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Tradable Permits and the Control of Air Pollution in the United States

by

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Abstract

In 1975 tradable permits were first implemented in the United States to control industrial air pollution. From this rather humble beginning this approach has now been expanded rather dramatically in several different directions. This paper describes this evolution, shows how the design of the system has been adapted as a result of lessons learned from earlier phases, and describes how the latest versions of this approach have transformed the regulatory process which spawned the approach in the first place.

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INTRODUCTION

BACKGROUND

Beginning in 1975, burgeoning costs associated with the rigidities inherent in its traditional predominantly legal approach to controlling air pollution led the U. S. Environmental Protection Agency (EPA) to begin experimenting with an economic incentive approach now known as the **Emissions Trading Program**, a limited version of a system of tradable permits. Since that time the tradable permits concept has been applied in several rather different contexts.

The newer tradable permits programs differ in some rather dramatic ways from the earliest versions. In part this was due to an "adaptive management" approach in which the newer programs benefited from the lessons gleaned from the earlier programs, but it was also due to an evolution of the underlying goals of the programs and the desire to gain support from major constituencies.

Support for the use of this market approach to environmental control has clearly grown in the United States, as reflected by the increasing number of applications by the federal government and by state governments. This political shift toward transferable permits has both benefited from, and contributed to, an increasingly favorable treatment in both in the popular business and environmental press. Some public interest environmental organizations have even adopted economic incentive approaches as a core part of their strategy for protecting the environment.

OVERVIEW

The tradable permits policy for controlling pollution in the United States has evolved considerably since its inception in the mid 1970s.[1] Though current and past policies share a common intellectual heritage, they differ considerably in their implementation details. They also differ in the amount of publicly available information on outcomes. While information

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[1] In the limited space permitted by this paper only a few highlights can be illustrated. All of the details of the proofs and the empirical work can be found in the references listed at the end of the paper. For a comprehensive summary of this work see ((Tietenberg 1985; Dudek and Palmisano 1988; Hahn 1989; Hahn and Hester 1989a; Hahn and Hester 1989b; Tietenberg 1990).

on the earlier programs is very sketchy, the latest programs have provided a wealth of data. These data have provided the basis for more detailed analysis which has resulted in deeper understanding about the programs. In this paper I will describe that evolution in general, will examine some key components in more detail, and will attempt to identify some of the causes and consequences of the evolution. Key design lessons will be extracted from the historical record.

THE POLICY CONTEXT

THE TRADITIONAL APPROACH

Stripped to its bare essentials, the U. S. pre-reform approach to pollution control, some of which remains in tact today, relied upon a **command-and-control** approach to controlling pollution. Ambient standards, which establish the highest allowable concentration of the pollutant in the ambient air or water for each conventional pollutant, represent the targets of this approach. To reach these targets emission or effluent standards (legal discharge ceilings) are imposed on a large number of specific discharge points such as stacks, vents, outfalls or storage tanks. Following a survey of the technological options of control, the control authority selects a favored control technology and calculates the amount of discharge reduction achievable by that technology as the basis for setting the emission or effluent standard. Technologies yielding larger amounts of control (and, hence, supporting more stringent standards) are selected both for emitters in areas where is it very difficult to meet the ambient standard (on the grounds that more control is justified in those circumstances) and for new emitters (on the grounds that achieving reductions as facilities are constructed is cheaper and easier than achieving the same reductions by retrofitting existing plants). The responsibility for defining and enforcing these standards is shared in legislatively specified ways between the national government and the various state governments.

THE EMISSIONS TRADING PROGRAM (1975-)

In an attempt to inject more flexibility into the manner in which the objectives of the Clean Air Act were met, during the last half of the 1970's the U. S. EPA created what has now become known as the Emissions Trading Program. The program attempts to facilitate compliance by allowing sources a much wider range of choice in how they satisfy their legal pollution control responsibilities than possible under the command-and-control approach. Any source choosing to reduce emissions at any discharge point more than required by its emission standard can apply to the control authority for certification of the excess control as an "emission reduction credit" (ERC). Defined in terms of a specific amount of a particular pollutant, the certified emissions reduction credit can be used to satisfy emission standards at other (presumably more expensive to control) discharge points controlled by the creating source or it can be sold to other sources. By making these credits transferable, the EPA allowed sources to find the cheapest means of satisfying their requirements, even if the cheapest means are under the control of another firm. The ERC is the currency used in emissions trading, while the offset, bubble, emissions banking and netting policies govern how this currency can be stored and spent.[2]

The **offset policy** requires major new or expanding sources in "nonattainment" areas (those areas with air quality worse than the ambient standards) to secure sufficient offsetting emission reductions (through the acquisition of ERC's) from existing firms that the air is cleaner after their entry or expansion than before. This is accomplished by requiring new sources to more than offset any remaining emissions they will add to the area after they adopt stringent emissions standards. These sources must acquire ERC's for 120% of the amount they will emit. (The extra 20% is retired as better air quality.) Prior to this policy no new firms were allowed to enter nonattainment areas on the grounds they would interfere with attaining the ambient standards. By introducing the offset policy EPA allowed economic growth to continue while insuring progress toward attainment.

The **bubble policy** receives its unusual name from the fact that it treats multiple emission points controlled by existing emitters (as opposed to those expanding or entering an area for the first time) as if they if they were enclosed in a bubble. Under this policy only the total emissions of each pollutant leaving the bubble are regulated. While the total leaving the bubble must be 20% less than the total permitted by adding up all the corresponding emission

[2] The details of this policy can be found in "Emissions Trading Policy Statement" 51 ***Federal Register*** (December 4, 1986):43829.

standards within the bubble, emitters are free to control some discharge points less than dictated by the corresponding emission standard as long as sufficient compensating ERC's are obtained from other discharge points within the bubble. In essence sources are free to choose the mix of control among the discharge points as long as the overall emission reduction requirements are satisfied. Multi-plant bubbles are allowed, opening the possibility for trading ERC's among very different kinds of emitters.

Netting allows modifying or expanding sources (but not new sources) to escape from the need to meet the requirements of the rather stringent new source review process (including the need to acquire offsets) so long as any net increase in emissions (counting any ERC's earned elsewhere in the plant) is below an established threshold. Insofar as it allows firms to escape particular regulatory requirements by using ERC's to remain under the threshold which triggers applicability, netting is more properly considered regulatory relief than regulatory reform.

Emissions Banking allows firms to store certified ERC's for subsequent use in the offset, bubble or netting programs or for sale to others.

MORE RECENT APPLICATIONS

LEAD IN GASOLINE (1982-1987)

Following the path broken by the Emissions Trading Program, the government began applying the transferable permit approach more widely in the mid-1980's. One application involved the process of eliminating lead from gasoline.

Prior to the issuance of new, more stringent regulations on lead in gasoline, EPA conducted a cost/benefit analysis of their expected impact. The analysis concluded that the proposed .01 grams per leaded gallon (gplg) standard would result in $36 billion ($1983) in benefits (from reduced adverse health effects) at an estimated cost to the refining industry of $2.6 billion. (Nussbaum 1992)

Although, according to this analysis, the regulation was unquestionably justified on efficiency grounds, EPA wanted to allow flexibility in how the deadlines were met without increasing the amount of lead used. While some refiners could meet early deadlines with ease, others could do so only at a significant increase in cost. Recognizing that meeting the goal did not require every refiner to meet the same deadline, EPA initiated the lead banking program to provide additional flexibility in meeting the regulations.

Under this program a fixed amount of lead rights (authorizing the use of a fixed amount of lead over the transition period) were allocated to the various refiners. Refiners who did not need their full share of authorized rights (due to earlier or larger reductions) could sell their rights to other refiners.

Refiners had an incentive to eliminate the lead quickly because early reductions freed up rights for sale. Acquiring these credits made it possible for other refiners to comply with the deadlines, even in the face of equipment failures or Acts of God; fighting the deadlines in court, the traditional response, was unnecessary. Designed purely as a means of facilitating the transition to this new regime, the lead banking program ended as scheduled on December 31, 1987.

EPA estimates suggest that the trading provisions saved the refinery industry $65 million, while the three years of banking reduced costs by about $200 million. Trading and banking provisions were also credited with producing an unusually sharp and rapid decrease in human exposure to lead. Nussbaum (1992)

This program was unique in that its purpose was to provide a more flexible means of eliminating a pollutant, rather than merely stabilizing or to reducing emissions.[3]

OZONE-DEPLETING CHEMICALS (1988-)

Responding to the threat to the ozone shield 24 nations signed the Montreal Protocol during September, 1988. According to this agreement signatory nations were to restrict their production and consumption of the chief responsible gases to 50% of 1986 levels by June 30, 1998. Soon after the protocol was signed, new evidence suggested that it had not gone far enough; the damage was apparently increasing more rapidly than previously thought. In response, 59 nations signed a new ozone agreement at a conference in London in July 1990. This agreement called for the complete phaseout of halons and CFCs by the end

[3] For a theoretical analysis of the economics of eliminating pollutants using tradable permits see (Toman and Palmer 1997)

of this century. Moreover two other destructive chemicals--carbon tetrachloride and methyl chloroform--were added to the protocol and are scheduled to be eliminated by 2000 and 2005, respectively.

The United States has chosen to use a transferable permit system to implement its responsibilities under the protocols. On August 12, 1988 the U.S. Environmental Protection Agency issued regulations implementing a tradable permit system to achieve the targeted reductions. (53 FR 30598) According to these initial regulations all major U.S. producers and consumers of the controlled substances were allocated baseline production or consumption allowances using 1986 levels as the basis for the proration. Each producer and consumer is allowed 100% of this baseline allowance initially, with smaller allowances being granted after predefined deadlines.

Following the London conference these percent-of-baseline allocations were reduced to reflect the new deadlines and limits. These allowances were transferable within producer and consumer categories and allowances can be transferred across international borders to producers in other signatory nations if the transaction is approved by EPA and results in the appropriate adjustments in the buyer or seller allowances in their respective countries.[4] Production allowances can be augmented by demonstrating the safe destruction of an equivalent amount of controlled substances by approved means. Some inter-pollutant trading is even possible within categories of pollutants. (The categories are defined so as to group pollutants with similar environmental effects). All information on trades is confidential (known only to the traders and regulators) so it is difficult to know how effective this program has been. One estimate suggests that as of September 1993 the traded amount was roughly 10% of the total permits. (Stavins and Hahn 1993)

Since the demand for these allowances is quite inelastic, the supply restrictions imposed by this program increased revenue. By allocating allowances to the seven major domestic producers of CFCs and halons, EPA created sizable windfall profits (estimated to be

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[4] Note that this approach does not require that both trading countries have implemented a transferable permit system. It does require both countries to adjust their production and consumption quotas assigned under the protocols to assure that the overall global limits on production and consumption are not affected by the trades. The European Union has also implemented a tradable permits scheme for ozone depleting chemicals. See Council Regulation (EEC) No 594/91 of 4 March 1991 on substances that deplete the ozone layer, Official Journal of the European Communities, 14.3.91

in the billions of dollars) for those producers. A revenue-starved Congress seized the opportunity by imposing a tax to soak up the rents created by the regulation-induced scarcity. The Revenue Reconciliation Act of 1989 includes an excise tax imposed on all ozone-depleting chemicals sold or used by manufacturers, producers or importers of these chemicals. The tax is imposed at the time the importer sells or uses the affected chemicals. It is computed by multiplying the chemical's weight by the base tax rate and the chemical's ozone depletion factor. In addition to soaking up some of the regulation-induced scarcity rent, this tax provides incentives to switch to less harmful (and therefore untaxed) substances.

This application was unique in two senses. It not only allowed international trading of allowances, but it involved the simultaneous application of permit and tax systems.

ACID RAIN (1993-)

Another quite different version of the tradable permits concept was incorporated by the Clean Air Act Amendments of 1990 into the U. S. approach for achieving further reductions in those electric utility emissions contributing to acid rain.[5] Under this innovative approach allowances to emit sulfur oxides have been allocated to older plants; the number of allowances will be restricted to assure a reduction of 10 million tons in emissions from 1980 levels by the year 2010[6].

Each allowance, which provides a limited authorization to emit one ton of sulfur, is defined for a specific calendar year, but unused allowances can be carried forward into the next year. They are transferable among the affected sources. Any plants reducing emissions more than required by the allowances could transfer the unused allowances to other plants. Emissions may not legally exceed the levels permitted by the allowances (allocated plus acquired). An annual year-end audit balances emissions with allowances. Utilities which emit more than authorized by their holdings of allowances must pay a $2000 a ton penalty and are

[5] This statute became law on November 15, 1990. See 104 Stat § 2584. For an analysis of the application of the emissions trading concept to acid rain see (Atkinson 1983; Oates and McGartland 1985; Feldman and Raufer 1987; Tietenberg 1989; Klaassen and Førsund 1994; Klaassen 1995; Klaassen 1996)].
[6] The details of the acid rain program can be found in 40 Code of Federal Regulations 73.

required to forfeit an equivalent number of tons in the following year. (Kete 1992; Kete 1994; Rico 1995)

Each year EPA withholds 2.24% of the allocated allowances to go into an auction run by the Chicago Board of Trade. These withheld permits are allocated to the highest bidders with successful buyers paying their bid price. The proceeds are refunded to the utilities from whom the allowances were withheld on a proportional basis. Trades can also take place between private parties any time of year; they must be reported to the Allowance Tracking System (ATS) so EPA can keep track of the allowances. (Hausker 1992)

Not all allowances sold at the auction are those withheld from utilities. Any allowance holder may chose to offer allowances for sale at these auctions. Potential sellers specify minimum acceptable prices. Once the withheld allowances have been disbursed EPA then matches the highest remaining bids with the lowest minimum acceptable prices on the private offerings and matches buyers and sellers until all remaining bids are less than the remaining minimum acceptable prices.

Despite lower prices and somewhat less trading volume than initially expected (Burtraw 1996; Conrad and Kohn 1996; Klaassen and Nientjes 1997), the program has brought about more emissions reductions sooner than expected. As of 1997 SO_2 emissions from electric power plants were more than 4 million tons below their 1980 levels. Overall, SO_2 emissions from all sources were more than 6 million tons below their 1980 levels and compliance costs are apparently about half that originally projected. From 1993 to 1997 the number of allowances bid for in the auctions tripled from 600,000 to 1.9 million, even though the amount available had only doubled.[7]

Trades outside of the auction system have also increased. Through June of 1997, nearly 2,700 transfers moving 42.4 million allowances were reported to the Allowance Tracking System. Approximately 75 percent of these allowances (31.6 million) were transferred within organizations. The remaining 10.8 million allowances transferred through June 1997 were transferred between organizations.[8]

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[7] These data are from: http://www.epa.gov/acidrain/auctions/auc97tlk.html, August 1, 1997.
[8] The data in this section came from the EPA Web Site located at: (http://www.epa.gov/acidrain/ats/qlyupd.html,August 1, 1997).

RECLAIM (1994-)

While all of the above programs were initiated and promoted by the federal government, the newest programs have arisen from state initiatives. One of the most ambitious of these programs is California's Regional Clean Air Incentives Market (RECLAIM) established by the South Coast Air Quality Management District (SCAQMD), the distinct responsible for the greater Los Angeles area (Robinson, Subramanian et al. 1994; Hall and Walton 1996; Lents 1996; McCann 1996; Klaassen and Nientjes 1997).[9] Under RECLAIM each of the participating industrial polluters (all sources emitting four tons or more of the two pollutants from permitted equipment) were allocated an annual number of Reclaim Trading Credits (RTCs) for nitrogen oxides and sulfur based on peak activity levels for each different type of equipment from the years between 1989 and 1992. Subject to some restrictions these credits can be used to fulfill legal obligations or traded to other sources. Allowable emissions (embodied in the RTCs) decrease between 1994 and 2000 based on a straight line rate of reduction. Average annual decreases range from 4.1% for sulfur to 7.1% for nitrogen oxides during this period. Somewhat larger annual average reductions (9.2% and 8.7% respectively) are required in the 2000-2003 period.

The RECLAIM program shares with the sulfur allowance program the characteristic that it sets a cap on total emissions from the controlled group rather than merely on emissions from each source; this limit requires that expansion must be accommodated within the cap (by cutting back a compensating amount somewhere else) rather than by allowing emissions to increase as the number of sources increases.

MOBILE SOURCES (1993-)[10]

Due in part to the emission reductions achieved from stationary sources, in many regions of the United States mobile sources now account for a high percentage of the

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[9] Another program has been initiated in Illinois. Under this program Companies that produce more than 10 tons of emissions during a five-month period will be required to participate in the program. Credits will be traded through an electronic bulletin board set up by the state. A special reserve of credits will be set aside for firms that are unable to purchase them. (Tim Landis, Springfield, [IL] State Journal-Register, 8/2 as cited in GREENWIRE 8/7/97).

[10] EPA published the overall guidance for mobile source emission reduction credits in 58 Federal Register (February 23, 1993): 11134. The details on how one state (California) has implemented its program within this guidance can be found on the web at http://www.aqmd.gov/rules/html/tofc16.html.

remaining pollution. Though individual new vehicles have also been controlled for many years by means of emissions standards imposed on new vehicles and inspection and maintenance programs for on-road vehicles, an increase in both the number of vehicles and the number of miles the average vehicle is driven has offset to a large degree the gains achieved from the production of cleaner vehicles.

The desire to reduce mobile source pollution beyond what can be achieved with traditional emissions standards has motivated recent attempts to include them in tradable permit programs designed to reduce ozone. (Boyd 1993; Kling 1994; Alberini, Harrington et al. 1995) Because remote sampling of in-use vehicles has confirmed that in many cases a substantial proportion of the mobile source pollution is coming from a relatively small number of vehicles, one approach specifically targets those vehicles for early retirement.

Under this approach, credits can be created by any source which acquires and retires high emission vehicles. The number of credits is determined by estimating the emissions avoided by vehicle retirement, which involves combining actual emissions tests on the retired vehicle with estimates of the number of miles the vehicle could have been driven over its remaining useful life and subtracting the emissions expected to be added by a replacement vehicle to produce the expected net emission reduction per vehicle. After aggregating the results over the fleet of retired vehicles and discounting the aggregated estimated reduction to account for uncertainties in the estimation process, credits are issued for the adjusted aggregate net emission reduction.

In an early California pilot program, for example, the UNOCAL Corporation, in cooperation with the California Air Resources Board, initiated a vehicle scrappage program. Offering $700 for each pre-1971 vehicle, the program ultimately was responsible for retiring some 8000 vehicles.(Dudek, Goffman et al. 1992)

Vehicle retirement strategies are not the only way to include mobile sources within an tradable permit program. A credit system can be used to provide manufacturers an incentive to produce cleaner cars than required by law (Rubin and Kling 1993) or to reward fleet operators for driving cleaner cars than required by law. California, for example, offers credits for the voluntary repair of on-road motor vehicles identified by remote sensing and the operation of new vehicles powered with engines certified to optional (much cleaner) emission standards.[11]

THE OTC NO_X BUDGET (1998-) [12]

In September 1994, the Ozone Transport Commission (OTC), a regional organization specifically created to coordinate interregional smog control, adopted a memorandum of understanding (MOU) to achieve regional emission reductions of NOx using a tradable permit system.[13] In this MOU the OTC members, in collaboration with the U.S. EPA, developed a model rule to promote consistency among the regulations in all participating states. Consistent regulations provide the foundation for an integrated interstate tradable permits program. Elements covered by the model rule include: program applicability, control period, NOx emissions limitations, emissions monitoring, record keeping of emissions and allowances, and electronic reporting requirements. Each state now has the responsibility for developing and adopting state rules that are consistent with the model rule.

Under this program, affected individual sources will be allocated allowances by their state government on either an annual or a multi-year basis. Each allowance permits a source to emit one ton of NOx during the designated control period (May through September) for the year for which it was allocated or any later control period. For each ton of NOx discharged in a given control period, one allowance is retired and can no longer be used.

Allowances may be bought, sold, or banked. Any entity may acquire allowances and participate in the trading system. Each covered source must comply with the program by demonstrating at the end of each control period that actual emissions do not exceed the amount of allowances held for that period. However, regardless of the number of allowances a source holds, it can not emit at levels that would violate other federal or state regulations.

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[11] The details of this program can be found at http://www.aqmd.gov/rules/html/tofc16.html.

[12] The details about this program can be found on the web at http://www.epa.gov/acidrain/otc/otcmain.html.

[13] The OTC includes the states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Delaware, the northern counties of Virginia, and the District of Columbia.

Generally, the program affects electric utilities and large industrial boilers. Specifically, the program affects all fossil fuel fired boilers or indirect heat exchangers with a maximum rated heat input capacity of 250 MMBtu/hour or more; and all electric generating facilities with a rated output of 15 MW or more. In addition to the sources identified in the MOU, states have the option of subjecting additional source categories to the program. Other stationary sources of NOx emissions have the option of voluntarily complying with the program (i.e., opt-in) on an individual basis.

For the control period of May through September 1999, the start of the first phase of the program, the region-wide seasonal NOx budget is 219,000 tons. This means that beginning in 1999, the sum of NOx emissions in the region can not exceed 219,000 tons. This cap will remain in place until 2003, the start of the second phase of the program, when the cap will be reduced to 143,000 tons of NOx across the region.

GLOBAL WARMING (PROPOSED)

The groundwork for using tradable permits in controlling greenhouse gases was established by the Climate Change Convention which went into force on March 21, 1994. Reducing carbon dioxide emissions to 1990 levels by the end of the decade was specified as a target within the convention. Subsequent negotiations will address future targets and deadlines.

The convention identifies a set of nations (listed in Annex I of the Convention) committed to achieving a stabilization of carbon dioxide emissions by 2000. As the Annex I nations seek to reduce emissions sufficiently to meet the target, they have two choices--they can either find the reductions within their own borders or they can seek them in other nations. (Bertram 1992; OECD 1992; United Nations Conference on Trade and Development 1992; Rose and Tietenberg 1993; Tietenberg 1994)

The United States has formally proposed a tradable permits system in its draft protocol.[14] Under this proposal each developed country would be assigned an emissions budget which would control cumulative emissions over some specified period. The emissions covered by this budget would be freely transferable among nations which have assigned

[14] The details of this proposal can be found on the web at http://www.epa.gov/globalwarming/sub3/events.htm

emissions budgets. Under this proposal emissions trading could take place even with developing counties who have not yet accepted emissions budgets under special "joint implementation" procedures.

Joint implementation procedures envision certification of emission reductions over and above a prespecified baseline. Certified reductions would then be available for subsequent use or trade to other countries. Pilot joint implementation projects, funded by the Global Environmental Fund (GEF), have been initiated in a number of countries including China, Jamaica, Mexico, and the Philippines. In addition to providing early reductions in greenhouse gas emissions, these projects are designed to examine some of the baseline, monitoring and enforcement issues which must be resolved before a full scale tradable permits program is implemented.

THE EVOLUTION OF DESIGN FEATURES

CREDIT DENOMINATION

The original Emissions Trading Program was based on a system of credits which were typically denominated in terms of a pollutant flow such as tons/year. The newer programs are based on allowances defined in discrete terms (for example, "tons" rather than "tons per year"). While the former confers a continuing entitlement to a flow, the latter is a one-time entitlement to emit one ton. Once the authorized ton has been emitted, the allowance is surrendered. Authorizing additional emissions requires the issuance of new allowances. In general this is done well in advance according to specific schedules so emitters have reasonable security for pollution control investment planning. Allocating allowances in advance has also facilitated the development of futures markets.

One of the big differences between allowances and credits involves the capacity for allowances to accommodate the creation and transfer of discrete emission reductions. One of the original criteria used by EPA for approving credits was that the emission reductions supporting them should be "permanent". Many useful strategies to reduce emissions, such as meeting a deadline early, produce temporary, rather than permanent, reductions. (As noted above the ability to set an earlier deadline in the Lead Phaseout Program was made possible by the flexibility inherent in an allowance program.) Allowance programs encourage both permanent and temporary reductions.

BASELINE

Credit trading, the approach taken in the bubble and offset policies, allows emission reductions above and beyond legal requirements to be certified as tradable credits. The baseline for credits is provided by traditional technology-based standards. Credit trading presumes the preexistence of these standards and it provides a more flexible means of achieving the aggregate goals which the source-based standards were designed to achieve.

Allowance trading, used in the Acid Rain Program, the Lead Phaseout Program, and RECLAIM in California, assigns a prespecified number of allowances to polluters. Typically the number of issued allowances declines over time and the initial allocations are not necessarily based on traditional technology based standards; in most cases the aggregate reductions implied by the allowance allocations exceed those achievable by standards based on currently known technologies.

Despite their apparent similarity the difference between credit and allowance-based trading systems should not be overlooked. Credit trading depends upon the existence of a previously determined set of regulatory standards. Allowance trading does not. Once the aggregate number of allowances is defined, they can, in principle, be allocated among sources in an infinite number of ways. The practical implication is that allowances can be used even in circumstances: (1) where a technology-based baseline either has not been, or cannot be, established or (2) where the reduction is short-lived (such as when a standard is met early) rather than permanent.

CAPS

Allowances and credits differ in another significant way. Allowances systems set a cap on aggregate emissions which cannot be eroded by economic growth. This characteristic is not shared either by traditional technology-based, source-specific emission standards or, in the absence of other constraints, by an emission credit system which is linked to technology-based standards. Because emission standards are source-specific, they exert no control over the aggregate amount of emissions from all sources. As the number of sources increases, the aggregate level of emissions increases. As a consequence credit trading, which is based on these source-specific standards, will also allow aggregate emission increases unless some additional constraint is built into the system.

In the U. S. the additional constraint was requiring all new or expanding sources in nonattainment areas to offset all emission increases by acquiring sufficient credits from existing emitters that air quality would improve as a result of their entering the area or expanding their operations. No such constraint was mandatory in attainment areas so credit trading provided no protection from emission increases in those areas as the number of sources increased.

ALLOCATION METHOD

In principle entitlements could either be auctioned off, with the sources purchasing them from their respective governments at the market-clearing price, (Lyon 1989; Lyon 1990) or distributed to each source on the basis of some allocation rule (typically, but not inevitably, historical use). Only a transferable permit system that allocates permits free of charge to sources on the basis of their historic emission rate would guarantee that existing sources would be no worse off than they would under a command-and-control system imposing the same degree of control. The financial outlays associated with acquiring allowances or credits in a traditional auction market (or, a comparable emissions charge) would be sufficiently large that sources would typically have lower financial burdens with the traditional command-and-control approach than with these particular economic incentive approaches. (Palmer, Mooz et al. 1980; Atkinson and Tietenberg 1982; Lyon 1982; Harrison 1983; Seskin, Anderson et al. 1983; Shapiro and Warhit 1983; Atkinson and Tietenberg 1984)

From the point of view of the source required to control its emissions, two components of financial burden are significant: (1) control costs and (2) expenditures on permits. While only the former represent real resource costs to society as a whole (the latter are merely transfers from one group in society to another), to the source both represent a financial burden. The empirical evidence suggests that when a traditional auction market is used to distribute permits (or, equivalently, when all uncontrolled emissions are subject to an emissions tax), the permit expenditures (tax revenue) would frequently be larger in magnitude than the control costs; the sources would spend more on permits (or pay more in taxes) than they would on the control equipment.(Tietenberg 1985) This characteristic is one factor inhibiting the adoption of these approaches within the United States.

Under the traditional command-and-control system firms make no financial outlays to the government. Although control costs are necessarily higher with the command-and-control system than with a marketable permit system, they are not automatically so high as to outweigh the additional financial outlays required in an auction market permit system (or an emissions tax system) For this reason existing sources understandably oppose distributing permits by a traditional auction market despite its social appeal, unless the revenue derived is used in a manner which is approved by the sources and the sources with which it competes are required to absorb similar expenses.

In the absence of either a politically popular way to use the revenue or assurances that competitors will face similar financial burdens, this political opposition could be substantially reduced by distributing the permits free-of-charge to existing sources. Though an infinite number of possible distribution rules exist, "grandfathered" rules tend to predominate. Grandfathering refers to an approach which gives some priority to existing firms. Under grandfathering, existing sources have only to purchase any additional permits they may need over and above the initial allocation (as opposed to purchasing all permits in an auction market).

Although politically the easiest path to sell, grandfathering has its disadvantages. Although reserving some permits for new firms is possible, this option is rarely exercised in practice. As a result under the free distribution scheme new firms typically have to purchase all permits, while existing firms get an initial allocation free. Thus the free distribution system imposes a bias against new sources in the sense that their financial burden is greater than that of an otherwise identical existing source, even if the two sources install exactly the same emission control devices. This new source bias has retarded the introduction of new facilities and new technologies by reducing the cost advantage of building new facilities which embody the latest innovations. (Maloney and Brady 1988; Nelson, Tietenberg et al. 1993)

"OPT IN" PROVISIONS

Each program applies to an eligible population. (For example, the sulfur allowance system applies to the slightly over 800 electric utilities in the United States and the RECLAIM program applies to approximately 390 industrial polluters in the No_x market and 41 facilities in the SO_x market). Usually the eligible population is not the sole source of the pollutants being controlled, but for monitoring or other reasons the remaining sources are not included. Leaving them out, unfortunately, reduces the set of trading opportunities and, therefore, increases the resulting cost.

This problem is reduced by creating a process by which polluters which are not part of the eligible population can voluntarily opt-in, or join the process. Usually in opt-in procedures the applicant faces the burden of proving that they can satisfy the basic conditions of participating in the program. This allows those individual emitters who satisfy the conditions to join without waiting for an entire category of emitters to qualify. The sulfur allowance program, for example, has opt-in provisions for (1) industrial boilers and, (2) under a provision known as the "substitution provision", utility units which are not required to participate in Phase I reductions, but can volunteer to participate.

Why would any initially ineligible individual source want to opt in? In many cases individual emitters are capable of reducing emissions well below their allowable levels. As long as they are not in the program surplus reductions are not rewarded. Once in the program, however, surplus reductions become transferable and can either be sold or used by plant owners in other locations. Montero (1997) has shown that a large number of utility units have opted in under the acid rain substitution provision. In this case the motivation seems to have less to do with emission reduction actions promoted by the program than with external economic circumstances which allowed plants to reduce costs and emissions at the same time. Early entry into the program allowed utilities to accumulate some allowances which they could subsequently use to ease the transition once the controls become much more stringent.

SHIFTING THE PAYOFF

The demonstration that the traditional regulatory policy was not cost-effective had two mirror-image implications. It either implied that the same air quality goals could be achieved at lower cost or that better air quality could be achieved at the same cost. While the earlier programs were designed to exploit the first implication, later programs attempted to produce better air quality and lower cost.[15]

Trading programs were used to produce better air quality in many ways. The lower costs offered by trading were used in initial negotiations to secure somewhat more stringent pollution control targets (Acid Rain Program and RECLAIM) or earlier deadlines (Lead Phaseout Program). Offset ratios for trades in nonattainment areas were set at a ratio greater than 1.0 (implying a portion of each acquisition would go for better air quality). Environmental groups are allowed to purchase and retire allowances (Acid Rain Program).

This shift toward sharing the benefits between environmental improvement and cost reduction has had two consequences. The cost savings are lower than they would have been without this benefit sharing, but the public support, and particularly the support from environmental organizations, has been increased a great deal. Politically this means that it is now easier to implement trading programs because the potential common ground has been expanded.

SUBSTITUTING FOR VS. COMPLEMENTING TRADITIONAL REGULATION

The earliest use of the tradable permit concept, the Emissions Trading Program, overlaid credit trading on an existing regulatory regime and was designed to facilitate implementation of that program. Trading baselines were determined on the basis of previously determined, technology-based standards and created credits could not be used to satisfy all of these standards. For some the requisite technology had to be installed.

More recent programs, such as the Acid Rain and RECLAIM programs, replace, rather than complement, traditional regulation. Allowance allocations for these programs

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[15] In an interesting analysis of the cost and emissions savings from implementing an emissions trading system for light-duty vehicles in California, Kling (1994) finds that although the cost savings from implementing an emission trading program (holding emissions constant) would be modest (on the order of 1% to 10%), the emissions savings possibilities (holding costs constant) would be much larger (ranging from 7% to 65%).

were not based on preexisting technology-based standards. In the case of RECLAIM the control authority (the South Coast Air Quality Management District) could not have based allowances on predetermined standards even if they had been inclined to do so. Defining a complete set of technologies which offered the necessary environmental improvement (and yet were feasible in both an economic and engineering sense) proved impossible. Traditional regulation was incapable of providing the degree of reduction required by the Clean Air Act.

The solution was to define a set of allowances which would meet the environmental objectives, leaving the choice of methods for living within the constraints imposed by those allowances up to the sources covered by the regulations. This approach fundamentally changes the nature of the control process. The historical approach involved making the control authority responsible not only for defining the environmental objectives and performing the monitoring and enforcement activities necessary to assure compliance with those objectives, but it was also assigned the responsibility for defining the best means for reaching those objectives. The allowance program transfers the last of these responsibilities to the private sector, while retaining for the public sector both the responsibility for defining the environmental target and performing the monitoring and enforcement function.

RESOLVING IMPLEMENTATION PROBLEMS

Certain design issues reoccur in establishing any tradable permits system. How these issues have been dealt with has depended on the particular context within which they have arisen, but it also has been shaped by experience gained in the earlier programs.

TRANSACTIONS COSTS

One aspect which has affected the effectiveness of tradable permit markets involves the costs of completing transactions. They include the costs of finding an appropriate trading partner, establishing the terms of the trade, and completing the arrangements.

Standard theory it clear that in the absence of transactions costs permit markets can reallocate control responsibility such that the control is achieved at minimum cost. (Baumol and Oates 1971; Montgomery 1972) At any point in time remaining lower cost control options create trading opportunities. The desire to lower private costs provides an incentive to exploit all of these opportunities. When all such opportunities have been exploited, the minimum cost-effective allocation has been achieved.

When transactions costs become significant, however, permit markets may not be fully cost-effective. (Stavins 1995) In essence the existence of transactions costs prevents some cost-saving trades from taking place.

Transactions costs also affect the ability of governments to use permit markets to simultaneously pursue efficiency and equity goals. (Stavins 1995) Whereas in the absence of transactions costs, permits can be allocated in an infinite number of ways without disturbing the ability of the system to achieve a cost-effective allocation of control (any initial deviations from the least cost allocation are corrected by trading), with transactions costs the degree of cost/effectiveness becomes functionally related to the initial allocation. When transactions costs are significant, pursuing a “fair” initial allocation of permits may extract a cost-effectiveness penalty.

Despite a paucity of information most observers of the Emissions Trading Programs in the late 1980s agreed that fewer trades took place than necessary to achieve full cost-effectiveness and that high transactions costs played a role in explaining this shortcoming. (Hahn 1989; Hahn and Hester 1989a; Hahn and Hester 1989b; Tietenberg 1990) Confirming anecdotal evidence for the significance of transactions costs can be found in the predominance of “internal” (within firm) transfers over “external” (between firm) transfers, the predominance of trades involving uniformly mixed pollutants (which don’t require additional air quality impact simulations as a condition of approval) and the important role played by brokers in the process. Subsequent empirical analysis (Foster and Hahn 1995) has confirmed these initial observations.

Even the Lead Phaseout Program, which is usually advanced as an early example of a well functioning tradable permits market (Hahn and Hester 1989a), was also plagued (albeit to a much lower degree) by the existence on nonneglible transactions costs. One econometric analysis (Kerr and Maré 1997) suggests that transactions costs produced efficiency losses (due to unexploited trades and to the direct cost of transactions) on the order of 10%. Smaller refineries, refineries that were not part of large companies, and refineries that did not have other refineries to trade with within the company seemed to be particularly inhibited from trading by transactions costs.

Neither the Emissions Trading Program nor the Lead Phaseout Program were consciously designed in such a way as to minimize transactions costs. Later programs have attempted to incorporate design features which reduce transactions costs.

One prime example was the auction market established as part of the sulfur allowance program.[16] This market reduced transactions costs not only by providing an easy means for buyers and sellers to transact, but also by providing (for the first time) systematic public information on prices. Better information on prices to buyers and sellers should have the effect of lowering the spread between the highest bid and the clearing price. It has. The spread has dropped considerably from $319 (in 1993) to $14 (in 1997) indicating the effect of public knowledge of price information.[17]

The greater availability of data on prices and the nature of trades benefits researchers as well as buyers and sellers. These data have facilitated the construction of econometric models to isolate the consequences of transactions costs. One study (Montero 1997) confirms that in the sulfur allowance program trading activity can be completely explained by conventional economic variables and hence the role of transactions costs seems to be fairly small.

Interestingly the RECLAIM system, which was also established in the 1990's, has apparently not yet been as successful in reducing transactions costs. Though it is a bit early to judge its ultimate effectiveness, a computer system set up to provide an easy means of trading has not been utilized to the expected extent. (Gangadharan 1997)

An econometric study (Gangadharan 1997) on the RECLAIM NOx market finds that both search and information cost variables explain the likelihood of being a buyer of RTCs in an ordered probit model. The author also finds, however, specific "learning by doing" effects in this market. In particular the results suggest that increasing the number of times a facility enters the market reduces information costs until a certain point (15 trades) is reached. After

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[16] This auction design unfortunately provides some incentives for inefficient strategic behavior. (Cason 1993)

[17] This information can be found at http://www.epa.gov/acidrain/auctions/auc97tlk.html.

that point further increases in the number of trades seem to have no affect in reducing information costs further.

COPING WITH SPATIAL ISSUES

Transferable permits seem to have worked particularly well for trades involving uniformly mixed pollutants (those for which only the level of emissions matters) and for trades of nonuniformly mixed pollutants (those for which emission location also matters) involving contiguous discharge points. The plurality of consummated trades in the Emissions Trading Program have involved uniformly mixed pollutants. (Tietenberg 1985) Since dispersion modeling is not required for uniformly mixed pollutants (even when the trading sources are somewhat distant from one another), trades involving these pollutants are cheaper to consummate. Additionally trades involving uniformly mixed pollutants need not be constrained by the need to prevent local air quality deterioration since the location of the emissions is not a matter of policy consequence.

But how about when emission location matters? When emission location matters, the dominance of economic instruments over traditional command-and-control strategies is less clear cut in practice than it might appear from theory. (Krumm and Wellsich 1995) Although the fully cost-effective system is relatively easy to define in this circumstance (Montgomery 1972), implementing such a system could impose a large administrative burden. (In general the number of different markets necessary to produce a cost-effective allocation of control responsibility for nonuniformly mixed pollutants is equal to the number of receptors where ambient air quality is monitored to ascertain compliance with the ambient standards.)(Tietenberg 1985)

Spatial considerations can also give rise to environmental justice concerns. In an unprecedented complaint filed in California during June 1997, the Los Angeles-based Communities for a Better Environment contents that the SCAQMD's pollution-trading program is allowing the continued existence of toxic "hot spots" in low-income communities. Under RECLAIM rules Los Angeles-area manufacturers can buy and scrap old, high-polluting cars to create emissions-reduction credits. These credits can be used to reduce the required reductions from their own operations. Under RECLAIM most California refineries have installed equipment that eliminates 95% of the fumes, but the terminals in question reduced less because the companies scrapped more than 7,400 old cars and received mobile source emission reduction credits which they credited toward their reduction requirements. The complaint notes that whereas motor vehicle emission reductions are dispersed throughout the region, the offsetting increases at the refineries are concentrated in low income neighborhoods. (Marla Cone, Los Angeles Times, as cited in GREENWIRE 7/23/97).

Since the economic and environmental benefits from allowing trading both in the short run and the long run (particularly their ability to stimulate technological progress and pollution prevention) are so large, attempts to implement "second-best" designs to resolve spatial concerns may be justified. All second-best designs involve an element of compromise with the cost-effectiveness goal, but they still can represent an improvement, sometimes a substantial improvement, over more traditional approaches.

The menu of promising second-best strategies is growing. (Atkinson 1994; Klaassen and Førsund 1994; Tietenberg 1995) While the most commonly discussed second-best strategies all have problems, slight modifications of those approaches as embodied in this new generation of programs does appear to offer the prospect for significant reductions in compliance costs, while assuring environmental improvement.

While space does not permit an elaboration of all the possibilities here, a few approaches can be illustrated. The starting point for this approach is the assumption that it is better to implement a basic system built around standard emission permits, dealing individually with those trades which would result in hot spots or excess pollution at the most severely affected receptors, rather than establishing wholesale restrictions on trades.

One illustration of how this type of constrained trading could be implemented has surfaced in the trading rules developed by the Ozone Transport Commission. Attempting to implement a truly regional strategy which deals realistically with the spatial elements of the problem, the OTC will allow regional trading of NOx offsets subject to some specific trading constraints.

Since the ozone plume typically moves in a particular direction and not all emissions in the region affect nonattainment status equally, in the absence of any constraints it would be possible for some specific offset trades to actually worsen the degree of nonattainment. To allow interstate trading while assuring environmental improvement in the most severely affected areas the OTC Plan imposes two restrictions on trading to eliminate these perverse outcomes: (1) offsets must come from an area with equal or more severe nonattainment [18] and (2) offsetting reductions must have contributed to violations of the ambient standard in the area of the new emissions. The first rule offers protection against trades which worsen pollution in the most severely affected areas, while the second rule, in effect, creates trading zones which conform to wind flow patterns. Compared to an unrestricted trading area these rules have the effect of reducing the number of possible trades. However, since they do allow some trades across large distances, they offer the possibility of faster compliance due to lower compliance costs.

The RECLAIM program approach is similar. The entire trading area is divided into two zones (Coastal and Inland). Due to local geographic and meteorological considerations, emissions in the coastal zone can affect air quality in both zones, but emissions in the inland zone affect only air quality in that zone. As a result the SCAQMD has allowed inland sources to buy permits from either zone, but some facilities in the coastal zone can only buy RTCs from other coastal zone sources. This has created a situation in which the prices for RTCs created in the coastal zone are considerably higher than prices for RTCs created in the inland zone. (Gangadharan 1997) Although these zones extract a cost-effectiveness premium, zonal permit trading still represents a considerable improvement over a system with no trading at all.

One solution to the “hot spots” problem is to allow unrestricted trading, but to exercise some control over how the permits are used. The sulfur allowance program, for example, attacks the problem with "regulatory tiering". Regulatory tiering involves applying more than one regulatory regime at a time. Sulfur allowance trading is overlaid on a

[18] Nonattainment areas are further classified into one of five categories depending on current ozone concentration levels (marginal, moderate, serious, severe, and extreme). These designations affect both the deadlines for achieving the ambient ozone standards and the rules affecting offset trading.

traditional system of regulations which specifies ambient air quality standards. Allowance usage is that constrained by the need to meet these ambient air quality standards. Thus trading is not restricted by spatial considerations (national trades are possible), but the use of acquired allowances is subject to local regulations protecting the ambient air quality in that area. The second regulatory tier (the ambient standards) protects against illegal hot spots (those which violate the ambient standards) by disallowing the use of any allowances which would trigger a violation. Notice that while this system protects citizens from trades which would trigger violations of the ambient standards, as the environmental justice suit described above suggests, it does not protect them from all deterioration.

DEALING WITH MARKET POWER

One of the fears that is expressed in almost any new discussion of transferable permits involves the degree to which this approach may either facilitate market power or be rendered ineffective by the existence of market power.

The first type of market power involves the ability of participants to manipulate prices strategically in the permit market either as a monopolistic seller or a monopsonistic buyer. Although only a few studies of the empirical impact of market power on emissions trading have been accomplished, their results are consistent with a finding that market power does not seem to have a large effect on regional control costs in most realistic situations. (Hahn, 1984).[19]

Within the class of grandfathered distribution rules, some rules create a larger potential for strategic price behavior than others. In general the larger the divergence between the number of permits received by the price-searching source and the cost-effective number of permits, the larger the potential for market power. When allocated an excess of permits by the control authority, price-searching firms can exercise power on the selling side of the market, and when allocated too few permits, they can exercise power on the buying side of the market.

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[19] For an analysis of how the existence of market power could affect the incentives to cheat see (Van Egteren and Weber, 1996)

According to the existing studies it takes a rather considerable divergence from the cost-effective allocation of permits to produce much difference in regional control costs. (Tietenberg 1985) Since most realistic rules used to distribute permits are estimated to affect control costs to such a small degree, the deviations from the least cost allocation caused by market power pale in comparison to the much larger potential cost reductions achievable by implementing a marketable emissions permit system.

Strategic price behavior is not the only potential source of market power problems. Firms could conceivably use also permit markets as a vehicle for driving competitors out of business. (Maleug 1989; Misiolek and Elder 1989; von der Fehr 1993) although, both as a conceptual matter (Sartzetakis 1997) and as an empirical matter (Tietenberg 1985) this problem is relatively rare. In most markets permits represent a very blunt instrument for attempting to gain a strategic advantage.

Even when the possibility of market power exists, the consequences can frequently be limited by proper program design. For example, the sulfur allowance program has two components which are designed to diminish the ability of any participant to exercise market power of either form. First, the auction market provides a continuous alternative source of permits, thereby limiting the ability of any participant or group of participants from cornering the market. In addition the program contains a set aside of allowances which the government can sell at $1500 a ton should the need arise.

THE TEMPORAL DIMENSION

Standard theory suggests that a fully cost-effective tradable permit system must have full temporal fungibility, implying that allowances can be both borrowed and banked.[20] (Cronshaw and Kruse 1996; Rubin 1996) Banking allows a source to store its allowances for future use. With banking, for example, a source could save unused 1998 allowances for use in 2001. When banking is not allowed, sources cannot use 1998 allowances after 1998. With borrowing a source can use allowances earlier than their stipulated date. For example, a source

[20] Profit regulation can inhibit cost-effectiveness even with full temporal fungibility. (Cronshaw and Kruse 1996)

could choose to use 2001 allowances in 1998, but that means, of course, that they would no longer be available for use in 2001.

No existing system is fully temporally fungible, although the U. S. proposed protocol for the Climate Change Convention envisions the establishment of a fully fungible system to control climate change.[21] Under this proposal each developed country party to the convention would be allocated an emissions budget covering a specified period. Within that time period the country would be free to bank or borrow emissions as long as the total cumulative emissions do not exceed the budgeted amount.

Older programs have had a more limited approach. The Emissions Trading Program allowed banking, but not borrowing. The Lead Phaseout Program originally allowed neither, but part way through the program it allowed banking, at least until the program officially ended and any remaining credits became unusable. The sulfur allowance program has banking, but not borrowing, and RECLAIM has neither.

Why do so few programs have full temporal fungibility? The answers seem to lie more in the realm of politics than economics.

The first concern involves the potential for creating temporal "hot spots". With complete freedom on their temporal use it is possible for emissions to be concentrated in time. Since concentrated emissions cause more damage typically than dispersed emissions, regulators have chosen to put *a priori* restrictions on the temporal use of permits despite the cost-effectiveness penalty that extracts.

A second concern has arisen particularly in the global warming context where imposing sanctions for noncompliance is difficult. Some observers have noted that enforcing the cumulative emissions budget on a nation which had borrowed heavily in the earlier years would become increasingly difficult over time. Given the inherent difficulties in enforcing international commitments under the best of circumstances, opponents of borrowing propose to forestall this difficulty by eliminating any possibility of borrowing. They view the resulting loss of cost-effectiveness as a reasonable price to pay for taking the pressure off future enforcement.

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[21] This proposal can be found on the web at http://www.state.gov/www/global/oes/protocol.html (July 24, 1997).

CONCLUSION

Transferable permit programs to control air pollution in the U. S. have undergone a considerable evolution from their earliest incarnations. Tracing this evolution reveals considerable variety in the implemented programs. Some (such as the Ozone Depleting Gas and Lead Phaseout Programs) were designed to eliminate pollutants, while others were designed to stabilize (Emissions Trading) or reduce (Sulfur Allowance and RECLAIM) emissions. While most programs (Emissions Trading, Sulfur Allowance, Ozone Depleting Gas, Lead Phasedown) were created by the federal government, newer programs (OTC Budget, RECLAIM) were created by regional or state authorities. While earlier programs (Emissions Trading, Lead Phasedown) tended to complement traditional regulation, newer programs (Sulfur Allowance and RECLAIM) tend to replace it.

The evolution also reveals a change in some fundamental attributes of tradable permit programs. The tradable commodity has changed from a credit to an allowance. By shifting the focus of control from the source to the aggregate level of emissions, greater control has been gained over total emissions. By defining the trading baseline in terms of emission objectives rather than specific control technologies, a much wider set of control options (including pollution prevention, demand management, etc.) has been encouraged. Finally, the role of banking and borrowing varies widely among the programs; no clear trend has emerged.

Newer programs have been able to take advantage of the mistakes of the past. In particular we now know that transactions costs and the difficulties associated with market power can frequently be reduced with proper design. Furthermore while tradable permit markets work particularly well for uniformly mixed pollutants, practical methods do exist for dealing (albeit imperfectly) with those pollutants where the location of the emissions is also a matter of concern.

When I started writing about tradable permits over 25 years ago, no policy maker had the slightest interest in this approach. Today, it seems, everyone has a interest in promoting market solutions (including, but not limited, to tradable permits). The momentum has clearly changed, but it is important to assure that enthusiasm does not outrun reality. Market approaches, including tradable permits, have shown that they deserve a place in the environmental policy arsenal, but they are not a cure-all.

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