CBO PAPER

FACTORS AFFECTING
THE RELATIVE SUCCESS OF EPA'S
NO_x CAP-AND-TRADE PROGRAM

June 1998

CONGRESSIONAL BUDGET OFFICE
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WASHINGTON, D.C. 20515

PREFACE

The Environmental Protection Agency (EPA) has proposed a rule for limiting emissions of nitrogen oxides (NO_x) in 22 eastern states and the District of Columbia. That rule includes a voluntary program for trading emission allowances among certain NO_x sources in those jurisdictions. EPA estimates that a trading program will save the electric power industry about $800 million a year compared with a more traditional approach that imposes a specific limit on emissions from each source. At the request of the Ranking Minority Member of the House Committee on Commerce, the Congressional Budget Office (CBO) has examined the factors that could affect the relative success of the NO_x trading program in achieving those savings.

Terry Dinan and Natalie Tawil of CBO's Natural Resources and Commerce Division wrote the paper under the supervision of Jan Paul Acton and Roger Hitchner. CBO analysts Kim Cawley, Pam Greene, and Diane Rogers made valuable comments. In addition, several staff members of EPA's Office of Air Quality Planning and Standards provided useful information.

Sherry Snyder and Christian Spoor edited the manuscript, and Melissa Burman proofread it. Rae Wiseman prepared the paper for publication. Laurie Brown and Martina Wojak-Piotrow prepared the electronic version for CBO's World Wide Web site (www.cbo.gov).

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June 1998

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SUMMARY

The Environmental Protection Agency (EPA) has proposed a rule that requires 22 eastern states and the District of Columbia to reduce their emissions of nitrogen oxides (NO_x), the principal component of smog. The aim of that rule—sometimes referred to as the Ozone Transport Rule—is to help areas meet the Clean Air Act's National Ambient Air Quality Standard for ground-level ozone in a cost-effective way. Wind patterns frequently carry ozone and its precursor chemicals (including NO_x) long distances, a process called ozone transport. Thus, reductions in NO_x emissions throughout the multistate region could help reduce ozone concentrations in many counties and metropolitan areas that violate the standard.

EPA estimates that the proposed Ozone Transport Rule will cost sources of NO_x emissions approximately $1.8 billion a year. The electric power industry is expected to bear 75 percent of that cost and other stationary sources the remaining 25 percent. The estimated cost to the electric power industry assumes that the required cuts in NO_x emissions are made through a regionwide program in which states distribute emission allowances to sources of NO_x emissions, and those sources can buy, sell, or trade the allowances among themselves. The total number of allowances is subject to a limit, or cap. States decide whether to participate in the program and also select the NO_x sources they want to include in it.

THE NO_X PROGRAM AND EPA'S ESTIMATE OF ITS COST

Under the cap-and-trade program envisioned by EPA, each participating state would allocate a pool of emission allowances among the sources that it deemed eligible. One allowance would permit the release of one ton of NO_x. Other than shutting down or decreasing their production, individual sources would then have two options for complying with the level of emissions that their allowances represented: they could install pollution-control technology to reduce their emissions and then sell their unneeded allowances to other sources in the region; or they could forgo investing in such technology and buy emission allowances from sources that choose the first option.

EPA does not have the authority to establish a federal emission trading program for NO_x under the Clean Air Act. Instead, individual states that choose to participate in the regional trading program will be responsible for establishing a framework for the program in their jurisdiction. To facilitate trading throughout the region, state programs will have to be consistent in such critical elements as their requirements for monitoring and reporting NO_x emissions.

The cap-and-trade program can potentially reduce NO_x emissions at a lower total cost than a "command-and-control" approach, in which each source is required to make a specific emission reduction. The reason is that trading encourages those sources with the lowest pollution-control costs to make the emission cuts. Under a mandated reduction, every source would have to reduce NO_x emissions to a comparable level, regardless of their cost of doing so.

EPA estimates that trading will reduce the electric power industry's cost of complying with the Ozone Transport Rule by 36 percent—or $800 million—compared with a command-and-control approach. That estimate is optimistic, however, because it assumes that the trading program will realize all possible cost savings. In reality, no trading program is likely to accomplish that, because markets rarely, if ever, function flawlessly.

FACTORS AFFECTING THE SUCCESS OF A NO_X CAP-AND-TRADE PROGRAM

Economists have encouraged the use of trading programs for three decades. Such programs have been employed to address a variety of environmental concerns and have had varying degrees of success. For example, the acid rain trading program, which began in 1995, was designed to cut utilities' emissions of sulfur dioxide (SO_2). Assessing the first year of that program, researchers estimate that participants failed to realize all of the possible cost savings. Compliance costs in 1995 were about 50 percent higher than they would have been if the allowance market had been functioning flawlessly.

The experience of the SO_2 and other trading programs indicates that several factors influence the extent to which participants are able to reduce their compliance costs. Those factors include a competitive market for allowances, minimal institutional constraints, low transaction costs, the allocation of at least some allowances through an auction, and the ability of participants to save up, or "bank," allowances for future use. The proposed NO_x trading program ranks favorably according to the first two criteria, but the other factors could pose problems.

A Competitive Market for Allowances

If an individual participant, or small group of participants, in a trading program has the potential to influence prices, the development of a competitive market can be jeopardized. That generally occurs when the number of buyers and sellers is small, or when a few participants control a large share of the market. Neither of those outcomes is likely in the NO_x trading program, however, assuming that states allocate emission allowances among sources in the way that EPA envisions.

EPA expects states to distribute allowances to individual electricity generators according to a measure related to the amount of electricity they produce from fossil fuels. The region covered by the Ozone Transport Rule contains 133 different utilities (based on ownership) that use nonrenewable energy sources. Even the largest of those utilities produces only a small share of the region's electricity generation; in fact, less than half the allowances allocated to utilities would be distributed among the 10 largest producers of electricity in the region. In addition, states would allocate allowances to some combustion devices (or units) that do not belong to utilities, further alleviating concerns about concentration in the allowance market.

Minimal Institutional Constraints

For the trading program to be successful, participating sources must act to lower their compliance costs. But state and federal regulations can reduce their incentives to do that. For example, the rules that govern state public utilities frequently allow utilities to depreciate investments in pollution-control technology at a rate that exceeds its physical rate of deterioration. Emission allowances, by contrast, do not qualify for depreciation. Thus, a utility may receive a higher rate of return from installing pollution-control equipment than from purchasing allowances, even though the allowances are cheaper. Other regulations and tax laws can also make more expensive compliance options look cheaper from the utility's point of view.

Recently, however, many states have begun deregulating the electricity-generating segment of the power industry. By encouraging competition in that sector, the movement toward deregulation will give utilities greater incentive to reduce their costs, including the cost of complying with limits on NO_x emissions.

Low Transaction Costs

Low transaction costs are an important characteristic of successful trading programs. Transaction costs include the cost of identifying potential trading partners and negotiating trades and the cost of obtaining any necessary regulatory approval for those trades. EPA expects that both types of transaction costs will be low for the NO_x program. First, the private sector can play an important role in reducing the cost of identifying partners and negotiating a trade—for example, by providing brokerage services, as it does in the market for SO_2 allowances. Second, the monitoring and reporting responsibilities that EPA expects states to include in their programs will minimize the need for regulatory oversight to ensure that trades involve legitimate allowances. Sources would measure their NO_x emissions using sophisticated monitoring systems (which the affected utilities already have in place) and would report the outcome to regulators at the end of each compliance period. The regulators

would then deduct the total number of tons emitted by each source from the allowances contained in its account. If the source's emissions exceeded the number of allowances in its account, regulators could impose penalties.

As noted above, however, EPA does not have federal authority to establish a NO_x trading program that would apply to all states affected by the Ozone Transport Rule. Thus, each jurisdiction covered by the rule that chooses to participate in the program will have to establish its own programmatic details. Small differences in language among state rules could lead to different interpretations, create uncertainty, and raise transactions costs. (Such consistency problems have already arisen in an ongoing attempt to establish a NO_x trading program for 12 northeastern states and the District of Columbia.) EPA hopes that a model trading rule it has proposed for state programs will encourage uniformity, but how effective that approach will be is not clear.

Allowance Auctions

Using a regional auction to allocate a share of the NO_x allowances may be helpful in establishing a competitive allowance market. Newly established markets sometimes have few transactions because participants do not have enough information about prices to determine their willingness to buy or sell. Auctions can provide price information that can stimulate direct trades between individual sources.

However, because the Clean Air Act does not give EPA the authority to compel states to participate in the trading program or to control the initial allocation of allowances, the agency cannot set aside a share of allowances for a regionwide auction. For their part, states are very unlikely to volunteer some of their allowances for a regional auction without a mechanism to guarantee that all states do so. If they did, they would be forfeiting their ability to provide those allowances at no cost to sources within their jurisdiction.

Flexibility in the Timing of Emission Reductions

Under the cap-and-trade program, sources could vary the timing of their emission reductions in two ways. The program might permit them to generate allowances by making early reductions (cutting emissions before the cap takes effect). It might also allow sources to bank allowances they do not use in a given compliance period once the cap is in place. In either case, sources could use the banked allowances to cover future NO_x emissions. That practice has several potential advantages.

Sources can help lower total compliance costs by generating allowances through early reductions, when the marginal cost of such reductions is lower, and

using them once the cap is in place, when the marginal cost is higher. In addition, early reductions can help sources plan for the relatively short transition to the NO_x cap. A given source might make cuts early at some units and delay them at others in order to have more time to explore its compliance options. That might allow sources to capitalize on cost-saving opportunities. Furthermore, early reductions in NO_x emissions could have health and environmental benefits.

Allowing banking once the cap is in place assures NO_x sources that their investments in pollution control will generate allowances that they can use or sell in the future. Banking can also protect utilities against variations in the availability of power-generating facilities and in the demand for electricity—both of which can lead to variations in their need for NO_x allowances. Finally, banking can protect against both a sharp change in allowance prices and a dramatic increase in emissions at the end of each year's compliance period.

Despite the potential advantages, allowing sources to vary the timing of their emission reductions does raise an important concern. If sources used a large number of banked allowances in a given year, the corresponding increase in NO_x emissions could have an important effect on whether areas met the ozone standard.

EPA has not yet proposed what—if any—form of banking it will include in its model trading rule. It is seeking comment on alternative banking options.

Conclusion

The presence of a competitive, unconcentrated market for emission allowances and the deregulation of part of the electric power industry should increase the likelihood that participants in the market for NO_x allowances will capitalize on their opportunities to make cost-saving trades. However, two other factors—the difficulty of ensuring low transaction costs and the absence of auctions to allocate some allowances—will decrease that likelihood. Both of those factors result because EPA must rely on states to set up comparable NO_x trading programs rather than establishing a uniform, regionwide program itself.

In addition, savings from the NO_x program will be limited if states or EPA restrict participants' ability to bank allowances out of concern that the practice could contribute to violations of the ozone standard. Preventing sources from banking allowances generated by early reductions could make it even more difficult for them to plan for the short transition to the NO_x cap. Finally, any of the 23 jurisdictions covered by the proposed Ozone Transport Rule could choose not to allow its sources to participate in the trading program. Such nonparticipation would further reduce savings.

CHAPTER I
THE PROPOSED NO_X CAP-AND-TRADE PROGRAM AND EPA'S ESTIMATE OF ITS COST

The Environmental Protection Agency (EPA) has proposed a rule that would require 22 eastern states and the District of Columbia to reduce their emissions of nitrogen oxides, or NO_x (see Figure 1). The proposed rule is based on EPA's conclusion that NO_x emissions from those jurisdictions contribute significantly to violations of the National Ambient Air Quality Standard for ozone in downwind areas.

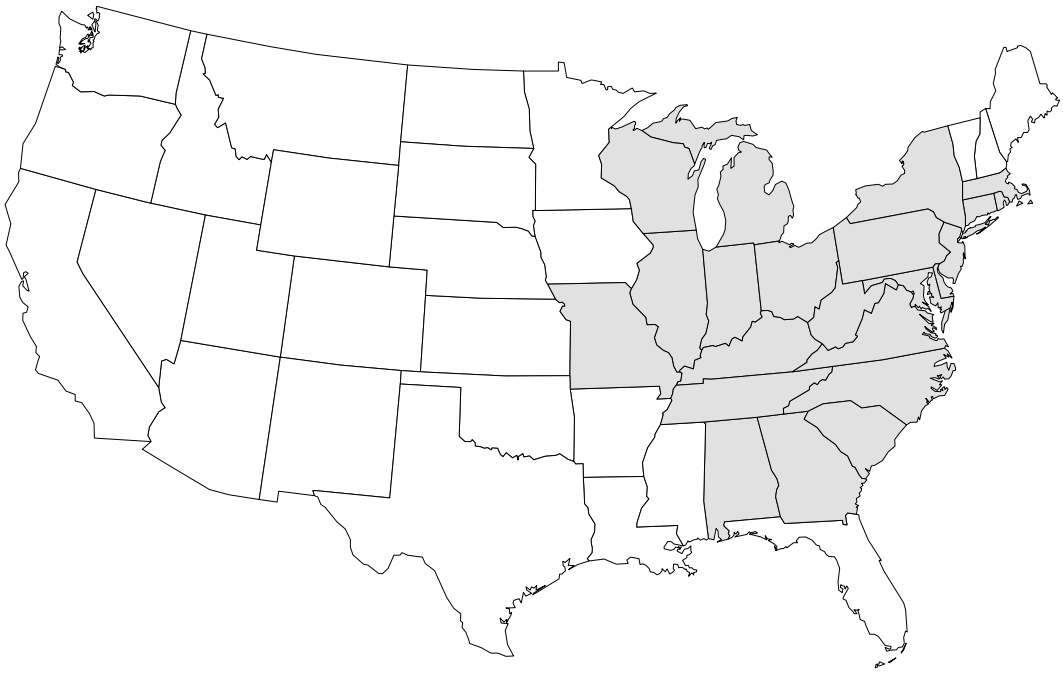
Ground-level ozone—the principal component of smog—results when NO_x and volatile organic compounds react chemically in the presence of sunlight. High ambient concentrations of ground-level ozone typically occur during the summer months: May 1 through September 30 is the ozone season. Wind patterns carry ozone and its chemical precursors long distances, particularly in the eastern United States. Thus, for many counties and metropolitan areas in that region, controlling emissions in their immediate vicinity may not be enough to attain the ozone standard. EPA's proposed rule requires states to cut their NO_x emissions as a means of achieving regionwide reductions.

Under the proposal, sometimes referred to as the Ozone Transport Rule, EPA would give each of the 23 jurisdictions a limit, or "budget," of permitted NO_x emissions. Within that overall budget, states could distribute tradable pollution rights, known as emission allowances, to eligible sources of NO_x pollution. Emissions from those sources would be limited, or "capped," to the amount determined by the sum of all states' allocations. Each participating source would then be able to trade, buy, or sell those emission allowances, depending on whether its emissions were above or below the level it was entitled to by its initial allocation of allowances.

Such a cap-and-trade program can lower the total cost of complying with the Ozone Transport Rule. The reason is that, under such a program, cuts in emissions can be made by the sources that can do so most cheaply. Those sources will have allowances left over after they reduce their emissions, and they can sell those allowances to sources that would find cutting their NO_x emissions more expensive.

EPA expects that the electric power industry will have to make most of the emission reductions under the Ozone Transport Rule. Thus, it will bear the highest compliance costs. Assuming that states allocate emission allowances in the manner it recommends, EPA estimates that a trading program will save the electric power industry $800 million compared with a rule that mandates a specific emission level for each source—a so-called command-and-control approach.

FIGURE 1. THE REGION AFFECTED BY EPA'S PROPOSED RULE FOR REDUCING NO_X EMISSIONS



SOURCE: Congressional Budget Office using information from the Environmental Protection Agency.

NOTE: NO_X = nitrogen oxides.

The Congressional Budget Office (CBO) has reviewed the proposed Ozone Transport Rule and assessed the likelihood that the trading program envisioned by EPA will actually save the electric power industry $800 million. This paper discusses that assessment. Drawing on the experience of previous trading programs, it also identifies factors that could influence whether a successful trading program for NO_x emissions will develop.

CURBING NO_X EMISSIONS

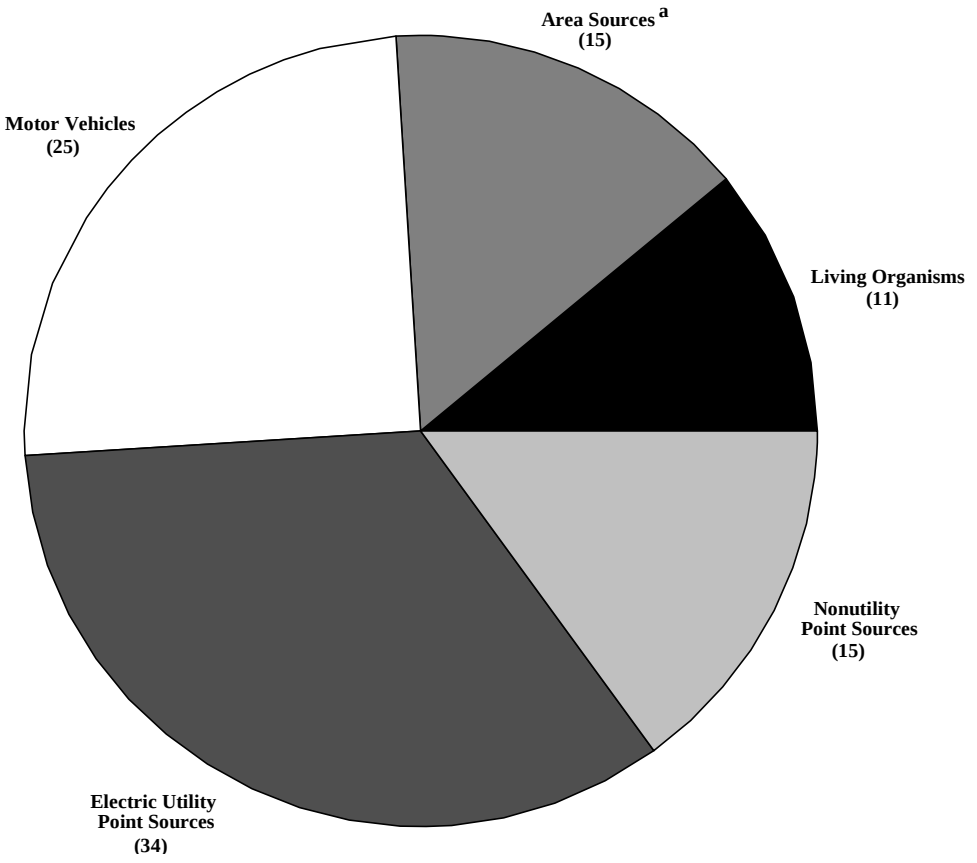
On an average summer day in the eastern United States, large stationary sources such as power plants and factories—called point sources—are responsible for about 49 percent of all NO_x emissions. Of those point sources, electric utilities release about 34 percent of average summer-day emissions, making them the largest single source of nitrogen oxides (see Figure 2). Nonutility point sources release about 15 percent. The emission sources that EPA expects states to include in the NO_x trading program are contained in those two categories.[1]

Motor vehicles are an important nonpoint source of NO_x, contributing about 25 percent of average summer-day emissions. The proposed Ozone Transport Rule requires states to follow the current and planned emission controls that other regulations have established for motor vehicles, but it does not incorporate additional restrictions on those emissions. EPA does not expect states to include motor vehicles in the trading program, because accurately monitoring and reporting NO_x emissions from mobile sources presents a host of practical challenges. Those challenges aside, however, if motor vehicles can reduce NO_x emissions more cost-effectively than some of the sources that are included in the program, then restricting their participation will reduce the potential savings from trading.

Area sources—including small stationary sources and engines not used for road transportation (such as engines in construction equipment)—discharge about 15 percent of average summer-day NO_x emissions. Living organisms account for the remaining 11 percent. Like mobile sources, EPA does not envision that states will include either of those categories in the trading program.

1. EPA projects that in 2007, emission sources included in trading will be responsible for 80 percent of NO_x emissions from point sources. See Environmental Protection Agency, *Model NO_x Cap and Trade Program, Second Draft Working Paper: Applicability and Monitoring*, December 7, 1997 (available at http://www.epa.gov/acidrain/modlrule/applic.html).

FIGURE 2. SOURCES OF NO_X EMISSIONS IN THE EASTERN UNITED STATES ON AN AVERAGE SUMMER DAY (In percent)



SOURCE: Congressional Budget Office based on Environmental Protection Agency, Ozone Transport Assessment Group, *Final Report* (1997), Chapter 3, Table 3-23 (available at http://www.epa.gov/ttn/otag/finalrpt/chp3/toc.htm).

NOTE: NO_x = nitrogen oxides.

a. Small stationary sources and engines not used for road transportation.

EPA's Ozone Transport Rule

In its Ozone Transport Rule, EPA is proposing a seasonal budget for total NO_x emissions for each of the 23 jurisdictions. The budget for each state is based on specific control measures that EPA considers cost-effective for that state. The proposed rule requires each state to submit a plan for meeting its NO_x budget, but it gives states leeway about how to reduce their emissions. Meeting those budgets would reduce total regional NO_x emissions during the ozone season by almost 1.6 million tons in 2007, EPA reports. As a result, emissions would be 35 percent lower than the level projected for 2007 if those jurisdictions simply complied with the Clean Air Act (CAA) and its amendments (see Table 1).[2]

EPA expects the electric power industry to reduce NO_x emissions during the ozone season by 1 million tons in 2007—a 64 percent decrease from the industry's projected emission levels for 2007 under existing CAA requirements.[3] The second largest source of cuts in emissions will be point sources that do not generate electricity. Those sources include businesses and other institutions that have industrial boilers, process heaters, stationary gas turbines, stationary internal combustion engines, or other industrial processes that emit nitrogen oxides. EPA assumes that such sources will reduce their emissions during the ozone season by 322,685 tons in 2007—a 45 percent decrease from their projected level for 2007 under current CAA requirements.

The NO_x Cap-and-Trade Program

EPA's estimate of the cost that the Ozone Transport Rule would impose on the electric power industry assumes that the industry achieves its emission reductions through a trading program that includes all 23 jurisdictions affected by the rule. EPA expects some point sources that do not generate electricity to participate in the program as well. However, the agency did not estimate the extent to which trading would reduce costs for those sources.

States will distribute allowances to eligible sources within their borders. They have some leeway in determining which sources are eligible, but EPA envisions that the trading program will include two types of sources that use fossil fuel: those

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2. Projected emission levels reflect measures that states have included in their state implementation plans for the CAA but have not yet put into effect.

3. Note that for electricity generators, the emission rate assumed by EPA in the proposed rule (0.15 pounds of NO_x per million British thermal units) represents an 85 percent reduction from the emission rate in 1990. See Environmental Protection Agency, *Fact Sheet: Proposed Rule for Reducing Regional Transport of Ground-Level Ozone (Smog)*, October 11, 1997 (available at http://www.epa.gov/ttn/oarpg/otag/otagfs.html).

TABLE 1. PROPOSED SEASONAL BUDGETS OF NO_X EMISSIONS FOR STATES COVERED BY THE OZONE TRANSPORT RULE

	No_x Emissions in 2007 (Tons)		
	Under the Clean Air Act (Projected)[a]	Under the Ozone Transport Rule (Proposed)	Percentage Reduction Under the Ozone Transport Rule
Alabama	241,564	155,617	36
Connecticut	52,014	39,909	23
Delaware	30,568	21,010	31
District of Columbia	7,978	7,000	12
Georgia	246,243	159,013	35
Illinois	350,154	218,679	38
Indiana	340,084	200,345	41
Kentucky	263,855	158,360	40
Maryland	118,065	73,628	39
Massachusetts	103,445	73,575	29
Michigan	283,821	199,238	30
Missouri	185,104	116,246	38
New Jersey	132,032	93,464	29
New York	230,310	185,537	19
North Carolina	234,300	153,106	35
Ohio	391,012	236,443	40
Pennsylvania	328,433	207,250	37
Rhode Island	12,175	10,132	17
South Carolina	169,572	109,267	36
Tennessee	291,225	187,250	36
Virginia	219,835	162,375	26
West Virginia	158,240	81,701	48
Wisconsin	142,759	95,902	33
Total	4,532,790	2,945,046	35

SOURCE: Congressional Budget Office based on Environmental Protection Agency, *Supplemental Notice for the Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for the Purposes of Reducing Regional Transport of Ozone* (April 28, 1998), Table III-7 (available at http://www.epa.gov/ttn/oarpg/otagsip.html).

NOTE: NO_x = nitrogen oxides.

a. Based on the measures included in states' implementation plans for the Clean Air Act and its amendments.

that serve an electricity generator and have a capacity greater than 25 megawatts, and those that do not generate electricity and have a capacity greater than 250 million British thermal units (mmBtu) per hour.[4] Each allowance will entitle the source holding it to emit one ton of NO_x during the ozone season.

Sources will be free to trade, buy, or sell allowances among themselves throughout the region. Trading provides an economic incentive for sources that can reduce NO_x emissions at low cost to exceed their required reduction and sell their excess allowances. Those sources can make a profit as long as their cost of "producing" the excess allowances (that is, reducing their emissions by more than the required amount) is less than the price at which they can sell them. Conversely, sources that have high abatement costs for NO_x have an economic incentive to buy allowances: it is cheaper for them to do so than to reduce their emissions.

How would trading work for sources in the electric power industry? EPA assumes that states will give enough allowances to each eligible combustion device (or unit) in the electric power industry to let it release NO_x at a rate of 0.15 pounds per million British thermal units.[5] Each unit can meet the limit in one of two ways: by reducing its emissions to that level, or by obtaining allowances from other units that reduce their emissions below that level and thus generate excess allowances. Electricity generators may transfer allowances among units they own. Alternatively, they can buy them from, or sell them to, other participants in the trading program.

The total cost of reducing emissions (that is, of achieving the NO_x cap) is minimized when the cost of further reductions—referred to as the marginal cost—is the same for all units. In that case, no further cost-saving trades can be made. The more the marginal cost of cutting emissions varies among sources, the more trading is necessary to lower the cost of achieving the cap. For example, the cost of reducing NO_x emissions varies among units in the electric power industry depending on characteristics such as age and size. Based on its analysis of the Ozone Transport Rule as proposed in October 1997, EPA estimates that 47 percent of the coal-fired electricity-generating capacity in the region would have to obtain additional

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4. See Environmental Protection Agency, *Supplemental Notice for the Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone,* April 28, 1998 (available at http://www.epa.gov/ttn/oarpg/otagsip.html). In calculating the state-specific emission budgets, EPA based them on a 0.15 lb/mmBtu emission rate for electricity generators and a 70 percent reduction in emissions from uncontrolled levels for other large stationary sources. Unless otherwise stated, CBO assumes that states allocate emission allowances to existing sources using the same formula that EPA used in setting the state-specific emission budgets.

5. EPA assumes that an emissions cap is set for the electric power industry during the summer months based on projections of expected emissions in 2007 given an emission rate of 0.15 lb/mmBtu. Btu is a measure related to the fuel input used by a facility. Based on EPA's assumptions, the industry would be allowed 564,784 tons of NO_x emissions. The actual level of the cap would vary based on the number of non-electricity-generating sources that were included and states' decisions about which sources could participate. The proposed rule requires that sources meet the cap by 2003.

allowances to meet an emission rate of 0.15 lb/mmBtu.[6] EPA's estimate of the cost to the industry from the Ozone Transport Rule therefore requires an active, competitive market for trading emission allowances.

Because the Clean Air Act does not give EPA the authority to establish a federal trading program for NO_x emissions, each state will need to establish its own program. To facilitate trading throughout the region, those programs will have to be consistent in such critical elements as requirements for monitoring and reporting NO_x emissions. With input from the affected states, EPA is developing a model trading rule that states can use in developing their programs. EPA hopes that the model rule will create enough uniformity among state programs for the regionwide trading program to succeed. How effective that approach will be is not yet clear.

EPA'S ESTIMATE OF SAVINGS UNDER THE NO_X TRADING PROGRAM

EPA proposed the Ozone Transport Rule in October 1997 and estimated that it would cost the electric power industry $1.7 billion a year. The agency compared that estimate with the $2.2 billion annual cost that it believes a command-and-control approach would impose on the industry. Under a command-and-control approach, all electricity-generating units would be required to meet an emission limit of 0.15 lb/mmBtu during the ozone season. The industry's total NO_x emissions would be the same as under a trading approach, but individual units would not have the option of trading emission allowances.[7] Based on the assumptions and data used in EPA's original Ozone Transport Rule, the agency expected a NO_x trading program to reduce the costs imposed on the electric power industry by $500 million, or 23 percent.

On April 28, 1998, EPA published a supplemental notice that modified the proposed rule and also revised the estimate of annual costs downward—to $1.4 billion. The lower estimate reflects the addition of lower-emitting NO_x sources expected to be built in the future (which had been inadvertantly omitted from the October 1997 cost estimate), revisions in state-specific growth rates for electricity

6. That figure comes from subtracting the amount of coal-fired electricity generation that would install selective catalytic reduction (SCR) under the trading program from the amount that would install SCR if all units were required to meet a 0.15 lb/mmBtu emission rate. That difference indicates the amount of generation that would depend on obtaining additional allowances under the program. EPA's analysis of the proposed Ozone Transport Rule, as revised in April 1998, does not allow for a similar calculation. See Environmental Protection Agency, *Proposed Ozone Transport Rulemaking Regulatory Analysis*, Appendix A, January 1998 (available at www.epa.gov/capi/capi/reganal2.html).

7. As modeled by EPA, total emissions are the same under a trading program and a command-and-control approach. In reality, the uniform emission rate under the latter could result in more variation in emissions, stemming from variations in either electricity demand or the availability of different types of electricity-generating capacity. For example, yearly variation in the amount of nuclear capacity has been shown to result in significant differences in the level of NO_x emissions under a requirement for a uniform emission. See Electric Power Research Institute, *The Timing of NO_x Emissions and Emission Trading in the Ozone Transport Region*, EPRI TR-107186 3835-02 (Palo Alto, Calif.: EPRI, December 1996).

demand, and changes in the structure of EPA's cost model. It also reflects the industry's costs in 2007, whereas the earlier estimate reflected costs for 2005.[8]

The current cost estimate of $1.4 billion is based on specific assumptions about existing NO_x controls in 12 northeastern states and the District of Columbia (see Box 1). Like the earlier cost estimate, the current estimate assumes that the electric power industry will achieve its emission reductions through a trading program and will realize all possible savings that might be obtained from trading. However, EPA did not reestimate the industry's compliance costs under a command-and-control approach using its revised data, assumptions, and model structure. It therefore did not update its estimate of how much money could be saved through trading.

Discussions with EPA staff suggest that the $2.2 billion estimate of compliance costs under a command-and-control program is still a valid point of comparison.[9] Thus, compliance costs for the electric power industry under such a program would be $800 million more than under a flawlessly operating trading market. In other words, trading NO_x emission allowances could reduce the electric power industry's compliance costs by as much as 36 percent.

EPA's assumption that participants in the trading program will realize all possible savings is very optimistic. In reality, that is unlikely to occur because markets rarely, if ever, function flawlessly. Other trading programs, such as one designed to reduce acid rain, have captured only a portion of the possible cost savings to date. Nonetheless, as sources develop confidence in the allowance market, they will probably hone their compliance strategies to capture more of the potential savings.

EXPERIENCES OF PREVIOUS TRADING PROGRAMS

The concept of distributing tradable pollution rights—what this paper refers to as emission allowances—first appeared in the academic literature in 1968.[10] Trading programs can be attractive alternatives to more traditional approaches that mandate specific pollution limits for all sources. A primary advantage of trading programs is

8. See Environmental Protection Agency, *Supplemental Ozone Transport Rulemaking Regulatory Analysis*, April 7, 1998 (available at http://www.epa.gov/capi/ipm/npr.htm).

9. Personal communication with Robert LaCount, Environmental Protection Agency, April 1998.

10. See J.H. Dales, *Pollution, Property and Prices* (Toronto: University of Toronto Press, 1968).

BOX 1.
AN EXISTING EFFORT TO CONTROL OZONE TRANSPORT: THE OZONE TRANSPORT COMMISSION

The proposed Ozone Transport Rule builds on an existing effort to reduce the movement of ground-level ozone and its chemical precursors. The 1990 Clean Air Act Amendments created the Ozone Transport Commission, made up of representatives from 12 northeastern states plus the District of Columbia. The commission has the authority, upon majority vote, to recommend strategies to the Environmental Protection Agency (EPA) for addressing violations of the ozone standard in the 13 jurisdictions.[1]

If EPA approves the majority's recommendations, each jurisdiction—whether or not it was part of the majority—must "include the approved additional control measures" in a revised state implementation plan.[2] For example, the Ozone Transport Commission recommended, and EPA approved, adopting California's Low-Emission Vehicle program. In addition, member states have agreed to work within their individual regulatory processes to establish limits on emissions of nitrogen oxides (NO_x) for power plants and other large boilers. They are working to implement those controls through a cap-and-trade program, with the cap taking effect in 1999. A task force of state representatives developed a model rule that member states are using to formulate their own programs: the rule defines numerous details of the program, including provisions for trading allowances, monitoring and reporting emissions, and banking allowances.

The proposed Ozone Transport Rule affects a larger area than that represented by the Ozone Transport Commission and builds on the commission's efforts to reduce NO_x emissions. The estimate of what the new rule will cost electricity generators depends on assumptions about which commission requirements will already be in place. EPA estimates that the proposed rule will cost the electric power industry $1.4 billion per year, assuming that electricity generators in the 13 jurisdictions represented by the Ozone Transport Commission install "reasonable available control technologies." That estimate falls to $1.25 billion per year if the commission's NO_x trading program is already operating.

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1. For more information on the Ozone Transport Commission and its agreements, see Congressional Budget Office, *Federalism and Environmental Protection: Case Studies for Drinking Water and Ground-Level Ozone* (November 1997).

2. Title I, subpart 2 of the Clean Air Act Amendments of 1990, 42 U.S.C. 7511c(c)(5), 104 Stat. 2450.

that they can lower the cost of achieving a given environmental goal by giving participants some flexibility.[11] Trading programs have been used for various purposes in the United States, such as to gradually reduce the amount of lead in gasoline.[12] Trading programs have also been used to reduce discharges into both Wisconsin's Fox River and Colorado's Dillon Reservoir.[13]

The most relevant comparison for the NO_x trading program is the program used to reduce the discharge of sulfur dioxide (SO_2). That trading program was established several years ago to limit the environmental damage resulting from acid rain.

The SO_2 Trading Program

Title IV of the 1990 Clean Air Act Amendments authorized the first large-scale use of tradable emission allowances. In 1995, all major electricity-generating units with relatively high SO_2 emissions received an allocation of tradable allowances, each one permitting the discharge of one ton of SO_2. Taken together, the allowances correspond to a specified reduction in total SO_2 emissions during the 1995-1999 period. In 2000, all electricity-generating units will receive tradable allowances that further limit national SO_2 emissions—to roughly 50 percent of 1980 levels.

To date, utilities have reduced their SO_2 emissions at significantly lower costs than analysts had expected. Not all of those savings stem from allowance trading, however; changes in the price of rail transport for low-sulfur coal and other unanticipated factors have also been instrumental in lowering abatement costs.[14]

To what extent have utilities realized the potential gains from trading allowances? According to a recent unpublished study, the electric power industry could have complied with title IV for $552 million in 1995, but it actually spent $832

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11. See David W. Montgomery, "Markets in Licenses and Efficient Pollution Control Programs," *Journal of Economic Theory*, vol. 5 (1972); and Tom H. Tietenberg, *Emissions Trading: An Exercise in Reforming Pollution Policy* (Washington, D.C.: Resources for the Future, 1985). Trading programs may offer other advantages as well. They may increase the certainty of achieving an environmental goal (compared with imposing taxes), and they may maintain environmental standards in the face of inflation and economic growth. See Robert W. Hahn and Roger G. Noll, "Designing a Market for Tradable Emissions Permits," in Wesley Magat, ed., *Reform of Environmental Regulation* (Cambridge, Mass.: Ballinger Publishing Company, 1982).

12. See Robert W. Hahn, "Environmental Markets in the Year 2000," *Journal of Risk and Uncertainty*, vol. 3 (1990).

13. See Robert C. Anderson, Lisa A. Hofmann, and Michael Rusin, *The Use of Economic Incentive Mechanisms in Environmental Management* (Washington, D.C.: American Petroleum Institute, August 1989).

14. Dallas Burtraw, "The SO_2 Emissions Trading Program: Cost Saving Without Allowance Trades," *Contemporary Economic Policy*, vol. 14 (April 1996), p. 80.

million to do so.[15] The reason, observers say, is that participants were reluctant to fully embrace the new trading program. Utilities wanted to be sure that they could use independent strategies (such as "banking," or reducing more than required in early years in order to have higher emissions in later years) to achieve compliance rather than relying on the allowance market. As a result, their costs exceeded what a perfectly operating market could have achieved by $280 million, or about 50 percent.

The use of SO_2 allowances for compliance in 1995 gives an idea of how actively utilities pursued cost savings from trading. Of the 8.69 million allowances issued for that year, sources used about 55 percent to cover emissions equal to or less than their original allocation, banked 39 percent to reduce their expected future costs of compliance, and acquired the remaining 6 percent to cover emissions that exceeded their original allocation.[16] Trades within utilities represented about two-thirds of the trading activity, and trades between utilities (primarily involving six utilities) accounted for about one-third.[17]

It would be premature to pass judgment on the long-run prospects for the SO_2 allowance market based solely on its first year of operation. There are indications that the electric power industry is adjusting to take better advantage of the program. For example, the number of trades virtually doubled in 1996 and again in 1997.[18] Furthermore, the introduction of competition in the electric power industry through deregulation is putting pressure on companies to capture all of the potential gains from trading emission allowances.

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15. The $552 million figure represents a 30 percent savings from the cost of complying with a uniform SO_2 emission standard for all units. See Curtis Carlson and others, "SO_2 Control by Electric Utilities: What Are the Gains from Trade?" (draft, Resources for the Future, Washington, D.C., December 1997).

16. A. Denny Ellerman and others, *Emissions Trading Under the U.S. Acid Rain Program: Evaluation of Compliance Costs and Allowance Market Performance* (Cambridge, Mass.: MIT Center for Energy and Environmental Policy Research, October 1997).

17. Douglas R. Bohi and Dallas Burtraw, "SO_2 Allowance Trading: How Do Expectations and Experience Measure Up?" *Electricity Journal* (August/September 1997), pp. 67-75.

18. Another indication of improved performance is that the industry increased SO_2 emissions slightly in 1996 compared with 1995, reflecting more cost-effective use of allowances to cover present releases. In 1995, utilities banked too much because they were reluctant to rely on the allowance market to ensure compliance. It would have been less expensive for them to use allowances to cover greater releases that year and incur future costs of compliance without relying on banked allowances. That is demonstrated by the fact that the weighted marginal cost of compliance in 1995 was greater than the present discounted value of future marginal compliance costs. See Dallas Burtraw, "Cost Savings, Market Performance and Economic Benefits of the U.S. Acid Rain Program" (draft, Resources for the Future, Washington, D.C., January 26, 1998).

The Relevance of the SO_2 Trading Program to the NO_x Program

Both the SO_2 and NO_x trading programs address electric utilities' contributions to interstate environmental problems caused by pollutants released into the air. Thus, experience with SO_2 emission trading can provide valuable lessons about the extent to which participants in a NO_x trading program could be expected to realize potential savings. Nevertheless, it is also critical to recognize two principal differences between the programs.

First, the proposed NO_x trading program lacks the SO_2 program's extensive federal legislative authority. The CAA Amendments established the two fundamental components of the SO_2 trading program: they identified participating emission sources, and they specified how many allowances each source would receive. The amendments also gave EPA authority to establish "a system for issuing, recording and tracking allowances, which shall specify all necessary procedures and requirements for an orderly and competitive functioning of the allowance system."[19] Interstate NO_x trading, by contrast, would operate on a foundation of 23 individual programs—one established by each of the jurisdictions covered by the Ozone Transport Rule.

Second, the environmental problems that the two programs combat are slightly different. The proposed NO_x trading program addresses a recurring, seasonal problem with air quality: violations of the National Ambient Air Quality Standard for ground-level ozone. The SO_2 trading program addresses the cumulative impact of acid deposition on the environment.

19. Clean Air Act Amendments of 1990, 42 U.S.C. 7651b(d)(1), 104 Stat. 2591.

CHAPTER II
FACTORS AFFECTING THE SUCCESS OF A NO_x CAP-AND-TRADE PROGRAM

Will the proposed cap-and-trade program for emissions of nitrogen oxides fulfill its potential to lower the cost of complying with the Ozone Transport Rule? Specifically, will the trading program cost the electric power industry $800 million less than requiring all electricity generators to meet the same emission rate, as the Environmental Protection Agency asserts? Based on the experience of previous trading programs, several factors will influence whether the answer is yes. Those factors include:

- o Having a competitive market for emission allowances,
- o Ensuring minimal institutional constraints,
- o Keeping transaction costs low,
- o Allocating a share of allowances through an auction, and
- o Allowing participants to "bank" allowances for future use.

A COMPETITIVE MARKET FOR ALLOWANCES

To be effective in lowering the cost of cutting regional NO_x emissions, the market for allowance trading must be a competitive one. Concerns about market concentration arise when the actions of one participant in the market have the potential to influence the price of emission allowances. That would occur if the number of buyers and sellers were small, or if a few participants controlled a large share of the market. But if states allocate NO_x allowances along the lines envisioned by EPA, neither of those scenarios is likely.

Under EPA's plan, the market for NO_x allowances will have many participants. EPA envisions that states will allocate allowances to an electricity generator based on a measure related to the amount of electricity it generates from fossil fuels. One group that would receive allowances is electricity-generating boilers with a capacity of 25 megawatts or more. Such boilers are responsible for most of the electricity generated from fossil fuels in the region subject to the proposed Ozone

Transport Rule. That region contains 133 different utilities (based on ownership), which account for 96 percent of the electricity generated there.[1]

Because the electricity-generating market is not highly concentrated, there is little potential for a few participants to control a large share of the market for allowances. The Congressional Budget Office examined the percentage of regional electricity generation attributable to each of the 133 utilities in the area. The utility responsible for the largest share produces just 8 percent of the regional total, and the next two largest account for only 7 percent and 6 percent, respectively. In all, the top 10 utilities produce less than 45 percent of the region's total electricity generation.[2] That implies that less than half of the allowances that states would allocate to utilities would be distributed among the 10 largest electricity producers in the region.

Looking beyond utilities, there is even less cause for concern that a few participants will control much of the allowance market. EPA anticipates that states will also give allowances to some electricity-generating units that do not belong to utilities as well as to combustion devices with a capacity greater than 250 million British thermal units per hour that do not generate electricity.

MINIMAL INSTITUTIONAL CONSTRAINTS

The rules established by state and federal institutions can affect the incentives that NO_x sources have to buy or sell emission allowances. Those rules include ones made by state public utility commissions and the federal Internal Revenue Service (IRS). For participants in the program to realize the potential cost savings from trading, institutional impediments to trading must be kept to a minimum.

Rules for State Public Utilities

At least two conditions are necessary (although not by themselves sufficient) for trading to achieve compliance with the NO_x cap at the lowest possible cost. First, participants must minimize the cost of reducing their NO_x emissions. Second, the

1. That includes utilities that rely on fossil-fuel and nuclear generation; it excludes utilities that produce less than 0.01 percent of net generation in the region and those that generate electricity wholly from renewable energy sources. See Department of Energy, Energy Information Administration, *Electric Power Annual, 1995*, vol. 1, DOE/EIA-0348(95)/1 (July 1996); and personal communication with staff members of the Federal Energy Regulatory Commission.

2. Ibid.

costs that they perceive for various compliance options must reflect the actual costs.[3] Because electricity generation is currently regulated in most states, those conditions may not hold.

The rules that regulators establish can distort the relative marginal cost of investments in pollution-control technology and in allowances. In other words, they can make more expensive compliance options look cheaper to a utility. Thus, options that minimize a utility's costs may not minimize costs to its customers.[4] For example, companies can often depreciate investments in pollution control technology at a rate that exceeds the physical rate of deterioration. Emission allowances, however, do not qualify for depreciation. As a result, utilities could receive a higher rate of return from installing pollution-control equipment than from purchasing allowances, even though allowances cost less.[5]

Further, most states require utilities to pass all profits from the sale of allowances on to their customers.[6] Some analysts argue that this requirement inappropriately discourages utilities from selling their allowances.[7] Other analysts say, however, that letting utilities keep a share of the profits from selling allowances can give them an incentive to reduce emissions more than is optimal for society.[8]

Recommending how to design public utility regulations so that utilities have appropriate incentives is beyond the scope of this paper. However, it is clear that some of the rules established by state regulators can determine whether utilities face incentives to reduce their NO_x emissions at the lowest cost. Ensuring that they do will require modifying the historical practices of state regulators.

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3. For a discussion of this issue in the context of utilities' decisions about sulfur dioxide, see Douglas R. Bohi, "Utilities and State Regulators Are Failing to Take Advantage of Emission Allowance Trading," *Electricity Journal* (March 1994).

4. For a more complete discussion of this issue, see Douglas R. Bohi and Dallas Burtraw, "Avoiding Regulatory Gridlock in the Acid Rain Program," *Journal of Policy Analysis and Management*, vol. 10, no. 4 (1991).

5. A review of the policies of 11 states that received 85 percent of the allowances issued during phase I of the SO_2 program revealed that six states actively promoted pollution-control equipment through favorable cost-recovery rules. See Bohi, "Utilities and State Regulators Are Failing to Take Advantage of Emission Allowance Trading."

6. One researcher identifies nine public utility commissions that developed guidelines or generic rules on how allowance transactions should affect the rate-making process. Only one of those states, Connecticut, allows utilities to retain the profits from the sale of allowances originally allocated to them. See Elizabeth Bailey, *Allowance Trading Activity and State Regulatory Rulings: Evidence from the U.S. Acid Rain Program*, Working Paper No. MIT-CEEPR 96-002 WP (Cambridge, Mass.: MIT Center for Energy and Environmental Policy Research, March 1996).

7. See Bohi, "Utilities and State Regulators Are Failing to Take Advantage of Emission Allowance Trading," p. 678.

8. That occurs when regulators allow utilities to pass the cost of pollution-control equipment on to customers. See Don Fullerton, Shaun P. McDermott, and Jonathan P. Caulkins, "Sulfur Dioxide Compliance of a Regulated Utility," *Journal of Environmental Economics and Management*, vol. 24, no.1 (September 1997).

Many states have started deregulating the sector of the electric industry that generates power (a process referred to as restructuring the industry), although they continue to regulate the distribution and transmission of electricity. Currently, nine of the 23 jurisdictions covered by the Ozone Transport Rule have either begun such restructuring or have definite dates to do so. All of the other jurisdictions are studying the issue, considering legislation to initiate restructuring, or both. In addition, the federal government is considering legislation to require such restructuring throughout the country. By increasing competition in the electric power industry, deregulation should put pressure on utilities to minimize their costs —including the cost of complying with limits on NO_x emissions.[9]

Tax Disincentives

Some people argue that current IRS rules could discourage the sale of NO_x emission allowances, as may have occurred with SO_2 allowances. Specifically, the IRS assesses the value of SO_2 allowances on a historical-cost basis. Since most of the allowances were distributed to utilities at no charge, their historical cost is zero. (The cost basis for purchased allowances is the purchase price.) Thus, when utilities sell freely obtained allowances, they realize a gain that is taxed at the same rate as corporate income. Allowances that are not sold, however, avoid taxation. That tax treatment may create an incentive for utilities to hold onto SO_2 allowances and could affect the market for NO_x allowances as well.[10] However, no empirical evidence exists about whether the tax treatment of allowances has impeded SO_2 trading. Thus, it is difficult to determine whether those rules would have a significant impact on the market for NO_x allowances.

LOW TRANSACTION COSTS

Transaction costs—the costs that participants incur to complete a trade of allowances—can play an important role in determining how well trading programs perform.[11] Transaction costs have two main components: the cost of identifying

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9. The Natural Resources Defense Council argues that one limitation of the Ozone Transport Rule is that utilities might shift power generation to facilities in states not covered by the rule. That would lead to higher emission levels in those states. See "Northeast Senators Call on Administration to Address Pollution in Restructuring Bill," *BNA Environment Reporter*, vol. 28, no. 39 (February 6, 1998), p. 2009.

10. See Kenneth Rose, "Implementing an Emissions Trading Program in an Economically Regulated Industry: Lessons from the SO_2 Trading Program," in Richard F. Kosobud and Jennifer M. Zimmerman, eds., *Market Based Approaches to Environmental Policy: Regulatory Innovations to the Fore* (New York: Van Nostrand Reinhold, 1997).

11. For example, researchers found that low transaction costs help explain the success of the trading program designed to reduce the lead content of gasoline. By contrast, they found that high transaction costs had a detrimental effect on emissions trading in the early 1980s and on the trading program designed to reduce discharges into Wisconsin's

trading partners (including the cost of negotiating the trade), and the cost of obtaining regulatory approval for the trade. EPA expects both types of costs to be low for the NO_x trading program. But that expectation will be fulfilled only if participating states incorporate certain key requirements into their trading programs and establish programs that are sufficiently compatible with one another. Lack of federal authority to establish a NO_x trading program could lead to transaction costs that are higher than EPA anticipates. Those costs in turn could limit the realization of potential savings.

The market for SO_2 allowances helped demonstrate that the private sector can play an important role in minimizing the first component, the cost of identifying partners and negotiating a trade. "Entrepreneurs have stepped in to make available a variety of services, including private brokerage, electronic bid/ask bulletin boards, and allowance price forecasts."[12] The private sector could play a similar role in the NO_x trading market.

High regulatory transaction costs typically result from the need to ensure that trading programs actually achieve the desired environmental goal. For example, the regulator will want to make sure that the party selling an allowance actually decreased its emissions by the amount necessary to generate that allowance. The allowance trading market cannot function well when the process of obtaining regulatory approval is costly or time consuming.

As envisioned by EPA, the regulatory costs of trading NO_x allowances will be minimal. The agency proposes using a process similar to that used to approve trades of SO_2 allowances—a process that generally takes only 24 hours. Participants would complete trades by submitting a form to EPA that requires only the signature of the selling party.[13]

Monitoring and Reporting Requirements

In the SO_2 trading program, monitoring and reporting requirements are the factors that keep transaction costs low while still ensuring the integrity of the program. Sources use continuous monitoring systems for emissions and report those emissions quarterly to EPA. The agency then deducts the tons of SO_2 emitted by each boiler

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Fox River. See Robert W. Hahn and Gordon L. Hester, "Marketable Permits: Lessons for Theory and Practice," *Ecology Law Quarterly*, vol. 16, no. 2 (1989).

12. See Robert N. Stavins, "What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading," *Journal of Economic Perspectives* (forthcoming).

13. Environmental Protection Agency, *Model NO_x Cap and Trade Program, Draft Working Paper: Elements of Model NO_x Cap and Trade Rule*, December 7, 1997 (available at http://www.epa.gov/acidrain/modlrule/element.html).

from the allowances in that boiler's account. If the boiler's SO_2 emissions exceed the allowances in its account, the government imposes statutory penalties.[14]

That system of tracking SO_2 emissions and allowances lets program participants make individual trades with minimal regulatory costs. Any failure to buy the appropriate number of allowances, or any attempt to sell allowances not associated with actual cuts in emissions, is detected during the tallying-up process at the end of the year. Automatic penalties discourage violations.

EPA expects that states will require NO_x sources in the trading program to comply with similar monitoring and reporting requirements. In fact, title IV of the Clean Air Act already requires many of the sources that are expected to be part of a NO_x trading program to collect, ensure the quality of, and report the necessary NO_x data.

To ensure the integrity of the NO_x program, EPA wants all of the sources included to have monitoring and reporting requirements that are as rigorous as those used in SO_2 trading.[15] As indicated above, however, states will have some leeway in determining which sources are included in the trading program.

State-Established Programs

Because EPA does not have the authority to set up a federal NO_x trading program, the agency will have less control over the elements of the program—including those elements that affect transaction costs—than it does over the SO_2 trading program. Each state will need to establish its own trading program, although it can choose not to.

In EPA's view, a successful trading market requires "a belief that all of the sources included in the program are following the same set of rules, and a belief that trades can be made easily, quickly and with a great deal of confidence that they will not be altered or denied."[16] Achieving that goal for the NO_x trading program will require uniform rules for each state program that are consistently implemented and enforced. Small differences in language among state rules could lead to different

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14. Those penalties are $2,000 per excess ton of emissions (indexed to inflation) and an automatic assessment of one allowance per excess ton. See Renee Rico, "The U.S. Allowance Trading System for Sulfur Dioxide: An Update on Market Experience," *Environmental and Resource Economics*, vol. 5 (1995), p. 117.

15. See Environmental Protection Agency, *Model NO_x Cap and Trade Program, Draft Working Paper: Elements of Model NO_x Cap and Trade Rule*.

16. See Environmental Protection Agency, *Supplemental Notice for the Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone*, April 28, 1998, p. 239 (available at http://www.epa.gov/ttn/oarpg/otagsip.html).

interpretations and create uncertainty and higher transaction costs than EPA anticipates.[17] For example, the Ozone Transport Commission has encountered problems with consistency in its attempt to establish a NO_x trading program for 12 northeastern states and the District of Columbia. States have chosen different allocation schemes—some issuing allowances for one year at a time and others for several years at a time.[18] Those differences could increase the transaction costs associated with negotiating trades and limit the potential for trading between NO_x sources in different states.

To help ensure uniformity among state programs, EPA has developed a model trading rule; it lists elements that the agency believes state programs must include in order for a regionwide trading program to succeed. If states establish programs with those key elements, EPA will administer the system that tracks the emissions and allowances of sources in those states. That arrangement gives states the opportunity to reduce their administrative costs by setting up a program that conforms with the model rule.

How successful EPA's approach will be is unclear. Although the model rule will help promote consistency among state programs, it is not likely to result in as much uniformity as a single, federally established trading program. Further, EPA cannot compel all states affected by the Ozone Transport Rule to participate in a trading program. If some states refuse to participate, the potential cost savings from trading will diminish.

ALLOWANCE AUCTIONS

In theory, the method used to allocate allowances—and the pattern of the initial allocation—should not affect the cost of achieving the emissions cap. The reason is that the trading that follows the initial allocation is what minimizes the cost of achieving the cap (assuming that transaction costs are minimal and that a competitive market for allowances exists).

In reality, however, some researchers argue that using auctions as a way to allocate at least some of the allowances can help in reducing transaction costs and

17. The possibility of alternative interpretations in different states could also lead to numerous legal challenges, with resulting delays and uncertainty.

18. For example, Massachusetts will issue allowances for four years at one time, whereas New Jersey will issue them annually. Personal communication with Nancy Seidman, Massachusetts Department of Environmental Protection; and New Jersey Department of Environmental Protection, "Policy and Planning/Air Quality Management: NO_x Budget Program," *New Jersey Register*, September 15, 1997, 29 N.J.R. 3934.

establishing a competitive allowance market.[19] The trading program assumed in EPA's cost estimate for the Ozone Transport Rule represents a new market for NO_x allowances. The initial number of buyers and sellers in that market is uncertain. Markets that are "thin" (that is, that have few transactions) have trouble reaching a stable price, because participants have too little information to use in deciding to buy or sell. In that case, auctioning a share of allowances can help provide price information, which can then stimulate direct trades between program participants. In the acid rain program, the Congress mandated that a share of SO_2 allowances be auctioned, in part to prompt early trades and serve that price-signaling function.[20]

The government could choose to allocate all allowances through an auction rather than giving some away. On the one hand, that approach would increase the costs incurred by program participants. For example, units serving electricity generators would have to buy allowances for all of their NO_x emissions, not just those over 0.15 lb/mmBtu. On the other hand, research indicates that gains in efficiency could result if the government kept the revenue from the auction and used it to lower taxes, such as those on labor and capital, without affecting the balance of the federal budget.[21] Lowering taxes on labor and capital could enhance economic efficiency by increasing people's incentives to work and save. Such "revenue recycling" can lower the net cost to society of achieving the emissions cap.[22] For example, some researchers estimate that the cost of the SO_2 trading program would be 25 percent less if allowances were auctioned rather than freely allocated and the revenues were used to reduce certain taxes.[23]

Because of EPA's lack of authority over the NO_x program, however, it cannot set aside a share of NO_x allowances for auction. States could voluntarily offer some of their NO_x allowances for a regionwide auction, but they would be very unlikely to do so. If one state did that and all other affected states did not, that state would be unilaterally reducing its emissions budget. States affected by the Ozone Transport

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19. For example, Ellerman and colleagues state that "the SO_2 auctions' most important role may have been to establish visible market values." See A. Denny Ellerman and others, *Emissions Trading Under the U.S. Acid Rain Program: Evaluation of Compliance Costs and Allowance Market Performance* (Cambridge, Mass.: MIT Center for Energy and Environmental Policy Research, October 1997), p. 33.

20. For a discussion of the role that auctions were expected to play in the SO_2 market, see Karl Hausker, "Coping with the Cap: How Auctions Can Help the Allowance Market Work," *Public Utilities Fortnightly* (May 24, 1990).

21. Different methods of allocating allowances will result in different income distributions. For example, program participants would have less income if the government chose to auction allowances than if it freely distributed them. Furthermore, workers and owners of capital would benefit if the government chose to offset auction revenues by lowering existing taxes on labor and capital.

22. Robert N. Stavins, "What Can We Learn from the Grand Policy Experiment?"

23. See Lawrence H. Goulder, Ian W.H. Parry, and Dallas Burtraw, "Revenue-Raising Versus Other Approaches to Environmental Protection: The Critical Significance of Preexisting Tax Distortions,"*RAND Journal of Economics*, vol. 28, no. 4 (Winter 1997).

Rule might benefit if all of them agreed to offer a share of their allowances for a regionwide auction. But without a mechanism to ensure such an agreement, no individual state has an incentive to do so.

Of course, states could decide to allocate allowances to sources within their borders through an auction. But such limited auctions would not provide useful price signals for the regionwide market. An auction will provide appropriate price signals only if it is open to all potential buyers and sellers. Because the market for NO_x allowances will cover the 23 jurisdictions assigned emission budgets under the Ozone Transport Rule, an appropriate price-signaling auction would need to be open to buyers and sellers throughout that region.

FLEXIBILITY IN THE TIMING OF EMISSION REDUCTIONS

Cap-and-trade programs can allow participants to vary the timing of their emission cuts in two ways. First, programs can let participants generate allowances by reducing their emissions before the cap goes into effect. The participant can then bank those allowances to use later when the cap is operating. Second, once the cap is in place, programs can allow participants to bank unused allowances for future use. For example, unused allowances in a source's account at the end of 2005 could be used in 2006.

Both forms of banking can play an important role in reducing the cost of meeting the NO_x cap and may offer other benefits as well. However, banking also has disadvantages. EPA has not yet proposed what, if any, type of banking it will include in its model trading rule.

The Advantages of Banking Early Reductions

Allowing participants to generate allowances by cutting emissions before the cap takes effect has at least three advantages. First, it can help sources plan for the transition to the cap. For example, if a utility makes early reductions at some of its units, it can delay controlling emissions from other units once the cap is in place. That gives the utility more time to explore various compliance options. That advantage can be particularly important when sources have a relatively short period in which to plan before the cap takes effect, as is the case with the Ozone Transport Rule.[24] A utility's decision about how to comply depends on the price of allowances,

24. States are required to submit state implementation plans, indicating how they will meet their emission budgets, in September 1999. Controls must be in place by September 2002. See Environmental Protection Agency, *Fact Sheet: Proposed Rule for Reducing Regional Transport of Ground-Level Ozone (Smog)*, October 10, 1997 (available at http://www.epa.gov/ttn/oarpg/otag/otagfs.html).

which is affected by other participants' decisions. By delaying compliance at some of its units, a utility can get preliminary information about allowance prices and thus be better able to reduce total compliance costs. That same benefit could also be obtained by phasing in the cap.

Second, letting participants bank allowances generated by early reductions gives them an economic incentive to cut their emissions before they are required to do so. By making early reductions, participants can save allowances for use when restrictions on NO_x emissions are tighter and the marginal cost of control is higher. Those early reductions can lower total compliance costs.

Third, early reductions mean that areas obtain the health and environmental benefits of lower NO_x emissions sooner than they would otherwise. Later on, however, emissions could be higher than they would have been if participants had not generated allowances through early reductions. In some cases, though, early cuts in nitrogen oxides, which occur when total emissions are high, could create larger health and environmental benefits than later reductions, which occur when total emissions are lower. That would be the case if the incremental damage from NO_x emissions increased as the total level of emissions rose.

The Advantages of Banking Once the Cap Is in Place

Allowing participants to save up unused allowances after the cap is in place could also have several benefits. For one thing, banking can facilitate trading. Pollution-control strategies for nitrogen oxides generally involve investment decisions that affect emissions for many years. Without banking, participants may be reluctant to make investments that would reduce their emissions beyond the required amount without knowing for sure that someone else will be able to purchase their allowances.[25] Banking assures participants that those investments will generate allowances that can be used or sold at a future date. That facilitates the development of a futures market for allowances, as has occurred with SO_2 allowances.[26]

For another thing, banked allowances can protect utilities against variations in the availability of power-generating facilities and swings in the demand for

25. Robert W. Hahn and Roger G. Noll, "Environmental Markets in the Year 2000," *Journal of Risk and Uncertainty*, vol. 3 (1990), p. 353.

26. Ellerman and others, *Emissions Trading Under the U.S. Acid Rain Program,* pp. 28-29.

electricity.[27] For example, generating power from nuclear facilities does not create NO_x emissions. Thus, variation in the amount of nuclear capacity available can lead to variation in a utility's need for NO_x allowances. In the SO_2 program, utilities initially tried to avoid relying on the allowance market to provide for unexpected future needs, preferring instead to bank their allowances to ensure future compliance.

In addition, like generating allowances through early reductions, having the ability to bank once the cap is in place gives sources an incentive to decrease their emissions earlier than might otherwise be the case. Those early decreases can result in benefits to human health and the environment.

Finally, banking can protect against instability in the price of allowances and spikes in emissions. Without banking, the price of allowances could change sharply at the end of each compliance period. If sources had saved extra allowances to provide for unexpected requirements throughout the compliance period, they would want to sell them at the end of that period. At that point, the price of allowances could fall sharply as many participants attempted to sell them before they expired. Emissions, in turn, could spike as sources used up the excess allowances.[28] Conversely, the price of allowances could increase sharply if unusual circumstances created a shortage at the end of a trading period.

The Potential Disadvantages of Banking

Despite its potential advantages, the use of banking in a NO_x trading program could lead to problems as well. If a large number of banked allowances were used in a given ozone season, the emissions cap for that season would be exceeded, which could contribute to violations of the ozone standard.

Banking has played an important role in the SO_2 trading program. Unlike the NO_x trading program, however, the SO_2 program addresses a problem that stems from the cumulative impact of a pollutant. Because of that difference, the use of banked SO_2 allowances does not raise the same concerns as the use of banked NO_x allowances.

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27. See Laurel J. Carlson, *NESCAUM/MARAMA NO_x Budget Model Rule* (prepared for the Northeast States for Coordinated Air Use Management (NESCAUM) and the Mid-Atlantic Regional Air Management Association (MARAMA) NO_x Budget Task Force's NESCAUM/MARAMA NO_x Budget Ad Hoc Committee and the Ozone Transport Commission's Stationary and Area Source Committee by Environmental Science Services, Providence, R.I., May 1, 1996), p. 19.

28. That can occur if sources turn off NO_x controls that have relatively high operating costs. See Electric Power Research Institute, *The Timing of NO_x Emissions and Emission Trading in the Ozone Transport Region*, EPRI TR-107186 3835-02 (Washington, D.C.: EPRI, December 1996), p. 5-5. The report was prepared by National Economic Research Associates of Cambridge, Massachusetts.

A report by National Economic Research Associates (NERA) examined whether banking in the Ozone Transport Commission's cap-and-trade program (see Box 1 in Chapter I) would be likely to lead to significant breaches of that program's cap. NERA concluded that "excessive" banking would be discouraged in at least two ways.[29] First, banking entails an opportunity cost, since banked allowances cannot earn interest, so sources will be willing to do it only if they expect the price of allowances to increase by more than the interest rate. Second, market forces should prevent excessive banking. As more sources choose to bank allowances, the expected price of allowances sold in the future will fall. Furthermore, the current price of allowances will rise as banking reduces the current supply. Those forces should have a moderating effect on the amount of banking that will occur. However, further analysis is necessary to better understand how much EPA's proposed cap might be exceeded under various banking provisions.

EPA did allow for banking (after the cap was in place) when it estimated the cost that the NO_x trading program would impose on electricity generators. The agency predicted that no banking would occur, however, because the cap is constant throughout the time period examined in its cost model and because EPA expects control costs to be constant or to decrease in real terms (that is, after accounting for inflation).[30] Thus, banking cannot reduce power generators' compliance costs. However, EPA's model did not account for important factors that could lead to banking. As described above, those factors include uncertainty about the future availability of power-generating facilities and swings in the demand for electricity.

EPA is seeking comment on what form of banking, if any, it should include in its model trading rule. One option under consideration is "flow-control" banking, which is part of the model trading rule developed by the Ozone Transport Commission. Flow control seeks to capture some of the advantages of banking while limiting the potential disadvantages. For a detailed explanation of how flow control would work, see Box 2.

29. Ibid, pp. 5-8 and 5-9.

30. Environmental Protection Agency, *Proposed Ozone Transport Rulemaking Regulatory Analysis*, January 1998, p. A3-29 (available at http://www.epa.gov/capi/capi/reganal2.html).

BOX 2.
FLOW-CONTROL BANKING

Under the flow-control version of banking, trading participants may bank as many emission allowances as they want. If the total number banked in a given year is less than a specified percentage of the regional cap on allowances for that year (the Ozone Transport Commission's trading program uses 10 percent), then banked allowances can be used in the upcoming year at full value. In that case, participants can emit one ton of nitrogen oxides (NO_x) for each banked allowance they use. If, by contrast, the number of banked allowances exceeds the specified percentage, then some of the banked allowances will be subject to a discount. In that case, participants may need to use more than one banked allowance for some of the tons of NO_x that they emit. The share of banked allowances that is subject to that discount in a particular year depends on the extent to which the number of allowances banked in the previous year exceeds the specified percentage of the cap.

The Ozone Transport Commission's flow-control banking provides an example of this concept in operation.[1] In 1999, the NO_x cap for the commission's 13-jurisdiction region will be 219,005 tons. If sources of NO_x emissions in those jurisdictions hold 29,200 banked allowances in 1999, they will exceed 10 percent of the NO_x cap for that year. Therefore, some of the banked allowances will be subject to a discount the following year (2000). The exact number subject to a discount in 2000 depends on how much the actual number of banked allowances in 1999 exceeds 10 percent of that year's NO_x cap:

$$\frac{0.10 \times NO_x \text{ cap in } 1999}{\#\text{ of allowances in the bank in } 1999} = \frac{21{,}901}{29{,}200} = 0.75$$

That ratio is applied to each source's account to identify the number of banked allowances that can be used on a one-for-one basis in 2000 and the number of allowances that can be used on a two-for-one basis. For example, if a source has 1,000 allowances in the bank, it may use 750 on a one-for-one basis and the remaining 250 on a two-for-one basis.

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1. See Laurel J. Carlson, *NESCAUM/MARAMA NO_x Budget Model Rule* (prepared for the Northeast States for Coordinated Air Use Management (NESCAUM) and the Mid-Atlantic Regional Air Management Association (MARAMA) NO_x Budget Task Force's NESCAUM/MARAMA NO_x Budget Ad Hoc Committee and the Ozone Transport Commission's Stationary and Area Source Committee by Environmental Science Services, Providence, R.I., May 1, 1996), pp. 21-22.

COULD TRADING MAKE SOME AREAS LESS LIKELY TO ACHIEVE THE OZONE STANDARD?

Another concern besides whether the trading program will achieve its potential cost savings is whether trading could make some areas less likely to meet the ozone standard. EPA's Ozone Transport Rule calls for significant reductions in NO_x emissions throughout the multistate region. Those reductions will be instrumental in reducing ozone concentrations and bringing many counties and metropolitan areas into compliance with the standard.

Although introducing allowance trading does not alter the magnitude of the regional abatement effort, it is likely to alter how that effort is distributed among the 23 jurisdictions covered by the rule. With trading, EPA estimates, NO_x emissions in 14 of those jurisdictions would be reduced by more than the amount specified in the Ozone Transport Rule. On the whole, electricity-generating sources in each of those 14 jurisdictions would be net sellers of emission allowances.[31]

The nine other jurisdictions, the agency estimates, would experience smaller cuts in NO_x emissions with trading than those specified in the Ozone Transport Rule. Thus, sources in each of those jurisdictions would, on the whole, be net buyers of emission allowances. For example, EPA estimates that annual NO_x emissions from electricity-generating sources in four states would be more than 15 percent higher with the introduction of a regionwide trading program than without it. Specifically, West Virginia's annual emissions from those sources would be 94 percent higher with trading than without it; Alabama's would be 22 percent higher; Michigan's would be 19 percent higher; and Georgia's would be 16 percent higher. [32]

Some states worry that the distribution of NO_x emissions under regionwide allowance trading will worsen air-quality problems, leading to violations of the ozone standard that would not have occurred under a requirement for a uniform emissions rate. A trading program in which all emissions are treated identically, regardless of the location of their source, is particularly problematic when the emissions from a source with relatively high abatement costs contribute relatively more to violations of the standard. In such cases, health and environmental considerations call for reducing emissions from that source, but cost considerations encourage that source to buy allowances instead of cutting emissions. In effect, the sale of allowances by

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31. All estimates are based on predicted emissions in 2007. See Environmental Protection Agency, *Supplemental Ozone Transport Rulemaking Regulatory Analysis*, April 7, 1998, Appendix D, Table D-1 (available at http://www.epa.gov/capi/ipm/npr.htm).

32. Ibid. Other states with higher estimated NO_x emissions from electricity-generating sources under trading are New Jersey and Maryland (7 percent), North Carolina (6 percent), Illinois (4 percent), and Pennsylvania (less than 1 percent).

low-cost, low-damage sources promotes an increase in emissions at high-cost, high-damage sources on a ton-for-ton basis.

EPA's proposed trading program does not prevent states from imposing control requirements on specific emission sources within their borders. States may choose to do that to prevent excessive releases from sources that have a particularly potent effect on ozone concentrations in areas in the state that are violating the standard. Such requirements would reduce the potential cost savings from trading by limiting participation in the allowance market, but they would be appropriate if they reflected the most cost-effective way to bring an area into compliance with the standard.[33]

Similarly, it might also be appropriate for states to prevent excessive releases from emitters in their jurisdiction that have an especially great impact on ozone concentrations in out-of-state areas that violate the standard. However, states are unlikely to choose to do that. Thus, federal authority would be necessary for the trading program to comprehensively address the location-based differences in effects that NO_x emissions have on air quality in areas violating the ozone standard throughout the multistate region. For a detailed discussion of how such geographic targeting might operate, see the appendix.

CONCLUSION: HOW THE NO_X PROGRAM RANKS ACCORDING TO THESE FACTORS

Trading programs are most likely to operate successfully when the market for allowances is competitive, when there are minimal institutional constraints and low transaction costs, when some allowances are allocated through an auction, and when participants can bank allowances for future use. How does the proposed NO_x trading program rank in terms of those factors?

By the first two criteria, the program ranks favorably. The market for NO_x allowances is likely to be competitive. Given the sources that EPA expects states to include in the trading program and the allocation procedures it expects states to follow, it is unlikely that any individual source or group of sources would be able to influence the price of allowances. In addition, existing institutional constraints should be reduced by the move toward deregulation of the electric utility sector. Deregulation should give utilities an incentive to engage in allowance trading when doing so can minimize their cost of reducing emissions.

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33. For example, suppose that reducing NO_x emissions at three North Carolina sources west and northwest of Charlotte turned out to be the only way for the city to achieve compliance with the ozone standard. Suppose further that those sources' relative marginal costs of abatement prompted them to buy allowances instead of cutting their emissions. Although reduced emissions elsewhere would make the allowances available, those abatement efforts would have no impact on whether Charlotte met the standard.

By the other factors, the program does not rank as favorably. In many instances, that is because EPA does not have authority to establish a regionwide NO_x trading program. For example, although EPA expects transaction costs to be low, its ability to ensure that they are is limited. In each of the jurisdictions covered by the proposed rule, participation in the trading program is contingent on state-level regulatory action. Differences in state rules could lead to delays, uncertainty, and higher transaction costs than EPA envisions. The agency has proposed a model rule that it hopes will encourage enough uniformity among state programs to minimize those problems, but how successful that strategy will be is unclear.

EPA's lack of authority to establish a regionwide program also precludes it from setting aside a share of allowances for a regional auction. Auctions can be useful in providing price information to participants in newly established markets, such as the NO_x allowance market. In the absence of such price information, markets can have trouble reaching a stable price, which discourages trading. Further, EPA does not have authority to compel states to participate in the trading program. If some states choose not to participate, the potential savings from trading will decrease and the cost of achieving the NO_x cap will rise.

EPA has not yet determined whether it will allow NO_x sources to bank allowances. Restricting sources' ability to bank allowances for future use can discourage trading and limit the potential savings from the program. Such restrictions might be justified, however, if the use of banked allowances would contribute to violations of the ozone standard. Further analysis is needed to determine whether restrictions on banking are warranted.

APPENDIX
GEOGRAPHIC TARGETING OF TRADES

The Clean Air Act requires all areas to comply with the National Ambient Air Quality Standard for ground-level ozone. The trading program for emissions of nitrogen oxides (NO_x) would be one way to help achieve that goal. As the Environmental Protection Agency (EPA) currently envisions the program, any participating source would have to use one allowance—obtained either through its initial allocation or through trading with other sources—for each ton of NO_x it emitted. Compared with an approach that required all sources to meet a uniform level of emissions, trading would lower the cost of achieving the regional NO_x cap by allowing cuts to be made by those sources that can do so most cheaply. A key question, however, is whether that is analogous to reducing the cost of bringing the multistate region into compliance with the ozone standard.

The answer to that question depends primarily on atmospheric science. If regional concentrations of ambient ozone respond similarly to cuts in NO_x emissions regardless of where those cuts occur, the answer is unequivocally yes. However, atmospheric modeling has shown that the impact of NO_x emissions on ambient ozone varies with the location and timing of emissions. Further, the effects of location and timing interact: emissions may have an impact on local concentrations of ozone fairly quickly but on distant concentrations with a significant lag.

AN AMBIENT TRADING PROGRAM

In theory, when transported pollutants have a critical effect on compliance with an air-quality standard, the most cost-effective way for a region to meet that standard is through an ambient trading program. Such programs are based on the concept of geographic targeting. For example, each area violating the NO_x standard could have a unique allowance market. The allowances traded in that market would give sources throughout the region permission to affect that area's ambient ozone concentration by so many parts per billion through their NO_x releases.[1] Thus, if nitrogen oxides from a given source altered the ambient ozone concentrations in five different areas, that source would have to deal in five different allowance markets. In EPA's proposed NO_x trading program, by contrast, sources are not subject to geographic

1. Note that from the perspective of economic efficiency, the appropriate ambient trading program for NO_x would define emission allowances in terms of the damage attributable to NO_x emissions (through ambient ozone concentrations and otherwise) in areas throughout the region.

targeting. Instead, they can trade allowances regardless of the resulting impact of their emissions on concentrations of ambient ozone throughout the region.[2]

In practice, an ambient trading program is very ambitious because it requires detailed information about the effect of every source's NO_x emissions on every area's ozone concentration. Scientists do not yet understand the formation and transport of ozone thoroughly enough to provide that information. In addition, such a program would entail large transaction costs because sources might have to participate in allowance markets for many different areas.[3] Those high transaction costs could overwhelm the potential savings from trading.

EPA could incorporate a less ambitious version of geographic targeting into its proposed NO_x trading program, which could reduce the cost of achieving compliance with the ozone standard. Compared with a "pure" ambient trading program, a modified version would require less detailed knowledge of how ozone is formed and transported and would entail lower transaction costs.

LESS AMBITIOUS GEOGRAPHIC TARGETING PROGRAMS

EPA could use two basic approaches to incorporate geographic targeting into its NO_x program: the trading-zone approach, and the location-weighted emissions approach. Both approaches require information about the geographic relationship between sources of NO_x emissions and area-specific concentrations of ozone. Unlike an ambient trading program, however, they can use more general information about that relationship.

Under the trading-zone approach, the region covered by the Ozone Transport Rule would be divided into separate zones, each with its own emissions cap and market. Zones could vary in size and might contain all or part of one or more states. Sources would be able to trade emission allowances only within their zone, and in each zone one allowance would be worth one ton of NO_x emissions.

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2. In its October 1997 notice of proposed rulemaking, EPA solicited comments on approaches that factor in the differential effects of emissions from varying locations on air quality in areas throughout the 23-jurisdiction region that violate the ozone standard. The agency's April 28, 1998, supplemental notice of proposed rulemaking states, "If after review of alternative approaches (including sub-regional modeling analyses submitted by states and other commenters) EPA concludes that a new approach is appropriate, EPA will issue a S(upplemental) N(otice) of P(roposed) R(ulemaking)." See Environmental Protection Agency, *Supplemental Notice for the Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone*, April 28, 1998 (available at http://www.epa.gov/ttn/oarpg/otagsip.html).

3. Taking both the location and timing of emissions into account would further increase the number of relevant markets. In addition, allowance prices would probably take time to stabilize in those very interdependent markets. Moreover, ambient ozone concentrations depend on NO_x emissions from all sources, not just those in the program, and on emissions of volatile organic compounds and meteorological conditions in different locations at different times.

The location-weighted emissions approach would maintain a regionwide market for allowances, but the number required for each ton of NO_x emissions would vary according to the location of the source.[4] For example, sources close to urban areas that violate the ozone standard might need two allowances for every ton of NO_x they release.

COST AND FLEXIBILITY OF THE LESS AMBITIOUS PROGRAMS

A decision about whether to use either of the less ambitious approaches to geographic targeting should consider the net effect of two factors: the increased costs associated with greater complexity, and the potential for reducing the cost of meeting the ozone standard. Even if the advantages outweigh the disadvantages under both approaches, the difference is likely to be greater with location-weighted emissions trading.

In principle, the trading-zone approach can reduce the opportunities for cost-saving trades because it includes multiple (and therefore small) allowance markets compared with EPA's proposed single market. Sources that can reduce NO_x emissions at lower marginal costs will have fewer potential buyers for the allowances they make available.[5] In addition, with fewer participants than a regionwide market, the market in each zone could be less competitive. Further, that approach would carry higher costs because of the need to administer a separate cap-and-trade program for each zone.

The location-weighted emissions approach would also involve higher administrative costs than the type of trading program that EPA now envisions. Program officials would have to specify the required number of allowances per ton of NO_x emitted from different sources.[6] In addition, to capture the cost savings

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4. This location-weighted emissions approach is analogous (subject to appropriate initial allocations) to establishing different trading ratios based on the location of the trading parties. Under a trading-ratio approach, sources do not trade allowances on a one-for-one basis. Instead, a ton of emissions reduced at one source trades for "x" tons of emissions released at another source. The value of "x" reflects the sources' marginal impact on areas' compliance with the ozone standard. The advantage of the location-weighted emissions approach is that it avoids the high transaction costs associated with the trading-ratio approach. Sources simply need an appropriate number of one-ton allowances to cover their emissions. A source determines that number by multiplying its emissions by the number of allowances required per ton released at its location.

5. Allowing one-way trades across appropriate boundaries could ease, but not eliminate, that problem. For example, California's South Coast Air Quality Management District established two zones for its NO_x and SO_2 (sulfur dioxide) trading program. Although sources in the coastal zone generally cannot use allowances from the inland zone, any source can use coastal zone allowances regardless of its location. That feature allows shifts in emissions away from zones subject to more stringent levels of control. In theory, such trades should be unlikely because marginal costs of abatement should be higher in those zones. Nevertheless, if the cost difference is reversed (because of the characteristics of certain sources), allowing one-way trades makes both economic and environmental sense.

6. The costs of notifying sources and monitoring their compliance are relatively minor. EPA notes, however, that substantial resources could be required to defend decisions that impose different compliance burdens on different sources (personal communication with Brian McLean, Director, Acid Rain Division, Environmental Protection

associated with that approach, officials would have to recalculate the states' emission budgets to correspond to a higher overall cap.[7]

However, the location-weighted emissions approach would avoid the limits on trading associated with the zone approach. Because all potential participants would be in the same market, they could fully capitalize on opportunities for cost-saving trades.

The other important advantage of the location-weighted emissions approach (compared with the trading-zone approach) is its flexibility. Assessing the extent to which the available scientific evidence can justify geographic targeting is beyond the scope of this paper.[8] At best, current understanding of ozone formation and variable patterns of ozone transport may only support modest implementation of geographic targeting. The location-weighted emissions approach provides a more adaptable mechanism through which to incorporate evolving scientific understanding about sources' relative contributions to violations of the standard. Initially, program officials could start with a trading program like the one envisioned by EPA by simply requiring one allowance for each ton of NO_x emitted, regardless of the location of its source. At predetermined intervals, program officials could change that requirement, making broad or fine distinctions between geographic areas, if the available scientific evidence supported that.[9]

Agency). For example, it is not true that the acid rain damage from a ton of SO_2 emissions is the same regardless of the source's location. Like ground-level ozone, acid rain varies considerably by area, in part because of long-range transport, but the impact of emissions tends to be greatest in areas where they are released. Since ecosystems also differ in their sensitivity to acid rain, the marginal damage caused by a ton of emissions varies widely. Although it is scientifically inaccurate to say that the location of SO_2 emissions does not affect the level of damages from acid rain, this regulatory fiction has proved to be very useful. It has made the goal of the acid rain program a reduction in overall emissions, thus avoiding the need to identify damages and specify responsible parties.

7. The location-weighted emissions approach requires more than one allowance per ton of NO_x emitted from sources that contribute significantly to violations of the ozone standard in the region. To preserve the incentive for greater reductions at those sources, officials would not want to give them the additional allowances created under the increased emissions cap. Instead, they would want to allocate those allowances among other sources.

8. Nonetheless, the prospects for geographic targeting merit some consideration. For example, state officials have expressed concern that compliance with the ozone standard could depend on what pattern of emissions results from the trading program that EPA envisions. Under the location-weighted emissions approach, officials could simply weight emissions from different sources more or less heavily—requiring a higher or lower number of allowances per ton of NO_x released—according to the sources' relative impact on areas' compliance with the standard. EPA expects to complete a modeling analysis over the next few months that will show predicted changes in ambient concentrations of ground-level ozone under its proposed trading program (personal communication with Norm Possiel of EPA, March 12, 1998). The agency's April 28, 1998, supplemental notice of proposed rulemaking reports the results of a modeling analysis that shows predicted changes in ozone concentrations throughout the region if each state meets its own NO_x emission budget without trading. See Environmental Protection Agency, *Supplemental Notice for the Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone*, April 28, 1998 (available at http://www.epa.gov/ttn/oarpg/otagsip.html).

9. Officials would also have the opportunity to address changes in the electric power industry that influenced emission patterns and thus areas' status with respect to the ozone standard. Any advisable changes in the value of weights would require recalculating states' emissions budgets to correspond to changes in the overall cap.