental Tools." *Environment* 39, number 4 (1997), pp. 12-20, 30-33.

[3]See, for example: Stavins, Robert N., ed. *Project 88 - Round II Incentives for Action: Designing Market-Based Environmental Strategies*. Sponsored by Senator Timothy E. Wirth, Colorado, and Senator John Heinz, Pennsylvania. Washington, D.C., May 1991; Stavins, Robert N., ed. *Project 88: Harnessing Market Forces to Protect Our Environment.* Sponsored by Senator Timothy E. Wirth, Colorado, and Senator John Heinz, Pennsylvania. Washington, D.C., December 1988; U.S. Environmental Protection Agency. *Economic Incentives, Options for Environmental Protection*. Document P-2001. EPA, Washington, D.C. ,1991; Organization for Economic Cooperation and Development. *Economic Instruments for Environmental Protection*. Paris, 1989; and Organization for Economic Cooperation and Development. *Environmental Policy: How to Apply Economic Instruments*. Paris, 1991. Another strain of literature — known as "free market environmentalism" — focuses on the role of private property rights in achieving environmental protection. See, for example: Anderson, Terry L. and Donald R. Leal. *Free Market Environmentalism*. Boulder: Westview Press, 1991.

if they are well designed and implemented, they encourage firms (and/or individuals) to undertake pollution control efforts that both are in those firms' (or individuals') interests and that collectively meet policy goals.

By way of contrast, conventional approaches to regulating the environment are often referred to as "command-and-control" regulations since they allow relatively little flexibility in the means of achieving goals. Early environmental policies, such as the Clean Air Act of 1970 and the Clean Water Act of 1972, relied almost exclusively on these approaches.[4]

In general, command-and-control regulations tend to force firms to shoulder similar shares of the pollution-control burden, regardless of the relative costs to them of this burden.[5] Command-and-control regulations do this by setting uniform standards for firms, the most prevalent of which are technology-based and performance-based standards. Technology-based standards specify the method, and sometimes the actual equipment, that firms must use to comply with a particular regulation. For example, all electric utilities might be required to employ a specific type of scrubber to remove particulates. A performance standard sets a uniform control target for firms, while allowing some latitude in how this target is met. For example, a regulation might limit the number of allowable units of a pollutant released in a given time period, but might not dictate the means by which this is achieved.

Holding all firms to the same target can be expensive and, in some circumstances, counterproductive. While standards may effectively limit emissions of pollutants, they typically exact relatively high costs in the process, by forcing some firms to resort to unduly expensive means of controlling pollution. Because the costs of controlling emissions may vary greatly among firms, and even among sources within the same firm, the appropriate technology in one situation may be inappropriate in another. Thus, control costs can vary enormously due to a firm's production design, physical configuration, age of its assets, or other factors. One survey of eight empirical studies of air pollution control found that the ratio of actual, aggregate costs of the conventional, command-and-control approach to the aggregate costs of least-cost benchmarks ranged from 1.07 for sulfate emissions in the Los Angeles area to 22.0 for hydrocarbon emissions at all domestic DuPont plants.[6]

Furthermore, command-and-control regulations tend to freeze the development of technologies that might otherwise result in greater levels of control. Little or no financial incentive exists for businesses to exceed their control targets, and both technology-based and performance-based standards discourage adoption of new technologies. A business that adopts a new technology may be "rewarded" by being held to a higher standard of performance, but is not given the opportunity to benefit financially from its investment, except to the extent its competitors have even more difficulty reaching the new standard.

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[4]For descriptions of the use of command-and-control instruments for various environmental problems, see the other chapters in this volume.

[5]But various command-and-control standards do this in different ways. See: Helfand, Gloria E. "Standards versus Standards: The Effects of Different Pollution Restrictions." *American Economic Review* 81(1991):622-634.

[6]See Tietenberg, Tom. *Emissions Trading: An Exercise in Reforming Pollution Policy*. Washington, D.C.: Resources for the Future, 1985.

1.2 Characteristics of Market-Based Policy Instruments

The two most notable advantages that market-based instruments offer over traditional command-and-control approaches are cost effectiveness and dynamic incentives for technology innovation and diffusion.

In theory, if properly designed and implemented, market-based instruments allow any desired level of pollution cleanup to be realized at the lowest possible overall cost to society, by providing incentives for the greatest reductions in pollution by those firms that can achieve these reductions most cheaply.[7] Rather than equalizing pollution levels among firms (as with uniform emission standards), market-based instruments equalize the incremental amount that firms spend to reduce pollution (their marginal cost).[8]

It is important to recognize that command-and-control approaches could — theoretically — achieve this cost-effective solution, but this would require that different standards be set for each pollution source, and, consequently, that policy makers obtain detailed information about the compliance costs each firm faces. Such information is simply not available to government. By contrast, market-based instruments provide for a cost-effective allocation of the pollution control burden among sources without requiring the government to have this information.

In contrast to command-and-control regulations, market-based instruments have the potential to provide powerful incentives for companies to adopt cheaper and better pollution-control technologies. This is because with market-based instruments, it always pays firms to clean up a bit more if a sufficiently low-cost method (technology or process) of doing so can be identified and adopted.[9]

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[7]Under certain circumstances, substituting a market-based instrument for a command-and-control instrument can lower environmental quality, because command-and-control standards tend to lead to over-control. On this, see: Oates, Wallace E., Paul R. Portney, and Albert M. McGartland. "The Net Benefits of Incentive-Based Regulation: A Case Study of Environmental Standard Setting." *American Economic Review* 79(1989):1233-1243.

[8]Each source's marginal cost of pollution control is the additional or incremental cost for that source to achieve an additional unit of pollution reduction. If this marginal cost of control is not equal across sources, then the same aggregate level of pollution control could be achieved at lower overall cost simply by reallocating the pollution control burden among sources, so that low-cost controllers controlled more, and high-cost controllers controlled proportionately less. Additional savings could theoretically be achieved through such reallocations until marginal costs were identical for all sources. See: Baumol, William J. and Wallace E. Oates. *The Theory of Environmental Policy*. Second Edition. New York: Cambridge University Press, 1988. Reference here is to marginal *abatement* cost, that is, marginal cost of *emission* reduction. Things become more complicated, but the general point holds with non-uniformly mixed pollutants, where the focus is on ambient concentration or exposure, not simply emissions. On this, see: Montgomery, David. "Markets in Licenses and Efficient Pollution Control Programs," *Journal of Economic Theory* 5(1972):395-418; and Tietenberg, Tom H. "Tradeable Permits for Pollution Control When Emission Location Matters: What Have We Learned?" *Environmental and Resource Economics* 5(1995):95-113.

[9]For a theoretical analysis of the dynamic incentives of technological change under alternative policy instruments, see, for example: Downing, Paul B. and Lawrence J. White. "Innovation in Pollution Control." *Journal of Environmental Economics and Management* 13(1986):18-27; Malueg, David. "Emission Credit Trading and the Incentive to Adopt New Pollution Abatement Technology." *Journal of Environmental Economics and Management* 16(1989):52-57; Milliman, Scott R., and Raymond Prince. "Firm Incentives to Promote Technological Change in Pollution Control." *Journal of*

1.3 Categories of Market-Based Instruments

Market-based instruments can be considered within four major categories: pollution charges; tradable permits; market barrier reductions; and government subsidy reductions.[10]

Pollution charge systems assess a fee or tax[11] on the amount of pollution that a firm or source generates.[12] Consequently, it is worthwhile for the firm to reduce emissions to the point where its marginal abatement cost is equal to the tax rate. Firms will thus control pollution to differing degrees, with high-cost controllers controlling less, and low-cost controllers controlling more. A challenge with charge systems is identifying the appropriate tax rate. Ideally, it should be set equal to the benefits of cleanup at the efficient level of cleanup, but policy makers are more likely to think in terms of a desired level of cleanup, and they do not know beforehand how firms will respond to a given level of taxation.

A special case of pollution charges is a *deposit refund system*, where consumers pay a surcharge when purchasing potentially polluting products, and receive a refund when returning the product to an approved center (for recycling or disposal). A number of states have implemented this approach through "bottle bills," to control litter from beverage containers and to reduce the flow of solid waste to landfills, and the concept has also been applied to lead-acid batteries.[13]

Environmental Economics and Management 17(1989):247-265; and Jung, Chulho, Kerry Krutilla, and Roy Boyd. "Incentives for Advanced Pollution Abatement Technology at the Industry Level: An Evaluation of Policy Alternatives." *Journal of Environmental Economics and Management* 30(1996):95-111. The empirical literature is considerably thinner. See: Jaffe, Adam B. and Robert N. Stavins. "Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion." *Journal of Environmental Economics and Management* 29 (1995): S-43-S-63.

[10]See, generally: Organization for Economic Cooperation and Development. *Evaluating Economic Incentives for Environmental Policy*. Paris, 1994; Organization for Economic Cooperation and Development. *The Distributive Effects of Economic Instruments for Environmental Policy*. Paris, 1994; and Organization for Economic Cooperation and Development. *Managing the Environment — The Role of Economic Instruments*. Paris, 1994.

[11]Pigou is generally credited with developing the idea of a corrective tax to discourage activities which generate externalities, such as environmental pollution. See Pigou, Arthur C. *The Economics of Welfare* 4th Ed., 1952.

[12]For example, a pollution charge might take the form of a charge per unit of sulfur dioxide emissions, but not a charge per unit of electricity generated. The choice of whether to tax pollution quantities, activities preceding discharge, inputs to those activities, or actual damages will depend upon tradeoffs between costs of abatement, mitigation, damages, and program administration, including monitoring and enforcement.

[13]See: Bohm, Peter. *Deposit-Refund Systems: Theory and Applications to Environmental, Conservation, and Consumer Policy*. Washington, D.C.: Resources for the Future, 1981; and Menell, Peter. "Beyond the Throwaway Society: An Incentive Approach to Regulating Municipal Solid Waste." *Ecology Law Quarterly* 17(1990):655-739.

Tradable permits can achieve the same cost-minimizing allocation of the control burden as a charge system, while avoiding the problem of uncertain responses by firms.[14] Under a tradable permit system, an allowable overall level of pollution is established and allocated among firms in the form of permits.[15] Firms that keep their emission levels below their allotted level may sell their surplus permits to other firms or use them to offset excess emissions in other parts of their facilities.

Market barrier reductions can also serve as market-based policy instruments. In such cases, substantial gains can be made in environmental protection simply by removing existing explicit or implicit barriers to market activity. Three types of market barrier reductions stand out: (1) *market creation*, as with measures that facilitate the voluntary exchange of water rights and thus promote more efficient allocation and use of scarce water supplies; (2) *liability rules* that encourage firms to consider the potential environmental damages of their decisions; and (3) *information programs*, such as energy-efficiency product labeling requirements.

Government subsidy reductions are the fourth and final category of market-based instruments. Subsidies, of course, are the mirror image of taxes and, in theory, can provide incentives to address environmental problems. In practice, however, many subsidies promote economically inefficient and environmentally unsound practices. This market distortion received much attention in the 104th Congress under the rubric of "corporate welfare," an example of which is the below-cost sale of timber by the U.S. Forest Service.

In the simplest models, pollution taxes and tradeable permits are symmetric, but that symmetry begins to break down in actual implementation.[16] First, permits fix the level of pollution control while charges fix the costs of pollution control. Second, in the presence of technological change and without additional government intervention, permits freeze the level of pollution control while charges increase it. Third, with permit systems as typically adopted, resource transfers are private-to-private, while they are

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[14]Thirty years ago, Thomas Crocker and John Dales independently developed the idea of using transferable discharge permits to allocate the pollution-control burden among firms or individuals. See: Crocker, Thomas D. "The Structuring of Atmospheric Pollution Control Systems," in *The Economics of Air Pollution*, (Harold Wolozin, Ed.), W. W. Norton & Company, Inc., NY (1966); and Dales, John. *Pollution, Property and Prices*. Toronto: University Press, 1968. David Montgomery provided the first rigorous proof that a tradeable permit system could, in theory, provide a cost-effective policy instrument for pollution control (1972). A sizeable literature on tradeable permits has followed. Early surveys of the literature are found in: Tietenberg, Tom. "Transferable Discharge Permits and the Control of Stationary Source Air Pollution: A Survey and Synthesis." *Land Economics* 56(1980):391-416; and Tietenberg (1985). Also see: Hahn, Robert and Roger Noll. "Designing a Market for Tradeable Permits." in *Reform of Environmental Regulation*. W. Magat, ed, 1982. Much of the literature on tradeable permits may actually be traced to Coase's treatment of negotiated solutions to externality problems. See generally: Coase, Ronald. "The Problem of Social Cost." *Journal of Law and Economics* 3(1960):1-44.

[15]Reference here is to so-called "cap-and-trade" programs, but — as we discuss later — some programs, such as EPA's Emissions Trading Program, operate differently, as "credit programs," where permits or credits are assigned only when a source reduces emissions below what is required by existing, source-specific limits.

[16]See: Stavins, Robert N. and Bradley W. Whitehead. "Pollution Charges for Environmental Protection: A Policy Link Between Energy and Environment." *Annual Review of Energy and the Environment* 17(1992):187-210.

private-to-public with ordinary pollution charges. Fourth, while both charges and permits increase costs on industry and consumers, charge systems tend to make those costs more obvious to both groups. Fifth, permits adjust automatically for inflation, while some types of charges do not. Sixth, permit systems may be more susceptible to strategic behavior.[17] Seventh, significant transaction costs can drive up the total costs of compliance, having a negative effect under either system, but particularly with tradeable permits.[18] Eighth and finally, in the presence of uncertainty, either permits or charges can be more efficient, depending upon the relative slopes of the marginal benefit and marginal cost functions[19] and any correlation between them.[20]

The degree of abatement achieved by a pollution tax and the tax's effect on the economy will depend — in part — on what is done with the tax revenue. There is widespread agreement that revenue recycling (that is, using pollution tax revenues to lower other taxes) can significantly lower the costs of a pollution tax[21]. Some researchers have suggested, further, that all of the abatement costs associated with a pollution tax can be eliminated through revenue recycling in the form of cuts in taxes on labor.[22] But pollution taxes can exacerbate distortions associated with remaining taxes on investment or labor. There is now common recognition that environmental taxes impose their own distortions that are at least as great as those from labor taxes.[23] Using revenues from an environmental tax (or from the auction of pollution

[17]See: Hahn, Robert W. "Market Power and Transferable Property Rights." *Quarterly Journal of Economics* 99(1984): 753-765; Malueg, David A. "Emission Credit Trading and the Incentive to Adopt New Pollution Abatement Technology." *Journal of Environmental Economics and Management* 16(1989):52-57; and Misolek, W. S. and H. W. Elder. "Exclusionary Manipulation of Markets for Pollution Rights." *Journal of Environmental Economics and Management* 16(1989):156-166.

[18]See: Stavins, Robert N. "Transaction Costs and Tradeable Permits." *Journal of Environmental Economics and Management* 29(1995):133-147.

[19]See: Weitzman, Martin L. "Prices vs. Quantities." *Review of Economic Studies* 41(1974):477-491; Adar, Z. and J.M. Griffin, "Uncertainty and the Choice of Pollution Control Instruments," *Journal of Environmental Economics and Management* 3(1976):178-188; and Tisato, P. "Pollution Standards vs Charges Under Uncertainty." *Environmental and Resource Economics* 4(1994):295-304.

[20]See: Stavins, Robert N. "Correlated Uncertainty and Policy Instrument Choice." *Journal of Environmental Economics and Management* 30(1996):218-232.

[21]See: Jorgenson, Dale and Peter Wilcoxen. "The Economic Effects of a Carbon Tax." Paper presented to the IPCC Workshop on Policy Instruments and their Implications, Tsukuba, Japan, January 17–20, 1994; and Goulder, Lawrence. "Effects of Carbon Taxes in an Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis." *Journal of Environmental Economics and Management* 29(1995):271-297.

[22]See: Repetto, Robert, Roger Dower, R. Jenkins, and Jackie Geoghegan. *Green Fees: How a Tax Shift Can Work for the Environment and the Economy*. World Resources Institute, Washington, D.C., 1992.

[23]See: Bovenberg, A. Lans and R. de Mooij. "Environmental Levies and Distortionary Taxation." *American Economic Review* 84(1994):1085-1089; Bovenberg, A. Lans and Lawrence H. Goulder. "Optimal Environmental Taxation in the Presence of Other Taxes: General-Equilibrium Analyses." *American Economic Review* 86(1996):985-1000; Goulder, Lawrence. "Environmental Taxation and the Double Dividend: A Reader's Guide." *International Tax and Public Finance* 2(1995):157-183; and Parry, Ian. "Pollution, Taxes, and Revenue Recycling." *Journal of Environmental*

permits[24]) to reduce labor taxes can reduce the efficiency costs of the environmental tax, but — in most cases — the substitution of an environmental tax for an investment or labor tax will reduce welfare, apart from the potentially beneficial environmental consequences of the tax. Thus, the primary justification for environmental taxes should be their environmental benefits, not reform of the tax system *per se*.

2. U.S. EXPERIENCE WITH TRADEABLE PERMIT SYSTEMS

The most frequently employed market-based environmental instruments in the United States have been tradeable permit systems.[25] Among these are the following: the U.S. Environmental Protection Agency's (EPA) Emissions Trading Program, the leaded gasoline phasedown, water quality permit trading, CFC trading, the SO_2 allowance system for acid rain control, the RECLAIM program in the Los Angeles metropolitan region, and tradeable development rights for land use (Table 1).[26]

Economics and Management 29(1995):64-77.

[24]See: Goulder, Lawrence, Ian Parry, and Dallas Burtraw. "Revenue-Raising Versus Other Approaches to Environmental Protection: The Critical Significance of Preexisting Tax Distortions." *RAND Journal of Economics* 28(1997):708-731; and Fullerton, Don, and Gilbert Metcalf. "Environmental Controls, Scarcity Rents, and Pre-Existing Distortions." National Bureau of Economic Research Working Paper No. 6091, July 1997.

[25]See, more broadly: Tietenberg, Tom. "Tradeable Permits and the Control of Air Pollution in the United States." Paper prepared for the 10th Anniversary Jubilee edition of *Zeitschrift Fürangewandte Umweltforschung*, 1997; and U.S. Environmental Protection Agency. *The United States Experience with Economic Incentives to Control Environmental Pollution*. EPA-230-R-92-001. Washington, D.C., 1992.

[26]In addition, the Energy Policy and Conservation Act of 1975 established a program of Corporate Average Fuel Economy (CAFE) standards for automobiles and light trucks. The standards require manufacturers to meet a minimum sales-weighted average fuel efficiency for their fleet of cars sold in the United States. A penalty is charged per car sold per unit of average fuel efficiency below the standard. The program operates much like an internal-firm tradeable permit system or "bubble" scheme, since manufacturers can undertake efficiency improvements wherever they are cheapest within their fleets. Firms that do better than the standard can "bank" their surpluses and — in some cases — are permitted to borrow against their future rights. For reviews of the literature on CAFE standards, with particular attention to the program's costs relative to "equivalent" gasoline taxes, see: Crandall, Robert W., Howard K. Gruenspecht, Theodore E. Keeler, and Lester B. Lave. *Regulating the Automobile*. Washington, D.C.: The Brookings Institute, 1986; and Goldberg, Penelopi K. "The Effects of the Corporate Average Fuel Efficiency Standards." Working Paper, Department of Economics, Princeton University, 1997. Light trucks, which are defined by the Federal government to include "sport utility vehicles," face significantly weaker CAFE standards. See: Bradsher, Keith. "Light Trucks Increase Profits But Foul Air More than Cars." *New York Times*, November 30, 1997, pp. A1, A38-A39. Also, California has used a vehicle retirement program that operates much like a tradeable-permit system to reduce mobile-source air emissions by removing the oldest and most polluting vehicles from the road. On this, see: Tietenberg (1997); Alberini, Anna, Winston Harrington, and Virginia McConnell. "Determinants of Participation in Accelerated Vehicle Retirement Programs." *RAND Journal of Economics* 26(1995):93-112; and Kling, Catherine L. "Emission Trading vs. Rigid Regulations in the Control of Vehicle Emissions." *Land Economics* 70(1994):174-188. In addition, the Northeast and Middle Atlantic states have organized a NO_x permit trading program to control regional smog (Tietenberg 1997).

2.1 EPA's Emissions Trading Program

Beginning in 1974, EPA experimented with "emissions trading" as part of the Clean Air Act's program for improving local air quality. Firms that reduced emissions below the level required by law received "credits" usable against higher emissions elsewhere. Companies could employ the concepts of "netting" or "bubbles" to trade emissions reductions among sources within the firm, so long as total, combined emissions did not exceed an aggregate limit.[27]

The "offset" program, which began in 1976, goes further in allowing firms to trade emission credits. Firms wishing to establish new sources in areas that are not in compliance with ambient standards must offset their new emissions by reducing existing emissions. This can be accomplished through internal sources or through agreements with other firms. Finally, under the "banking" program, firms may store earned emission credits for future use. Banking allows for either future internal expansion or the sale of credits to other firms.

EPA codified these programs in its Emissions Trading Program in 1986,[28] but the programs have not been widely used. States are not required to use the program, and uncertainties about its future course seem to have made firms reluctant to participate.[29] Nevertheless, companies such as Armco, DuPont, USX, and 3M have traded emissions credits, and a market for transfers has long since developed.[30] Even this limited degree of participation in EPA's trading programs may have saved between $5 billion and $12 billion over the life of the program.[31]

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[27]The "netting" and "bubbles" concept aggregates emissions from all the components of an industrial plant and considers them a single source for purposes of regulation. An evaluation of EPA's Emissions Trading Program can be found in: Tietenberg, Tom. *Emission Trading: An Exercise in Reforming Pollution Policy*. Washington, D.C.: Resources for the Future, 1985; and Foster, Vivien and Robert W. Hahn. "Designing More Efficient Markets: Lessons from Los Angeles Smog Control." *Journal of Law and Economics* 38(1995):19-48. For a broader assessment of EPA's experience with tradeable permit policies, see Robert W. Hahn. "Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders." *Journal of Economic Perspectives* 3 (1989): 95-114.

[28]U.S. Environmental Protection Agency, *Emissions Trading Policy Statement*, 51 Fed. Reg. 43,814 (1986) (final policy statement).

[29]See Liroff, Richard A. *Reforming Air Pollution Regulations: The Toil and Trouble of EPA's Bubble*. Washington, D.C.: Conservation Foundation, 1986.

[30]See Main, Jeremy. "Here Comes the Big New Cleanup." *Fortune* (November 1988): p. 102-118.

[31]See Hahn, Robert W. and Gordon L. Hester. "Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program." *Yale Journal of Regulation* 6 (1989): 109-153.

2.2 Lead Trading

The purpose of the lead trading program, developed in the 1980s, was to allow gasoline refiners greater flexibility in meeting emission standards at a time when the lead-content of gasoline was reduced to 10 percent of its previous level. In 1982, the EPA authorized inter-refinery trading of lead credits.[32] If refiners produced gasoline with a lower lead content than was required, they earned lead credits. In 1985, EPA initiated a program allowing refineries to bank lead credits, and subsequently firms made extensive use of this program.[33] EPA terminated the program at the end of 1987, when the lead phasedown was completed.

The lead program was clearly successful in meeting its environmental targets. And, although the benefits of the trading scheme are more difficult to assess, the level of trading activity [34] and the rate at which refiners reduced their production of leaded gasoline[35] suggest that the program was relatively cost-effective. The high level of trading between firms far surpassed levels observed in earlier environmental markets.[36] EPA estimated savings from the lead trading program of approximately twenty percent over alternative programs that did not provide for lead banking,[37] a cost savings of about $250 million per year.

2.3 Water Quality Permit Trading

The United States has had very limited experience with tradable permit programs for controlling water pollution, though nonpoint sources, particularly agricultural and urban runoff, may constitute the major, remaining American water pollution problem.[38] An "experimental program" to protect the Dillon

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[32]U.S. Environmental Protection Agency. *Regulation of Fuel and Fuel Additives.* 38,078-90 (proposed rule). 49,322-24 (final rule).

[33]In each year of the program, more than 60 percent of the lead added to gasoline was associated with traded lead credits. See Robert W. Hahn and Gordon L. Hester, "Marketable Permits: Lessons for Theory and Practice," *Ecology Law Quarterly* 16 (1989): 361-406.

[34]See: Kerr, Suzi and David Maré. "Efficient Regulation Through Tradeable Permit Markets: The United States Lead Phasedown." Department of Agricultural and Resource Economics, University of Maryland, College Park, Working Paper 96-06, January 1997.

[35]See: Nichols, Albert L. "Lead in Gasoline." *Economic Analyses at EPA: Assessing Regulatory Impact*, ed. Richard D. Morgenstern, pp. 49-86. Washington, D.C.: Resources for the Future, 1997.

[36]The program did experience some relatively minor implementation difficulties related to imported leaded fuel. It is not clear that a comparable command-and-control approach would have done better in terms of environmental quality. See U.S. General Accounting Office, *Vehicle Emissions: EPA Program to Assist Leaded-Gasoline Producers Needs Prompt Improvement,* GAO/RCED-86-182 (Washington, DC: U.S. GAO, August 1986)

[37]See: U.S. Environmental protection Agency, Office of Policy Analysis, *Costs and Benefits of Reducing Lead in Gasoline, Final Regulatory Impact Analysis.* Washington, DC: February 1985.

[38] See: Peskin, Henry M. "Nonpoint Pollution and National Responsibility." *Resources* (Spring 1986): p. 10-11, 17.

Reservoir in Colorado demonstrates how tradable permits could be used, in theory, to reduce nonpoint-source water pollution.

Dillon Reservoir is the major source of water for the city of Denver. Nitrogen and phosphorus loading threatened to turn the reservoir eutrophic, despite the fact that point sources from surrounding communities were controlled to best-available technology standards.[39] Rapid population growth in Denver, and the resulting increase in urban surface water runoff, further aggravated the problem. In response, state policy makers developed a point-nonpoint-source control program to reduce phosphorus flows, mainly from nonpoint urban and agricultural sources. The program was implemented in 1984;[40] it allowed publicly owned sewage treatment works to finance the control of nonpoint sources in lieu of upgrading their own treated effluents to drinking water standards.[41] EPA estimated that the plan could save over $1 million per year,[42] due to differences in the marginal costs of control between nonpoint sources and the sewage treatment facilities. However, very limited trading occurred under the program, apparently because high regional precipitation diluted concentrations in the reservoir.

2.4 CFC Trading

A market in tradable permits was used in the United States to help comply with the Montreal Protocol, an international agreement aimed at slowing the rate of stratospheric ozone depletion.[43] The Protocol called for reductions in the use of CFCs and halons, the primary chemical groups thought to lead to ozone depletion. The market places limitations on both the production and consumption of CFCs by issuing allowances that limit these activities. The Montreal Protocol recognizes the fact that different types of CFCs are likely to have different effects on ozone depletion, and so each CFC is assigned a different weight on the basis of its depletion potential. If a firm wishes to produce a given amount of CFC, it must have an allowance to do so,[44] calculated on this basis.

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[39]See: Office of Policy Analysis, Environmental Protection Agency. “Case Studies on the Trading of Effluent Loads, Dillon Reservoir.” Final Report, 1984.

[40]See: Kashmanian, R. “Beyond Categorical Limits: The Case for Pollution Reduction Through Trading.” Unpublished paper presented at the 59th Annual Conference of the Water Pollution Control Federation, 1986.

[41]See: Hahn, Robert. “Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor’s Orders.” *Journal of Economic Perspectives* 3 (1989): p. 103.

[42]See: Hahn, Robert and Hester, Gordon. “Marketable Permits: Lessons for Theory and Practice.” *Ecology Law Quarterly* 16 (1989): 395.

[43]The Montreal Protocol called for a 50-percent reduction in the production of particular CFCs from 1986 levels by 1998. In addition, the Protocol froze halon production and consumption at 1986 levels beginning in 1992.

[44]See Hahn, Robert W. and Albert M. McGartland. “Political Economy of Instrumental Choice: An Examination of the U.S. Role in Implementing the Montreal Protocol.” *Northwestern University Law Review* 83(1989):592-611.

Through mid-1991, there were 34 participants in the market and 80 trades.[45] However, the overall efficiency of the market is difficult to determine, because no studies were conducted to estimate cost savings. The timetable for the phaseout of CFCs was subsequently accelerated, and a tax on CFCs was introduced.[46] Indeed, the tax may have become the binding (effective) instrument.[47] Nevertheless, relatively low transaction costs associated with trading in the CFC market suggest that the system was relatively cost-effective.

2.5 SO_2 Allowance System

A centerpiece of the Clean Air Act Amendments of 1990 is a tradable permit system that regulates sulfur dioxide (SO_2) emissions, the primary precursor of acid rain.[48] Title IV of the Act reduces sulfur dioxide and nitrous oxide emissions by 10 million tons and 2 million tons, respectively, from 1980 levels.[49] The first phase of sulfur dioxide emissions reductions was achieved by 1995, with a second phase of reduction to be accomplished by the year 2000.

In Phase I, individual emissions limits were assigned to the 263 most SO_2-emissions intensive generating units at 110 plants operated by 61 electric utilities, and located largely at coal-fired power plants east of the Mississippi River. After January 1, 1995, these utilities could emit sulfur dioxide only if they had adequate allowances to cover their emissions.[50] During Phase I, the EPA allocated each affected unit, on an annual basis, a specified number of allowances related to its share of heat input during the baseline period (1985-87), plus bonus allowances available under a variety of special provisions.[51] Cost-

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[45]Letter from Richard D. Feldman, U.S. Environmental Protection Agency, 7 January 1991. In addition, there have been a very small number of international trades, but such trading is limited by the Montreal Protocol.

[46]The CFC tax was enacted principally as a "windfall-profits tax," to prevent private industry from retaining scarcity rents created by the quantity restrictions. See: Merrill, Peter R., and Ada S. Rousso. "Federal Environmental Taxation." Presented at the Eighty-third Annual Conference of the National Tax Association, San Francisco, California, November 13, 1990.

[47]As of 1992, no firms were producing CFCs up to their maximum allowable level and permits could not be banked (carried forward). As a result, there was an excess supply of permits. It is possible, however, that there would be an excess supply even if there were no tax and with an effective price of zero for permits, because firms reacted to changes in regulations and new policy initiatives that called for a more rapid phaseout of CFCs and halons.

[48]See Clean Air Act Amendments of 1990, Public Law No. 101-549, 104 Statute 2399, 1990.

[49]For a description of the legislation, see Ferrall, Brian L. "The Clean Air Act Amendments of 1990 and the use of Market Forces to Control Sulfur Dioxide Emissions." *Harvard Journal on Legislation* 28 (1991): 235-252.

[50]Under specified conditions, utilities that had installed coal scrubbers to reduce emissions could receive two-year extensions of the Phase I deadline plus additional allowances.

[51]Utilities that install scrubbers receive bonus allowances for early clean up. Also, specified utilities in Ohio, Indiana, and Illinois receive extra allowances during both phases of the program. All of these extra allowances are essentially compensation intended to benefit Midwestern plants which rely on high-sulfur coal. On the political origins of this aspect of the program, see: Joskow, Paul L. and Richard Schmalensee. "The Political Economy of Market-based

effectiveness is promoted by permitting allowance holders to transfer their permits among one another and bank them for later use.

Under Phase II of the program, beginning January 1, 2000, almost all electric power generating units are brought within the system. Certain units are excepted to compensate for potential restrictions on growth and to reward units that are already unusually clean. If trading permits represent the carrot of the system, its stick is a penalty of $2,000 per ton of emissions that exceed any year's allowances (and a requirement that such excesses be offset the following year).

A robust market of bilateral SO_2 permit trading has emerged, resulting in cost savings on the order of $1 billion annually, compared with the costs under command-and-control regulatory alternatives.[52] Although the program had low levels of trading in its early years,[53] trading levels increased significantly over time.[54] Concerns have been expressed that state regulatory authorities would hamper trading in order to protect their domestic coal industries, and some research indicates that state public utility commission cost-recovery rules have provided poor guidance for compliance activities.[55] Other analysis suggests that this has not been a major problem.[56] Similarly, in contrast to early assertions that the structure of EPA's small

Environmental Policy: The U.S. Acid Rain Program." *Journal of Law and Economics* 41(1998):81-135.

[52]Cost savings are the difference between the costs experienced with the allowance trading program and what the costs would otherwise have been. Hence, any estimate of cost savings is sensitive to the choice of counterfactual for comparison purposes.

[53]See: Burtraw, Dallas. "The SO_2 Emissions Trading Program: Cost Savings Without Allowance Trades." *Contemporary Economic Policy* 14(1996):79-94.

[54]For an assessment of the program's performance, see: Schmalensee, Richard, Paul L. Joskow, A. Denny Ellerman, Juan Pablo Montero, and Elizabeth M. Bailey. "An Interim Evaluation of Sulfur Dioxide Emissions Trading." *Journal of Economic Perspectives*, volume 12, number 3, summer 1998, pp. 53-68; and Stavins, Robert N. "What Have We Learned from the Grand Policy Experiment: Lessons from SO_2 Allowance Trading." *Journal of Economic Perspectives*, volume 12, number 3, summer 1998, pp. 69-88.

[55]See: Rose, Kenneth. "Implementing an Emissions Trading Program in an Economically Regulated Industry: Lessons from the SO_2 Trading Program," in *Market Based Approaches to Environmental Policy: Regulatory Innovations to the Fore*, Richard F. Kosobud and Jennifer M. Zimmerman, eds. New York: Van Nostrand Reinhold, 1997; and Bohi, Douglas. "Utilities and State Regulators Are Failing to Take Advantage of Emissions Allowance Trading." *The Electricity Journal* 7(1994):20-27.

[56]See: Bailey, Elizabeth M. "Allowance Trading Activity and State Regulatory Rulings: Evidence from the U.S. Acid Rain Program." MIT-CEEPR 96-002 WP, Center for Energy and Environmental Policy Research, Massachusetts Institute of Technology, 1996.

permit auction market would cause problems,[57] the evidence now indicates that this has had little or no effect on the vastly more important bilateral trading market.[58]

2.6 The RECLAIM Program

The South Coast Air Quality Management District (SCAQMD), which is responsible for controlling emissions in a four-county area of southern California, launched a tradable permit program in January, 1994, to reduce nitrogen dioxide and sulfur oxide emissions in the Los Angeles area.[59] One prospective analysis predicted 42% cost savings, amounting to $58 million annually. [60] As of June 1996, 353 participants in this Regional Clean Air Incentives Market (RECLAIM) program, had traded more than 100,000 tons of nitrogen oxide (NO_x) and SO_2 emissions, at a value of over $10 million.[61] The RECLAIM program, which operates through the issuance of permits that authorize specified decreasing levels of pollution over time, governs stationary sources that have emitted more than four tons of NO_x and SO_2 annually since 1990.[62] The SCAQMD has considered expanding the program to allow trading between stationary and mobile sources.[63]

2.7 Transferable Development Rights

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[57]See: Cason, Timothy N. "An Experimental Investigation of the Seller Incentives in EPA's Emission Trading Auction." *American Economic Review* 85(1995):905-922.

[58]See: Joskow, Paul L., Richard Schmalensee, and Elizabeth M. Bailey. "Auction Design and the Market for Sulfur Dioxide Emissions." *American Economic Review*, forthcoming, 1998.

[59]For a detailed case study of the evolution of the use of economic incentives in the SCAQMD, see chapter 2 in *The Environment Goes to Market: The Implementation of Economic Incentives for Pollution Control*. National Academy of Public Administration, July 1994. See also: Thompson, Dale B. "The Political Economy of the RECLAIM Emissions Market for Southern California." Working paper, University of Virginia, March 1997; and Harrison, David Jr. "Turning Theory into Practice for Emissions Trading in the Los Angeles Air Basin," in *Pollution as Property: Tradable Permits, Tradable Quotas, and Joint Implementation*, S. Sorrell and J. Skea (Eds.). London: Edward Elgar, forthcoming.

[60]See: Anderson, Robert. *The U.S. Experience with Economic Incentives in Environmental Pollution Control Policy*. Washington, D.C.: Environmental Law Institute, 1997.

[61]See Brotzman, Thomas. "Opening the Floor to Emissions Trading." *Chemical Marketing Reporter* (May 27, 1996): p. SR8. For an early assessment of the program, see: Johnson, Scott Lee and David M. Pekelney. "Economic Assessment of the Regional Clean Air Incentives Market: A New Emissions Trading Program for Los Angeles." *Land Economics* 72(1996):277-297. A prospective critique was provided by: Johnston, James L. "Pollution Trading in La La Land." *Regulation*, 1994, number 3, pp. 44-54. Additional analyses are by: Lents, James. "The RECLAIM Program at Three Years." Working Paper, April 28 (1998); and Klier, Thomas H., Richard H. Mattoon, and Michael A. Prager. "A Mixed Bag: Assessment of Market Performance and Firm Trading Behaviour in the NO_x RECLAIM Programme." *Journal of Environmental Planning and Management*, 40(6):751-774, 1997.

[62]Some sources, such as equipment rental facilities and essential public services (including landfills and wastewater treatment facilities), are excluded.

[63]See Fulton, William. "The Big Green Bazaar." *Governing Magazine* (June 1996): page 38.

There is a considerable history of local governments in the United States using transferable development rights to balance some of the attributes and amenities ordinarily addressed by zoning provisions with the demands of economic growth and change.[64] A relatively recent application of the same general instrument with an environmental focus has been for the protection of wetlands.

Certain development activities in wetlands are regulated in the United States by Section 404 of the Clean Water Act, which establishes conditions and procedures under which such activities can occur. Firms or individuals must apply for permits for activities that will have negative impacts on wetlands. In some cases, compensating mitigation is required of potential developers, and applicants are allowed to purchase mitigation credits from land banks to meet these obligations.[65] These mitigation banks have been established in a number of states, including: California, Florida, Minnesota, New Jersey, and North Carolina.

3. U.S. EXPERIENCE WITH CHARGE SYSTEMS

The conventional wisdom is that U.S. environmental policy has made increasing use of tradeable permit systems, while essentially ignoring the option of taxes or charges. This is not strictly correct, and if one defines charge systems broadly, a significant number of applications can be identified. These applications can be categorized as: effluent charges; deposit-refund systems; user charges; insurance premia; sales taxes; administrative charges; and tax differentiation.

Most applications of charge systems in the United States have probably not had the incentive effects associated with a Pigovian tax, either because of the structure of the systems or because of the low

[64]See, for example: Field, B. C. and J. M. Conrad. "Economic Issues in Programs of Transferable Development Rights." *Land Economics* 51(1975):331-340; Bellandi, R. L. and R. B. Hennigan. "The Why and How of Transferable Development Rights." *Real Estate Review* 7(1977):60-64; and Mills, D. E. "Transferable Development Rights Markets." *Journal of Urban Economics* 7(1980):63-74.

[65]See: Tripp, James T. B. and Daniel J. Dudek. "Institutional Guidelines for Designing Successful Transferable Rights Programs." Yale Journal of Regulation 6(1989):369-391; Voigt, Paul C., and Leon E. Danielson. "Wetlands Mitigation Banking Systems: A Means of Compensating for Wetlands Impacts." Applied Resource Economics and Policy Group Working Paper AREP96-2, Department of Agricultural and Resource Economics, North Carolina State University, 1996; and Scodari, Paul, Leonard Shabman, and D. White. "Commercial Wetland Mitigation Credit Markets: Theory and Practice." IWR Report 95-WMB-7. Institute for Water Resources, Water Resources Support Center. Alexandria, Virginia: U.S. Army Corps of Engineers, 1995.

levels at which charges have been set.[66] Nevertheless, it appears that a limited number of these systems may have affected behavior.

3.1 Effluent Charges

The closest that any charge system comes in the United States to operating as a Pigovian tax may be the unit-charge approach to financing municipal solid waste collection, where households (and businesses) are charged the incremental costs of collection and disposal.[67] So called "pay-as-you-throw" policies, where users pay in proportion to the volume of their waste, are now used in well over one hundred jurisdictions.[68] This collective experience provides evidence that unit charges have been somewhat successful in reducing the volume of household waste generated.[69]

3.2 Deposit-Refund Systems

As the costs of legal disposal increase, incentives for improper (illegal) disposal also increase. Hence, waste-end fees designed to cover the costs of disposal, such as unit curbside charges, can lead to

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[66]Effluent charges have been used more extensively in Europe than in the United States, although it is questionable whether the levels have been sufficient to affect behavior in significant ways. For a discussion of the economics and politics surrounding taxation of sulfur dioxide, nitrous oxide, and carbon dioxide in the Scandinavian nations, the Netherlands, France, and Germany, see: Cansier, D., and R. Krumm. "Air Pollution Taxation: An Empirical Survey." *Ecological Economics*. Forthcoming, 1998. Also see: Organization for Economic Cooperation and Development. *Taxation and the Environment, Complementary Policies*. Paris, 1993; and Organization for Economic Cooperation and Development. *Environmental Taxation in OECD Countries*. Paris, 1995.

[67]See the chapter on solid waste policy in this volume.

[68]See: U.S. Congress, Office of Technology Assessment. *Environmental Policy Tools: A Users Guide*. Washington, D.C., 1995.

[69]See: Efaw, Fritz and William N. Lanen. "Impact of User Charges on Management of Household Solid Waste." Report prepared for the U.S. Environmental Protection Agency under Contract No. 68-3-2634. Princeton, NJ: Mathtech, Inc., 1979; McFarland, J. M. "Economics of Solid Waste Management." In *Comprehensive Studies of Solid Waste Management, Final Report*. Sanitary Engineering Research Laboratory, College of Engineering and School of Public Health, Report no. 72-3:41-106, University of California, Berkeley, CA, 1972; Skumatz, Lisa A. "Volume-Based Rates in Solid Waste: Seattle's Experience." Report for the Seattle Solid Waste Utility. Seattle: Seattle Solid Waste Utility, 1990; Stevens, B. J. "Scale, Market Structure, and the Cost of Refuse Collection." *The Review of Economics and Statistics* 40(1978):438-448; Wertz, Kenneth L. "Economic Factors Influencing Households' Production of Refuse." *Journal of Environmental Economics and Management* 2(1976):263-72; Lave, Lester and Howard Gruenspecht. "Increasing the Efficiency and Effectiveness of Environmental Decisions: Benefit-Cost Analysis and Effluent Fees" *Journal of Air and Waste Management* 41:680-690 (May 1991); Repetto, Robert, Roger C. Dower, Robin Jenkins, and Jacqueline Geoghegan. *Green Fees: How a Tax Shift Can Work for the Environment and the Economy*. World Resources Institute: Washington D.C., 1992; Fullerton, Don and Thomas C. Kinnaman. "Household Responses to Pricing Garbage by the Bag." *American Economic Review* 86(1996):971-984; and Miranda, Marie Lynn, Jess W. Everett, Daniel Blume, and Barbeau A. Roy Jr. "Market-Based Incentives and Residential Municipal Solid Waste." *Journal of Policy Analysis and Management* 13(1994):681-698.

increased incidence of illegal dumping.[70] For waste that poses significant health or ecological impacts, *ex post* clean up is an especially unattractive option. For these waste products, the prevention of improper disposal is particularly important. One alternative might seem to be a front-end tax on waste precursors, since such a tax would give manufacturers incentives to find safer substitutes and to recover and recycle taxed materials. But substitutes may not be available at reasonable costs, and once wastes are generated, incentives that affect choices of disposal methods are still problematic.

This dilemma can be resolved with a special front-end charge (deposit) combined with a refund payable when quantities of the substance in question are turned in for recycling or disposal. This refund can provide an incentive to follow rules for proper disposal (and to prevent losses in the process in which the substance is used). The mechanics of the system vary by product, but the general framework is that producers or initial users of regulated materials pay a deposit when those materials enter the production process. In principle, the size of the deposit is based upon the social cost of the product being disposed of illegally. As the product changes hands in the production and consumption process (through wholesalers and distributors to consumers), the purchaser of the product pays a deposit to the seller. Thus, once the producer sells the product, responsibility for proper disposal is passed to the next party, this process continuing until the ultimate consumer of the good turns the product in to a certified collection center responsible for recycling or proper disposal.

Deposit-refund systems[71] are most likely to be appropriate when the incidence and the consequences of improper disposal are great,[72] but these systems have frequently been portrayed as mechanisms to foster greater levels of recycling. In general, properly scaled deposit-refund systems can be attractive for three reasons. First, government's monitoring problem is converted from the nearly impossible one of preventing illegal dumping of small quantities of waste at diverse sites in the environment to what may be the more manageable problem of assuring that products being returned for refund are what they are purported to be. Second, the system can provide firms with incentives to prevent losses of the material in the industrial process in which it is used. Third, because of inevitable net losses in the production and consumption processes, incentives exist for firms to look for less environmentally damaging substances — that is, substances to which the deposit-refund system does not apply.[73] For some products, a nationwide approach may be appropriate if: firms face national markets and products are easily transportable; toxicity problems associated with improper disposal do not vary greatly by geographic area;

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[70]See: Fullerton, Don and Thomas C. Kinnaman. "Garbage, Recycling and Illicit Burning or Dumping." *Journal of Environmental Economics and Management* 29(1995):78-92.

[71]See: Bohm, Peter. *Deposit-Refund Systems: Theory and Applications to Environmental, Conservation, and Consumer Policy*. Baltimore: Resources for the Future, Johns Hopkins University Press, 1981.

[72]See: Macauley, Molly K., Michael D. Bowes, and Karen L. Palmer. *Using Economic Incentives to Regulate Toxic Substances*. Washington, D.C.: Resources for the Future, 1992.

[73]For further discussion of this point, see: Russell, Clifford S. "Economic Incentives in the Management of Hazardous Wastes." *Columbia Journal of Environmental Law* 13(1988):257-274.

and the national approach is likely to be less costly for manufacturers and recyclers than a diversity of state or local programs.

The major application of this approach in the United States has been in the form of state-level "bottle bills" for beverage containers (Table 2). A brief examination of these systems provides some insights into the merits *and* the limitations of the approach. Deposit-refund systems on beverage containers have been implemented in ten states to reduce littering and reduce the flow of solid waste to landfills, but since the initial enthusiasm in the late 1970's and early 1980's, no other states have taken action.

In most programs, consumers pay a deposit at the time of purchase which can be recovered by returning the empty container to a redemption center. Typically, the deposit is the same regardless of the type of container. In some respects, these bills seem to have accomplished their objectives; in Michigan, for example, the return rate of containers one year after the program was implemented was 95%;[74] and in Oregon, littering was reduced and long-run savings in waste management costs were achieved.[75]

By charging the same amount for each type of container material, however, these programs do not encourage consumers to choose containers with the lowest product life-cycle costs (including those of disposal). In particular, if bottle bills do not include deposits and refunds for metal, plastic, and glass containers, they may encourage a shift of consumer purchases from easily-recyclable to less-recyclable containers. Furthermore, by requiring consumers to separate containers and deliver them to redemption centers, deposit-refund systems can foster net welfare losses, rather than gains. Additionally, by removing some of the most profitable elements from the waste stream, bottle bills may undermine the viability of more comprehensive alternatives, such as curbside programs.

Analysis of the effectiveness, let alone the cost-effectiveness or efficiency, of beverage container deposit-refund systems has been limited. A major cost of bottle bills is associated with labor and capital required for implementation, including, for example, the area set aside and labor employed at grocery stores for collection purposes. Also of economic significance are the personal inconvenience costs of returning containers to retail outlets. These inconvenience costs may be quite significant, and the few rigorous studies that have been carried out of the benefits and costs of bottle bills have found that the social desirability of deposit law depends critically on the value of the time it takes consumers to return empty containers and the willingness to pay for reduced liter.[76]

Deposit-refund systems are most likely to be appropriate where: (1) the objective is one of reducing illegal disposal, as opposed to such objectives as general reductions in the waste stream or

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[74]See: Porter, Richard. "Michigan's Experience with Mandatory Deposits on Beverage Containers." *Land Economics* 59(1983):177-194.

[75]U.S. General Accounting Office. *Solid Waste: Trade-offs Involved in Beverage Container Deposit Legislation*. Report #GAO/RCED-91-25. Washington, D.C., 1990.

[76]See, for example: Porter, Richard. "A Social Benefit-Cost Analysis of Mandatory Deposits on Beverage Containers." *Journal of Environmental Economics and Management* 5(1978):351-375.

increased recycling; and (2) there is a significant asymmetry between *ex ante* (legal) and *ex post* (illegal or post-littering) clean-up costs. For these reasons, deposit refund systems may be among the best policy options to address disposal problems associated with containerizable hazardous waste, such as lead.[77]

As a means of reducing the quantity of lead entering unsecured landfills and other potentially sensitive sites, several states have enacted deposit-refund programs for lead acid motor vehicle batteries (Table 2).[78] Under these systems, a deposit is collected when manufacturers sell batteries to distributors, retailers, or original equipment manufacturers; likewise, retailers collect deposits from consumers at the time of battery purchase. Consumers can collect their deposits by returning their used batteries to redemption centers; these redemption centers, in turn, redeem their deposits from battery manufacturers.

The programs are largely self-enforcing, since participants have incentives to collect deposits on new batteries and obtain refunds on used ones, but a potential problem inherent in the approach is an increase in incentives for battery theft. The higher the deposit, the greater the incentive for theft, particularly if one only needs to show up at a redemption center with a battery to claim a refund. An alternative is to require a sales receipt upon redemption or to permit refunds only for those exchanging an old battery for a new one. Either of these alternatives, however, will reduce the comprehensiveness of the program.[79] In any event, a deposit of $5 to $10 per battery exceeds the typical market value of used batteries. Thus, it may be small enough to avoid much of the theft problem, but large enough to encourage a substantial level of return.

3.3 User Charges

User charges raise funds for the management and maintenance of resources. Charges of the magnitude necessary to fully cover costs have not been implemented at the Federal level, with the possible exception of an experimental fee program for the National Parks, initiated in 1996. A variety of Federal recreation and transportation taxes can be considered user charges, however, because their revenues are dedicated to support usage (Table 3).

Recreation and entrance fees in the National Park System and other Federally managed recreational areas have been legally mandated since 1951,[80] but the revenues from these fees have

[77]See: Sigman, Hilary A.. "A Comparison of Public Policies for Lead Recycling," *RAND Journal of Economics*. Vol. 26, No. 3, Autumn (1995):452-478.

[78]Minnesota was the first state to implement deposit refund legislation for car batteries in 1988. By 1991, there were ten states with such legislation: Arizona, Arkansas, Connecticut, Idaho, Maine, Michigan, Minnesota, New York, Rhode Island, and Washington. Deposits range from $5 to $10.

[79]Requiring a sales receipt for a refund removes the incentive for the return of batteries that have already been purchased. Further, given the extended life of most batteries, it may be unrealistic to expect consumers to maintain a receipt for many years.

[80]See: U.S. Congress, 1951. Independent Offices Appropriations Act of 1951, August 31, 1951, ch 375, §501, 654 Stat. 290. 31 U.S.C. §9701.

historically gone to the U.S. Treasury, to be reappropriated to the park system as a whole. In 1996, Congress approved a three-year experimental program, the Recreation Fee Demonstration Program, which permits 50 specified parks to raise entrance fees and keep up to 80 percent of incremental revenues. Some of the fee increases have been quite substantial; fees in Yosemite, Grand Canyon, and Yellowstone National Parks, for example, doubled from $10 to $20.[81]

3.4 Insurance Premium Taxes

A number of Federal taxes are levied on industries or groups to fund insurance pools against potential environmental risks associated with the production or use of taxed products (Table 4). Such taxes can have the effect of encouraging firms to internalize environmental risks in their decision making, but, in practice, these taxes have frequently not been targeted at respective risk-creating activities. For example, to support the Oil Spill Liability Trust Fund, all petroleum products are taxed, regardless of how they are transported, possibly creating small incentives to use less petroleum, but not to use safer ships or other means of transport.

An excise tax on specified hazardous chemicals is used to fund (partially) the clean-up of hazardous waste sites through the Superfund program. The tax functions as an insurance tax to the extent that funds are used for future clean-ups.[82] The Leaking Underground Storage Trust Fund, established in 1987, is replenished through taxes on all petroleum fuels,[83] and the Oil Spill Liability Trust Fund, established subsequent to the Exxon Valdez oil spill, receives revenue from a tax on petroleum and petroleum products. The fund can be used to meet unrecovered claims from oil spills.[84] Finally, the Black Lung Disability Trust Fund was established in 1954 to pay miners who became sick and unable to work because of prolonged exposure to coal dust in mines. Since 1977, it has been financed by excise taxes on coal from underground and surface mines.[85]

[81]Two states, New Hampshire and Vermont, have created nearly "self-financing" park systems. See: Reiling, Stephen D. and M. J. Kotchen. "Lessons Learned from Past Research on Recreation Fees" In *Recreation Fees in the National Park Service: Issues, Policies and Guidelines for Future Action,* ed A. L. Lundgren. Minnesota Extension Service Pub. No. BU-6767. Cooperative Park Studies Unit, Department of Forest Resources, University of Minnesota, St. Paul, 1996.

[82]See: Barthold, Thomas A. "Issues in the Design of Environmental Excise Taxes." *Journal of Economic Perspectives* 8(1994), number 1, pp. 133-151.

[83]See: Public Law 99-499, Sec. 522(a), 1986.

[84]See: Public Law 101-239, Revenue Reconciliation Act of 1989.

[85]See: Sect. 9501 of Internal Revenue Code of 1954.

3.5 Sales Taxes

It has been argued that only two Federal sales taxes have affected behavior in the manner of a Pigouvian tax: the "gas guzzler tax" on new cars, and the excise tax on ozone-depleting chemicals,[86] although it is far from clear that the CFC tax actually affected business decisions (Table 5).

The Energy Tax Act of 1978 established a "gas guzzler" tax on the sale of new vehicles that fail to meet statutory fuel efficiency levels, set at 22.5 miles per gallon. The tax ranges from $1,000 to $7,700 per vehicle, based on fuel efficiency; but the tax does not depend on actual performance or on mileage driven. The tax is intended to discourage the production and purchase of fuel inefficient vehicles,[87] but it applies to a relatively small set of luxury cars, and so has had limited effects.[88]

To meet international obligations established under the Montreal Protocol to limit the release of chemicals that deplete stratospheric ozone, the Federal government set up a tradable permit system and levied an excise tax on specific chlorflourocarbons in 1989. Producers are required to have adequate allowances, and users pay a fee (set proportional to a chemical-specific ozone depleting factor). There is considerable debate regarding which mechanism should be credited with the successful reduction in the use of these substances.[89]

Additionally, several states impose taxes on fertilizers and pesticides, but at levels below that required to affect behavior significantly. The taxes generate revenues that are used to finance environmental programs. For example, the Iowa Groundwater Protection Act of 1987 imposes taxes on fertilizers and pesticides (0.1% on pesticide sales at the retail level, 0.2% of manufacturer sales, and $.75 per ton of nitrogen fertilizer). Revenues fund statewide programs for sustainable agriculture and for testing and research on public water supplies.[90]

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[86]See: Barthold, Thomas A. "Issues in the Design of Environmental Excise Taxes." *Journal of Economic Perspectives* 8(1994), number 1, pp. 133-151.

[87]See: U.S. Congress. 26 USC Sec. 4064, Gas Guzzler Tax. 1978.

[88]Light trucks, which include "sport utility vehicles," are fully exempt from the tax. See: Bradsher, Keith. "Light Trucks Increase Profits But Foul Air More than Cars." *New York Times*, November 30, 1997, pp. A1, A38-A39.

[89]See: Hahn, Robert W. and Albert M. McGartland. "Political Economy of Instrumental Choice: An Examination of the U.S. Role in Implementing the Montreal Protocol." *Northwestern University Law Review* 83(1989):592-611; U.S. Congress. The Omnibus Budget Reconciliation Act of 1989 Sect. 7506: Excise Tax on the Sale of Chemicals Which Deplete the Ozone Layer and of Products Containing Such Chemicals. Washington, DC., 1989; and U.S. Congress, Office of Technology Assessment. *Environmental Policy Tools: A Users Guide*. Washington, D.C., 1995.

[90]See: Morandi, Larry. "An Outside Perspective on Iowa's 1987 Groundwater Protection Act," National Conference of State Legislatures, 1992; and International Institute for Sustainable Development. *Green Budget Reform: An International Casebook on Leading Practices*. London: EarthScan, 1995.

3.6 Administrative Charges

These charges raise revenues to help cover the administrative costs of environmental programs (Table 6). Although the charges are not intended to change behavior, this method of raising public funds is broadly consistent with the so-called "polluter-pays principle." For example, under the National Pollution Discharge Elimination System of the Clean Water Act, charges for discharge permits are based on the quantity and type of pollutant discharged. Likewise, the Clean Air Act Amendments of 1990 allow states to tax regulated air pollutants to recover administrative costs of state programs, and allow areas in extreme non-compliance to charge higher rates. Under this structure, the South Coast Air Quality Management District (SCAQMD) in Los Angeles has the highest permit fees in the country.[91]

3.7 Tax Differentiation

We use the phrase, "tax differentiation," to refer to credits, tax cuts, and subsidies for environmentally desirable behavior (Table 7). These serve as implicit taxes on environmentally undesirable behavior. A number of Federal and state taxes have been implemented in attempts to encourage the use of renewable energy sources, implicitly taking into account externalities associated with fossil fuel energy generation and use. In the Energy Policy Act of 1992, for example, electricity produced from wind and biomass fuels receives a 1.5 cent per kWh credit, and solar and geothermal investments can receive up to a 10 percent tax credit. Although economists' natural response to energy-related externalities is to advise that fuels or energy use be taxed, there is econometric evidence that energy-efficiency technology adoption subsidies may be more effective — in some circumstances — than proportional energy taxes.[92]

From 1979 to 1985, employers could provide implicit subsidies to employees for certain commuting expenses, such as free van pools and mass transit passes on a tax-free basis. Likewise, subsidies from utilities for energy conservation investments have been excludable from individual income taxes. On the state and local level, many jurisdictions offer subsidies and various kinds of tax relief to encourage investments in technologies that use recycled products.[93]

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[91]See: U.S. Congress, Office of Technology Assessment. *Environmental Policy Tools: A Users Guide*. Washington, D.C., 1995.

[92]See: Jaffe, Adam B., and Robert N. Stavins. "Dynamic Incentives of Environmental Regulation: The Effects of Alternative Policy Instruments on Technology Diffusion." *Journal of Environmental Economics and Management* 29(1995):S43-S63.

[93]See the chapter on solid waste policy in this volume.

4. U.S. EXPERIENCE WITH REDUCING MARKET BARRIERS

In some situations, environmental protection can be fostered by reducing explicit or implicit barriers to market activity. We consider three types of such market barrier reductions: (1) *market creation*, as with measures that facilitate the voluntary exchange of water rights and thus promote more efficient allocation and use of scarce water supplies; (2) *liability rules* that encourage firms to consider the potential environmental damages of their decisions; and (3) *information programs*, such as energy-efficiency product labeling requirements.

4.1 Market Creation

Two examples of using market creation as an instrument of environmental policy stand out: measures that facilitate the voluntary exchange of water rights and thus promote more efficient allocation and use of scarce water supplies; and particular policies that facilitate the restructuring of electricity generation and transmission. We consider both in this section of the chapter.

First, the western United States has long been plagued by inefficient use and allocation of its scarce water supplies, largely because users do not have incentives to take actions consistent with economic and environmental values. Voluntary market-oriented transfers of water rights have begun to address this problem by encouraging rational conservation measures, better allocation of supplies among competing users, and improvement in water quality.

For more than a decade, economists have noted that Federal and state water policies have been aggravating, not abating, these problems.[94] For example, as recently as 1990, in the Central Valley of California, some farmers were paying as little as $10 for water to irrigate an acre of cotton, while just a few hundred miles away in Los Angeles, local authorities were paying up to $600 for the same quantity of water. This dramatic disparity provided evidence that increasing urban demands for water could be met at relatively low cost to agriculture or the environment (i.e., without constructing new, environmentally-disruptive dams and reservoirs). Subsequent reforms allowed markets in water to develop, so that voluntary exchanges could take place that made both parties better off. For example, an agreement was reached to transfer 100,000 acre-feet of water per year from the farmers of the Imperial Irrigation District (IID) in southern California to the Metropolitan Water District (MWD) in the Los Angeles area.[95]

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[94]See: Anderson, Terry L. *Water Crisis: Ending the Policy Drought*. Washington, D.C.: Cato Institute, 1983; Frederick, Kenneth D., ed. *Scarce Water and Institutional Change*. Washington, D.C.: Resources for the Future, 1986; El-Ashry, Mohamed T. and Diana C. Gibbons. *Troubled Waters: New Policies for Managing Water in the American West*. Washington, D.C.: World Resources Institute, 1986; and Wahl, Richard W. *Markets for Federal Water: Subsidies, Property Rights, and the Bureau of Reclamation*. Washington, D.C.: Resources for the Future, 1989.

[95]In March of 1983, the Environmental Defense Fund (EDF) published a proposal calling for MWD to finance the modernization of IID's water system in exchange for use of conserved water. See: Stavins, Robert N. *Trading Conservation Investments for Water*. Berkeley, California: Environmental Defense Fund, March, 1983. In November, 1988, after five years of negotiation, the two water giants agreed on a $230 million water conservation and transfer arrangement, much like EDF's original proposal to trade conservation investments for water. See: Morris, Willy. "IID Approves State's First Water Swap with MWD." *Imperial Valley Press*, November 9, 1988.

Subsequently, policy reforms spread throughout the west, and transactions emerged elsewhere in California, and in Colorado, New Mexico, Arizona, Nevada, and Utah.[96]

A second example of "market creation" is the current revolution in electricity restructuring that is motivated by economic concerns[97] but may have significant environmental impacts. For many years, utilities — closely overseen by state public utility commissions (PUCs) — have provided electricity within exclusive service areas. The utilities were granted these monopoly markets and guaranteed a rate of return on their investments, conditional upon their setting reasonable rates and meeting various social objectives, such as universal access. The Energy Policy Act of 1992 took a major step toward opening the industry up to competition by allowing independent electricity generating companies to sell power directly to utilities, and in 1996, the Federal Energy Regulatory Commission (FERC) moved things further by issuing regulations that require utilities with transmission lines to transmit power for other parties at reasonable rates.[98]

The purpose of these regulatory changes was to encourage competition at the wholesale (electricity generation) level, but several states — including California, Illinois, Massachusetts, and New Hampshire — have taken this further by facilitating competition at the retail level, so that consumers can contract directly for their electricity supplies. Legislation has been introduced in the U.S. Congress to establish guidelines for retail competition throughout the nation.[99]

These changes have environmental implications. First, as electricity prices fall in the new competitive environment, electricity consumption is expected to increase. This might be expected to increase pollutant emissions, but to whatever degree electricity substitutes for other, more polluting forms of energy, the overall effect may be environmentally beneficial. Second, deregulation will unquestionably make it easier for new firms and sources to enter markets. Since new power plants tend to be both more efficient and less polluting (relying more on natural gas), environmental impacts may decrease.[100] Third,

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[96]See: MacDonnell, Lawrence J. *The Water Transfer Process As a Management Option For Meeting Changing Water Demands, Volume I*. Submitted to the U.S. Geological Survey, Washington, D.C., April, 1990.

[97]The primary arguments for restructuring are: (1) the electricity industry is no longer a natural monopoly, since small generation technologies are now competitive with large centralized production; (2) consumers will benefit from buying cheaper electricity from more efficient producers, who currently face significant barriers to entry; and (3) the old system with cost-of-service pricing provides poor incentives for utilities to reduce costs. For background on the history of electricity restructuring, see: Brennan, Timothy J., Karen L. Palmer, Raymond J. Kopp, Alan J. Krupnick, Vito Stagliano, and Dallas Burtraw. *A Shock to the System: Restructuring America's Electricity Industry*. Washington, DC. Resources for the Future, 1996.

[98]Federal Energy Regulatory Commission. Order 888. April 1996.

[99]The Electric Consumers' Power to Choose Act (104 H.R. 3790 and 105 H.R. 655) is one example of such legislation. For a brief overview of the politics of electricity restructuring, see: Kriz, Margaret. "A Jolt to the System" *National Journal*. August 3, 1996, pp. 1631-1636.

[100]There is considerable debate on this point, since — in the short run — more electricity may be generated from old surplus capacity coal plants in the Midwest, increasing pollutant emissions. In any event, in the long run, competition will encourage a more rapid turnover of the capital stock. See: Palmer, Karen and Dallas Burtraw. "Electricity

more flexible and robust markets for electricity can be expected to increase the effectiveness of various market-based incentives for pollution control, such as the SO_2 allowance trading system.[101]

4.2 Liability Rules

Liability rules can have the effect of providing strong incentives to firms to consider the potential environmental damages of their decisions, and thereby can have the effect of changing those decisions.[102] In theory, a liability rule can be cost effective as a policy instrument because technologies or practices are not specified. For example, taxing hazardous materials or their disposal creates incentives for firms to reduce their use of those materials, but does *not* provide overall incentives for firm to reduce societal *risks* from those materials. An appropriately designed liability rule can do just this.[103] On the other hand, transaction costs associated with litigation may make liability rules most appropriate only for acute hazards. It is in these situations, in fact, that this approach has been employed at the Federal level: liability for toxic waste sites and for the spill of hazardous materials.[104]

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 established retroactive liability for companies that are found responsible for the existence of a site requiring clean up. Governments can collect cleanup costs and damages from waste producers, waste transporters, handlers, and current and past owners and operators of a site. Similarly, the Oil Pollution Act makes firms liable for cleanup costs, natural resource damages, and third party damages caused by oil spills onto surface waters; and the Clean Water Act makes responsible parties liable for cleanup costs for a spill of hazardous substances.

Restructuring and Regional Air Pollution." *Resource and Energy Economics* 19(1997):139-174.

[101]Environmental advocates, however, are very concerned that state PUCs will have much less influence than previously over the industry. In the past, PUCs encouraged "demand side management" and supported the use of renewable forms of electricity generation through the investment approval process or by requiring full-cost pricing for generation. Several policies have been proposed to provide these functions in the new, more competitive environment: for example, a system of tradable "renewable energy credits," wherein each generator would need to hold credits for a certain percentage of their generation; and a tax on the transmission of electricity, used to subsidize renewable generation.

[102]These incentives are frequently neither simple nor direct, because firms and individuals may choose to reduce their exposure to liability by taking out insurance. In this regard, see the earlier discussion in this chapter of "Insurance Premium Taxes."

[103]See: Revesz, Richard L. *Foundations in Environmental Law and Policy*. New York: Oxford University Press, 1997.

[104]See chapter on hazardous wastes and toxic substances in this volume.

4.3 Information Programs

Since well functioning markets depend, in part, on the existence of well-informed producers and consumers, information programs can — in theory — help foster market-oriented solutions to environmental problems.[105] One approach to government improving the available set of information available to consumers is a product labeling requirement (Table 8). The Energy Policy and Conservation Act of 1975 specifies that certain appliances and equipment (including air conditioners, washing machines, and water heaters) carry labels with information on products' energy efficiency and estimated annual energy costs.[106] More recently, EPA and the U.S. Department of Energy (DOE) developed the Energy Star program, in which energy efficient products can display an *EnergyStar* label. The label does not provide specific information on the product, but signals to consumers that the product is, in general, "energy efficient." This program is much broader in its coverage than the appliance labeling program; by 1997, over 13,000 product models carried the *Energy Star* label.[107] There has been little rigorous economic analysis of the efficacy of such programs, but limited econometric evidence suggests that product labeling (specifically appliance efficiency labels) can have significant impacts on efficiency improvements, essentially by making consumers (and therefore producers) more sensitive to energy price changes.[108]

A second type of government information program is a reporting requirement. The country's first such program was New Jersey's Community Right-to-Know Act, passed in 1984. Two years later, a similar program was established at the national level. The Toxics Release Inventory (TRI) was initiated under the Emergency Planning and Community Right-to-Know Act (EPCRA).[109] The TRI requires firms to report (to local emergency planning agencies) information on use, storage, and release of hazardous chemicals. Such information reporting serves compliance and enforcement purposes, but may also increase public awareness of firms' actions, which may be linked with environmental risks. This public scrutiny can encourage firms to alter their behavior.

The Safe Drinking Water Act and Toxic Enforcement Act were adopted in California as a ballot initiative ("Proposition 65") in 1986. The law covers consumer products and facility discharges, and

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[105]For a comprehensive review of information programs and their apparent efficacy, see: Tietenberg, Tom. "Information Strategies for Pollution Control." Paper presented at the Eighth Annual Conference, European Association of Environmental and Resource Economists, Tilburg, The Netherlands, June 26-28, 1997. For an overview of international experience with "eco-labels," see: Morris, Julian and Lynn Scarlett. "Buying Green: Consumers, Product Labels and the Environment." Policy Study No. 202. Los Angeles: The Reason Foundation, August 1996.

[106]See: *United States Code of Federal Regulations*. 16 C.F.R., Chapter 1, Federal Trade Commission, Part 305 – Appliance Labeling Rule. Washington, D.C., 1995; and U.S. Congress, Office of Technology Assessment. *Building Energy Efficiency*. Washington, D.C., 1992.

[107]See: U.S. Department of State. *US Climate Action Report*. Publication 10496. Washington, D.C., 1997.

[108]See: Newell, Richard G., Adam B. Jaffe, and Robert N. Stavins. "The Induced Innovation Hypothesis and Energy-Saving Technological Change." Working paper, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts, October 18, 1997.

[109]See chapter on hazardous wastes and toxic substances in this volume.

requires firms to provide a "clear and reasonable warning" if they expose populations to certain chemicals. In 1987, California enacted its Air Toxics Hot Spots Information and Assessment Act, which sets up an emissions reporting system to track emissions of over 700 toxic substances. The law requires the identification and assessment of localized risks of air contaminants and provides information to the public about the possible impact of those emissions on public health.

5. U.S. EXPERIENCE WITH REDUCING GOVERNMENT SUBSIDIES

A final category of market-based instruments is government subsidy reduction. Since subsidies are the mirror image of taxes, they can — in theory — provide incentives to address environmental problems. But, in practice, a variety of subsidies are believed to promote economically inefficient and environmentally unsound practices. Here, we consider two examples: the below-cost sale of timber by the U.S. Forest Service; and explicit and implicit subsidies that are conveyed to suppliers of energy.

5.1 Below-Cost Timber Sales

The public lands of the United States, which encompass more than 25 percent of the nation's entire land base, contain valuable natural resources, such as timber, minerals, coal, oil, and natural gas, all of which are valued (and priced) in the market place. These lands also provide a variety of public goods, which tend not to be fully valued and priced in the market: wilderness, fish and wildlife habitats, watersheds, and recreational opportunities. Because it is difficult for individual landowners to provide these public goods profitably, the burden for providing such environmental amenities tends to fall on the public lands.

Subsidies that benefit selected extractive industries may impede the provision of such amenities on public lands. Below-cost timber sales — where the U.S. Forest Service does not recover the full cost of making timber available — constitute an important case in point. It has been estimated that removal of these subsidies would foster environmental protection and could save taxpayers up to $1.2 billion over five years.[110]

Congress has mandated that the Forest Service pursue a policy of multiple-use management for timber, recreation, wildlife habitat, and watershed purposes.[111] But the Forest Service is not under legal or regulatory requirements to sell its timber at a price that will recover the government's costs of growing and marketing that timber, and a substantial amount of publicly-owned timber is sold below cost. That is, the commercial activity of moving timber from public lands into the marketplace frequently costs the Federal

[110]See: U.S. Congressional Budget Office. *Reducing the Deficit: Spending and Revenue Options.* Washington, D.C., February 1990.

[111]See: Bowes, Michael D. and John V. Krutilla. *Multiple-Use Management: The Economics of Public Forestlands.* Washington, D.C.: Resources for the Future, 1989.

government more than it gets in return. This implicit subsidy has most frequently been in the form of credits to private lumber companies for road building.

There are approximately 380,000 miles of roads in National Forests, roughly eight times the length of the Interstate highway system. While they do have recreational and other uses, these roads primarily serve as access for logging companies. They have been constructed either directly by the Forest Service or through a "purchaser road credit" system. The road credit system began with the 1964 Forest Roads and Trails Act which allows the Forest Service to credit logging companies for their expenses in constructing the logging roads they need to access timber. Under this system, companies deduct road construction expenses directly from the amount they pay the Forest Service for the timber they extract. In 1996, direct outlays totaled $84 million and purchaser credits were valued at nearly $50 million.[112]

Claims have been made that the Forest Service's disregard of timber-production costs has led to excessive logging in unproductive National Forests.[113] In response to such concerns, several administrations and Congresses have considered various initiatives to deal with the problem, each of which would essentially direct that more attention be given to economic considerations when managing and selling Federal timber. But, through 1997, no significant action had been taken.[114]

5.2 Fossil-Fuel Energy Subsidies

Because of concerns about global climate change, increased attention has been given to Federal subsidies and other programs that promote the use of fossil fuels. One EPA study indicates that eliminating these subsidies would have a significant effect on reducing carbon dioxide (CO_2) emissions.[115] The Federal government is involved in the energy sector through the tax system and through a range of individual agency programs. One other study indicates that these activities together cost the government $17 billion annually.[116]

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[112]See: Senator Richard Bryan, Statements before Senate, Oct. 28, 1997; Conference Report on Interior Appropriations Act.

[113]See: Repetto, Robert and Malcolm Gillis, eds. *Public Policies and the Misuse of Forest Resources*. New York: Cambridge University Press, 1988; and Hyde, William F. "Timber Economics in the Rockies: Efficiency and Management Options." *Land Economics* 57(1981):630-37.

[114]On November 11, 1997, after a prolonged debate on below-cost timber sales, President Clinton signed a spending bill that included provisions to continue subsidies for the construction of logging roads in national forests.

[115]See: Shelby, Mike, Robert Shackleton, Malcolm Shealy, and Alex Cristofaro. *The Climate Change Implications of Eliminating U.S. Energy (and Related) Subsidies*. Washington, D.C.: U.S. Environmental Protection Agency, October 1997.

[116]See: Alliance to Save Energy. *Federal Energy Subsidies: Energy, Environmental and Fiscal Impacts*. Lexington, Massachusetts, 1993.

A substantial share of these subsidies and programs were enacted during the "oil crises" to encourage the development of domestic energy sources and reduce reliance on imported petroleum. They favor energy supply over energy efficiency.[117] Although there is an economic argument for government policies that encourage new technologies that have particularly high risk or long term payoffs, mature and conventional technologies currently receive nearly 90% of the subsidies. Furthermore, within fossil fuels, the most environmentally benign fuel — natural gas — receives only about 20% of the subsidies.

On the other hand, it should also be recognized that Federal user charges (Table 3) and insurance premium taxes (Table 4) include significant levies on fossil fuels, and that Federal tax differentiation has tended to favor renewable energy sources and non-conventional fossil fuels (Table 7). In any event, the Clinton Administration's 1997 proposal to address global climate change includes a program of $5 billion (over five years) worth of government-funded research and development and private-industry tax credits for renewable energy sources and energy efficiency.[118]

6. WHY HAVE THERE BEEN RELATIVELY FEW APPLICATIONS OF MARKET-BASED INSTRUMENTS?

Despite the great interest given to market-based instruments by politicians in recent years and the great progress that has been made, market-based instruments have yet to transform fundamentally the landscape of U.S. environmental policy. For the most part, these instruments still exist only at the fringes of regulation.

6.1 A Stock-Flow Problem

Market-based instruments represent only a trivial portion of existing regulation. The reasons for this are many. Perhaps the most obvious is that there has not been a great deal of new environmental regulation. Since 1990, the Clean Air Act and Safe Drinking Water Act are the only major environmental regulations to be reauthorized. Given that Title 40 of the Code of Federal Regulations, titled "Protection of the Environment," contains over 14,310 pages of environmental regulations, it could take a very long time indeed for market instruments to become the core of environmental policy, unless Congress is willing to use them for "old" problems as well as new ones.

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[117]The Alliance to Save Energy study claims that end-use efficiency receives $1 for every $35 received by energy supply.

[118]See: Easterbrook, Gregg. "Greenhouse Common Sense: Why Global-Warming Economics Matters More than Science." *U.S. News and World Report*, December 1, 1997, pp. 58-62.

6.2 Resistance from Interest Groups

Within the government environmental bureaucracy there exists a desire to see effective environmental regulation adopted, but traditional regulatory programs require regulators with a technical or legal-based skill-set, while market-based instruments require market-trained thinkers, including MBAs, economists, and others. Members of the government bureaucracy may rationally be resisting the dissipation of their human capital.[119]

Although some environmental groups have increasingly welcomed the selective use of market-based instruments,[120] others are concerned that increased flexibility in environmental regulation will result in the reduction of the overall degree of environmental protection. And in parts of the environmental community, the sentiment remains that environmental quality is an inalienable right and that market-programs inappropriately condone the "right to pollute." Lastly, some environmental professionals, like their government counterparts, may be resisting the dissipation of *their* human capital.

The ambivalence of the regulated community itself has also served to retard the use of market-based instruments. Many industries and companies have applauded market-based instruments in the abstract, because of the promise of flexibility and cost effectiveness. But few businesses have actually supported the adoption of new applications. One factor is reluctance to promote any regulation, no matter how flexible or cost effective. Businesses may believe that political forces beyond their control might unfavorably distort the design and implementation of these instruments. First, cost savings might be taken away from them by an increase in the stringency of standards. Second, the design of instruments may limit their flexibility. Third, the rules may be changed over time. For businesses to optimize environmental investments, regulations not only have to be flexible, but predictable. Fourth, some firms remain concerned that "buying the right to pollute" could lead to negative publicity. Fifth and finally, private industry representatives may resist these reforms to prevent the dissipation of *their* human capital.

6.4 Public Resistance

The slow penetration of market-based instruments into environmental policies may also be due to these instruments not being well understood by the general public. The benefits to consumers of market instruments are typically not visible, while the perceived costs can be transparent. Under traditional command-and-control policies, consumers may see prices go up, but they clearly find it difficult to associate those price increases with environmental regulations. For example, it is *not* readily apparent to consumers that gasoline and electricity prices are lower than they otherwise would have been because of the use of market-based programs to phase out lead or reduce SO_2 emissions. At the same time, market-based instruments – especially charges – may suffer from making environmental costs *more* transparent. While

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[119]Hahn, Robert W. And Robert N. Stavins. "Incentive-based Environmental Regulation: a New Era from an Old Idea?" *Ecology Law Quarterly* 18(1991): 1-42.

[120]During the mid-1980's, the Environmental Defense Fund (EDF) was the first environmental advocacy organization to aggressively welcome the use of market-based instruments. See: Krupp, Frederic. "New Environmentalism Factors in Economic Needs." *Wall Street Journal*, November 20, 1986: p. 34.

encouraging individuals to consciously link environmental costs and benefits may be a good thing, it can certainly undermine the enthusiasm with which market-based instruments are embraced.

7. WHY HAS THE PERFORMANCE RECORD BEEN MIXED?

When market-based environmental policy instruments have been used, they have not always performed as predicted. Why?

7.1 Inaccurate Predictions

One reason market-based instruments have sometimes fallen short in delivering predicted cost savings is that the predictions themselves have often been unrealistic: premised on perfect performance under *ideal* conditions. That is, these predictions have assumed that the cost-minimizing allocation of the pollution-control burden among sources would be achieved, and that marginal abatement costs would be equated across all sources. In a frequently cited table, Tietenberg calculated the ratio of the cost of an actual command-and-control program to a least-cost benchmark,[121] but others have mistakenly used this ratio as an indicator of the potential gains of adopting specific market-based instruments. The more appropriate comparison would be between actual command-and-control programs and either actual or reasonably constrained theoretical market-based programs.[122]

In addition, predictions made during policy debates have typically ignored factors that can adversely affect performance: transaction costs involved in implementing market-based programs; uncertainty as to the property rights bestowed under programs; uncompetitive market conditions; a pre-existing regulatory environment that does not give firms incentives to participate; and the inability of firms' internal decision-making capabilities to fully utilize program opportunities.

7.2 Design Problems

Many of the factors cited suggest the need for changes in the design of future market-based instruments. While some program design elements reflect miscalculations of market reactions, others were known to be problematic at the time the programs were enacted, but nevertheless were incorporated into programs to ensure adoption by the political process. One striking example is the "20% rule" under EPA's Emission Trading Program.[123] This rule, adopted at the insistence of the environmental community,

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[121]See: Tietenberg, Tom. *Emissions Trading: An Exercise in Reforming Pollution Policy*. Washington, D.C.: Resources for the Future, 1985.

[122]See: Hahn, Robert and Robert Stavins. "Economic Incentives for Environmental Protection: Integrating Theory and Practice." *American Economic Review* 82 (May 1992): 464-468

[123]See: Hahn, Robert W. "Regulatory Constraints on Environmental Markets." *Journal of Public Economics* 42(1990): 149-175.

stipulates that each time a permit is traded, the amount of pollution authorized thereunder must be reduced by 20%. Since permits that are not traded retain their full quantity value, this regulation discourages permit trading and thereby increases regulatory costs.

7.3 Limitations in Firms' Structure

A third explanation for the mixed performance of implemented market-based instruments is that firms are simply not well equipped internally to make the decisions necessary to fully utilize these instruments. Since market-based instruments have been used on a limited basis only, and firms are not certain that these instruments will be a lasting component on the regulatory landscape, most companies have chosen not to reorganize their internal structure to fully exploit the cost savings these instruments offer. Rather, most firms continue to have organizations that are experienced in minimizing the costs of complying with command-and-control regulations, not in making the strategic decisions allowed by market-based instruments.[124]

The focus of environmental, health, and safety departments in private firms has been primarily on problem avoidance and risk management, rather than on the creation of opportunities made possible by market-based instruments. This focus has developed because of the strict rules companies have faced under command-and-control regulation, in response to which companies have built skills and developed processes that comply with regulations, but do not help them benefit competitively from environmental decisions. Absent significant changes in structure and personnel, the full potential of market-based instruments will not be realized.

8. THE CHANGING POLITICS OF MARKET-BASED INSTRUMENTS

Given the historical lack of receptiveness by the political process to market-based approaches to environmental protection, why has there been a recent rise in the use of market-based approaches?[125] It would be gratifying to believe that increased understanding of market-based instruments had played a large part in fostering their increased political acceptance, but how important has this really been? In 1981, political scientist Steven Kelman surveyed Congressional staff members, and found that support and opposition to market-based environmental policy instruments was based largely on ideological grounds:

[124]There are some exceptions. Enron, for example, has attempted to use market-based instruments for its strategic benefit by becoming a leader in creating new markets for trading acid rain permits. Other firms have appointed environmental, health, and safety leaders who are familiar with a wide range of policy instruments, not solely command-and-control approaches, and who bring a strategic focus to their company's pollution-control efforts. See: Hockenstein, Jeremy B., Robert N. Stavins, and Bradley W. Whitehead. "Creating the Next Generation of Market-Based Environmental Tools." *Environment* 39, number 4 (1997), pp. 12-20, 30-33.

[125]For a more thorough exploration of the answers to this question, see: Keohane, Nathaniel O., Richard L. Revesz, and Robert N. Stavins. "The Positive Political Economy of Instrument Choice in Environmental Policy." *Environmental Economics and Public Policy*, eds. Paul Portney and Robert Schwab. London: Edward Elgar, Ltd., forthcoming 1998; and Stavins, Robert N. "What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading." *Journal of Economic Perspectives*, volume 12, number 3, summer 1998, pp. 69-88.

Republicans who supported the concept of economic-incentive approaches offered as a reason the assertion that "the free market works," or "less government intervention" is desirable, without any real awareness or understanding of the economic arguments for market-based programs. Likewise, Democratic opposition was largely based upon analogously ideological factors, with little or no apparent understanding of the real advantages or disadvantages of the various instruments.[126] What would happen if we were to replicate Kelman's survey today? My refutable hypothesis is that we would find increased support from Republicans, greatly increased support from Democrats, but insufficient improvements in understanding to explain these changes.[127] So what else has mattered?

First, one factor has surely been increased pollution control costs, which have led to greater demand for cost-effective instruments. By the late 1980's, even political liberals and environmentalists were beginning to question whether CAC regulations could produce further gains in environmental quality. During the previous twenty years, pollution abatement costs had continually increased, as stricter standards moved the private sector up the marginal cost-of-control function. By 1990, U.S. pollution control costs had reached $125 billion annually, nearly a 300% increase in real terms from 1972 levels.[128]

Second, a factor that became important in the late 1980's was strong and vocal support from some segments of the environmental community.[129] By supporting tradeable permits for acid rain control, the Environmental Defense Fund (EDF) seized a market niche in the environmental movement, and successfully distinguished itself from other groups.[130] Related to this, a third factor was that the SO_2 allowance trading program, the leaded gasoline phasedown, and the CFC phaseout were all designed to *reduce* emissions, not simply to *reallocate* them cost-effectively among sources. Market-based instruments are most likely to be politically acceptable when proposed to achieve environmental improvements that would not otherwise be feasible (politically or economically).

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[126]See: Kelman, Steven. *What Price Incentives?: Economists and the Environment*. Boston: Auburn House, 1981.

[127]But there has been some increased understanding of market-based approaches among policy makers. This has partly been due to increased understanding by their staffs, a function — to some degree — of the economics training that is now common in law schools, and of the proliferation of schools of public policy. See: Hahn, Robert W. and Robert N. Stavins. "Incentive-based Environmental Regulation: a New Era from an Old Idea?" *Ecology Law Quarterly* 18(1991):1-42.

[128]See: U.S. Environmental Protection Agency, *Environmental Investments: The Cost of a Clean Environment*, report of the administrator to Congress. Washington, D.C.: U.S. EPA, December 1990; and Jaffe, Adam B., Steven R. Peterson, Paul R. Portney, and Robert N. Stavins. "Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tells Us?" *Journal of Economic Literature* 33(1995):132-163.

[129]But the environmental advocacy community is by no means unanimous in its support for market-based instruments. See, for example: Seligman, Daniel A. *Air Pollution Emissions Trading: Opportunity or Scam? A Guide for Activists*. San Francisco: Sierra Club, 1994.

[130]When the memberships (and financial resources) of other environmental advocacy groups subsequently declined with the election of the environmentally-friendly Clinton-Gore Administration, EDF continued to prosper and grow. See: Lowry, Robert C. "The Political Economy of Environmental Citizen Groups." Unpublished Ph.D. thesis, Harvard University, 1993.

Fourth, deliberations regarding the SO_2 allowance system, the lead system, and CFC trading differed from previous attempts by economists to influence environmental policy in an important way: the separation of ends from means, i.e. the separation of consideration of goals and targets from the policy instruments used to achieve those targets. By accepting — implicitly or otherwise — the politically identified (and potentially inefficient) goal, the ten-million ton reduction of SO_2 emissions, for example, economists were able to focus successfully on the importance of adopting a cost-effective means of achieving that goal. The risk, of course, was "designing a fast train to the wrong station."

Fifth, acid rain was an unregulated problem until the SO_2 allowance trading program of 1990; and the same can be said for leaded gasoline and CFC's. Hence, there were no existing constituencies — in the private sector, the environmental advocacy community, or government — for the *status quo* approach, because there was no *status quo* approach. We should be more optimistic about introducing market-based instruments for "new" problems, such as global climate change, than for existing, highly regulated problems, such as abandoned hazardous waste sites.

Sixth, by the late 1980's, there had already been a perceptible shift of the political center toward a more favorable view of using markets to solve social problems. The Bush Administration, which proposed the SO_2 allowance trading program and then championed it through an initially resistant Democratic Congress, was (at least in its first two years) "moderate Republican;" and phrases such as "fiscally responsible environmental protection" and "harnessing market forces to protect the environment" do have the sound of quintessential moderate Republican issues.[131] But, beyond this, support for market-oriented solutions to various social problems had been increasing across the political spectrum for the previous fifteen years, as was evidenced by deliberations on deregulation of the airline, telecommunications, trucking, railroad, and banking industries. Indeed, by 1990, the concept (or at least the phrase), "market-based environmental policy," had evolved from being politically problematic to politically attractive.

Seventh, the adoption of the SO_2 allowance trading program for acid rain control — like any major innovation in public policy — can partly be attributed to a healthy dose of chance that placed specific persons in key positions, in this case at the White House, EPA, the Congress, and environmental organizations.[132] The result was what remains the golden era for market-based environmental strategies.

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[131]The Reagan Administration enthusiastically embraced a market-oriented ideology, but demonstrated no interest in employing actual market-based policies in the environmental area.

[132]Within the White House, among the most active and influential enthusiasts of market-based environmental instruments were: Counsel Boyden Gray and his Deputy John Schmitz, Domestic Policy Adviser Roger Porter, Council of Economic Advisers (CEA) Member Richard Schmalensee, CEA Senior Staff Economist Robert Hahn, and Office of Management and Budget Associate Director Robert Grady. At EPA, Administrator William Reilly — a "card-carrying environmentalist" — enjoyed valuable credibility with environmental advocacy groups; and Deputy Administrator Henry Habicht was a key, early supporter of market-based instruments. In the Congress, Senators Timothy Wirth and John Heinz provided high-profile, bi-partisan support for the SO_2 allowance trading system and, more broadly, for a wide variety of market-based instruments for various environmental problems through their "Project 88" (Stavins 1988). And, finally, in the environmental community, EDF Executive Director Fred Krupp, Senior Economist Daniel Dudek, and Staff Attorney Joseph Goffman worked closely with the White House to develop the initial allowance trading proposal. Moreover, a number of individuals within the government supported market-based instruments as far back as the Carter

9. CONCLUSION

Some eighty years ago, economists first proposed the use of corrective taxes to internalize environmental and other externalities. Fifty years later, the portfolio of potential economic-incentive instruments was expanded to include quantity-based mechanisms — tradeable permits. Thus, economic-incentive approaches to environmental protection are clearly not a new policy idea. Over the past two decades, they have held varying degrees of prominence in environmental policy discussions.

Market-based instruments have now moved center stage, and policy debates look very different from the time when these ideas were characterized as "licenses to pollute" or dismissed as completely impractical. Market-based instruments are considered seriously for each and every environmental problem that is tackled, ranging from endangered species preservation[133] to regional smog[134] and what may be the greatest of environmental problems, the greenhouse effect and global climate change.[135] It seems clear that market-based instruments — and, in particular, tradeable permit systems — will enjoy increasing acceptance in the years ahead.

No particular form of government intervention, no individual policy instrument — whether market-based or conventional — is appropriate for all environmental problems. Which instrument is best in any given situation depends upon a variety of characteristics of the environmental problem, and the social, political, and economic context in which it is being regulated. There is no policy panacea. Indeed, the real challenge for bureaucrats, elected officials, and other participants in the environmental policy process comes in analyzing and then selecting the best instrument for each situation that arises.

Administration, helping to lay the groundwork for what was to come.

[133]See, for example: Goldstein, Jon B. "The Prospects for Using Market Incentives to Conserve Biological Diversity." *Environmental Law* 21(1991), Northwestern School of Law, Portland, Oregon; and Bean, Michael J. "Shelter from the Storm: Endangered Species and Landownders Alike Deserve a Safe Harbor." *The New Democrat*, March/April 1997, pp. 20-21.

[134]See: U.S. Environmental Protection Agency. "EPA Proposes Emissions Trading Program to Help Protect Eastern U.S. from Smog." Press Release, April 29, 1998.

[135]See the chapter in this volume on global climate policy. Also see: Fisher, B., S. Barrett, P. Bohm, B. Fisher, M. Kuroda, J. Mubazi, A. Shah, and R. Stavins. "Policy Instruments to Combat Climate Change." *Climate Change 1995: Economic and Social Dimensions of Climate Change*, eds. J.P. Bruce, H. Lee, and E.F. Haites, pp. 397-439. Intergovernmental Panel on Climate Change, Working Group III. Cambridge, England: Cambridge University Press, 1996; Hahn, Robert and Robert Stavins. "Trading in Greenhouse Permits: A Critical Examination of Design and Implementation Issues." *Shaping National Responses to Climate Change: A Post-Rio Policy Guide*, ed. Henry Lee, pp. 177-217. Cambridge: Island Press, 1995; Schmalensee, Richard. *Greenhouse Policy Architecture and Institutions.* Paper prepared for National Bureau of Economic Research conference, "Economics and Policy Issues in Global Warming: An Assessment of the Intergovernmental Panel Report," Snowmass, Colorado, July 23-24, 1996; and Stavins, Robert N. "Policy Instruments for Climate Change: How Can National Governments Address a Global Problem?" *The University of Chicago Legal Forum*, volume 1997, pp. 293-329.

TABLE 1:
MAJOR FEDERAL TRADEABLE PERMIT SYSTEMS*

Program	Traded Commodity	Period of Operation	Environmental and Economic Effects
Emissions Trading Program	Criteria air pollutants under the Clean Air Act	1974-Present	Environmental performance unaffected; total savings of $5-12 billion
Lead Phasedown	Rights for lead in gasoline among refineries	1982-1987	More rapid phaseout of leaded gasoline; $250 million annual savings
Water Quality Trading	Point-nonpoint sources of nitrogen & phosphorous	1984-1986	No trading occurred, because ambient standards not binding
CFC Trading for Ozone Protection	Production rights for some CFCs, based on depletion potential	1987-Present	Environmental targets achieved ahead of schedule; effect of tp system unclear
Acid Rain Reduction	SO_2 emission reduction credits; mainly among electric utilities	1995-Present	Environmental targets achieved ahead of schedule; annual savings of $1 billion
RECLAIM Program	Local SO_2 and NO_x emissions trading among stationary sources	1994-Present	Unknown as of 1997

*The RECLAIM program in southern California is a regional initiative intended to achieve Federal and state targets; "tp" is an abbreviation for "tradeable permit."

SOURCE: Hahn, Robert W. and Gordon L. Hester. "Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program." *Yale Journal of Regulation* 6 (1989): 109-153; Robert W. Hahn. "Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders." *Journal of Economic Perspectives* 3 (1989): 95-114; and Schmalensee, Richard, Paul L. Joskow, A. Denny Ellerman, Juan Pablo Montero, and Elizabeth M. Bailey. "An Interim Evaluation of Sulfur Dioxide Emissions Trading." *Journal of Economic Perspectives*, volume 12, number 3, summer 1998, pp. 53-68.

TABLE 2:
DEPOSIT-REFUND SYSTEMS

Regulated Products	Jurisdiction	Date of Initiation	Size of Deposit
Specified Beverage Containers	Oregon	1972	5¢ (2¢ refillables)
	Vermont	1973	5¢
	Maine	1978	5¢
	Michigan	1978	10 ¢
	Iowa	1979	5¢
	Connecticut	1980	5¢
	Delaware	1983	5¢
	Massachusetts	1983	5¢
	New York	1983	5¢
	California	1987	*
Auto Batteries	Minnesota	1988	$5.00
	Rhode Island	1989	
	Washington	1989	
	Arizona	1990	
	Connecticut	1990	
	Idaho	1991	
	New York	1991	
	Wisconsin	1991	
	Michigan	1990	$6.00
	Maine	1989	$10.00
	Arkansas	1991	

*In California, deposits for aluminum and bi-metal beverage containers smaller than 24 ounces are 2.5¢ and 5¢, respectively, and 3¢ and 6¢, respectively, for containers 24 ounces and larger. Florida had an advance disposal fee (an upfront processing fee charged to plastic and glass containers) which is no longer in effect.

SOURCE: U.S. General Accounting Office. *Solid Waste: Trade-Offs Involved in Beverage Container Deposit Legislation*. Report GAO/RCED-91-25. Washington, D.C., 1990; and U.S. Environmental Protection Agency. *States' Efforts to Promote Lead-Acid Battery Recycling*. Washington, D.C., 1992.

TABLE 3:
FEDERAL USER CHARGES

Item Taxed	First Enacted/Modified	Rate	Use of Revenues
Motor fuels	1932/1993	$.183/gal	Highway Trust Fund/Mass Transit Account
Annual use of heavy vehicles	1951/1993	$100-$500/vehicle	
Trucks and trailers (excise tax)	1917/1984	12%	
Noncommercial motorboat fuels	1932-1992	$.183/gal	Aquatic Resource Trust Fund
Inland waterways fuels	1978/1993	$.233/gal	Inland Waterways Trust Fund
Non-highway recreational fuels and small-engine motor fuels	1932/1993	$.183/gal gasoline $.243/gal diesel	National Recreational Trails Trust Fund and Wetlands Account of Aquatic Resources Trust Fund
Sport fishing equipment	1917/1984	10% (except 3% for outboard motors)	Sport Fishing Restoration Account of Aquatic Resources Trust Fund
Bows and arrows	1972/1984	11%	Federal Aid to Wildlife Program
Firearms and ammunition	1918/1969	10%	

SOURCE: Barthold, Thomas A. "Issues in the Design of Environmental Excise Taxes." *Journal of Economic Perspectives* 8(1994), number 1, pp. 133-151.

TABLE 4:
FEDERAL INSURANCE PREMIUM TAXES

Item/Action Taxed	First Enacted/Modified	Rate	Use of Revenues
Chemical production	1980/1986	$.22 to $4.88/ton	Superfund (CERCLA)
Petroleum production	1980/1986	$.097/barrel crude	
Corporate income	1986	0.12%*	
Petroleum and petroleum products	1989/1990	$.05/barrel	Oil Spill Liability Trust Fund
Petroleum-based fuels, except propane	1986/1990 (expired 1995)	$.001/gal	Leaking Underground Storage Trust Fund
Coal production	1977/1987	$1.10/ton underground $.55/ton surface	Black Lung Disability Trust Fund

*0.12% of "alternative minimum taxable income" that exceeds $2 million.

SOURCE: Barthold, Thomas A. "Issues in the Design of Environmental Excise Taxes." *Journal of Economic Perspectives* 8(1994), number 1, pp. 133-151.

TABLE 5:
FEDERAL SALES TAXES

Item/Action Taxed	**First Enacted/Modified**	**Rate**	**Use of Revenues**
New automobiles exceeding fuel efficiency maxima	1978/1990	$1,000 - $7,700 per auto	U.S. Treasury
Ozone-depleting substances	1989/1992	$4.35/pound	U.S. Treasury
New tires	1918/1984	$.15 - $.50/pound	U.S. Treasury

SOURCE: Barthold, Thomas A. "Issues in the Design of Environmental Excise Taxes." *Journal of Economic Perspectives* 8(1994), number 1, pp. 133-151.

TABLE 6:
ADMINISTRATIVE CHARGES

Item/Action Taxed	First Enacted/Modified	Rate	Use of Revenues
Water Pollutant Discharges	1972	Varies by substance	State administrative cost of National Pollution Discharge Elimination System, Clean Water Act
Criteria Air Pollutants	1990	Varies by implementing state	State administrative cost of state clean air programs under Clean Air Act

SOURCE: U.S. Office of Technology Assessment. *Environmental Policy Tools: A User's Guide*. Washington, D.C., 1995.

TABLE 7:
FEDERAL TAX DIFFERENTIATION

Item/Action Taxed	Provision	First Enacted/Modified	Rate
Motor Fuels Excise Tax Exemptions*	Natural Gas	1978/1990	$.07/gal
	Methanol	1978/1990	$.06/gal
	Ethanol	1978/1990	$.054/gal
Income Tax Credits	Alcohol Fuels	1980/1990	$.60/gal methanol
			$.54/gal ethanol
	Business Energy	1980/1990	10% solar
			10% geothermal
	Non-conventional Fuels	1980/1990	$3.00/Btu-barrel equivalent of oil
	Wind Production	1992	1.5¢/kWh
	Biomass Production	1992	1.5¢/kWh
	Electric Automobiles	1992	10% credit
Other Income Tax Provisions	Van Pools	1978	Tax-free employer provided benefits
	Mass Transit Passes	1984/1992	
	Utility Rebates	1992	Exclusion of subsidies from utilities for energy conservation measures
Tax Exempt Private Activity Bonds	Mass Transit	1968/1986	Interest exempt from Federal taxation
	Sewage Treatment	1968/1986	
	Solid Waste Disposal	1968/1986	
	Waster Treatment	1968/1986	
	High Speed Rail	1988/1993	

*Exemptions from the motor fuels excise tax of $0.183/gallon (see Table 3).

SOURCE: Barthold, Thomas A. "Issues in the Design of Environmental Excise Taxes." *Journal of Economic Perspectives* 8(1994), number 1, pp. 133-151.

TABLE 8:
FEDERAL INFORMATION PROGRAMS

Information Program	Year of Implementation	Enabling Legislation
Energy Efficiency Product Labeling	1975	Energy Policy and Conservation Act, Title V
NJ Hazardous Chemical Emissions	1984	New Jersey Community Right-to-Know Act
Toxic Release Inventory	1986	Emergency Planning and Community Right-to-Know Act
CA Hazardous Chemical Emissions	1987	California Air Toxics Hot Spots and Information Assessment Act
CA Proposition 65	1988	California Safe Drinking Water Act and Toxic Enforcement Act
Energy Star	1993	Joint program of the U.S. EPA and the U.S. DOE