The Design of Marketable Permit Schemes to Control Local and Regional Pollutants*

Jonathan Remy Nash†
Richard L. Revesz‡

Introduction

The idea of establishing markets in pollution rights is not new. J.H. Dales strongly advocated this regulatory technique in the late 1960s.[1] Thereafter, tradable permit regimes became popular among academic economists. In a 1985 article that had considerable influence on the legal literature, Bruce Ackerman and Richard Stewart strongly advocated tradable permits as an alternative to command-and-control regulation.[2]

In recent years, there has been a steady rise in the in the use of tradable permits in the regulatory process. They have been employed as tools to control both air and water pollution, and have been implemented on local, regional, and national scales. While trading regimes have to date been used mostly in the United States, they are attracting increasing attention abroad, and there is now considerable interest in emissions trading on a global scale to address the problem of anthropogenic greenhouse gases.

The design of the trading regime most commonly advocated in the academic literature – based upon a single market in emission permits – is relatively straightforward. A policymaker determines the total number of emission permits that will be allocated to a region. These permits are then distributed among polluters, generally either by means of an initial auction or through grandfathering. Subsequently permits trade in an open market. Assuming that a robust market for permits arises, a tradable emission permit regime reduces aggregate emissions to the chose aggregate level at least cost.

Such a trading regime, however, does not control the distribution of those emissions throughout the region. As a result, it does not ensure that an ambient standard – specifying a maximum permissible concentration of the pollutant – would be met throughout the region. For example, to the extent that trades result in a disproportionate concentration of the pollutant in some portion of the region, ambient standards could be violated. More generally, a tradable emission permit regime does not prevent the formation of "hot spots" of pollution – that is, location at which the damage caused by pollutants is particularly severe. Ackerman and Stewart acknowledge this shortcoming: "[T]he market system we have described could allow the creation of relatively high concentrations of particular pollutants in small areas within the larger pollution control region."[3] They note that "[t]he extensive literature on marketable permits … points to a variety of feasible means for dealing with the hot spot problem,"[4] and recommend that "a long-run strategy for institutional reform should strive to take advantage of these

---

* This article is adapted from "Markets and Geography: Designing Marketable Permit Schemes to Control Local and Regional Pollutants, forthcoming in the Ecology Law Quarterly.
† Harry A. Bigelow Fellow and Lecturer in Law, University of Chicago Law School.
‡ Lawrence King Professor of Law, New York University School of Law.
1 *See* J.H. DALES, POLLUTION, PROPERTY & PRICES (1968).
2 *See* Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law*, 37 STAN. L. REV. 1333 (1985).
3 *See, e.g.*, Ackerman & Stewart, *supra* note 2, at 1350.
4 *Id.* at 1351 (footnote omitted).

more sophisticated market solutions to the problem of intraregional variation."[5]

Over the years, commentators have advocated several alternative design structures to deal with the problem of ambient standard violations and hot spots. Each of these alternatives, however, has significant drawbacks, either providing only an incomplete solution to the problem or introducing complexity that could stand in the way of the efficient functioning of the market.

In this article, we propose an alternative that would avoid the violation of ambient standards and formation of hot spots without greatly increasing administrative complexity or introducing excessively high transaction costs. Our idea is to construct a market in tradable emission permits under which trading would be entirely unfettered, with the sole exception that a prospective buyer and seller would have to receive approval from a website before they could consummate their trade. The website, administered by the government, would contain emissions data for all sources in the region. When a proposed trade was submitted for approval, the website would temporarily update its saved data to reflect the change in the geographic distribution of emissions that would result from the proposed trade. The website then would use an atmospheric dispersion model to predict the impact of the emissions from all the sources in the region – as modified by the proposed trade – on ambient pollution levels at various receptor points. The website would reject any trade resulting in the violation of an applicable ambient standard and would approve all other trades.

Part I of this Article describes the functioning of the typical regime of tradable emission permits. It examines how such a regime can lead to the violation of ambient standards and the formation of hot spots.

Part II describes the structure of three recent and prominent U.S. regulatory programs involving tradable emission permits: the national sulfur dioxide trading program, regional trading in ozone precursors in the northeast, and local trading in sulfur and nitrogen oxides emissions in the Los Angeles metropolitan area. It explains why these programs are poorly suited to ensure the attainment of ambient standards or the prevention of hot spots. It also discusses the unsuccessful efforts to correct these shortcomings.

Part III evaluates three proposals that commentators have advanced as alternatives to the typical emission trading regime. We first examine a system in which the emissions market is divided into zones and interzonal trades are prohibited. Next, we analyze a system of markets in units of environmental degradation, under which permits do not entitle a holder to emit a fixed amount of pollutant, but rather to cause a fixed amount of environmental damage at a certain receptor point. Last, we discuss pollution offset markets, under which trading in emission permits does not occur on a one-to-one ratio.

Part IV presents our proposal for a tradable emission permit regime designed to solve the problem of ambient standard violations. First, we explain its major elements. Second, we compare its relevant features to those of the three alternatives examined in Part III. Third, we highlight our proposal's impacts on the structure of the permit markets.

Part V discusses how our proposal would deal with a number of important issues. In particular,

[5] *Id.*

we analyze purchases of permits by sources that locate in the area after the establishment of the market; variable – as opposed to uniform – ambient standards throughout the region; auctions of permits, either at the time of the initial distribution or subsequently; and purchases of permits with the intent to bank them for use at a future time, retire them in order to improve environmental quality, or hold them as an investment with the goal of reselling them in the future.

I. Tradable Emission Permits and the Violation of Ambient Standards and Formation of Hot Spots

We first examine the structure of the most common tradable pollution permit regime, in which trades take place in a single market, in units of emissions, and on the basis of a one-to-one trading ratio. Next, we explain how this regime can lead to the violation of ambient standards and the formation of hot spots.

A. Elements of a Market System

The design and implementation of a tradable emission permit regime proceeds in several steps. First, the policymaker identifies the pollutant to be regulated, and the region over which the regulation will extend. In the paradigmatic regime, the entire region constitutes a single trading zone.

Next, the policymaker determines what aggregate level of emissions in a given year (or other time period) will be deemed acceptable. It then subdivides this amount into a number of discrete emission permits, each of which authorize the holder to emit a fixed amount of the regulated pollutant. The policymaker also defines the bundle of rights that accompanies each permit, including their longevity, whether the government can eliminate permits before their expiration, and whether unused permits can be retained for future use.

The policymaker then adopts a mechanism for allocating these permits among prospective polluters. For example, it can distribute the permits to existing polluters according to their prior emission history. If it chooses this grandfathering option for the initial allocation of permits, the policymaker can distribute the permits at no charge, or it can charge some pre-determined amount. Alternatively, it can distribute all the permits, or some subset, through an auction.

The policymaker must also devise rules for the subsequent trading of the permits in an open market. For example, should non-polluters be free to buy and hold emission permits, either for investment purposes or in order to retire them as a means of improving environmental quality?

B. Impact of Trading on Environmental Quality

In discussing the impact of a particular pattern of emissions on environmental quality, it is important to distinguish among three different types of pollutants. For "global" pollutants, this impact is independent of the location of the various sources; only the aggregate amount of emissions matters. Greenhouse gases are a prominent example of a global pollutant. For example, the adverse impact of a ton of carbon dioxide is the same regardless of whether it is discharged in the United States or China.

Most pollutants, however, do not have this feature. Instead, their harm depends on the location at which they are emitted. For "local" pollutants, the location of the emissions and the place where the harm occurs are relatively coextensive. "Regional" pollutants travel further – hundreds of miles and across state and national boundaries in the case of sulfur dioxide – but the affected region is defined by reference to where the emissions come from. Thus, for both local and regional pollutants, the location of the emissions determines the location and magnitude of the adverse environmental consequences. In the vocabulary of environmental economics, the emission of one unit of pollution at different locations results in "spatially differentiated" externalities.

For local and regional pollutants, the environmental impacts of trading are a function of two important sets of variables. First, the costs of pollution control faced by the various participants in the market determine the distribution of emissions among these sources. A polluter will reduce its emissions up to the point at which a further unit of reduction is more costly than the market price of a permit. A polluter that can reduce its emissions for less than the market price of a permit will invest additional resources in pollution control technology and sell permits. In contrast, a polluter with comparatively high costs of pollution control will save money by increasing its emissions and buying additional permits. Trading continues until each source's marginal cost of pollution reduction – the cost of an additional unit of emission reduction – is equal to the market price of the permit.

Second, emissions at different locations throughout a region have different effects on environmental quality. For example, in the case of air pollution, the height of the stack from which pollutants are emitted has an important effect on ambient air quality levels: typically, higher stacks produce greater impacts further from the source and smaller impacts closer to the source. The effects are also dependent on topographic and meteorological conditions, particularly wind patterns. Thus, for local and regional pollution, trades among sources within a region can have an impact on the levels of environmental quality at particular locations even though the aggregate level of emissions in the region remains constant.

If the public policy objective were to maximize social welfare, the optimal distribution of pollution concentrations in the region would depend on the shape of the damage function – the function linking the pollutant's concentrations to its adverse effects. If the damage function is convex (*i.e.*, an additional unit of pollution concentration causes greater harm at higher concentrations), social welfare is maximized by spreading the pollutant concentrations throughout the region. Indeed, additional levels of pollutant concentrations cause greater harm in dirtier areas. In contrast, if the damage function is concave (*i.e.*, an additional unit of pollution concentration causes greater harm at lower concentrations), social welfare is maximized by concentrating the pollution rather than spreading it around. In this case, additional concentrations of a pollutant cause a smaller adverse effect in areas that are already highly polluted.

Whereas disproportionate concentrations of pollution at a particular location can be either desirable or undesirable from the perspective of maximizing social welfare, they tend to be undesirable from the standpoint of distributional concerns. For example, the environmental justice movement worries about any disproportionate concentration of pollution because of fears that its impacts will be felt primarily by the most vulnerable members of society. This concern is independent of the shape of the pollutant's damage function. Even if the aggregate social welfare would be increased by concentrating pollution in a particular area, environmental justice advocates would nonetheless favor dispersion.

The academic literature has focused almost exclusively on the possibility that emissions trading will give rise to excessive concentrations of pollution at particular locations, and has expressed concern over two separate manifestations of this phenomenon: the formation of hot spots and the violation of ambient air quality standards. In the case of local pollutants, such hot spots are likely to be in locations in which the levels of emissions are particularly high. But geographic factors matter as well. For example, for a given level of emissions, a hot spot is more likely to develop if the area is close to a topographical barrier, such as a mountain range, and where prevailing winds blow the pollution toward the range rather than away from it. In the case of regional pollutants, what matters is not only the location of the emissions but also the manner in which emissions are transported. As a result, there may be a hot spot at a downwind location even if the emissions are not concentrated at any upwind location.

Environmental justice advocates, in particular, worry that marketable permit regimes will exacerbate hot spots. The oldest, most highly polluting factories are often located in lower income neighborhoods. If the initial allocation of permits is performed through grandfathering, these older plants will get a disproportionate number of permits and will be able to continue polluting at their historic rates without facing any additional costs. In contrast, under a command-and-control regime, they might eventually face more stringent standards. Moreover, older factories are more likely to have higher marginal costs of pollution reduction. As a result, they will purchase additional permits following the initial allocation, and increase their pollution rather than spend money on more effective pollution control technology.

In fact, even if older facilities were not located in predominantly poor or minority communities when the government first implements a trading program, "market dynamics" in the housing market may change that situation over time. In particular, the placement of a locally undesirable land use in a community may "convert" the community into one whose residents are more likely to be poorer and more likely to be of color. Thus, any concentration of pollution in a particular area, even if it was not originally a predominantly poor or minority area, could have adverse environmental justice consequences.

In addition to producing hot spots, trading regimes can also lead to violations of ambient standards. Several existing environmental programs feature such standards. The Clean Air Act, for example, establishes national primary and secondary ambient air quality standards (NAAQS), which provide protection against adverse effects on the public health and public welfare, respectively. Similarly, under the Clean Water Act, the states must promulgate ambient water quality standards.

The leading proposals for tradable permit regimes do not contain a mechanism for ensuring that ambient standards are met. So, for example, if the ambient air quality level in an area is equal to the ambient standard before the transition to a trading regime, subsequent purchases of permits by sources in the area could lead to a violation of the ambient standards. As a result, trading regimes lose the strong rhetorical claim that they are simply a way of achieving the same level of environmental protection more cheaply than under command-and-control regulation. But a regulatory regime that does not ensure that such standards will be met cannot be said to provide the same level of protection as one that does, even if the aggregate amount of emissions are the same under both programs.

II. Shortcomings of the Existing Tradable Pollution Permit Regimes

This Part analyzes three U.S. regulatory regimes employing tradable emission permits: the national sulfur dioxide trading program, regional trading in ozone precursors in the northeast, and local trading in sulfur and nitrogen oxides emissions in the Los Angeles metropolitan area. In each of these three programs, permits are generally traded in a single market, with no geographic restrictions. We highlight how these programs are not well designed to deal with local and regional pollution and discuss the unsuccessful efforts to ameliorate this problem.

A. The National Sulfur Dioxide Trading Program and the Control of Acid Rain

1. Design of the Trading Program

One of the principal causes of acid deposition, commonly known as acid rain, is the transformation in the atmosphere of sulfur dioxide emissions into sulfates. These sulfates, which are acidic compounds, can travel hundreds of miles as a result of prevailing winds before being dissolved into rain or snow.

Although EPA promulgated NAAQS for sulfur oxide in 1971, these standards are designed to deal with the pollutant's local effects, not its transformation into sulfates. Over the years, there were unsuccessful attempts to compel EPA to revise these NAAQS to address acid deposition, and to promulgate a separate NAAQS for sulfate particles. In connection with part of this litigation, the Second Circuit explicitly stated that the NAAQS "were not designed to protect against the deleterious effects of [sulfur oxides] associated with acid rain and dry deposition.'[6] Moreover, even though the Clean Air Act has specific provisions seeking to constrain interstate pollution, the courts have consistently upheld EPA's position that the impact of transformed pollution, such as sulfates, need not be taken into account in evaluating whether the upwind pollution is excessive.

During the 1980s, Congress rejected various proposals to control acid rain. The failure of these initiatives was due in large part to regional feuding over how to allocate, among the various regions, the costs of addressing the problem.

After all these false starts, the Clean Air Act amendments of 1990 finally established the national sulfur dioxide trading program as a means of controlling acid rain. It was the first pollution trading program authorized by Congress, as well as the first with nationwide scope. Under the program, each allowance or permit authorizes the holder to emit one ton of sulfur dioxide in one year.

The program's implementation has proceeded in two stages. From January 1, 1995 through December 31, 1999, Phase I was in effect. It covered 261 sources at 110 electric utilities, which were considered the dirtiest in the nation. The goal of Phase I was to achieve a 3.5 million ton reduction in sulfur dioxide emissions. The initial allocation of permits was performed through a grandfathering scheme under which the covered sources obtained, for free, an amount equal to the product (in tons) of (i) each source's baseline fossil fuel consumption (in British Thermal Units (BTUs)), which is taken to be the average consumption during 1985 through 1987, and (ii) an assumed emissions rate of 2.5 pounds of sulfur dioxide emissions per million BTUs of fuel consumption. The sources covered under Phase I all had actual emissions rates greater than or equal to 2.5 pounds of sulfur dioxide emissions per million BTUs of fuel consumption. Thus, their prior emissions were not fully grandfathered.

Phase II of the sulfur dioxide trading program, which began on January 1, 2000, subjects virtually all fossil-fueled electric generating plants, including new sources, to an annual nationwide cap on sulfur dioxide emissions. It is expected to lead to further reductions in sulfur dioxide emissions of 6.5 million tons. Although the Phase II allocation provisions contain numerous rules and bonus allocations, the underlying logic of the initial grandfathering is to give each existing source a number of allowances

[6] Environmental Defense Fund v. Thomas, 870 F.2d 892, 895 (2d Cir.), *cert. denied*, 493 U.S. 991 (1989).

equal to the product (in tons) of (i) the source's baseline fuel consumption, determined in the same manner as for Phase I, AND (ii) the lesser of 1.2 pounds of sulfur dioxide per million BTUs and its actual 1985 emissions rate (in pounds of sulfur dioxide per million BTUs).

A small portion of the permits to which sources would be entitled under this grandfathering formula – 2.8 percent – is withheld by EPA and auctioned annually. These allowances are obtained by withholding 2.8 percent of the permits to which each source would otherwise be entitled under the grandfathering formula discussed above. The Chicago Board of Trade conducts these auctions on behalf of EPA. The proceeds are distributed pro rata to sources from which the allocated allowances were withheld.

Following the initial allocation of allowances, the sulfur dioxide trading program authorizes their purchase and sale not only among covered pollution sources, but among anyone who chooses to participate in the market. The market is national and there are no geographic restrictions on trading. The requirements for a transfer to be effective are only ministerial. Brokers facilitate the functioning of the market by maintaining price information and by matching buyers with sellers.

In addition to these intra-source transfers, holders of allowances may "bank" them for use in a future year. Such banking is a form of intra-source trade. An allowance that is valid for use in a future year, however, may not be used before that year.

2. Shortcomings of the Trading Program

The sulfur dioxide trading program is poorly suited to guard against hot spots of acid rain. Most importantly, because trading occurs in a single national market, it pays no attention to the impact of the location of the sulfur dioxide emissions on the production of acid rain.

The region that contributes most to the problem of acid rain in the United States is the Ohio River Valley. Prevailing winds generally carry sulfur dioxide emissions from this region to the Northeast, where acid deposition harms fragile lakes with limited buffering capacity. The sulfur dioxide trading program can exacerbate this problem by permitting sales from northeastern to midwestern polluters. Indeed, sulfur dioxide emissions in the Northeast produce acid rain over the Atlantic Ocean, which has a large buffering capacity that limits the extent of the harm. When northeastern emissions are sold to the Midwest, however, the acid rain falls over the Northeast, where the harm is far larger.

Some commentators suggest that, in practice, this problem is not serious. For example, an analysis of allowance transfer data suggests that, thus far, the trading program has not resulted in the development or exacerbation of hot spots.[7] The reason appears to be that the number of permits received by the dirty sources in the Midwest was smaller than their historic pattern of emissions. As a result, even if such sources became net purchasers of permits, their aggregate emissions would be less than they were before the implementation of the trading program. In essence, the argument of these supporters of the current trading program is that any adverse consequences of trading are dominated by the reduction in emissions produced by the grandfathering scheme. The fact remains, however, that it might be desirable to design a trading regime that does not produce adverse consequences.

---

[7] *See* A. DENNY ELLERMAN ET AL., MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM 130-36 (2000); Byron Swift, *Allowance Trading and SO_2 Hot Spots – Good News from the Acid Rain Program*, 31 Env't Rep. (BNA) 954 (May 12, 2000).

Another study suggests that the Northeast will not suffer net harms as a result of Phase II trading.[8] The study acknowledges, however, that "[t]rading leads to an increase in emissions in the Midwest and a decrease in the East and Northeast." It finds, however, that as a result of the geographic shift in emissions among sources in the Midwest, there is slight decrease in acid deposition in the Northeast.[9]

But regardless of what the aggregate impacts of trading might be, nothing in the sulfur dioxide trading program prevents the development or exacerbation of acid rain hot spots. More generally, the program does not allocate emissions between upwind and downwind sources in a way that minimizes their adverse consequences.

3. Efforts to Redesign the Trading Program

Concerns about the adverse environmental consequences of having trading take place in a single national market received sustained congressional attention during the consideration of the 1990 amendments to the Clean Air Act. Moreover, almost immediately following the passage of the legislation, states and environmental groups sought to introduce constraints into the trading program as a way to prevent the development or exacerbation of hot spots.

a. Pre-Enactment

Even though the final acid rain legislation created a single national market for the trading of sulfur dioxide allowances, Congress did consider imposing various forms of trading constraints, in part to guard against the possibility of hot spots. A public policy study sponsored by Senators Heinz and Wirth in 1988 was the genesis of the trading scheme to control acid rain.[10] The study, under the direction of Robert Stavins, envisioned that trading "would occur on a national or regional basis."[11] The report acknowledges that "[t]he source-receptor relationship must be considered, since reducing acid rain precursors in California, for example, will not reduce acid rain on the East Coast."[12]

On June 12, 1989, President Bush announced his proposal to control acid rain by means of a market in sulfur dioxide emission allowances. The proposal generally restricted trading during Phase I to intrastate transfers. Interstate trading was authorized only for intra-utility trades. During Phase II, "full interstate trading would be allowed."[13]

The Administration's bill, transmitted to Congress on July 21, 1989, similarly authorized only intrastate or intra-utility trading during Phase I.[14] With respect to Phase II, however, it modified (or perhaps clarified) the proposal announced a month earlier to provide that "allowances may be

---

8 *See* DALLAS BURTRAW & ERIN MANSUR, THE EFFECTS OF TRADING AND BANKING IN THE SO2 ALLOWANCE MARKET 2 (March 1999) (Resources for the Future Discussion Paper 99-25).

9 *Id.*; *see* Dallas Burtraw, *Appraisal of the SO2 Cap-and-Trade Market*, *in* EMISSIONS TRADING: ENVIRONMENTAL LAW'S NEW APPROACH 133, 143-49 (Richard F. Kosobud et al. eds., 2000) (hereinafter "EMISSIONS TRADING").

10 *See* PROJECT 88 - HARNESSING MARKET FORCES TO PROTECT OUR ENVIRONMENT: INITIATIVES FOR THE NEW PRESIDENT 32 (1988).

11 *Id.*

12 *Id.*

13 *See* White House Fact Sheet on the President's Clean Air Plan, I PUB. PAPERS: GEORGE BUSH 710 (June 12, 1989).

14 *See* H.R. 3030 § 501, *reprinted in* SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS, A LEGISLATIVE HISTORY OF THE CLEAN AIR ACT AMENDMENTS OF 1990, at 3972 (1993) (hereinafter "LEGISLATIVE HISTORY").

transferred among affected sources within each of the geographic regions of the country, as prescribed by regulation." [15] The bill did not explain how EPA would define these multi-state regions within which trading would be allowed, but commentators believed that there would be two regions.

Hearings before the Subcommittee on Environmental Protection of the Senate Committee on Environment and Public Works, conducted in October 1989, devoted considerable attention to the structure of the trading markets. For example, Senator Lieberman raised questions about unfettered national trading:

> If we allow an open market, free market of trading of permits here, is there any danger that the sources of the acid rain that are hitting New England will acquire the permits to continue to do so? In other words, that reductions, if they're imposed on a national basis, may actually occur in plants other than the ones in the Midwest that seem to be the source of our problem?[16]

Senator Lieberman thus was concerned that midwestern sources would buy additional permits, beyond their initial allocation, and thus exacerbate the acid rain problem in the Northeast.

Senator Heinz stated in response:

> I don't think so ... for two reasons. The first is that the first wave of reductions is largely targeted to the area that I think you believe is responsible for the most acid rain in the Northeast and second, there are as I understand it, restrictions within the President's proposal that have the effect that ensuring that you don't have those kind of bicoastal trades that you might be worried about.[17]

Senator Heinz appears to rely on the fact that the initial allocations to midwestern sources would be less than their historical emissions. His response fails to address Senator Lieberman's concern over the impact of subsequent trades on the distribution of emissions. Moreover, the division of the country into two trading zones, which would indeed have prohibited bicoastal trades as indicated by Senator Heinz, would probably have authorized the Midwest/Northeast trades that worried Senator Lieberman.

At the same hearing, David Hawkins of the National Resources Defense Council, testifying on behalf of the National Clean Air Coalition, expressed concern about the effects of the trading program on the West: "We think new sources of pollution in the western United States might be tempted if they were permitted to do so to purchase allowances from the eastern United States and build dirtier plants in the West."[18] He added:

> [T]he pristine air quality in the West is a global treasure. You cannot compensate for the damage to that air quality that would be caused by building a dirty plant in the West simply by getting emission reductions hundreds of miles away in another region of the country.[19]

Hawkins' statement reflects strong concern, consistent with a concave damage function, that one unit of

---

[15] *Id.*, *reprinted in* LEGISLATIVE HISTORY, *supra* note 14, at 3972-73.
[16] S. Hrg. No. 101-331, pt. 5, at 13 (Oct. 3, 1989).
[17] *Id.*
[18] *Id.* at 38.
[19] *Id.*

sulfur dioxide produces greater harm in pristine western areas, which include many important national parks, than in industrialized areas.

The bill reported out of the Senate Committee on Environment and Public Works on November 16, 1989 direct[ed] that EPA regulations "shall permit transfers only within each of the two major geographic regions of the country as defined by such regulations."[20] The Report accompanying the bill explains: "Allowances transferred between the owners and operators of units that receive allowances or others who lawfully hold allowances under this title may only be transferred to units within the region in which the unit for which the allowances were originally issued is located."[21] It adds that "[t]he Administrator should give exclusive consideration to the environmental protection objectives of this title in defining such regions."[22] A plausible goal for EPA would therefore have been to define the regions in the manner least likely to lead to the violation of the NAAQS for sulfur oxides or to the formation of acid rain hot spots.

The bill passed by the Senate on April 3, 1990, provided for a single national market, with no geographic restrictions on trading. The debate on the Senate floor does not explain why the two-region restriction on trading was dropped.

On the House side, the bill reported out of the House Committee on Energy and Commerce on May 17, 1990, provided for two trading regions. It delegated to EPA the definition of "the 2 major geographic regions of the country."[23] Trading across regions was prohibited, with two exceptions. First, new sources could buy allowances without geographic restriction. Second, the bill permitted intra-firm trades among units in operation on the date of the enactment of the legislation. These restrictions on interregional trading, applicable during both Phase I and Phase II, were retained in the bill passed by the House on May 23, 1990, following only limited floor debate.

The conference bill followed the Senate model of interstate trading in a single national market with no geographic restrictions. The House passed the bill on October 26, 1990 and Senate on the following day, and it was signed by President Bush on November 15, 1990.

The decision to adopt a trading program with no geographic restrictions appears to be largely attributable to the fact that the emphasis throughout the debate was on the large decrease in aggregate sulfur dioxide emissions. For a sufficiently large reduction, the acid rain problem would be ameliorated across the board even if the emissions were not allocated between upwind and downwind sources in an optimal manner. As one commentator explained, "it was understood that the greater the overall size of the reduction [in overall emissions], the more indifferent society could be to the spatial impacts of trades ..."[24]

b. Post-Enactment

The concern over geographically unrestricted trading was not laid to rest with the passage of the

[20] S. 1630 § 401, *reprinted in* LEGISLATIVE HISTORY, *supra* note 14, at 8205.

[21] S. REP. NO. 101-228, *reprinted in* LEGISLATIVE HISTORY, *supra* note 14, at 8645.

[22] *Id.*, *reprinted in* LEGISLATIVE HISTORY, *supra* note 14, at 8661.

[23] *See* Larry B. Parker et al., *Clean Air Act Allowance Trading*, 21 ENVTL. L. 2021, 2041 & n.90 (1991).

[24] *See* Nancy Kete, *The U.S. Acid Rain Control Allowance Trading System*, *in* OECD, CLIMATE CHANGE: DESIGNING A TRADEABLE PERMIT SYSTEM 78, at 83 (1992).

legislation. Commenting on EPA's proposed regulations setting forth the details of the sulfur dioxide markets, several northeastern states criticized EPA for crafting a program that focused on the total sulfur dioxide emissions rather than on the existence of acid rain hot spots. They urged EPA to consider the effects of the structure of the trading program on the formation of acid rain. In addition, New York filed separate comments urging EPA to preclude emission permit trading between sources in different regions of the country until EPA could develop appropriate trading ratios. As a result, if one ton of sulfur dioxide had a greater impact on acid rain if emitted by the purchaser rather than the seller, the purchaser would have to buy more than one ton in permits in order to emit an additional ton, with the ratio being determined by the relative contributions of the two sources to the acid rain problem.

In adopting its final regulations, EPA rejected these criticisms, establishing a single national market, in which allowances for sulfur dioxide emissions traded on a one-to-one ratio, with no geographic constraints. The agency indicated that Congress had already made the policy choice on this matter: "Geographical limitations on allowance transfers were included in early Senate and House versions of the bill, but later rejected in favor of national transfers."[25] The regulations, moreover, bar the states from prohibiting or otherwise restricting the ability of sources within their jurisdiction from purchasing or selling permits.

The hypothetical concerns voiced by some states about the sale of in-state allowances to out-of-state sources soon became a reality. In 1992, the Wisconsin Power and Light Company sold 35,000 allowances to the Tennessee Valley Authority, and sought to keep the transaction secret. Similarly, in 1993, a New York utility – the Long Island Lighting Company (LILCO) – sold allowances to AMAX, a non-utility supplier of energy, that in turn intended to resell the allowances to midwestern utilities. LILCO also tried to keep the identity of the purchaser a secret, but New York's public service commission denied its request.

In March 1993, New York State and an environmental group filed an action in the D.C. Circuit complaining that the sulfur dioxide trading program improperly permitted such trades. The action sought to compel EPA to restrict trades that would lead to heightened acid deposition damage in environmentally sensitive areas of New York.

Moreover, bills introduced in the New York and Wisconsin legislatures sought to constrain or discourage the sale of in-state allowances to out-of-state sources. Wisconsin's bill, which was never enacted, would have required public disclosure of, and the approval of the state Public Service Commission for, any transaction of allowances by a Wisconsin utility. In New York, similar bills introduced first in 1993, and again in subsequent years also failed to be enacted.

In 1998, LILCO entered into a memorandum of understanding with New York State not to sell allowances to sources in upwind states, in certain nearby states, or in New York. The agreement also contained a provision purporting to prohibit any purchaser of LILCO allowances to sell them to polluters in states with which LILCO was not permitted to trade. Between 1994 and the date of this agreement, LILCO had sold 260,000 allowances, "the vast majority of them going to polluters in the

---

[25] *See* Acid Rain Program: General Provisions and Permits, Allowance System, Continuous Emissions Monitoring, Excess Emissions and Administrative Appeals, 58 Fed. Reg. 3590, 3614-15 (1993) (hereinafter Acid Rain Program: General Provisions).

upwind states."[26]

In 2000, New York enacted a law designed to remove the incentive for sales of sulfur dioxide allowances to utilities located in upwind states.[27] Specifically, the law applies to sales of so-called "select SO2 allowance credits," which are defined as sulfur dioxide permits under the national sulfur dioxide program "issued to generating sources located within the boundaries of the state of New York."[28] The law effectively allows the State Public Service Commission to deprive a New York seller of proceeds from the sale of such credits to a polluter located in an "acid precipitation source state"[29] – generally states located upwind from New York.

The statute provides that "[n]othing in this section shall discourage or prohibit allowance trades (such as for retirement purposes) that will have a beneficial impact on sensitive receptor areas in the state of New York."[30] It is unclear whether, under this provision, a sale to an "acid precipitation source state" might be exempted if the trade nonetheless would have a beneficial impact on acid deposition in environmentally sensitive areas of New York – perhaps by reducing in-state emissions causing worse harm.

The statute contains a safe harbor to sellers of allowances that include a restrictive covenant in the sale documents. To be effective, the covenant must restrict the use of the transferred allowances to an acid precipitation source state. This safe harbor suggests that the law's scope may extend to sales of an allowance originally issued to New York sources, even where the original New York holder sold the allowance to an out-of-state entity not located in an acid precipitation state, where this latter entity subsequently transfers the allowance to a source in a covered state. Absent the safe harbor, at the time of the second sale the New York seller would apparently become liable for the proceeds of the first sale.

4. Assessing the State Efforts to Constrain the Trading Market

Piecemeal efforts undertaken by the states are unlikely to be a desirable solution to the acid rain problem. Laws such as New York's may encourage a state-by-state patchwork approach to ameliorating the poor design of the national sulfur dioxide trading program. Such a piecemeal approach would undermine the market for sulfur dioxide allowances and potentially render the national program ineffective by subjecting it to multiple, and possibly inconsistent, state regulations. A national market subject to multiple limitations on trading may well not survive. Such approaches would also discourage sales that produce adverse effects in the state in which the seller is located even if there are greater beneficial effects elsewhere.

Moreover, the New York law does not necessarily promote even the state's own interest. Presumably not every sale of an allowance by a New York holder to a source in an "acid precipitation source state" would result in an increased acid rain problem in New York. Merely because some portion of a state is upwind from New York does not imply that emissions from every location in that

---

[26] Raymond Hernandez, *LILCO Is to Stop Selling Credits to Upwind Polluters*, N.Y. TIMES, Apr. 30, 1998, at B1.

[27] Ass'y Bill 9090, 223d Leg. (N.Y. 1999) (enacted May 24, 2000) (to be codified in N.Y. PUB. SERV. LAW § 66-k, N.Y. ENVTL. CONSERV. LAW. § 19-0921(3), N.Y. STATE FIN. LAW § 99-G, N.Y. PUB. AUTH. LAW § 1854(10-a)).

[28] Ass'y Bill § 2 (adding N.Y. Pub. Serv. Law § 66-k(1)(c)).

[29] Ass'y Bill § 2 (adding N.Y. Pub. Serv. Law § 66-k(1)(d)).

[30] *Id*. § 2 (adding N.Y. Pub. Serv. Law § 66-k(5)).

state adversely affect New York. Thus, the law would constrain sales that, on balance, might be good for New York by reducing local pollution.

In addition to these policy flaws, the constitutionality of laws such as New York's is at best uncertain. The New York law may run afoul of the dormant Commerce Clause by unduly burdening the interstate market in sulfur dioxide allowances. New York might argue that its statute is necessary to protect in-state health and welfare. This argument, however, is somewhat compromised because the law overbroadly reaches transactions that might produce adverse effects on New York. Moreover, the New York law may be preempted by the provisions of the Clean Air Act establishing the market in sulfur dioxide emissions. The claim would be that New York's constraints on the transfer of allowances undermine Congress' goal of achieving pollution reduction on a nationwide scale as cost-effectively as possible, and impose unintended constraints on the ability of sources outside New York to purchase allowances.

B. Regional NOx Trading Programs and the Control of Tropospheric Ozone

1. Processes of Ozone Formation

Nitrogen oxides (NO_x) are the primary precursors of tropospheric, or ground-level, ozone. Ozone, in turn, is the primary ingredient in smog, which causes numerous human health risks, adversely affects plants and ecosystems, and contributes to acid deposition.

Tropospheric ozone is formed by the photolysis of nitrogen dioxide (NO_2). Other compounds, however, affect the rate at which ozone is produced. In particular, through a series of complex chemical reactions, certain volatile (or highly reactive) organic compounds (VOCs) help to convert nitrogen monoxide (NO) into nitrogen dioxide, thereby increasing the production of ozone.

The production of ozone, however, does not vary proportionately with the concentrations of NOx and VOCs in the atmosphere. As a result, decreasing NOx and/or VOC concentrations does not necessarily result in a proportionate decrease in ozone production. Indeed, for certain ratios of NOx to VOC concentrations, a *decrease* in the concentration of NOx actually will lead to an *increase* in ozone production. The reason for this facially counterintuitive result is the role of the hydroxyl radical (OH) in the atmospheric photochemistry that leads to the formation of ozone. Its presence is a prerequisite for the series of reactions that allows VOCs to accelerate the conversion of nitrogen monoxide into nitrogen dioxide. The hydroxyl radical, however, also reacts with nitrogen dioxide. Thus, at comparatively low VOC to NOx concentrations (*i.e.*, where NOx is relatively abundant), the nitrogen dioxide "effectively competes with the VOCs for the [hydroxyl] radical."[31] This reaction decreases the ability of VOCs to convert nitrogen monoxide into nitrogen dioxide, and thus reduces the rate of production of ozone. As a result, if NOx concentrations are lowered relative to VOC concentrations, "more of the [hydroxyl] radical pool is available to react with the VOCs, leading to greater formation of ozone."[32]

A consequence of these complex interactions is that the best strategy for reducing ozone production depends on the local ratio of VOC to NOx concentrations. At relatively low VOC to NOx concentration ratios (of around 10 or less), reductions in NOx concentrations may have little impact on,

---

[31] NATIONAL RESEARCH COUNCIL, RETHINKING THE OZONE PROBLEM IN URBAN AND REGIONAL AIR POLLUTION 167-68 (1991).
[32] *See id*. at 168.

or even increase, ozone concentrations; the preferable strategy is to decrease VOC concentrations. At larger ratios (in excess of 20), reductions in NOx will be far more effective than VOC reductions. For moderate ratios (between 10 and 20), there is no global "best strategy" – the control of NOx emissions, VOCs emissions, or both, might work best, depending upon the particular circumstances.[33]

NOx emissions not only affect the local concentrations of ozone, but also pose a regional pollution problem. Winds that carry chemicals great distances and mix atmospheric components can significantly augment the rate of ozone production.

In the United States, interstate pollution transport is generally a greater problem in the eastern portion of the country, as a result of a combination of prevailing weather patterns, topography, and a sizeable concentration of pollution sources east of the Continental Divide. In the case of NOx and ozone, regional disputes have erupted between the South and Midwest – where many NOx and ozone emissions originate – and the Northeast – where the impact of these emissions is often felt.

To date, the Clean Air Act's attempts to address the problem of long-distance ozone transport have been unsuccessful. The NAAQS for nitrogen dioxide and ozone are poorly suited to control interstate spillovers. They simply establish the minimum permissible levels of environmental quality at a location. They do not constrain the amount of the pollution at that location that can come from upwind sources. In fact, "a state might meet its ambient standards precisely because it exports a great deal of its pollution."[34]

In the 1990 amendments to the Clean Air Act, Congress tried to address the problem of regional NOx transport by imposing emissions limitations on certain sources. Unlike the case of sulfur dioxide, however, Congress did not create the possibility of trading. The resulting high costs imposed on polluting facilities by this command-and-control regime make it difficult for EPA to regulate at a level that would make a significant dent on the regional ozone problem.

As a result, there has been increasing momentum for a NOx allowance trading regime in the Eastern United States, even though Congress has not specifically authorized such an approach. In the last few years, three independent regimes have been designed: the Ozone Transport Commission's program, EPA's optional state model program, and EPA's mandatory federal program. All three are modeled generally on the EPA's sulfur dioxide trading program. In particular, they create a single market with no restrictions on trading.

The preceding discussion of the chemistry of ozone production suggests problems with a single regional trading market. First, while NOx emissions have a regional impact on ozone levels, they also have a substantial local impact. As a result, trades in nitrogen oxides emissions may lead to local ozone hot spots. For example, because of the higher concentration of VOCs in urban areas, trades that increase urban NOx concentrations may lead to a net increase in the production of ozone. Second, because the best strategy for reducing ozone levels turns heavily on the ratio of VOCs to NOx concentrations, trades between regions with different ratios can have negative effects at both the buyer's and seller's locations. For example, in rural areas reductions in NOx leads to reductions in ozone formation, but in many urban areas, such reductions lead to increased ozone concentrations. Thus, a sale of a permit from such an urban area to a rural area has adverse effects at both locations.

---

[33] *See id*. at 353.

[34] Richard L. Revesz, *Federalism and Interstate Environmental Externalities*, 144 U. PA. L. REV. 2341, 2350 (1996).

2. The Ozone Transport Commission's Trading Program

To address the problem of regional ozone transport, the 1990 amendments to the Clean Air Act established the Ozone Transport Commission (OTC), which is composed of twelve Northeastern and mid-Atlantic states, and the District of Columbia. In September 1994, the members of OTC – with the exception of Virginia – signed a memorandum of understanding to reduce regional NOx emissions in two stages – to 219,000 tons by 1999, and to 143,000 tons in 2003 (from 490,000 tons in 1990). The memorandum divided the OTC region into three zones defined by reference to geography and to the degree by which ambient air quality levels exceeded the NAAQS. It established different emission reduction requirements in each zone on the basis of the relative impact of emissions from different zones on regional air quality.

In 1996, OTC, in conjunction with EPA, developed a model rule that envisioned the implementation of a regional cap-and-trade NOx emission allowance regime designed to achieve OTC's regional reduction goals. The model rule departed from the three-zone approach of OTC's memorandum of understanding by designing a unified regional market. It did not, however, formally adopt such a system, instead leaving this decision to the OTC members.

OTC's NOx trading program is based upon tradable emission allowances, each of which authorizes the holder to emit one ton of NOx. Each state receives a quota of emission allowances annually, set by reference to a 1990 baseline that is reduced proportionately to reflect the emission reduction goals. The states can choose how to distribute their allocations to their various sources. No source may emit more NOx than authorized by its allowance holdings during the months of May through September – the period when ozone concentrations are most problematic.

Moreover, in an application of "regulatory tiering,"[35] a holder of an allowance may not use the allowance if to do so would result in a violation of some other federal or state limit on emissions. Participants are generally free to bank allowances for use in a future control period if they so choose. If too many allowances for a given annual control period are banked, however, a certain proportion of them become unusable.

OTC acknowledged the 1994 memorandum's division of the region into zones and noted that, "[o]ptimally, inter-zone trading would be established to encourage actual emission reductions where such reductions would do the most good for air quality."[36] It relied, however, on a simulation that demonstrated to OTC's satisfaction that there was "no discernible difference" in terms of environmental impacts between a scenario in which trading between zones was strictly prohibited and one in which trading was authorized region-wide with no trading ratios.[37] OTC concluded that "institution of a trading ratio would appear to have no influence on where emissions would be reduced in the region."[38] Accordingly, it decided "not to apply a trading ratio to discount allowances if they are traded across

[35] *See* Tom Tietenberg, *Tradable Permits for Pollution Control When Location Matters*, 5 ENVTL. & RESOURCE ECON. 95, 103 (1991).

[36] LAUREL J. CARLSON, NESCAUM/MARAMA NOX BUDGET MODEL RULE § 5.0, at 17 (1996) (available at <http://www.epa.gov/acidrain/otc/otcmain.html>).

[37] *Id.*

[38] *Id. See also* Interview with Bill Gillespie, Senior Program Manager at the OTC (June 27, 2000).

zones."[39]

3. EPA's Trading Programs

While EPA was helping OTC develop its NOx trading program, it also endeavored to establish a broader program, into which the OTC scheme could eventually be merged. It designed both a model program that would be implemented, on a voluntary basis, by the states in their State Implementation Plans (SIPs), and a mandatory, but more limited, federal program.

a. The State Model Program

The Clean Air Act requires each state to submit to EPA for its approval a SIP detailing how it intends to control sources within its jurisdiction so that the NAAQS are met within its borders. If, subsequent to such approval, EPA determines that a SIP has become inadequate "to attain or maintain" the NAAQS or "to mitigate adequately ... interstate pollution transport", it can issue a "SIP call" requiring the state to correct the inadequacies in its SIP.[40] In October 1998, EPA issued a SIP call and promulgated a so-called NOx SIP rule requiring upwind states to take action to ensure that the transport of ozone precursors – primarily NOx – would not contribute significantly to nonattainment of the ozone NAAQS, or impede their maintenance, in downwind states. Various states and industry groups challenged EPA's authority to issue the SIP call and promulgate the NOx SIP Rule, but in March 3, 2000, the D.C. Circuit upheld EPA's action. As a result of this challenge, however, EPA extended the initial date by which states must file SIPs complying with the NOx SIP Rule to September 1, 2000.

The NOx SIP Rule requires 22 Eastern states and the District of Columbia to reduce NOx emissions sufficiently to bring the majority of non-attainment areas into attainment with the NAAQS. In fashioning its remedial approach, EPA relied upon the work of the Ozone Transport Assessment Group (OTAG) – a working group comprised of representatives of states, EPA, and industry and environmental groups. OTAG had envisioned two possible trading programs. Under the first, states could adopt a NOx emission permit cap-and-trade scheme. All states that elected this option would combine to form a single market in NOx emissions.

Alternatively, states could elect to implement a trading regime without emission caps. Under such schemes, sources generally receive credits for emission reductions beyond those required by law, and are free to sell those credits to other sources. Trading would initially be intrastate, with the possibility of multistate arrangements evolving over time.

Although OTAG did not incorporate the notion of trading zones into its proposal, its final recommendation recognized the problem of hot spots and directed a workgroup to consider the possibility of trading zones:

> Subregional modeling and air quality analysis should be carefully evaluated to determine whether geographical constraints should be placed on emissions trading. Appropriate mechanisms, such

[39] CARLSON, *supra* note 36, § 5.0, at 17.
[40] 42 U.S.C. § 7410(k)(5) (1994).

as trading ratios or weights, could be developed if significant effects are expected.[41]

In the NOx SIP Rule, EPA followed OTAG's first recommended track, announcing a model NOx trading program that states could adopt as part of their revised SIPs. The model program is designed so as to allow for it to incorporate the preexisting OTC NOx trading program. It applies to sources with high capacities, although certain other sources can opt into the program.

EPA's model trading program suggests a procedure states might use to allocate the allowances in their budgets, but like the OTC program leaves the decision to the individual states. Also, like its OTC counterpart, the EPA program allows for banking but places certain limits on the use of banked allowances.

In structuring its model NOx trading program, EPA considered the possibility of imposing geographic restraints on trading. When EPA proposed the trading regime, it described a single-zone scheme, but invited comments on the issue. The agency raised the possibility of constructing subregions between which trading would either be barred, or allowed only subject to a interregional exchange ratio.

EPA received over 50 comments on the appropriateness of geographic constraints on trading. According to EPA,

> [t]he majority of commenters on this subject favored unrestricted trading within areas having a uniform level of control. Most commenters supporting unrestricted trading stated that restrictions would result in fewer cost-savings without achieving any additional environmental benefit and would increase the administrative burden of implementing the program. The expressed concern that discounts or other adjustments or restrictions would unnecessarily complicate the trading program, and therefore reduce its effectiveness.[42]

EPA decided to structure the model program as "a single jurisdiction trading program allowing all emissions to be traded on a one-for-one basis, without restrictions or limitations on trading allowances within the trading area."[43] In justifying its decision, EPA relied on a model predicting that "significant shifts in the location of emissions reductions would not occur with unrestricted trading compared to where the reductions would occur under command-and-control and intrastate only trading scenarios."[44]

b. The Federal Program

EPA also developed a mandatory federal NOx trading program in response to petitions filed by eight states, under section 126 of the Clean Air Act, complaining about an excessive upwind contribution to their failure to meet the NAAQS for ozone. EPA upheld portions of six of the eight petitions in May 1999. In a final rule issued in January 2000, EPA required that certain sources participate in a federal NOx trading program to address the problems asserted in the petitions filed by the downwind states. This program formally applies to a limited number of large NOx emitters in

---

[41] *See* Mary A. Gade & Roger A. Kanerva, *Emissions Trading Designs in the OTAG Process, in* EMISSIONS TRADING, *supra* note 9, at 91; OTAG's final recommendation for a trading program framework is presented in Appendix A thereto at 114.

[42] *See* NOx SIP Final Rule, 63 Fed. Reg. at 57,475.

[43] *Id*.

[44] *Id*.

upwind states. In addition, certain other sources in those states may opt into the program.

The program generally follows the structure of the SIP Model NOx trading program. Sources covered by the federal NOx trading program that are located in states that choose to implement the model program can buy and sell allowances on that market. In authorizing this integration of the two programs, EPA relied on computer simulations showing that trading under the integrated programs "will not significantly change the location of emissions reductions."[45]

C. The Los Angeles Metropolitan Area's Local Smog Precursor Trading Program

The South Coast Air Quality Management District (SCAQMD) administers an urban smog trading program in the Los Angeles metropolitan area. The program is a part of the California SIP, and relies on a market in emission permits of two smog precursors: sulfur oxides and nitrogen oxides.

SCAQMD's trading regime consists of three distinct programs. The principal program, the Regional Clean Air Incentives Market (RECLAIM), is designed to achieve a regional 75% reduction in nitrogen oxide emissions, and a 60% reduction in sulfur oxide emissions, by 2003. All facilities within the SCAQMD's jurisdiction that emit at least four tons of either pollutant annually are subject to RECLAIM; other facilities can choose to participate in the program.

Each permit entitles the holder to emit one pound of a specific pollutant. Participating facilities receive annual emission permits in proportion to prior pollution levels. In order to meet the air quality improvement mandated by federal law, SCAQMD decreases the total number of RECLAIM permits, as well as the total number of permits allocated to each facility, by approximately five to eight percent each year.

The RECLAIM program establishes two trading zones – a coastal zone and an inland zone. Restrictions on trading between these zones apply only to new sources, sources that relocate, and sources that seek to increase emissions above their initial allocation of permits. Such sources may purchase permits only from sources in their zone. In contrast, inland facilities may purchase permits from either zone. These trading restrictions were predicated on the use of computer models: "In view of modeling results of the prevailing winds, trading was permitted from coastal sources to inland but not the other way around."[46]

The second component of SCAQMD's trading regime is a mobile source emissions credit program. It is designed to address the complaint that the RECLAIM program, standing alone, did not incorporate automobile emissions, one of the largest sources of air pollution in the area. Under this program, which is voluntary, SCAQMD awards allowances to "licensed car scrappers" who purchase and destroy old cars based upon the predicted emissions of the cars had they not been destroyed.[47] Mobile source emissions credits awarded for sulfur and nitrogen oxide reductions can be bought and sold on the RECLAIM market.

---

45 *See* 65 Fed. Reg. at 2693.

46 Richard F. Kosobud, *Emissions Trading Emerges from the Shadows, in* EMISSIONS TRADING, *supra* note 9, at 24.

47 *See* Lily N. Chinn, Comment, *Can the Market Be Fair and Efficient? An Environmental Justice Critique of Emissions Trading*, 26 ECOLOGY L.Q. 80, 92 (1999); Richard Toshiyuki Drury *et al*., *Pollution Trading and Environmental Injustice: Los Angeles' Failed Experiment in Air Quality Policy*, 9 DUKE ENVTL. L. & POL'Y F. 231, 246-47 (1999).

SCAQMD's third trading regime is a source credit program. This program, which is also voluntary, brings small pollution sources such as household and small business furnaces, which otherwise would be unregulated, into the trading fold. Owners of these small sources can earn area source credits by upgrading older, high emission equipment. Area source credits can be traded on the RECLAIM market.

Data from the first three years of the RECLAIM program reveal a "robust" trading market.[48] Through December 31, 1997, there had been 1200 trades, with a total value of $42 million. These trades represent the transfer of 244,000 tons of nitrogen and sulfur oxides.

Environmental justice groups have assailed SCAQMD's emission trading regime. These groups allege, consistent with the general environmental justice criticism of trading, that areas immediately proximate to pollution sources have not seen improvement, or have experienced deterioration, in air quality. According to these groups, the adversely affected areas tend to be economically disadvantaged and contain relatively higher percentages of ethnic and racial minorities.

Of particular concern is the fact that mobile source credits can be sold on the RECLAIM market. Environmental justice advocates find this arrangement problematic because automobile emissions are dispersed, so that their effects are distributed fairly homogeneously across the regulated area. In contrast, a small number of industrial polluters, primarily four oil companies, has purchased these allowances. These polluters are disproportionately located in minority areas. Indeed, one commentator notes that of the four companies that have purchased most of the emission credits, "three are located close together" in two communities that are heavily populated by Latinos.[49]

In 1997, one local environmental group, Communities for a Better Environment (CBE) filed an administrative complaint with the EPA against SCAQMD and the California Air Resources Board, under Title VI of the Civil Rights Act of 1964. It claimed that the mobile source program exacerbates hot spots in Latino communities. Although there have been calls to halt the trading during the pendency of the litigation, the SCAQMD's various programs remain in place.

III. Addressing the Problem of Ambient Standard Violations and the Formation of Hot Spots

As we have explained, for local and regional pollutants, the location and extent of the damage caused by a unit of emissions vary according to the location of the emissions. Markets in emissions permits, such as those implemented in the regulatory programs discussed in Part II, however, treat emissions at different locations as interchangeable. As a result, such markets cannot ensure against the violation of ambient standards or the formation of hot spots.

In this Part, we analyze the three leading proposals for constructing marketable permits schemes that avoid or at least mitigate this problem: subdividing the emissions market into zones and prohibiting interzonal trading; designing markets in units of environmental degradation, rather than units of emissions; establishing emissions offset markets: markets in which the trading in units of emissions does not take place on a one-to-one ratio.

For expositional ease, our primary focus in the remainder of the Article is on the violation of

[48] James M. Lents, *The RECLAIM Program (Los Angeles' Market-Based Emissions Reduction Program) at Three Years*, *in* EMISSIONS TRADING, *supra* note 9, at 219, 232.
[49] *See* Drury *et al.*, *supra* note 47, at 252-53.

ambient standards rather than on the formation of hot spots. The analysis we present, however, is equally relevant to both problems.

A. Emissions with Multiple Trading Zones

One way to reduce the potential negative effects of emissions trading is to divide a region into separate zones, create a separate permit market in each zone, and prohibit interzonal trades. The market price for permits in each zone would be determined by the supply and demand for permits within that zone. Market prices would therefore differ across zones.

In Part II, we discussed proposals, that ultimately were not implemented, to divide the nation into two trading zones in the national sulfur dioxide trading regime, and the possible division of the OTC NOx trading program into three trading zones. The RECLAIM program in Los Angeles, in contrast, does feature two zones, with trading prohibited from the inland zone to the coastal zone.

The division of a regulated region into distinct trading zones may ameliorate the threat of ambient standard violations for two reasons. First, by precluding trades across zonal boundaries, a zoned market limits the number of permits that any source can acquire. Second, emissions from different sources in a smaller zone are likely to have a more similar impact – in terms both of location and magnitude – than emissions from different sources in a larger zone. Especially if the policymaker takes topography and the prevailing wind patterns into account in constructing zonal boundaries, emissions from within a trading zone may have substantially equivalent adverse effects. Under such circumstances, trading within the zone might not generate ambient standard violations.

A zoned emission permit regime, however, does not eliminate the possibility of ambient standard violations. No matter how much attention the policymaker devotes to constructing zonal boundaries in light of topography and wind patterns, emissions of local and regional pollutants from different locations are not equivalent. Rather, they remain spatially differentiated and will have somewhat different impacts – in terms of location and magnitude. As Alan Krupnick, Wallace Oates, and Eric Van De Verg explain:

> [T]he assumption under [emissions permit trading] that a unit of emissions from one source in a zone is precisely equivalent in its effects on air quality to a unit of emissions from any other source in the zone *may*, under certain circumstances, do serious violence to reality. The ambient effects of emissions do not depend solely on the geographical location of the source; they depend in important ways on such things as stack height and diameter, and on gas temperature and exit velocity.[50]

A further complication is raised by the fact that the ambient air quality levels in a zone depend not only on emissions from sources in that zone but also on transported pollution from upwind zones. Thus, for example, if an upwind source with a relatively short stack sells a permit to a source with a taller stack, the ambient air quality levels in the downwind zone will worsen.

Moreover, even if zoned regimes performed relatively well in terms of avoiding violations of ambient standards, one needs to worry about other complications. First, they reduce the size of each trading market (and increase the number of markets). Because a smaller market has fewer participants,

---

[50] *See* Alan J. Krupnick *et al*., *On Marketable Air-Pollution Permits: The Case for a System of Pollution Offsets*, 10 J. ENVTL. ECON. & MANAGEMENT 233, 244 (1983) (emphasis in original).

market power is more likely to be concentrated in the hands of a relative few. These participants with market power – whether buyers or sellers – would have the incentive to engage in anticompetitive practices. In particular, sellers with power would be able effectively to set the price for allowances above the efficient market price, while buyers with power would do the opposite.

A non-global pollutant, by definition, causes different damage – in terms both of magnitude and location – depending on the location from which it is emitted. The factors giving rise to these spatially differentiated effects, such as topography, temperature, and wind patterns, can vary significantly across relatively small distances. As a result, to achieve a viable market that respects ambient standards one of two conditions must hold: the regulated pollutant must have the characteristic that only relatively large shifts in its emission locations affect the spatial distribution of the harm, or there must be a sufficiently large concentration of potential market participants. Under the former condition, the trading zone can be relatively large; under the latter, the zone's small geographic size does not stand in the way of a robust market.

If neither of these conditions is met, the policymaker must make a tradeoff. It can assign sufficiently numerous sources to each zone, but heighten both the probability and magnitude of ambient standard violations. Alternatively, it can mitigate the probability and magnitude of ambient standard violations by assigning fewer sources to each zone, but heighten the probability of thin markets and of the resulting deleterious effects.

Another negative consequence of the division of a region into trading zones is that the lowest-cost reduction of pollution to the desired level (one of the primary promises of tradable permit schemes) is unlikely to be realized. Indeed, dividing the regulated region into zones among which trading is barred can result in the preclusion of some cost-saving trades that would not lead to ambient standard violations.

More generally, a zoned scheme will not achieve the most cost-effective pollution reduction unless the policymaker allocates the "correct" number of permits to each of the various zones.[51] That will not happen unless – as seems unlikely – the policymaker is privy to pollution-reduction cost information for polluters in each zone. Because trading across zonal boundaries is prohibited, subsequent trading cannot ameliorate the initial misallocation of permits. The policymaker could adjust the allocation of permits across zones over time as it gains more information about control costs, but the administrative costs of such an approach are likely to be substantial.

To address the shortcomings of zoned schemes, some commentators have suggested allowing trading across zonal boundaries under an exchange ratio that converts permits traded in one market into permits traded in another. Consider, for example, a situation in which permits traded within Zone I cause twice as much damage at a given location as permits traded within Zone II. A buyer in Zone I could then purchase permits for two units of emissions from a seller in Zone II for every unit of emissions that it wishes to discharge. But this relatively straightforward exchange works only because, in the example, the location of the damage is independent of the location of the emissions. If, instead, emissions in Zone I affected ambient air quality in both Zones I and II, but emissions in Zone II affected ambient air quality levels only in Zone II, trading at a fixed exchange rate would not guarantee the attainment of ambient standards.

---

[51] *See* Scott E. Atkinson & T. H. Tietenberg, *The Empirical Properties of Two Classes of Designs for Transferable Discharge Permit Markets*, 9 ENVTL. ECON. & MGMT. 101, 104 (1982).

B. Markets in Units of Environmental Degradation

To address the problem of ambient standard violations caused by trading, commentators have proposed schemes in which permits are denominated in units of environmental degradation, rather than in units of emissions. Under this approach – often referred to in the literature as an "ambient permit system" – the policymaker determines the ambient quality that it deems acceptable at numerous receptor points distributed over the region. For each receptor point, the policymaker issues permits of environmental degradation, so that the sum of the environmental degradation authorized by all the permits issued at a given receptor point is set by reference to the ambient standard at this point.

Each receptor point defines a separate market. A firm wanting to increase its emissions would have to determine, through the use of computer modeling, which receptor points are affected by its emissions and the extent of the environmental degradation at each such point. Then, it would need to obtain sufficient permits at each relevant market. As long as the policymaker chooses representative receptor points, the computer modeling accurately predicts the ambient impacts of emissions at different locations, and robust markets for the various environmental degradation permits develop, the trading will not interfere with the attainment of the ambient standards throughout the region.

Markets in units of environmental degradation have certain undesirable features, which in some cases may be sufficiently severe to undermine the vitality of the markets and compromise the benefits of trading. First, such schemes require the establishment and maintenance of permit markets at each of the receptor points. Thus, the system is likely to impose substantial market supervision costs, as well as costs on prospective market participants who must enter multiple markets.

Second, markets in units of environmental degradation will be thinner than single-zone emission markets. Indeed, polluters participate only in the markets at which their emissions cause damage; thus, not every polluter participates in every market. At some receptor points, the number of prospective market participants might not be sufficient to support an efficient market.

Third, these problems are exacerbated by the segmentation of the property rights. As we noted above, a firm that seeks to increase its emissions must obtain additional permits at each receptor point at which its emissions cause damage. If the firm is able to purchase permits only in some markets but not others, the purchased permits would be useless. Only a full portfolio of permits gives the firm the right to increase its emissions.

This emphasis on portfolios is likely to affect a firm's bidding strategy. For example, if a firm knew that obtaining permits in one market would be especially difficult, it might wait until it obtained those permits before attempting to purchase permits in other markets.

Prospective sellers face similar problems. While brokers presumably would work to match willing buyers to willing sellers, it is unlikely that the seller would find a buyer that needed the precise portfolio of permits that the seller was offering. Only in relatively rare instances would the seller be able to dispose of its permits in one transaction. In the more likely scenario, it would have to engage in multiple transactions, with the consequent rise in transaction costs.

The interlinking of the different markets, which results from the need of both buyers and sellers to trade portfolios of permits, gives rise to the potential that thin markets at some receptors will cause a domino effect. If the market for a permit to degrade the environment at one receptor point has an insufficient number of prospective market participants, markets at other points also might become thin if too many prospective participants rely on purchasing or selling permits on the first market to make transacting on the other markets worth their while.

C. Pollution Offset Markets

Given the problems of zoned emission markets and of markets in units of environmental degradation, environmental economists have searched for alternative ways to construct pollution markets. Alan Krupnick, Wallace Oates, and Eric Van De Verg have proposed a pollution offset market,[52] which entails a single market in emission permits but in which trades are not effected on a one-to-one basis. Rather, "the parties exchange emission permits at ratios depending on the relative effects of the associated emissions on ambient air quality at receptors with potential to violate the standard ..."[53] Under a pollution offset market regime, a buyer need only purchase emission permits if the buyer's emissions would otherwise cause a violation of an ambient standard at a receptor point. A buyer requiring permits in order to increase its emissions, can purchase them from a particular seller only if the emissions of both the buyer and seller adversely impact ambient air quality at a common receptor point. The exchange rate is determined by reference to the relative rates by which emissions of the regulated pollutant by the buyer and seller contribute to ambient concentrations at this receptor point: it equals the ratio of the seller's contribution to that of the buyer.

A numerical example is illustrative. Let us say that an ambient standard of 10 :g/m^3 of pollutant *P* governs at receptor point □, and that emissions from firms *A* and *B* contribute to levels of *P* at □. In particular, let us say that the level of *P* at □ increases by 3 :g/m^3 for every ton of *P* emitted annually by *A*, while the level of *P* increases by 1 :g/m^3 for every ton of *P* emitted annually by *B*. At present, *A* has 2 permits and *B* has 4; each permit entitles the holder to emit 1 ton of *P* annually. Thus, the ambient level of *P* at □ precisely equals the ambient standard:

(2 tons) x (3 :g/m^3 per ton) + (4 tons) x (1 :g/m^3 per ton) = 10 :g/m^3.

Now say that *A* decides to purchase 1 permit from *B*. If the trade were conducted on a one-to-one basis, then *A* and *B* each could emit 3 tons of *P* per year, with the resulting annual average ambient level of *P* at □:

(3 tons) x (3 :g/m^3 per ton) + (3 tons) x (1 :g/m^3 per ton) = 12 :g/m^3.

This concentration exceeds the ambient limit of 10 :g/m^3. Instead, the trade must be accomplished using an exchange rate based on *A*'s and *B*'s relative contribution to the level of *P* at □. Here, the exchange rate is 1/3. Thus, the seller *B* reduces its emissions by 1 ton (since it is selling 1 permit), but the amount by which *A* is permitted to increase its emissions is restricted by the exchange rate:

(1/3) x (1 ton/permit) x (1 permit) = 1/3 ton.

Thus, the additional permit obtained by *A* enables *A* to emit a total of 2-1/3 tons of *P* per year; *B* is permitted to emit 3 tons annually. The 10 :g/m^3 ambient level of *P* at □ is then not violated:

---

[52] *See* Krupnick et al., *supra* note 50, at 233.

[53] Albert McGartland, *A Comparison of Two Marketable Discharge Permits Systems*, 15 J. ENVTL. ECON. & MGMT. 35, 37 (1988).

(2-1/3 tons) x (3 :g/m^3 per ton) + (3 tons) x (1 :g/m^3 per ton) = 10 :g/m^3.

The calculation of ratios is more complicated where a buyer and seller share more than one common receptor point, because the trade cannot result in an ambient standard violation at *any* receptor point. Thus, the trading ratio is determined by reference to the receptor at which the ratio of the buyer's to the seller's impact on ambient quality is lowest.

Offset markets have another layer of complexity: the treatment of "slack." Slack occurs when the pollution level at a receptor is below the ambient standard, so that this standard is not constraining. Under the logic of a pollution offset regime, a source can simply increase its emissions without purchasing any permit if these emissions affect only receptors at which the ambient standard is not constraining. This feature leads to a "first-come, first-served" allocation of the slack in which, by increasing its pollution, a source can claim a valuable economic right.

An offset market system is fraught with complexity, both for the market supervisor and for market participants. This complexity arises in large measure because the commodity subject to trade, while nominally an emissions permit, in fact conveys different rights to different holders at different times. The government must therefore maintain a record of the rights accompanying each permit. It also imposes higher transaction costs on prospective market participants. Also, the presence of slack gives rise to additional difficulties, again leading to higher administration and transaction costs.

IV. A Proposal for a Constrained Emissions Permit Regime

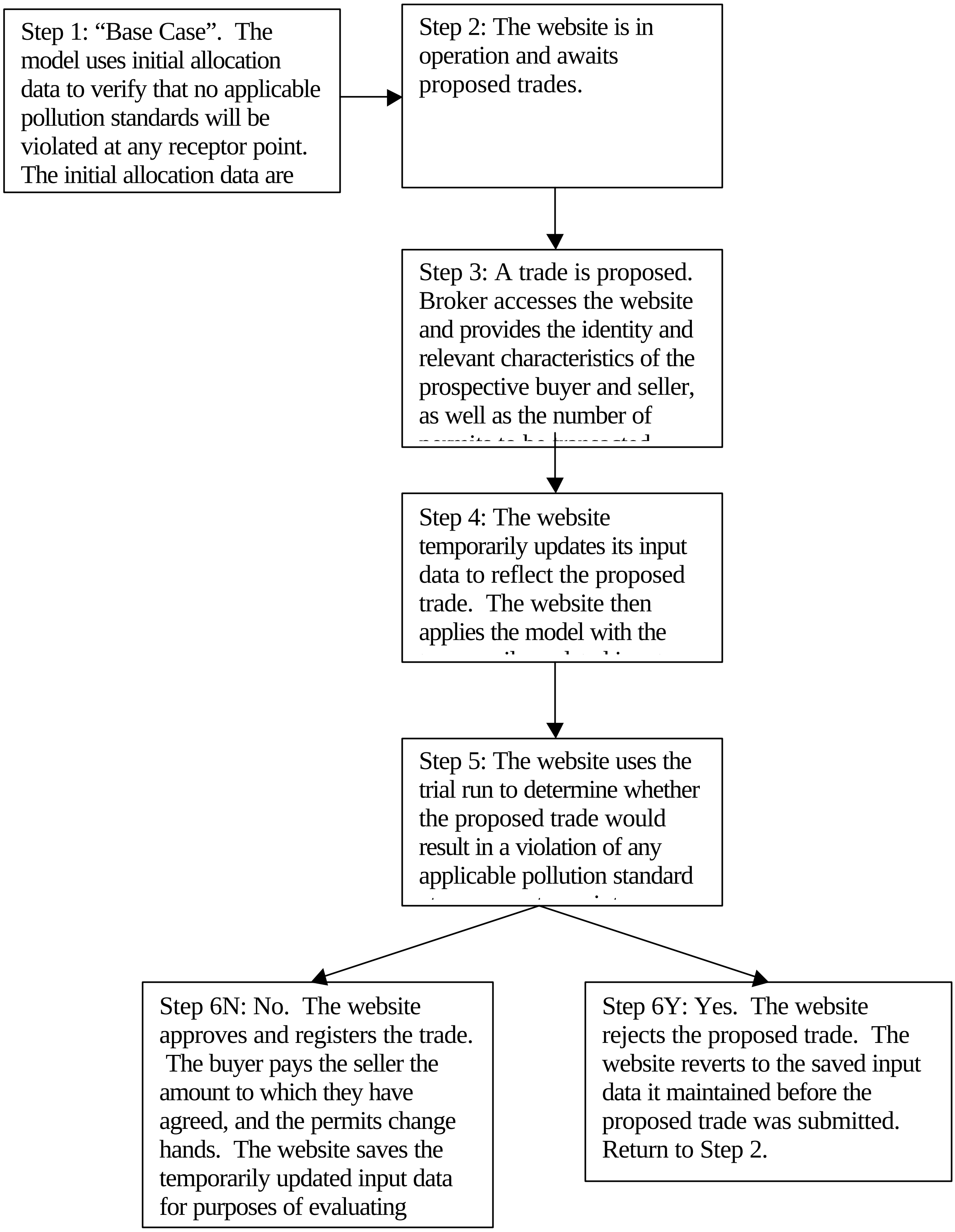
In this Part, we present our proposal for a constrained emission permit regime that respects ambient standards. Our regime relies upon the preclearance of transactions by a website containing information on the impacts of emissions on ambient air quality levels throughout a region. Section A sets forth the elements of our proposal. Section B explains why it is superior to the alternative means of structuring markets to avoid or mitigate the violation of ambient standards. Section C analyzes the impact of our approach on the structure of the emissions markets. Finally, Section D illustrates the operation of our proposal by means of a simulation of the air pollution dispersion model recommended by EPA.

A. Structure of the Proposal

The constrained trading regime that we propose consists of a single market in units of emissions, but in which a proposed trade is rejected if it leads to the violation of an ambient standard at any receptor point. The determination of whether a proposed trade is approved would be performed through computer modeling, using an atmospheric dispersion model that predicts the impact of emissions from each source in the region on ambient air quality levels at the various receptor points. The model calculates the impacts on ambient air quality levels of the increase in emissions by the prospective purchaser and the decrease by the prospective seller, and determines whether these changes cause a violation of an ambient standard.

Our proposed trading scheme consists of six steps, which are illustrated in Figure 1. At Step 1, EPA, as the market supervisor, uses the computer model to verify that the initial allocation of permits did not result in the violation of any applicable ambient standards at any receptor point within the regulated region. This distribution of permits constitutes the ‘base case’ scenario. Thereafter, at Step 2, the website is ready to consider proposals for trades. We assume, as is currently the case in the sulfur dioxide emissions market, that brokers match prospective buyers

FIGURE 1 -- FLOWCHART OF PROPOSAL



with prospective sellers.

Under a simple emissions trading regime, once the buyer and seller agree on a price and quantity, the transaction is finalized, and the exchange of permits is registered with the government or other market supervisor. In contrast, under our proposal, the trade is approved and registered only if the computer model predicts no violations of the applicable ambient standards at any receptor point.

The market supervisor facilitates this process by granting brokers (or the market participants themselves) access to its computer model over the internet. This verification takes place in Step 3 of Figure 1. In particular, the website allows the broker to enter the sources' identities, the quantity of permits that would change hands, and the characteristics of the sources that have an impact on ambient air quality levels at any points (such as location, stack height, stack diameter, and speed and temperature of emissions).

The website program then prepares a trial run. As Step 4 in Figure 1 indicates, for purposes of the trial run, the website modifies temporarily the saved input data by increasing the buyer's emissions, and decreasing the seller's emissions, to reflect the proposed trade.

In Step 5, the website uses the computer modeling program to predict how pollution will disperse, given the temporarily modified input data. It thereby determines whether the proposed trade will result in the violation of an ambient standard at any receptor point.

If the model indicates that the proposed trade will not result in a violation of any applicable pollution standard at any receptor point, then – as Step 6N indicates – the trade is approved and registered. The buyer pays the seller for the permits, and the permits change hands. Following approval of a trade, the website automatically updates the input data to incorporate the buyer's and seller's new emissions profiles. Thus, at the time that other prospective buyers and sellers approach the website with proposals for trades, the website's input data will reflect all the previously approved trades.

In contrast, if the computer simulation reveals that the proposed trade will result in a violation of an ambient standard at any receptor point, then – as Step 6Y indicates – the trade is not allowed to go forward. In the case of disapproved trades, the website does not update its input data. After the website finishes with Step 6, either by approving the trade in Step 6N or rejecting it in Step 6Y, the website returns to Step 2. There, it awaits the next proposal for a trade.

B. Comparison of the Alternative Trading Regimes

We turn now to a comparison of our proposal for a constrained single-zone emission regime with other pollution trading regimes. We perform this analysis by reference to four criteria: the likelihood that the trading will result in the attainment of the applicable ambient standards; the thickness of the markets; the transaction costs of market supervision and participation; and the treatment of slack. Table 1 presents our conclusions with respect to each of the criteria.

TABLE 1 – Characteristics of Tradable Pollution Permit Regime Design Structures

	Traditional Single-Zone Markets	Multiple Zone Markets	Environmental Degradation Markets	Offset Markets	Ambient-Restricted Single-Zone Markets
Likely Attainability of Ambient Standards	Poor	Fair	Very Good	Very Good	Very Good
Thickness of Markets	Very Good	Poor	Fair	Good	Good
Ease of Implementation and Participation	Very Good	Fair	Poor	Poor	Good
Treatment of Slack	Very Good	Very Good	Fair	Poor	Very Good

1. Attainability of the Ambient Standards

Only three of the five trading regimes that we analyze – environmental degradation markets, offset market, and our proposal for constrained single-zone markets – provide for the attainment of ambient standards. As we have explained, of the remaining two regimes, multiple-zone markets perform somewhat better from this perspective than single-zone markets, but fall short of meeting the goal.

Even single- and multiple-zone markets can lead to the attainment of ambient standards if they are coupled with a second regulatory tier. This tier would impose use restrictions on certain permits in order to attain ambient standards. We believe that our approach is preferable, in that it provides a tangible means by which a prospective purchaser can ascertain, in advance of the purchase, whether the permits that it seeks would in fact allow it to increase its emission. In contrast, under a system of use restrictions, there is not a clear way of determining when an ambient violation takes place. Presumably such a violation would come to the attention of a regulator only after the violation had already occurred. Moreover, to the extent that more than one source contributes to the degradation of ambient air quality at the point of the violation, it is not clear how the use restrictions would be apportioned among the various contributing sources. A determination of this type would need to be made through some kind of administrative procedure, adding further delay to the resolution of the problem.

In contrast, our approach is quite specific as to what trades can and cannot go forward. Thus, it lowers the transaction costs and provides better assurances that the ambient standards will, in fact, be met.

2. Thickness of Markets

Thin markets can interfere with the goal of reducing pollution in a cost-effective manner. They can produce situations in which either buyers or sellers have market power and in which, as a result, trades do not take place at competitive prices. Multiple-zone emission markets fare most poorly in this regard because they permit trading only between buyers and sellers in the same zone, rather than among all the sources in the region.

Environmental degradation markets may fare somewhat less poorly. The market at each receptor point is open only to participants who affect ambient air quality level at that point. Unlike the zoned-market scheme, eligibility for trading on a market is determined not by location of the source, but by the location of the receptor points at which the source's emissions cause damage. Sources, however, typically trade in multiple markets, potentially ameliorating the problem of thin markets.

Pollution offset markets also permit only less-than-universal trading. Like environmental degradation markets, they preclude trades that would produce ambient violations at a particular point. Unlike environmental degradation markets, however, they allow trades between parties that do not affect ambient levels at the same point. Thus, the resulting markets are somewhat thicker.

From the perspective of market thickness, our proposal for constrained single-zone markets has comparable properties to pollution offset markets. It leads to somewhat thicker markets however, because any increase in emissions requires resort to the market, whereas under pollution offset markets, increases that do not produce any ambient violations can be appropriated as slack. Only a single-zone market with no trading constraints produces thicker markets.

3. Transaction Costs

Transaction costs, whether borne by the government as market organizers or by the trading parties, impede the effectiveness of market systems, both by consuming resources that could otherwise be used in more productive endeavors and by preventing trades that otherwise would be socially beneficial. Single-zone markets give rise to the lowest transaction costs because they require the establishment of, and participation in, a single market, and impose no trading constraints. The government needs only to keep track of who holds which permits at what times.

Environmental degradation market systems and offset markets have comparatively high transaction costs. The former requires the government to establish a market at each receptor point, and requires each source to purchase permits at each receptor point at which it has an adverse impact on ambient concentrations. The latter require the government and market participants to keep track of what rights are associated with each permit at all times. Moreover, the proposals for such trading schemes do not contain a low-cost mechanism for determining the appropriate trading ratios.

A multiple-zone market scheme does only slightly better. It too involves the establishment of multiple markets. It also imposes on the government the burden of determining how to allocate permits among the various zones. On the other hand, each source needs to buy permits in only one market.

The constrained trading regime that we propose adds some complexity to the standard single-zone market. We believe, however, that the website containing the atmospheric dispersion model provides a fast and straightforward way to determine whether ambient standards would be violated, thereby imposing relatively low transaction costs on the government and market participants.

4. Slack

Market-based schemes that contain slack give rise to conceptual and administrative problems. If slack is offered on a “first-come, first-served” basis, it results in inefficient expenditures by sources to capture the slack as well as in inefficient allocations of the slack among the sources. The government must also keep track of which sources have obtained the right to utilize slack. If the government allocates the slack in some other way, for example, by periodic auctions, it faces complicated design problems in determining at what rate and in what manner to make the slack available to the market.

As we discuss above, slack is endemic to pollution offset schemes and has received the attention of academic commentators. Slack is also a problem for environmental degradation markets, though the literature has not addressed the issue. Environmental degradation markets exhibit slack if the government's goal is to meet an ambient standard where some areas had ambient quality levels that are better than this standard. Then, a source could increase its emissions without purchasing any permits if this increase did not lead to the violation of an ambient standard at any receptor point.

In contrast, single-zone markets, multiple-zone markets, and the constrained single-zone markets that we propose do not have slack problems. Any source that wishes to increase its emissions needs to buy permits from another source.

In sum, our proposal performs well across the relevant criteria. It dominates multiple-zone markets, environmental degradation markets, and offset markets, doing better along some dimensions but no worse along any dimension. Our proposal does not perform as well as single-zone markets with respect to two of the criteria: thickness of markets and transaction costs. If one attaches sufficient importance to the attainment of ambient standards, however, our proposal is preferable.

C. Likely Impacts of the Proposal

This Section analyzes some likely features of the market for permits under our proposal to require website approval as a precondition to a valid trade. We focus on the impact of our proposal on the order of trades, the ability of particular prospective buyers and sellers in fact to engage in trades, and the price of permits.

1. Importance of the Order of Trades

The order in which trades occur may have an impact on what trades will be permitted thereafter. Recall that the website modifies its saved input data when – and only when – a trade is approved and registered. Although the website would modify temporarily the saved data to reflect a proposed trade for purposes of a trial run, that modification would become permanent only if the trade ultimately were approved; if not, the saved input data would remain unchanged.

This structure has ramifications for prospective market participants. For example, it is possible that multiple pairs of buyers and sellers may contemplate trades at substantially the same time. Even if each of the trades would be accepted if it were the first to be presented to the website for approval, some trades might not be acceptable if presented later, after other trades have been registered. Conversely, a prior trade may render viable a subsequent trade that otherwise would have been impermissible.

The following example illustrates this feature. Let us say that *A* is contemplating purchasing 10 permits from *B*, and at the same time that *C* is contemplating purchasing 100 permits from *D*. Assume that emissions from *A* and *C* contribute substantially to high pollution levels – though not in excess of any applicable standards – at a receptor point . In the case of a local pollutant, this effect could be attributable to the proximity of the sources, whereas in the case of a regional pollutant it might be caused by their relative stack heights and the prevailing wind patterns at and around their respective locations. Assume further that, given the existing distribution of permits, the website would approve either trade – separate trial runs of the computer model would reveal no violation of any applicable ambient standard.

Let us say that *A* and *B* carry out their trade before *C* and *D* do so. The shift of 10 permits from *A* to *B* is approved, and the website modifies – now permanently – its saved input data to reflect the transaction.

C and *D* now seek approval for their trade. Assume that the additional 10 permits purchased by *A* have increased the ambient concentration at receptor point □ enough that the acquisition of another 100 permits by *C* would produce a violation of the ambient standard. In that case, the website would disapprove the proposed transaction between *C* and *D*, even though it would have approved this trade before *A*'s transaction with *B*. Similarly, had *C* and *D* carried out their transaction first, *A*'s transaction with *B* would have been precluded.

2. Ability of Particular Buyers and Sellers to Engage in Trades

The constrained emissions trading regime that we propose potentially precludes certain sellers from selling permits to certain buyers. We discuss in this Section a common pattern of constraints on the permissibility of trades.

We consider a situation in which emissions from a group of sources cause harm at the same location. This location has the worst ambient air quality levels of the region throughout which trading is allowed and the ambient standard constrains further degradation. As already indicated, in the case of a local pollutant this location would be in the vicinity of the sources, whereas in the case of a regional pollutant it could be hundreds of miles away.

Our proposed trading regime generally would allow sources in this group to trade permits with one another. In such cases, the increase in the purchaser's emissions would be counteracted by a decrease in the seller's emissions. If the emissions of the two parties have similar impacts on ambient air quality at the point at which the standard is constraining, the transaction should not lead to the violation of these standards.

Similarly, our trading regime would generally allow sales from the concentrated group of polluters to sources elsewhere in the region. Such transactions would ease the pressure on ambient air quality levels at the location with the highest concentrations. A comparable increase in ambient concentrations at locations with better air quality would not be problematic.

In contrast, our trading regime would not allow sources in the concentrated group to purchase permits from outside the group. Increased net emissions from within the group would lead to the violation of the ambient standards. Thus, sources in this group can generally trade permits with one another, can sell permits to sources outside the group, but cannot purchase permits from sources outside the group.

This discussion highlights an important difference between our constrained single-zone trading regime and a multiple-zone regime. Under the latter, a group of sources located close together would presumably be placed in the same zone in which trading among the sources was authorized, and trading with sources outside the zone would be prohibited. Our scheme preserves the ability of sources within the group to trade with one another. But unlike the case of multiple-zone markets, it also allows sources in this group to sell to sources at other locations, thus reducing the barriers on permissible transactions.

3. Price of Permits

The preceding discussion shows how our proposal would inhibit the ability of certain polluters to sell permits to certain buyers. This feature implies that, at any given time, permits in the market might sell at different prices.

The price of permits, like prices of all goods, is determined by their supply and demand. If a potential purchaser affects ambient air quality levels at a receptor at which the ambient standard is constraining, the universe of potential sellers will be reduced. In particular, the potential purchaser will not be able to buy permits from sources that do not have an impact at the same location, or from sources for which the impact of a unit of emissions at the constraining location is smaller.

This reduced supply potentially leads to an increase in the price of the permits that the prospective purchaser can acquire. In particular, sellers that might have been able to supply permits at relatively low prices would not be permitted to participate in certain transactions.

In contrast, a potential purchaser that affects ambient levels in areas in which the quality is better than the ambient standard would not face similar constraints. Its market for permits would not be similarly truncated. The larger supply of potential sellers would reduce the market price.

One feature of our regime is that it would provide disincentives for new sources to locate in areas that contribute to ambient air quality levels at receptors in which the ambient standards are constraining – or, by extension, where these standards are close to being constraining. The higher market price for permits at such locations should encourage new sources to locate elsewhere. We regard this feature of our regime to be highly desirable.

V. Refinements of the Proposal

In this Part, we analyze several possible refinements to our proposed trading regime. The first two relate to the choice of and use of the air pollution dispersion model. Then, we consider the purchase of allowances by new sources and the possibility of having different ambient standards at different locations. The remaining refinements concern ways to incorporate into our proposal certain practices of existing trading regimes, such as auctions of allowances, retirement of allowances, purchases of allowances for investment purposes, and banking of allowances. All of these extensions could easily be incorporated into our simulation.

A. The Choice and Use of the Air Pollution Dispersion Model

1. Choice of Model

One objection that might be leveled against our proposal concerns the reliability of the air pollution dispersion model used to determine violations with the ambient standards. Such models are useful devices to predict what should happen to air pollutants based upon physical formulae and prior empirical data. It is possible, however, that a model does not accurately capture all the intricacies of weather patterns, topography, and chemistry that determine air pollution dispersion. Further, even if a model is otherwise designed accurately to predict air dispersion, the model's predictions will be only as good as the empirical data that are used as inputs.

Our proposal, however, does not rely on models and input data any more than existing EPA programs and regulations do. For example, the Clean Air Act requires states to develop SIPs indicating how they will control their existing sources in order to meet the NAAQS. EPA mandates that states use atmospheric modeling to demonstrate that their SIPs will lead to the attainment of the NAAQS. The

Act also requires that SIPs include a means of evaluating modifications of existing sources and constructions of new sources to ensure that such changes do not interfere with the attainment of the ambient standards. Atmospheric models must be used to make these determinations. EPA maintains a list of approved atmospheric dispersion models. For our simulation, we used one of the models that EPA recommends, the ISC3 Model, which is the "work-horse" for EPA's compliance determinations. Thus, to the extent that the ISC3 Model might lead to imprecise predictions, its use under our trading scheme would not lead to more inaccurate results than those generated under the current regime.

We recognize, however, that, as technology and science's understanding of the physics of air and weather patterns and the chemistry of air pollutants advance, more accurate atmospheric models will emerge. For example, two newer models were presented at a recent EPA conference on air quality modeling – AERMOD and CALPUFF. AERMOD, another Gaussian dispersion model, is more advanced than ISC3. Accordingly, EPA has proposed that AERMOD replace the ISC3 Model "for many air quality impact assessments."[54] Moreover, EPA is proposing to recommend the use of CALPUFF "for refined use in modeling long-range transport and dispersion to characterize reasonably attributable impacts from one or a few sources for [prevention of significant deterioration] Class I impacts."[55]

Another atmospheric dispersion model that might one day be incorporated into our trading proposal is the Regional Air Pollution Information and Simulation (RAINS) model. RAINS was developed by the Austrian-based International Institute for Applied Systems Analysis to evaluate problems of transboundary transport of air pollutants in Europe, and has been relied upon in treaty negotiations.[56] In particular, RAINS has been used to match areas that contribute sulfur emissions with the areas and ecosystems that are harmed by those emissions, and to determine what emission reductions would be required from what regions to protect adequately the downwind areas and ecosystems.

The use of the ISC3 Model is not essential to our proposal. The website could be programmed to rely upon any atmospheric dispersion model to make predictions as to ambient pollutant concentrations at the receptor points. Thus, there is nothing in our proposal that would preclude the integration of AERMOD, CALPUFF, or RAINS (or of any more advanced, and more accurate, atmospheric dispersion model) in place of the ISC3 Model when EPA determines that other models are indeed preferable.

2. Refining the Use of the Model

In our simulation, we placed receptors homogeneously throughout the regulated region. Because our regime bars a trade only if it would result in the violation of an ambient standard at a receptor point, a trade might result in a violation at a location between receptor points but nonetheless be approved. While current models do not allow for the calculation of expected pollutant concentrations at all points within a region, which would involve the inclusion of an infinite number of receptor points, three modifications to our trading regime would ameliorate this potential problem.

---

[54] 65 Fed. Reg. at 21,507.

[55] 65 Fed. Reg. at 21,508.

[56] See Cleaner Air for a Cleaner Future: Controlling Transboundary Air Pollution <http://www.iiasa.ac.at/Admin/INF/OPT/Summer98/feature.htm> (visited July 21, 2000).

One possibility is simply to place more receptors. For example, the ISC3 Model, as run on a DOS system, allows for the placement of up to 500 receptors and up to five receptor networks. Moreover, those numbers can be increased, depending upon the available memory capacity. Additional receptor points, however, may slow down the computations. Thus, there may be a tradeoff between more accurate predictions and predictions that are sufficiently fast to satisfy the market participants.

Second, receptors should be placed where violations of ambient standards are most likely to occur. For example, if measurements of air quality indicate that pollutant concentrations are especially high in a given area, the computer program should include additional receptors in that area. Similarly, additional receptors should be included on the windward side of a mountain range because substantial amounts of pollution may be trapped on the side of the range.

A third course of action would be to program the website automatically to include additional receptors in the immediate vicinity of an existing receptor if the model predicts that the ambient pollutant concentration at this receptor comes within a certain range of the applicable ambient standard. For example, if a standard run of the model for sulfur dioxide concentrations reveals that the predicted annual average ambient concentration at a given receptor will be 79 :g/m^3 – within 1 :g/m^3 of the applicable NAAQS – the website program could add, say, 20 additional receptors, at a relatively small radius around the existing receptor.

B. New Sources

The simulation in Part IV dealt only with transfers of allowances among existing sources. The treatment of purchases of allowances by new sources would proceed no differently. The website would obtain the location of the new source and temporarily update its emission data to consider whether the proposed emissions increase at that location, combined with the decrease of emissions at the seller's location, would contribute to the violation of an ambient standard. If the proposed transfer would produce a violation, the website would reject it. If not, the website would approve the transfer and save permanently the new emissions data.

C. Variable Ambient Standards

The simulation in Part IV also assumed, for expositional convenience, that uniform ambient standards would apply throughout the region. Despite the uniformity of the NAAQS, the Clean Air Act in fact imposes disuniform ambient standards throughout the country. In areas that have ambient air quality levels that are better than the NAAQS, the Prevention of Significant Deterioration (PSD) program imposes a more stringent ambient standard, defined by reference to a baseline plus an increment. In contrast, areas that have failed to comply with the NAAQS – the nonattainment areas – are subject to a less stringent requirement. Until some time in the future, such areas must make "reasonable further progress" toward attainment, rather than actually achieve attainment.[57]

The website could easily be programmed to apply different ambient pollution concentration constraints at different locations. For example, the website might reject trades that would result in annual average ambient concentrations of sulfur dioxide in excess of 80 :g/m^3 at some locations, but in excess of 60 :g/m^3 at other locations. The website could also be programmed to reject trades that would result in any increases in ambient concentration levels at certain receptor points.

---

[57] See 42 U.S.C. § 7502(c)(2); see also 42 U.S.C. §§ 7501(1) (1994) (defining "reasonable further progress").

D. Current Market Practices

We focus here on how our proposal would deal with various practices under the national sulfur dioxide trading program: auctions of allowances, retirement of allowances, purchases of allowances for investment purposes, and banking of allowances.

1. Auctions of Allowances

As we explained above, the sulfur dioxide program provides for an annual auction of allowances, in addition to the grandfathering of existing sources. The Chicago Board of Trade, operating on EPA's behalf, currently conducts the sulfur dioxide allowance auction. Interested parties submit bids indicating the number of allowances they seek to purchase and the price they are willing to pay. The Chicago Board of Trade determines the price that would lead to the sale of all the available allowances. All bids at or above that price are then accepted, with each successful bidder paying the amount it bid.

Consistent with the logic of our proposed trading regime, before accepting a bid the Chicago Board of Trade could verify that the transfer of the allowance to the successful bidder would not result in the violation of an ambient standard at any receptor point. In light of the current auction structure, it would make sense for bidders placing higher bids to receive priority in determining whether the bidder's purchase would result in an ambient standard violation. In other words, to the extent that two bidders' purchases taken together would result in an ambient standard violation but individually would not, the system would approve the higher bidder's bid and reject the lower bid.

Our approach would have the effect of lowering somewhat the total revenues from the auction. Indeed, because certain high bidders might not be able to purchase permits as a result, the Chicago Board of Trade would need to turn to lower bidders.

2. Retirement of Allowances

Environmentalists and environmental groups sometimes purchase allowances for the purpose of retiring them so as to reduce the total amount of pollution. Our proposal readily accommodates such transactions. The purchaser simply would indicate that it sought to retire them. The website would then decrease the seller's emissions accordingly, but there would be no corresponding increase in emissions at another location. As a result, the website would never prohibit a retirement transaction.

3. Purchases of Allowances for Investment Purposes

Investors might be interested in purchasing pollution allowances for investment purposes, intending to hold them until they can be sold at a profit. Also, brokers may purchase allowances to act as 'market-makers,' without intending to use the allowances or resell them immediately. As in the case of retirement transactions, the website would credit an emission reduction but not add a corresponding increase in emissions. Again, no such transaction would ever be rejected.

When the holder was ready to sell the allowances, however, it would have to receive permission from the website to proceed with the sale. As in the case of all other transactions, the website would determine whether the increase in emissions would result in violations of ambient standards. Unlike the case of transactions between contemporaneous emitters, there would be no corresponding decrease in emissions, because this decrease would already have been taken into account at the time the investor purchased the allowances.

Our proposal would complicate matters for allowance purchasers with investment motives. Prospective investors would have to take account of the possibility that allowances that they purchase now may be saleable only to a limited pool of buyers at some point in the future. In that case, the allowances would command a lower price than in a system of unconstrained trading – although, for the same reason, the investor may have bought them at a lower price as well. Moreover, investors might feel pressure to sell allowances earlier out of fear that a delay might preclude (or make less attractive) sales later. At the same time, however, if an investor finds that it cannot sell the allowances at an acceptable price because of a limited pool of buyers, it would have the option of holding them until a later date.

4. Banking of Allowances

Some entities obtain allowances with the intent of using them only in the future. Our proposed trading regime is compatible with such banking of allowances. It simply would require that the website maintain emission input data for multiple years into the future.

A source seeking to bank an allowance for future use would notify the website of the year in which it intended to use the allowance. The website first would test whether the proposed use of the allowance in the future year would result in the violation of an ambient standard in that year, given the existing emission input data for that year, as augmented by the proposed additional emissions. If the model predicted that an ambient standard would be violated, it would reject the proposed banking. If not, the transaction would be approved and the website would update the emissions profile for the future year. It would also modify the emissions date for the current year to reflect the resulting decrease in emissions.

We acknowledge that our trading regime would impose some limits on the ability of sources to bank their emissions. Moreover, sources would have an incentive to declare their intent to bank sooner, before too many other sources had done so. Such constraints, however, are necessary to ensure the attainment of the applicable ambient standards.

Conclusion

This Article highlights how traditional tradable pollution permit regimes fail to guard against the violation of ambient standards and the formation of hot spots. The existing regulatory programs that provide for such market transactions all exhibit these problems. Similarly, three alternative design structures advocated by commentators either provide incomplete solutions or give rise to other potentially serious shortcomings.

We propose a new trading regime that might increase the attractiveness of market-based schemes. Under this regime, the government maintains a website containing current emissions data for all the sources of a regulated pollutant. Using an atmospheric dispersion model, the website determines whether a proposed trade leads to a violation of an applicable ambient standard (or the formation of a hot spot), and disapproves trades causing such violations. We demonstrate, by means of a computer simulation, how our trading regime would function, and explain why it performs better than the existing alternatives.