Chapter 7

Legislating Emissions Reductions

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Chapter 6 presented four approaches available to Congress for addressing transported air pollutants. Under the first approach—further controlling the sources of pollutant emissions—three options were discussed. These correspond to broad *strategies* for further emissions control: mandating a small-scale emissions reduction program; mandating a large-scale program; and establishing a control program based on an environmental quality standard.

If Congress decides to enact an emissions control program at this time, the choice of one of these three broad strategies is only the first step in designing legislation. Policy makers would also have to make a number of complex, interrelated decisions to specify the *details* of the chosen strategy. For example, more than 10 bills before the 98th Congress propose large-scale emissions reductions, but the differences among them are substantial.

Accordingly, this chapter is intended to serve as a guide for turning the broad emissions control strategies presented in chapter 6 into a legislative proposal. It also provides a framework for evaluating specific provisions of the many acid deposition control bills introduced to date. The chapter expands on the brief discussion of the eight control-policy decisions presented in the previous chapter. Table 6 summarizes the eight decisions, along with their corresponding options.

Other transported air pollutants, such as ozone and airborne sulfates, will be mentioned where appropriate, but detailed options for controlling them, either separately or in combination with acid deposition, are not presented. Where possible, each discussion will assess the current state of knowledge, the possibility of acquiring further relevant information in the near future, and the societal value choices involved.

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SOURCE: Off Ice of Technology Assessment.

Decision 1: Which Pollutants Should Be Further Controlled?

Discussion:

Most acid rain control proposals to date have focused on reducing emissions of sulfur dioxide. There are several reasons for this.

Substantially greater amounts of sulfur dioxide are released into the atmosphere in the Eastern half of the United States than nitrogen oxides. Eastern U.S. sulfur dioxide emissions in 1980 were about

22 million tons, whereas nitrogen oxides emissions were about 14 to 15 million tons. Sulfur dioxide and its transformation products currently contribute about twice as much to ***precipitation acidity*** in the Northeast as do nitrogen oxides.

Once deposited, sulfur compounds are more likely to threaten natural ecosystems than nitrogen compounds. While sulfur and nitrogen are both essential nutrients in soil ecosystems, most Eastern forests require and retain far greater amounts of nitrogen than of sulfur. Consequently, sulfur compounds are more likely to travel through watersheds and increase the acidity of water bodies, while nitrogen compounds are more frequently taken up by plants before they reach lakes and streams. * Finally, approaches to controlling sulfur dioxide are more developed than for nitrogen oxides.

Nitrogen oxides emissions, however, are expected to contribute an increasing share to Eastern acid deposition, as nitrogen oxides emissions are projected to rise at a faster rate than sulfur dioxide emissions. In the Western United States, nitrogen compounds currently contribute as much to precipitation acidity as sulfur compounds do, and in many regions a greater amount. Nitrogen oxides are also involved in the production of ozone, a transported air pollutant known to damage crops and forests.

Air concentrations of both nitrogen oxides and hydrocarbons influence the rate at which sulfur dioxide is transformed to sulfates. Model-based studies indicate that altering nitrogen oxides and hydrocarbon concentrations does not affect total sulfur deposition nearly as much as does directly reducing sulfur dioxide concentrations. The presence of these "co-pollutants' can alter wet sulfur deposition, but does not significantly affect dry sulfur deposition. The limited understanding of atmospheric chemistry, however, provides little guidance for designing a control program involving these pollutants ***along with*** sulfur dioxide. Appendix C discusses how these other pollutants may potentially affect the amount of sulfur deposited within the Eastern United States.

* Nitrogen compounds deposited in snowfall are of greatest concern to aquatic ecosystems when they are released during spring snow melt. The "acid shock" caused by the acidity released from snow melt occurs during spawning periods, when fish populations are most susceptible to damage.

Conclusions and Options:

Three pollutants are possible candidates for acid deposition control: sulfur dioxide, nitrogen oxides, and hydrocarbons. Any program to control Eastern levels of acid deposition should include reductions in sulfur dioxide emissions. Depending on the desired degree of resource protection and geographic extent and scheduling of the control program, other pollutants might be included as well.

Options available to the Congress are described below.

Option la: Reduce Emissions of Sulfur Dioxide

Over the Eastern United States, deposition of sulfur oxides is generally greater than deposition of nitrogen oxides. In addition, sulfur oxides appear to have greater potential for damaging ecosystems and degrading visibility, and are of concern because of possible health effects from airborne sulfates. While co-pollutants may affect the ***degree*** to which cutting back sulfur dioxide reduces deposition, reducing sulfur dioxide emissions is the most plausible means of reducing acid deposition in the Eastern United States.

Option lb: Reduce Emissions of Both Oxides of Sulfur and Nitrogen

While cutting back sulfur dioxide emissions ***alone*** may substantially reduce Eastern acid deposition, controlling nitrogen oxides emissions ***in addition*** to sulfur oxides would provide further protection to sensitive natural resources. Currently, nitrogen oxides are the second greatest manmade source of acidity. Nitrogen oxides emissions, however, have increased much more rapidly than sulfur dioxide emissions during the past few decades, and are projected to increase an additional 25 percent by 2010. Thus, they will contribute an increasing share of acid deposition. Reductions of nitrogen oxides emissions would also help lower regional ozone levels.

Congressional action to reduce acid deposition in the Western United States, if desired, must also address nitrogen oxides emissions. A nationwide acid deposition control program might therefore involve both pollutants.

Option 1c: Reduce Emissions of Sulfur Dioxide, Nitrogen Oxides, and Hydrocarbons

Sophisticated models of both the chemistry and meteorology of the atmosphere may eventually make it possible to design more cost-effective strategies relying on control of all three pollutants involved in acid deposition. The modeling capability to design such a strategy for a near-term control program, however, does not yet exist; and it is uncertain whether this capability will be available within the next decade. Such multiple-pollutant control might best be considered for future refinements to an ongoing acid deposition control program.

Decision 2: How Widespread Should a Control Program Be?

Discussion:

Most of Eastern North America—from southern Ontario and Quebec to northern Mississippi, Alabama, and Georgia, and from the Atlantic Coast as far west as the Mississippi River—receives precipitation more acidic than pH 4.5. This area includes large regions with lakes and streams considered sensitive to the effects of acid deposition at this level.

While a substantial fraction of pollutant emissions is deposited locally, the remainder travels with air masses moving over a region, and is deposited at distances and directions determined by prevailing chemical and meteorological conditions. Pollutants contributing to acid deposition may travel well over 500 miles. A large share of sulfur deposition—in some regions, over half-originates from sources over 300 miles away. For example, model analyses suggest that 50 to 70 percent of the sulfur deposited in northern New York State, New England, and parts of southeastern Canada is emitted from sources more distant than 300 miles. * Consequently, acid deposition is regional in scope: emissions sources in a multi-State region contribute to deposition in many other regions, depending on complex and variable atmospheric conditions.

Many legislative proposals to date have focused on a 31-State region encompassing the States east of, and the first tier of States west of, the Mississippi River. Of the 26 to 27 million tons of sulfur dioxide emitted in the continental United States in 1980, about 22 million tons, or 80 to 85 percent, came from this 31-State region. In addition, sulfur dioxide control proposals have focused on electric utilities, which emit about three-quarters of Eastern sulfur dioxide. In the West, utilities emit about 30 percent, while industrial sources emit about 60 percent (half of which comes from smelters). The prevailing use of low-sulfur coal in the West results in significantly lower sulfur dioxide emissions rates.

Of the 21 to 22 million tons of nitrogen oxides emitted in the continental United States in 1980, about two-thirds, or 14 million tons, came from the 31-State region. In the East, about 35 percent came from utility combustion and about 15 percent from nonutility combustion. In the West, utilities contribute about 20 percent and nonutility combustion about 30 percent of the total. Mobile sources emit about 45 percent of nitrogen oxides in both regions.

As discussed in Decision 1, either sulfur oxides, nitrogen oxides, or some combination of the two could be controlled uniformly across the chosen region, or separately for subregions within it. Table 7 shows emissions data for the United States as a whole and for several regional breakdowns.

Conclusions and Options:

All of the legislative proposals to control acid deposition to date have included emissions reductions in, at least, the 21 Northeastern States. We present four possible emissions control regions—all of which include this region, but extend south and west depending on the geographic extent of resource protection desired. Congress could specify the size of the control region directly in legislation, or require EPA to establish a control region that best meets congressional goals.

Congressional options are described below.

Option 2a: Require Emissions Reductions From 21 Northeastern States

Given the geographic extent of sensitive resources exposed to high levels of acid deposition and the

● These model-based analyses are discussed more thoroughly in ch. 3 and app. C.

Table 7.-Sulfur and Nitrogen Oxide Emissions by Region

	SO_2 emissions (thousand tons)	Percent of U.S. total	NO_x emissions (thousand tons)	Percent of U.S. total
48 States.	26,420	100 "/0	21,120	100 "/0
37 States.	23,640	89	17,910	85
31 States.	21,810	83	14,000	66
21 States.	16,540	63	9,720	46
Rockies, west.	2,780	11	3,210	15
17 Western States	4,620	17	7,120	34

SOURCE: *Costs. and Engineering Assessment,* Work Group 3B, United States-Canada Memorandum of Intent on Transboundary Air Pollution, June 15, 1982.

average distance of pollutant transport, we feel the smallest effective control region would consist of the States east of the Mississippi River and north of (and including) Tennessee and North Carolina. This region roughly covers the portion of the United States receiving the most acidic precipitation—in 1980 averaging lower than pH 4.5, a level thought to harm sensitive lakes and streams. About 65 percent of the Nation's sulfur oxides and 45 percent of its nitrogen oxides are emitted in this region.

The region excludes, however, several major emission-producing contiguous States—i. e., Missouri, the fifth largest sulfur dioxide-emitting State, and the southern States of Georgia, Alabama, and Florida. Major nitrogen oxide-emitting States that border the region are Louisiana, Missouri, and the above-mentioned Southern States.

Option 2b: Require Emissions Reductions From 31 Eastern States

This region consists of those States east of and bordering on the Mississippi River, and has been the focus of most legislative proposals and control strategies to date. It emits about 80 to 85 percent of the Nation's sulfur oxides and 65 percent of its nitrogen oxides, One large emitter, Texas, borders this region, ranking sixth-highest in sulfur dioxide and first in nitrogen oxide emissions among the 50 States. Texas utilities generally emit sulfur dioxide at relatively low rates, however, averaging 0.3 lb per million Btu fuel burned.

Option 2c: Require Emissions Reductions From the 37 Eastern States

This region encompasses all States east of the Mississippi, plus two tiers of Western States, i.e., the States east of the Rocky Mountains. This region emits about 90 percent of the Nation's sulfur oxides and 85 percent of its nitrogen oxides. Because emissions rates in the six additional States are relatively low, applying most of the current acid rain control proposals to this region would not appreciably change reductions required from the 31 Eastern States.

Option 2d: Require Emissions Reductions From the Entire 48 Contiguous States

This option treats acidic deposition as a national problem and requires all regions to further control emissions. While effects from acid deposition are currently of greatest concern in the East, highly acidic precipitation events have been observed in parts of the Western States. As discussed previously, different pollutants might be controlled in the East (where sulfur dioxide is the major pollutant) and the West (where nitrogen oxide emissions are greater).

Option 2e: Allow EPA To Define the Appropriate Control Region

Rather than legislating a specific control region, Congress could define the goals of a control program and require EPA to establish the control region by a specified date. EPA could then use information available at that time (e. g., pollution transport models, maps of sensitive regions, control cost estimates) to demarcate a region consistent with congressional guidelines.

Decision 3: What Level of Pollution Control Should Be Required?

Discussion:

The decision on how much to reduce emissions must take into account two important components:

1) the scientific *question* of the relationship between emissions reductions and resource protection, and 2) the policy ***question*** of what is the socially desirable level of resource protection. The latter involves such policy concerns as balancing the costs of reductions with the expected resource-protection benefits, and distributing the risks and costs equitably among different groups and geographic areas.

No unique ' 'formula" exists for comparing the risks of resource damage with the costs of further emissions controls. Neither scientific nor economic methods can presently analyze the various policy concerns precisely. Moreover, differing priorities among regions and interest groups will lead each to weigh these concerns differently. Several reference points are available, however, for comparing both the benefits and costs of various levels of reduction.

Several groups[1] have estimated maximum levels of acid deposition that most sensitive lakes and streams could receive without undergoing further damage. Specifying deposition limits to protect against damage to such other resources as crops, forests, or materials is not yet possible.

OTA's analysis of how emissions reductions would affect deposition levels concludes that in areas of highest deposition—e. g., western Pennsylvania and northern West Virginia—reducing sulfur dioxide emissions 8 to 10 million tons per year below current levels ***might not*** be sufficient to bring deposition levels within these recommended targets for protecting all *but the most sensitive* aquatic resources. In areas of lower deposition, such as northern New England, the southern Appalachians, and the upper Midwest, the recommended deposition limits ***might*** be achievable through sulfur dioxide emissions cutbacks of this magnitude. Thus, reductions of this magnitude would probably *not overshoot* a possible congressional goal of protecting all but the most sensitive aquatic resources.

[1] Work Group 1, Impact Assessment, U.S.-Canada Memorandum of Intent on Transboundary Air Pollution, *Phase II Summary Report,* October 1981; National Research **Council,** ***Acid Deposition,*** *Atmospheric Processes in Eastern* ***North America,*** Committee on Atmospheric Transport and Chemical Transformation in Acid Precipitation (Washington, D. C.: National Academy Press, 1983); L. S. Evans, et al., "Acidic Deposition: Considerations for an Air Quality Standard, " *Water, Air and Soil Pollution* 16:469-509, *1981.*

Risks of damage to sensitive forests, materials, and crops would also be reduced. In addition, airborne fine-particulate levels would be lower, improving visibility and reducing risks to human health.

Whether this is the ***desired level*** of protection must be addressed, however. Reducing emissions by about 8 to 10 million tons of sulfur dioxide per year below current levels (including offsets for expected new growth) would cost about $3 to $6 billion per year (1982 dollars), depending on the design of the program. Smaller, less expensive cutbacks will provide less protection for sensitive resources, but how much less is unknown. Larger emissions reductions might protect more resources, but the costs would rise steeply.

In addition to preventing potential future damages, reductions might improve water quality in currently acidified lakes and streams. Projections from a simple computer model have been used to estimate how reductions in sulfate deposition might improve water quality. * If sulfur dioxide emissions were reduced to 8 to 10 million tons below 1980 levels, about 15 to 40 percent of the aquatic resources already acidified or extremely sensitive to further acid deposition might experience some recovery.

With emissions about 4 to 5 million tons below 1980 levels, we estimate that water quality will improve in a maximum of 10 to 25 percent of these aquatic resources. Reductions of this magnitude, including offsets for emissions growth, might be achievable for $1 to $3 billion per year (1982 dollars).

Congress, however, might decide that the uncertain magnitude of benefits to be gained does not justify such multibillion-dollar expenditures. Holding emissions levels constant, or possibly decreasing them slightly below current levels, might be considered more appropriate until more is known about the extent of the risks to sensitive aquatic resources, forests, agriculture, materials, and human health. For expenditures of about $1 billion per year or less, about 2 to 5 million tons of sulfur dioxide can be

* This model assumes that the effects of acid deposition are not cumulative and ***are*** reversible in a short time period. If these conservative assumptions are incorrect, the level of recovery will be slower.

eliminated annually—certainly enough to offset projected emissions growth through 2000, and possibly to decrease emissions levels 2 to 3 million tons below 1980 levels by that time. This is likely to provide some benefit to sensitive resources but, again, such benefits cannot be quantified accurately.

Given the uncertainty that reducing emissions will decrease resource damage to the extent, and in the locations expected, and the resulting difficulty in estimating the benefits, policymakers may have to determine the level of emissions reductions qualitatively. Even if both the benefits and costs of emissions reductions could be rigorously quantified--e.g., by the multiyear research program currently under way in EPA and other agencies—several other factors would enter into the decision.

Many of the resources at risk from continued acid deposition, such as lakes and forests, provide benefits that cannot be calculated solely in economic terms. While these resources do generate income—e.g., freshwater fishing and forestry are multibillion-dollar industries—they are valued for noneconomic reasons as well. Similarly, losses in employment in the high-sulfur coal industry from emissions reductions may cause greater hardships than estimates of lost income indicate.

Finally, benefits and costs of controlling transported pollutants differ substantially among various economic sectors and geographic areas within a control region. Calculating aggregate benefits and costs for the entire affected region ignores these distributional effects.

Conclusions and Options:

Congress could specify emissions reductions to reach a socially desired level of resource protection, considering the costs of further emissions control, the potential resource protection benefits, and other policy concerns, The level of reduction chosen, however, must of necessity be a "best guess" based on incomplete information.

For expenditures of $1 billion per year or less, enough sulfur dioxide emissions could be eliminated to hold emissions constant (i. e., offset expected industrial and utility growth), or to reduce emissions levels 2 to 3 million tons below current levels by the year 2000. This would reduce future risks to sensitive aquatic resources, forests, agriculture, materials, and health, but by how much is uncertain. Eliminating 8 to 10 million tons of sulfur dioxide annually from existing utilities by this date would cost $2 to $5 billion per year.

Reductions of this magnitude might protect all *but the most sensitive* aquatic resources in many areas, but might not afford this level of protection in areas currently receiving the highest levels of acidic deposition. The level of emissions reductions necessary to protect against potential damage to such other resources as crops, forests, or materials is not yet known.

Once the aggregate regional level of emissions reductions is chosen, Congress must further decide whether the control program should be designed to accomplish: 1) a ''one-time' emissions reduction (i. e., eliminating a specified emissions tonnage from existing sources, but not restricting future emissions growth), or 2) an absolute ''ceiling' on regional emissions, thus requiring further reductions as new sources are built.

An increase of about 1 to 3 million tons of sulfur dioxide emissions per year is projected by 1995. The highest rates of emissions growth are expected in the South and the West. Thus, an absolute ceiling on emissions would be difficult to achieve in these regions, as well as in those States that currently have low emissions rates.

Alternatively, Congress could give EPA responsibility for setting reduction levels.

Options available to Congress are described below.

Option 3a: Mandate Specific Levels of Emissions Reductions

A congressionally mandated emissions control program could range from preventing projected increases in emissions to large-scale reductions below current levels. In the Eastern 31-State region, a pragmatic estimate of about 11 to 12.5 million tons of sulfur dioxide per year constitutes the upper limit of feasible emissions reductions, given current technology and costs. Larger reductions would require stricter emission rate limitations for all ***existing*** utility plants than those currently applicable to ***new*** plants under New Source Performance Standards.

Table 8 presents estimates of the costs of controlling ***utility*** sulfur dioxide emissions in the Eastern 31 States. Cost estimates are for control strategies based on specified maximum allowable emission rates, assuming 1980 emissions and emission rates. The costs of other programs will vary, depending on how emissions reductions are allocated and implemented. However, both the amount of sulfur dioxide emissions eliminated from existing facilities and the extent of future emissions growth determine the net reductions at any future date. Future emissions growth in the region might shrink the reductions presented in table 8 by about 1 to 3 million tons per year by 2000.

Option 3b: Mandate Reductions, Including Offsets for Future Emissions Growth

If Congress specifies emissions reductions, it must also determine how to treat future growth in emissions. For example, added emissions from ***new*** sources would shrink an 8-million-ton cutback in sulfur dioxide emissions from ***existing*** sources to an overall reduction of 5.5 to 6.5 million tons below current levels by 1995. This might be considered adequate through about 2000, when the effectiveness of the program can be reevaluated.

However, to reduce overall emissions by, for example, 8 million tons below current levels by 1995, existing sources would have to reduce emissions by 9.5 to 10.5 million tons. To offset emissions from sources not yet built— already subject to tight control under current New Source Performance Standards—State plans would have to eliminate enough ‘‘extra’ current emissions to accommodate potential future emission levels, or face the risk of discouraging new industrial or utility growth.

For the more stringent emissions control programs listed in table 8, offsetting future emissions growth as well might cost an additional $1 to $2 billion per year.

Option 3c: Require EPA To Specify Emissions Reductions To Meet Congressional Goals

Congress could give EPA responsibility for setting reduction levels by a given date, according to specified congressional goals for resource protection and economic considerations. EPA could then incorporate emerging research findings into its technical judgment of what level of reductions are consistent with congressional goals. The choice could be left completely to EPA discretion, or be bounded by the Congress (e. g., eliminating 2-to-5 million, or 5-to-10 million tons of sulfur dioxide emissions).

Scientists might soon be able to ***estimate*** the extent of aquatic resource protection afforded by various levels of emissions reductions, but might require many years to develop similar estimates for other resources. Nonetheless, such estimates, even for aquatic resources, are likely to remain controversial for many years, due to uncertainties over how reductions in emissions would affect deposition levels, and how reductions in deposition levels would affect aquatic resources. If Congress required EPA to weigh the benefits and costs of emissions reductions, it would also need to specify the economic goals to be met, the kinds of benefits to be included in calculations, and the treatment of regional differences in costs and benefits.

Table 8.—Costs of Reducing Sulfur Dioxide Emissions in the Eastern 31 States (Excludes costs to offset future emissions growth; all costs in 1982 dollars)

Emission rate limitation (lbs. SO_2/million Btu)	Emissions reductions (million tons SO_2)	Total cost[a] ($ billions)	Average cost of reductions ($/ton)	Marginal cost of reductions ($/ton)
2.5	4.6	0,6-0.9	170-240	320
2.0	6.2	1.1-1.5	200-280	440
1.5	8.0	1.8-2.3	260-330	700
1.2	9.3	2.6-3.4	310-400	740
	10.3	3.2-4.1	350-440	830
0.8	11.4	4.2-5.0	400-480	1,320

aExcludes costs to meet current SIPs
bCost *(in dollars* per ton) to achieve the next increment of reductions.

SOURCE: Office of Technology Assessment, based on analyses by E. H. Pechan & Associates, Inc., 1983.

Decision 4: By What Time Should Reductions Be Required?

Discussion:

This decision focuses on the tradeoff between the risk of resource damage from continued levels of acid deposition, and the risk of inefficient or unnecessary control expenditures by acting on limited knowledge of many of the atmospheric and ecological processes involved. Throughout the discussion, it is necessary to keep in mind that further emissions controls would take at a minimum about 6 to 10 years to implement, given the planning, contracts, construction, and other steps necessary to significantly reduce pollutant emissions.

A **"fast-track' program—one requiring emissions reductions in 6 to 10 years—could probably be met only if Congress directly specified the amount of reductions.** Such a program would require individual control decisions to be made quickly; even then, if large-scale reductions were mandated, it might not be possible to install scrubbers and expand low-sulfur coal supplies rapidly enough to meet the deadline.

Waiting 4 to 6 years for further research results would increase the time required to reduce deposition to 10 to **16 years, but might lead to a better control program. During the waiting period, knowledge of acid deposition and its effects will advance, and more cost-effective control technologies might be developed. However, it is not possible to count on significant scientific breakthroughs in this relatively short time.**

An intermediate schedule could mandate reductions now, but allow more time for implementation than the ' 'fast-track' program. The program could be designed to incorporate results from the Federal acid deposition research program in about 3 to 5 years, to determine whether the control program should remain intact, be modified, or be discontinued. Federal and State planning processes could proceed without delay—recognizing that the research program might not substantially alter current understanding-but such a program would not require additional pollution control expenditures until ***after*** the reevaluation point.

Innovative approaches to pollution control—e.g., technologies such as LIMB (limestone injection multistage burners) or regenerable processes, discussed in appendix A—raise additional scheduling-related issues, as they may take longer to plan and install than more traditional approaches. Congress could provide incentives to try these potentially more cost-effective technologies by extending compliance deadlines when they are used.

Conclusions and Options:

A major emissions control program would require, at minimum, about 6 to 10 years to implement. A longer compliance period might be desired to allow policy makers the opportunity to consider the results of the Federal acid deposition research plan. The additional delay, however, might result in more extensive resource damage.

Options available to the Congress with regard to scheduling emissions reductions are described below.

Option 4a: Require Reductions in 6 to 10 Years

Achieving significant reductions within 6 to 10 years would probably require Congress to specify emissions reductions or emission rate limitations. State-level planning and source-level implementation of reductions would have to proceed rapidly. Federal and private-sector acid precipitation research findings might occur too late to be used for modifying the program.

Option 4b: Require Reductions in 10 to 16 *Years, Allowing a Delay for Research*

Delivery of Federal research results in 4 to 6 years could serve as the starting date for planning specified reductions or an environmental quality standard. Compliance with the program would then require an additional 6 to 10 years.

Option 4c: *Require Reductions* in 8 to 12 *Years, With a "Mid-course' Reevaluation*

Federal and State planning could begin immediately, but the compliance date could be set so that individual sources would not have to begin planning construction and contracts until after a reevaluation period in about 3 to 5 years. New research results, if any appeared, could be used to determine whether the control program should remain intact, be modified, or be eliminated.

Option 4d: Stagger Compliance Schedules

To promote potentially more cost-effective technologies, sources using innovative emissions control approaches could be given extra time to comply with any of the schedules outlined in options 4a through 4c.

If interim reductions are desired in conjunction with longer compliance schedules (e. g., options 4b and 4c), earlier reductions could be required from sources switching to low-sulfur fuels or from those sources emitting at the highest rates. Mandatory coal washing, though more expensive than approaches that allow each source to choose its least-expensive alternative, is another method for achieving interim reductions. This alternative has the advantage of being potentially less disruptive to the coal industry.

Decision 5: What Approach to Control Should Be Adopted?

Discussion:

Several regulatory frameworks are available to the Congress for controlling transported air pollutants. These fall into two broad categories:

1. "Environmental quality" approaches—setting goals or standards for ***resource exposure*** to pollutants—including:
   - Establishing environmental quality goals or standards based on *air* ***concentrations*** of pollutants.
   - Establishing environmental quality goals or standards based on pollutant ***deposition rates.***
2. "Source-based" approaches—directly regulating ***emissions*** from sources or regions—including:
   - Specifying *total* emissions reductions (in tons of pollutants per year), or allowable pollutant emission *rates* (most commonly expressed as pounds of pollutant per unit of fuel burned for stationary sources, and grams of pollutant per mile for automobiles).
   - Requiring either specific *types* of control technologies (e. g., scrubbers), or technology-based *performance* standards.

Air quality goals are currently implemented through both approaches. For example, National Ambient Air Quality Standards (NAAQS) are ***environmental quality*** standards, Allowable air concentrations of pollutants are set to protect the public health and welfare. New Source Performance Standards (NSPS) are ***source-based*** standards. They seek to minimize ***future*** pollutant emissions by regulating emission rates, even for cases in which NAAQS would be met without their use. NSPS for coal-fired utilities both set a maximum allowable emissions rate and require the removal of 70 to 90 percent of potential sulfur dioxide emissions by technological means.

NAAQS might be used as a framework for controlling transported pollutants. Welfare-based secondary standards for these pollutants could be made more stringent and enforced more rigorously. Such an approach might be effective for controlling resource damage from ozone. To address acid deposition, Congress could require EPA to establish NAAQS for sulfate and nitrate particulate, the principal transformation products of sulfur dioxide and nitrogen oxides. To make the NAAQS approach effective, EPA would have to broaden its consideration of long-range pollution transport.

The NAAQS are ***air*** concentration standards, however, designed to minimize human health effects from breathing pollutants, crop and forest damage from exposure to pollutant gases, or materials damage from exposure to gases or particles. A different type of environmental quality standard—a ***deposition*** **standard-would be more consistent with our understanding of the environmental effects of acid deposition. Though conceptually attractive, a deposition standard would be quite difficult to implement. Natural variations in precipitation and wind patterns can cause an area's deposition to vary considerably from year to year.**

Due to the many source regions and sensitive receptor regions involved, designing measures to comply with the standards, either at the Federal or State level, would be a difficult and time-con-

suming administrative and political process. Moreover, while existing models can link large source regions to large receptor regions, identifying specific sources responsible for deposition in specific areas far downwind is beyond their current capabilities.

A *source-based* approach—the one embodied in most of the acid rain control proposals to date—would require emissions reductions throughout a ***broad region*** believed to contribute to acidification in sensitive areas. Unlike deposition standards, the implementation of source-based approaches is not restricted by the major uncertainties and inherent characteristics of the acid deposition problem. Two types of source-based regulatory approaches are possible: 1) directly specifying emissions reductions or allowable emissions rates, and 2) limiting emissions by requiring the use of specific technologies or technology-based performance standards.

The first approach can be used either to directly control sources or to assign reductions to regions, leaving the choice of which sources to control to another decisionmaking body. The advantages and disadvantages of these alternatives are discussed in ***Decision 6: How Should Emissions Reductions Be Allocated?***

Specified emissions or emissions rates give each emitter the option of choosing the least expensive control method, according to individual plant conditions. The second approach—technology-based standards—reduces or eliminates a plant's options. Technology-based standards, however, avoid some of the adverse effects of 'nontechnological' methods of pollution control—i. e., switching to cleaner fuels. Technological standards would minimize production and employment losses in many Eastern U.S. coal regions. As discussed in detail in Decision 8, there is a tradeoff between minimizing these adverse, indirect effects of control, and allowing emitters to choose the least expensive control method.

Conclusions and Options:

If Congress decides that an acid deposition control program should be implemented in the near future—within about 10 to 15 years-several "source-based' approaches to control are feasible. A control program based on an "environmental quality" standard (similar to the ambient air quality standards of the Clean Air Act) might be possible in the future, but the scientific tools needed to support such an approach are not yet available.

Options available to Congress are discussed below.

Option 5a: Directly Specify Emissions Reductions or Emissions Rate Limitations

Emissions limitations may be specified for either a class of sources or by region. Decision 6 discusses the distributional implications of various kinds of reduction programs. The approach presumes that the effects of acid deposition are significant enough to warrant emissions reductions, but that scientific uncertainties permit no more resolution in a control approach than to reduce aggregate, regional emissions. Limiting emissions by region or source category may involve inefficiencies in that it does not specifically seek to connect the location and amount of emissions to the location and sensitivity of areas of deposition. This approach, however, best reflects current knowledge about the relationship between emissions and acid deposition.

Option 5b: Specify the Use of Control Technologies

Emissions could also be reduced by specifying technology performance standards (e. g., 50-percent reduction, "best available, " and so on) or mandating the use of specific technologies (e. g., coal washing). Like option 5a, the approach does not depend on linking source regions to receptor regions.

Technology-based standards are potentially more expensive than a control program that allows each emitter to meet the required reductions through the least-expensive (or otherwise advantageous) method of control. Technology standards are administratively simple, however, and would minimize coal market disruptions that might result from other approaches to control. (Potential effects on coal production are discussed in detail in Decision 8.)

Option 5c: Specify an "Environmental Quality Standard" Approach

Acid deposition control strategies could be pursued by: 1) establishing and enforcing more stringent secondary NAAQS for sulfur dioxide and nitrogen oxides, or 2) developing NAAQS for air concentrations of sulfates and nitrates. Secondary NAAQS for ozone are currently identical to the health-based primary standard—a l-hour maximum allowable concentration. A secondary standard based on a longer averaging time might better reflect potential terrestrial resource damages from chronic ozone exposure.

Alternatively, to control acid ***deposition,*** standards could be developed to limit the rate of deposition of acidity or sulfur and nitrogen compounds over a given surface area, These standards could vary regionally, depending on the sensitivity of resources to acid deposition.

Because transported air pollutants routinely cross State boundaries, implementing an environmental quality standard to control transported pollutants would require Federal or regional mechanisms for revising State Implementation Plans to meet the new standards. This strategy is constrained by the problem of linking well-defined source areas to well-defined receptor areas—a scientific question that may not be resolved for many years. Even if transport models were improved, the inherent variability of the atmosphere would require limiting the total amount of pollutants emitted from a State or similar-size region, rather than setting emissions limits for individual sources. Moreover, this approach would involve a long and detailed standard-setting and implementation process. *

Decision 6: How Should Emissions Reductions Be Allocated?

Discussion:

Strategies for controlling transported air pollutants must address the following issues:

- Who is to allocate emissions reductions to sources or States?
- If Congress chooses to allocate reductions directly, what method should be used?

*For purposes of comparison, although Clean Air Act revisions in 1977 directed EPA to review and revise the existing NAAQS for five pollutants by 1980, as of 1983 only the standard for ozone had been revised. A revision had been proposed for carbon monoxide; the standards review of the remaining three pollutants will probably be completed by the end of 1984.

The question of who is to pay the control costs—a matter distinct from who is to reduce emissions—is discussed in Decision 7.

Two approaches are available to Congress for directly specifying emissions reductions: 1) mandating a reduction formula for all or a subset of individual sources within the region, or 2) allocating reductions to States or other subregions, allowing another decisionmaking group, such as a State or EPA, to allocate emissions reductions to individual sources.

Congress could also allocate emissions reductions indirectly by assigning responsibility for designing allocation schemes, either with or without accompanying guidelines. Congress might set a goal of reducing deposition within a specified region, recognizing that a wide variety of allocation formulas could achieve that goal. Reductions from one subregion could be substituted for those in a different subregion, within certain bounds, while still maintaining the same average pattern of deposition reductions.

Congress might provide additional guidelines—for example, that the eventual formula allocate reductions on the basis of the current best estimates of how much sources contribute to deposition in given areas. Other guidelines might include minimizing costs to the control region as a whole, limiting the percentage of emissions to be eliminated in any given region, or considering past pollution control efforts.

Four broad policy considerations are pertinent to designing an allocation formula for reducing emissions, or providing guidelines for others to follow:

- Who is to gain the benefit of resource protection,
- Who is to bear the burden of reductions,
- The plan's administrative efficiency, and
- The plan's economic efficiency.

In planning an allocation formula, tradeoffs among these various interrelated concerns must be considered. For example, a plan that attempts to maximize economic efficiency may be difficult to administer, or might concentrate reductions in one or more regions.

Political consideration of "Who is to gain the benefit of resource protection" is intertwined with several of the issues discussed previously. Congress could either attempt to reduce deposition in selected high-deposition areas with large concentrations of sensitive resources, or attempt broader-scale protection. A uniform deposition standard, for example, implies the goal of protecting all areas equally, regardless of their concentrations of sensitive resources. Targeting specific areas for deposition reductions, however, favors one State's resources over another's.

The decision on who reduces emissions must consider the scope of desired resource protection, as well as other aspects of any allocation scheme. A plan that provides uniform protection might disperse the required reductions over a larger area than one focusing on sensitive regions. In addition, each specific formula affects the relative share allocated to utilities as opposed to industries; regions whose local coals are higher or lower in sulfur content; and so on.

Allocating reductions on the basis of emissions per area differs in costs and distributional implications from a plan based on an allowable pollutant emission rate per amount of fuel burned. The first approach concentrates reductions in areas with a high density ***of sources*, even** if these sources are relatively pollution-free. The second approach focuses on sources with high ***rates of pollution*,** even though the sources might be few and far between. Neither approach directly addresses such factors as past emissions reductions or patterns of pollution deposition.

Appendix A presents eight alternative allocation formulas for reducing sulfur dioxide emissions, and the implicit rationales and distributional consequences of each. Three are based on ***total emissions, five* on *utility emissions alone.*** Variants include formulas based on: emissions per area; emissions per capita; equal percentage reductions per State; State-average utility emissions rates; emissions above a specified emissions rate; and emissions per quantity of electricity generated (including nonfossil energy).

Another aspect of choosing an allocation formula is administrative feasibility. For example, many control proposals have allocated emissions reductions based on utility emissions not only because they emit about three-quarters of the sulfur dioxide in the 31 Eastern States, but also because the remaining emissions are difficult to characterize. Accurate estimates of emissions rates for many small industrial boilers are unavailable. Industrial process emissions would have to be regulated according to emissions per product, rather than per quantity of fuel burned, and separate standards would have to be set for each industry.

Finally, for a given overall reduction, each allocation formula results in a different *distribution* of costs, as well as different *total* costs. Controlling plants that emit at high rates is usually cheaper per ton of pollutant removed than controlling lower emitting plants. However, the potential cost to the particular source—or to the State with a large proportion of plants emitting at high rates—increases as the required reductions increase. Allocation formulas that minimize total program costs tend to concentrate reduction requirements on States with the highest average emissions rates.

Conclusions and Options:

If Congress decides to directly assign emissions reduction responsibilities to either sources or States, many reduction formulas are possible. Several policy considerations pertinent to designing an allocation formula include: 1) the resulting distribution of reductions (which determines both the distribution of costs and deposition reductions; 2) the plan's total costs, and 3) the plan's economic efficiency. Tradeoffs among these various interrelated concerns must be considered.

In addition to options for congressional allocation of emissions reductions, we also present options for: 1) assigning allocation responsibilities to either EPA or the governors of States in the control region, and 2) adding flexibility to the chosen formula by allowing trading of emissions reductions requirements.

Options available to Congress for allocating emissions reductions are described below.

Option 6a: Allocate Emissions Reductions Directly to Sources

Emissions reductions could be allocated directly to sources by two means:

1. ***Legislating maximum allowable emissions rates.*** Congress could set maximum allowable emis-

sions rates for electric utilities, industrial boilers, and industrial process emissions. Reductions achievable by specifying alternative maximum emissions rates for utilities, industrial and commercial boilers, and all large boilers are presented for the 3 l-State Eastern region in table 9 and for the contiguous 48 States in table 10.

2. ***"Targeting" emissions reductions to specific sources.*** Reductions could also be allocated to only the largest sources. Of the 16 million tons of sulfur dioxide emitted by utilities in the 31-State Eastern region during 1980, close to 60 percent came from the top 50 sources, about 70 percent from the top 75 sources, and close to 80 percent from the top 100 sources. Alternatively, Congress could target those plants emitting at the highest rates. About 75 percent of 1980 utility sulfur dioxide emissions came from plants emitting in excess of 2.5 lb of sulfur dioxide per million Btu, and 60 percent came from plants emitting in excess of 3.0 lb of sulfur dioxide per million Btu.

These relatively few sources could substantially reduce regional emissions by using scrubbers under procedures similar to the existing New Source Performance Standards. Each of these "targeted reduction' schemes, however, draws an arbitrary cutoff line—those just above it would be required to reduce emissions substantially (e. g., 90 percent

Table 9.—Sulfur Dioxide Emissions Reductions With Emission Rate Limitations—31 Eastern States

lbs. $SO_2/10^6$ Btu	1.0	1.2	1.5	2.0	2.5	3.0	4.0
	All boilers (1980 emissions = 19,200 thousand tons/year)						
Thousand tons/year	11,600	10,400	8,900	6,800	5,100	3,700	2,000
Percent reduction in class	*60*	*54*	*46*	*35*	*26*	*19*	*10*
Percent reduction below total[a]	53	48	41	31	23	17	9
	Utility boilers (1980 emissions = 16,070 thousand tons/year)						
Thousand tons/year	10,300	9,320	8,020	6,170	4,620	3,370	1,730
Percent reduction in class	64	58	50	38	29	21	11
Percent reduction below total[a]	47	43	37	28	21	15	8
	Nonutility boilers (1980 emissions = 3,200 thousand tons/year)						
Thousand tons/year	1,300	1,100	900	640	460	360	220
Percent reduction in class	40	35	28	20	15	11	7
Percent reduction below total[a]	6	5	4	3	2	2	1

a1980 total sulfur dioxide emissions = 21,800 thousand tons/year.

SOURCE: E. H. Pechan & Associates, from Energy Information Administration data (EIA forms 4 and 423), and EPA National Emissions Data System (NEDS).

Table 10.—Sulfur Dioxide Emissions Reductions With Emission Rate Limitations—Entire United States

lbs. $SO_2/10^6$ Btu	1.0	1.2	1.5	2.0	2.5	3.0	4.0
	All boilers (1980 emissions = 21,000 thousand tons/year)						
Thousand tons/year	11,900	10,600	9,000	6,900	5,100	3,700	2,000
Percent reduction in class	57	48	43	33	24	18	9
Percent reduction below total[a]	45	40	34	26	19	14	7
	Utility boilers (1980 emissions = 17,380 thousand tons/year)						
Thousand tons/year	10,530	9,470	8,100	6,200	4,630	3,370	1,730
Percent reduction in class	61	55	47	36	27	19	10
Percent reduction below total[a]	40	36	31	23	17	13	7
	Nonutility boilers (1980 emissions = 3,600 thousand tons/year)						
Thousand tons/year	1,300	1,100	930	660	480	370	230
Percent reduction in class	37	32	26	18	13	10	6
Percent reduction below total[a]	5	4	4	2	2	1	1

a1980 total sulfur dioxide emissions = 26,400 thousand tons/year

SOURCE: E. H. Pechan & Associates, from Energy Information Administration data (EIA forms 4 and 423), and EPA National Emissions Data System (NEDS).

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reduction by technological means), while those just below the cutoff would be exempt.

Option 6b: Allocate Emissions Reductions to States (or Other Jurisdictional Entities

Congress could allow States to achieve specified emissions reductions in any way they choose. Other appropriate jurisdictional units include Air Quality Control Regions (AQCRs) or even operating utilities (which often own several individual sources).

While this approach would add another layer of administrative complexity, allowing each State or other jurisdiction to allocate reductions offers potentially significant cost savings over uniform emissions rate requirements. For example, OTA estimates that for cutbacks of about 8 to 10 million tons per year, allowing States to design "least-cost" allocation plans could reduce costs by about 20 to 25 percent from those that impose uniform limits on emission rates.

Congress could allocate emissions reductions to States in many ways. The allocation formula could be based on: 1) utility emissions alone (the sector for which the most accurate emissions data exist, 2) emissions from both utility and nonutility combustion, or 3) total emissions (including industrial process emissions).

Reductions based on each State's utility emissions or combined utility, industrial, and commercial boiler emissions could be calculated from:

- emissions in excess of a specified rate (sulfur dioxide emitted per quantity of fuel burned), or
- average emission rates (giving credit to States for less polluting sources).

Reductions based on total emissions could be calculated from:

- emissions per unit area,
- emissions per capita,
- equal percentage reductions for each State, or
- a series of allowable emission rates set separately for each major sector (i. e., utilities, industrial boilers, and major industrial processes).

Other factors that could be incorporated into State-level allocation formulas include:

- extent of use of nonfossil or low-emitting energy sources, or
- upper limits on the extent of reductions required.

Table 11 compares the State-by-State emissions reductions required under several of these alternatives to achieve a total regional reduction of about 8 million tons of sulfur dioxide per year.

Option 6c: Direct the Governors of the States in the Control Region To Allocate Emissions Reductions

Rather than assigning specific reductions to States, Congress could require the governors of the States within the control region to design an allocation formula. Congress could either provide guidelines or allow the governors complete freedom to develop a plan. Congress would have to determine the number of governors necessary to reach agreement (e. g., either a simple or a two-thirds majority) and alternative mechanisms in the event that agreement is not reached.

Option 6d: Provide Control Program Guidelines and Direct the Administrator of EPA To Develop the Allocation Formula

This option must be used if Congress adopts an environmental quality standard approach, but could also be used for developing an allocation formula following more general principles. For example, Congress could legislate resource protection goals (specifying equal protection from pollutants for all regions or greater protection in areas with high concentrations of sensitive resources), upper and lower limits on any State's emissions reductions requirements, guidelines for considering past reductions, and so on. The Administrator of EPA would then translate these goals as closely as possible into regulatory language.

Option 6e: Allow Trading of Emissions Reductions Requirements

To reduce the cost of implementing emissions reductions, Congress could allow sources or States

Table 11.—Emissions Reductions Required by Alternative Allocation Approaches (percent below 1980 emissions)

State	Utility emissions only				otal SO_2 emissions			
	1.5 lb/MMBtu rate imitation		1.3 lb/MMBtu average		35% reduction		16 tons/mi²	
	Percent below:		Percent below:		Percent below:		Percent below:	
	Utility	Total	Utility	Total	Jtility	Total	Utility	Total
Alabama	38	27	42	30	48	35	4	3
Arkansas . .	35	9	35	9	>100	35	35	9
Connecticut	0	0	0	0	78	35	0	0
Delaware	44	21	44	21	73	35	>100	70
District of Columbia	0	0	0	0	>100	35	>100	93
Florida	34	22	24	16	52	35	21	14
Georgia	47	41	53	47	39	35	0	0
Illinois	58	44	51	39	45	35	50	38
Indiana	65	50	67	52	45	35	93	71
Iowa . .	46	32	40	28	49	35	0	0
Kentucky	58	52	62	56	38	35	47	42
Louisiana	0	0	0	0	>100	35	0	0
Maine . .	8	1	8	1	>100	35	0	0
Maryland	34	22	38	25	53	35	75	50
Massachusetts	24	19	25	20	43	35	77	61
Michigan	31	19	28	17	56	35	0	0
Minnesota	24	16	13	9	51	35	0	0
Mississippi	44	20	0	0	77	35	0	0
Missouri	67	59	69	61	39	35	16	14
New Hampshire	47	41	53	46	40	35	3	3
New Jersey	24	9	0	0	88	35	>100	55
New York . .	33	17	7	3	68	35	31	16
North Carolina	4	2	11	8	48	35	0	0
Ohio	62	50	65	53	42	35	91	75
Pennsylvania	44	32	48	34	48	35	88	64
Rhode Island	0	0	0	0	>100	35	0	0
South Carolina	29	19	32	21	53	35	0	0
Tennessee	59	51	63	55	40	35	43	37
Vermon	0	0	0	0	>100	35	0	0
Virginia	3	1	5	2	77	35	2	1
West Virginia	49	43	51	44	40	35	74	64
Wisconsin	60	45	60	46	45	35	0	0
Eastern 31 state	50	37	50	37	48	35	50	37

SOURCE: Office of echnology Assessment, based on analyses by ≤ H. Pechan & Asssociated, Inc., 1983.

to purchase reductions, rather than requiring each source or State to meet its own requirement directly, This type of flexibility would allow sources with higher-than-average control costs—due, for example, to engineering design or poor availability of alternative fuels—to purchase the rights to more cost-effective reductions.

Congress could allow this type of trading throughout the entire control region, or permit it only within smaller areas (e. g., EPA Federal regions) to maintain a desired regional pattern of reductions. Such trading could be allowed freely on the open market, or through a marketable permit system to assist and monitor transactions.

If future emissions from sources not yet built must be offset by reductions from existing sources, allowing trading would be particularly helpful to States with high rates of utility or industrial growth.

Option 6f: Allow ***Substitution of Nitrogen Oxides Emissions for Part of Required Sulfur Dioxide Emissions Reductions***

For some sources, reducing nitrogen oxide emissions costs less than reducing sulfur dioxide emissions. To lower the costs of implementing required reductions, Congress could allow sources to choose the mix of pollutant cutbacks that minimizes control costs, subject to a specified substitution formula. Substitution of nitrogen oxides could be allowed on a ton-for-ton basis, 1.4 to 1 (the ratio of the acidifying potential of the two pollutants), or be based on estimates of how the two pollutants affect natural ecosystems. Because much of the deposited nitrogen is used by plants, substitution ratios ranging from 2 tons of nitrogen oxides for each ton of sulfur dioxide, to ratios as high as 4 to 1, might be considered.

Because the current inventory of nitrogen oxide emissions is not very accurate, however, a substitution program based on historical emissions (e. g., 1980) would be difficult to administer. Given the uncertainties in nitrogen oxide emissions and in control cost data, OTA cannot estimate the extent of use or potential cost savings of such a provision.

Decision 7: Who Should Pay the Costs of Emissions Reductions?

Discussion:

Emissions control costs can be allocated according to two general approaches: 1) full costs of control could be paid by sources required to reduce emissions, or 2) control costs could be funded from a group larger than those required. For example, a tax on pollutant emissions or electricity sales could be used to generate a trust fund to pay for reductions.

Currently, sources of emissions incur lower costs of production through their ability to dispose of pollutants in the atmosphere. These pollutants create costs to people whose livelihoods depend on the resources at risk from acid deposition. The situation, however, is not a simple case of ' 'polluting region' versus "receptor region. The benefits of lowered production costs are shared throughout the Nation in the form of lower product prices, although the greatest benefit accrues in the locale of the source, Likewise, people living outside regions that have resources at risk benefit from using those resources, but the people within these regions benefit most.

The first approach allocates the control costs to those who would be responsible for reductions. Yet since it is not possible to precisely link emissions from any given source to damage in areas far removed, some assert that this would be unfair.

The alternative approach would distribute the costs of reductions to a larger group. For example, imposing a pollution tax implies that all emissions contribute to the risk of resource damage, not just those from sources emitting in excess of a specified rate. Because so few sources are actually monitored, however, such an approach would be administratively complex.

Other trust fund approaches, such as a tax on electricity generation, are also possible. Because electricity generation is carefully monitored, this approach would be much easier to implement. Though an electricity tax approach is not based on

the amount of pollution produced, it recognizes that energy consumption creates much of the pollution. This approach, however, spreads the burden of control costs to all energy consumers, even those in regions with lower polluting sources such as natural gas or hydropower, and those already paying for pollution control. Another alternative is an electricity tax that is graduated on the basis of a pollution emission rate, combining aspects of the two previous approaches.

A trust-fund approach has some undesirable economic and administrative aspects, though it is difficult to estimate how severe these may be. A fund that covered most or all of the costs of emissions control could reduce incentives for sources to minimize control costs. In addition, substantial plant-to-plant variations in scrubber costs and region-to-region variations in fuel-switching costs could create considerable difficulties in establishing allowable cost schedules.

OTA has compared the distributional implications of three tax approaches: 1) a tax on electricity generation; 2) a tax on sulfur dioxide emissions; and 3) a tax on both sulfur dioxide and nitrogen oxide emissions, set so that two-thirds of the revenues are generated from sulfur dioxide and one-third from nitrogen oxide emissions. This is roughly the ratio of sulfur and nitrogen compounds deposited in precipitation in the Eastern United States. All three tax approaches are assumed to apply to all 50 States.

A tax on electricity generation would collect all revenues from electricity consumers. A sulfur dioxide tax would collect about 70 percent of revenues from the utility sector, and about 30 percent from industry. Taxing both sulfur dioxide and nitrogen oxide emissions would collect 55 to 60 percent of the total revenues from utilities, 25 to 30 percent from industry, and 10 to 15 percent from highway vehicles. Emissions from residential and other miscellaneous sources were not included in either of the pollution-tax approaches.

OTA analyzed how the alternative tax approaches would affect costs for each State's electricity consumers only. Since man y manufactured goods are distributed nationwide, industrial costs are often borne by consumers over a much larger area than the State in which the industry is located. A tax on highway vehicles (e. g., a sales or registration tax) would be distributed on a roughly per-capita basis.

Table 12 displays estimates of percentage increases in residential electricity rates from an electricity tax raising $5 billion annually. State-to-State variations are due solely to differences in the average electricity rate currently paid by consumers in each State. Table 12 also shows residential electricity rate increases under both pollution-tax alternatives.

These approaches result in lower nationwide-average rate increases than an electricity tax because part of the costs is borne by other sectors. Because of the large variation in pollution emission rates among utility plants, however, costs would be less evenly distributed, both within each State and from State to State. Because utilities emit a larger share of nationwide sulfur dioxide than nitrogen oxide emissions, rate increases are typically somewhat lower for a tax on both sulfur dioxide and nitrogen oxide emissions (column 2) than on sulfur dioxide emissions alone (column 3).

Rate increases shown in table 12 illustrate the relative distribution of costs under 1980 conditions. Future changes in electricity demand and pollutant emissions could alter these estimates substantially. For example, reducing sulfur dioxide emissions by 10 million tons per year would reduce total revenues collected under a pollution tax by about 15 to 30 percent, depending on the tax approach. Further details can be found in appendix A.

Conclusions and Options:

Under the Clean Air Act, sources that are required to reduce pollutant emissions must pay the entire costs of control. Several acid deposition control bills introduced to date would maintain this policy. Others have proposed a cost-sharing mechanism, whereby a tax on electricity or pollutant emissions would be used to help fund the costs of control.

Options available to Congress are described below.

Table 12.—5O-State Taxes Raising $5 Billion per Year During the Early 1980's (total in later years will vary with changes in emissions and electricity generated)

	Average residential electricity rate increase (percent) from alternate tax approaches		
		(Before control, 1980 emissions)	
State	Total electricity	SO_2 and NO_x	SO_2 only
Alabama	4.0	2.0	2.5
Alaska	4.0	0.9	1.4
Arizona	3.1	0.7	0.7
Arkansas	4.4	0.6	0.5
California	3.0	0.2	0.2
Colorado	3.7	1.3	1.2
Connecticut . .	2.5	0.3	0.3
Delaware.	2.4	1.4	1.8
District of Columbia . .	4.5	2.2	2.7
Florida..	3.1	1.7	2.2
Georgia	4.2		4.5
Hawaii	1.8	0.8	1.1
Idaho	8.2	0.0	0.0
Illinois	3.6	2.9	3.6
Indiana	3.8	5.9	7.7
Iowa.		3.0	3.5
Kansas	3.7	1.8	2.0
Kentucky.	4.5	5.7	
Louisiana	4.2	0.5	0.2
Maine.	3.3	0.4	0.6
Maryland	3.6	1.8	2.3
Massachusetts	2.9	1.6	2.1
Michigan	4.3	2.5	3.0
Minnesota. . . .	3.8	1.8	2.0
Mississippi . . .	4.0		2.6
Missouri	4.1	6.6	8.8
Montana	6.4	0.9	0.9
Nebraska.	4.7	1.3	1.3
Nevada	3.9	1.0	0.9
New Hampshire . . .	2.9	2.9	3.6
New Jersey. . .	2.6	0.8	
New Mexico . .	2.9	1.0	0.9
New York	2.1	0.7	0.9
North Carolina	3.7	1.8	2.1
North Dakota .	4.1	1.9	2.0
Ohio.	3.3	4.5	5.9
Oklahoma	4.5	0.6	0.3
Oregon		0.1	0.1
Pennsylvania .	3.1	2.7	3.5
Rhode Island .	3.0	1.3	1.5
South Carolina	3.6	1.4	1.7
South Dakota.	3.6	1.1	1.1
Tennessee . . .	4.9	5.3	7.0
Texas.	3.7	0.7	0.5
Utah	3.6	0.8	0.6
Vermont	3.5	0.1	0.0
Virginia	3.3	1.2	
Washington . .	9.5	0.5	0.7
West Virginia .	4.2	4.1	5.1
Wisconsin	4.4	4.1	5.2
Wyoming.	6.1	3.0	2.9
U.S. total . . .	3.3	1.9	2.3

SOURCE: Off Ice of Technology Assessment.

Option 7a: Require the Sources Allocated Emissions Reductions, and Their Customers, To Pay the Cost of Those Reductions

This approach is simple to administer and provides the greatest incentives for each source to minimize control costs. Given the difficulty of precisely linking emissions in one region with resource damage in another, however, many have questioned the ' 'fairness' of the cost allocation.

Option 7b: Establish a Trust Fund To Provide Some or All of the Necessary Funds for Reducing Emissions

Funds could be drawn from a tax on emissions, a tax on electricity production, or even from general revenues, This approach is administratively complex and might reduce incentives for minimizing control costs. Costs would be distributed more uniformly among States than under option A; still, this distribution of the costs and benefits of emissions reductions also raises regional equity concerns.

Decision 8: What Can Be Done To Mitigate Employment and Economic Effects of a Control Policy?

Discussion:

Two industries are likely to be most affected by legislated reductions in sulfur dioxide emissions: coal mining and electric utilities, In the absence of restrictions imposed by Congress, emissions reductions would be achieved through a mix of switching to lower sulfur fuels and installing flue-gas desulfurization units ("scrubbers"). Individual sources' control decisions—unless specified by Congress—will be determined by the relative cost effectiveness of the two approaches for that source and location.

Both control options have undesirable consequences: fuel switching is projected to cause some coal production to shift from high-sulfur to low-sulfur producing regions, affecting employment and economic patterns. Scrubbing allows the continued use of high-sulfur coal, but imposes high capital costs on a utility industry already requiring additional capital for continued growth and health.

As discussed in chapters 3 and 5, a program to reduce sulfur dioxide emissions by 10 million tons per year might reduce mining employment in high-sulfur coal regions by 20,000 to 30,000 jobs from otherwise projected future levels, and to cause economic activity in the range of $600 to $800 million per year to shift from high- to low-sulfur producing regions. These chapters also discuss the utility industry's recent financial situation, showing that during 1980 utilities in a number of Eastern States were in relatively poor positions to raise new capital either through bond-related borrowing or by issuing additional stock. An acid rain control program could have some effect on the financial health of these utilities, but the magnitude of the effect is unknown.

Two approaches are available to minimize the effects of an acid rain control program on the coal industry:

- The "technological approach, i.e, either directly or indirectly mandating the use of control technologies. For example, Congress could require that a set percentage of the sulfur potentially emitted from coals be removed by technological means, regardless of how much sulfur the coal contains.
- The "local coal approach, which would restrict utility coal consumption on the basis of the *location* of the coal supply, as in Section 125 of the Clean Air Act.

The technological approach could, in effect, require sources to achieve reductions via high-removal emissions control technologies, such as wet or dry flue-gas "scrubbers. Such an approach is the basis for current New Source Performance Standards, which require 70- to W-percent removal of potential emissions by technological means. Because the use of scrubbers cannot be avoided by switching to lower-sulfur fuels, locally available higher sulfur coals—which tend to be cheaper because of lower transportation costs—would often be preferred.

Such a policy is not without additional costs, however. OTA analyzed the cost of installing scrubbers on 50 of the largest utility plants emitting sulfur dioxide at a rate greater than 3 lb per million Btu. These 50 plants emitted about 7.6 million tons of sulfur dioxide in 1980 and consume about 60 percent of the high-sulfur coal produced for utilities. Mandating the use of scrubbers on these plants would cost about $1.5 billion per year *more* than allowing each plant to use the most cost-effective method of achieving the same reductions.

In a control program eliminating 10 million tons of sulfur dioxide emissions per year, such a provision would increase total program costs by an additional one-third to one-half. Moreover, many available technology-based emissions reduction methods (e. g., wet scrubbing) produce large quantities of liquid or solid effluents. A typical 1,000 MW plant scrubbing high-sulfur coal produces about 200,000 tons of sludge per year. This must be disposed of—posing additional environmental risks— if useful products cannot be recovered economically.

If more modest sulfur dioxide emissions reductions are desired—less than 2.5 million tons per year—Congress could require physical cleaning for all coal above a specified sulfur content. This technology-based approach would also help prevent production and unemployment losses in high-sulfur coal regions.

Additional coal-cleaning could eliminate moderate amounts of sulfur emissions at a relatively low cost for existing boilers that use higher-sulfur coals. Costs range from about $250 to $350 per ton of sulfur dioxide removed for Midwestern high-sulfur coals to $1,000 to over $3,000 per ton removed for southern Appalachian low- and medium-sulfur coals. The low range of coal-cleaning costs is competitive with or slightly higher than costs for fuel-switching.

Generally, the higher the sulfur content of the coal, the more economical y the sulfur can be removed from it. Depending on the type of coal, 10 to 40 percent of its sulfur can be fairly easily removed. If a greater percentage of the sulfur must be removed, physical coal washing alone becomes economically inefficient.

Coal washing is currently a widely used technique. One-third of the utility coal mined in the Eastern high-sulfur coal producing States was washed in 1979, removing about 10 percent of potential sulfur dioxide emissions (about 1.8 million tons) from these coals.

In many instances, the benefits of coal cleaning can partially offset the cost, because: 1) cleaning reduces the ash content of coal, reducing both costs of transportation to the powerplant and ash disposal requirements at the powerplant; 2) removal of impurities increases the heating value (energy per unit of weight) of coal; and 3) washing creates a more uniform fuel that can increase boiler operation efficiency.

The second major approach to mitigating the coal-market effects of proposed emissions reductions is based on section 125 of the Clean Air Act, which allows the States or EPA to restrict coal consumption to coals produced "locally or regionally, if such an action would "prevent or minimize significant local or regional economic disruption or unemployment. " The potential effectiveness of the current section 125 is difficult to judge because neither the statute, nor EPA in its ongoing proceedings, has defined "locally or regionally' available coal or "significant' economic disruption. No ruling has yet been made under section 125, although EPA has proposed a ruling based on a petition filed by the United Mine Workers and others in the State of Ohio in 1978.

Appropriately defining "locally or regionally" available coal is extremely important for designing a workable local-coal policy. If, for example, "local or regional" was to be considered synonymous with State boundaries, invoking section 125 would leave interstate trade in high-sulfur coal vulnerable to control-induced disruption. Table 13 presents interstate exports of medium- and high-sulfur coal as a percentage of total utility coal production for each coal State. As much as 66 percent of Illinois' and 82 percent of Kentucky's high-sulfur coal would remain vulnerable under such a definition.

Protection can be increased only by expanding the area considered local or regional, thereby incorporating larger percentages of a State's high-sulfur coal market. For example, if the Illinois ' 'region" were expanded to include Missouri, Indiana, and Michigan, the proportion of high-sulfur coal exported outside the "region' would fall from 66 percent (when considering only Illinois) to 21 percent (when considering all four States).

The variation in sulfur content of a "region's' coal reserves is another factor that must be con-

Table 13.—Interstate Coal Shipments

Major coal-producing States	1980 production for utility market (millions of tons)	Noncompliance[a] coal exported to other States (percent of State production)	Major destination States (shipments greater than 1 million tons)
Alabama	15.8	10	
Arizona	10.5	0	
Colorado	13.6	3	
Illinois	*54.4*	*66*	FL, GA, IN, 1A, MO, WI
Indiana	27.3	22	GA, KY
Kentucky	112.4	73	AL, FL, GA, IN, Ml, MS, NC, OH, SC, TN, VA, WV, WI
(East)	(73.9)	(75)	
(West)	(38.5)	(69)	
Missouri	5.0	34	KS
Montana	27.9	52	MN, WI
New Mexico	17.0	1	
North Dakota	15.3	21	SD
Ohio	34.3	27	AL, Ml, PA
Pennsylvania	50.9	30	MD, NY, OH, WI
Tennessee		35	
Texas	27.0	0	
Utah	8.5	7	
Virginia	13.8	71	
West Virginia	53.1		MI, NJ, NC, OH, PA
(North)	(30.8)	(46)	
(South)	(22.3)	(30)	
Wyoming	89.7	10	IL, 1A

[a]"Noncompliance" coal is defined as coal that would not permit utilities to comply with a 1.2 lb SO_2/million Btu emissions limit without applying control technology.

SOURCE: DOE/EIA Form 423, supplied to OTA by E. H. Pechan & Associates.

sidered when designing appropriate regional boundaries. Including reserves of vastly different sulfur content in the same region is unlikely to prevent disruption to the high-sulfur coal industry. For instance, defining a region to include southern West Virginia and Ohio would still permit dramatic shifts from high- to low-sulfur coal under the statutory constraints of section 125, since major quantities of low-sulfur reserves lie in southern West Virginia.

Thus, section 125 could effectively mitigate control-induced coal-market shifts only if regions could be designed to include a significant portion of a State's coal customers, while excluding large reserves of coal with differing sulfur content. In practice, a balance would have to be struck between defining regions large enough to protect sufficient amounts of coal, and small enough to exclude significantly different coal reserves.

The analysis above suggests that issues of definition may present significant problems for effective implementation of section 125. Moreover, restricting competition among coal suppliers on the basis that a given level of unemployment warrants Federal action could cause a great deal of political controversy. EPA concludes that its "experience with Section 125 casts considerable doubt on the workability of this portion of the statute.

EPA suggested a third alternative, analogous to programs providing adjustment assistance to workers, firms, and communities injured by foreign competition resulting from free-trade laws. A program could be designed to provide special compensation to workers and communities seriously affected by environmental regulations.

As of 1980, Congress had established about 20 special worker-assistance laws that supplement regular Federal-State unemployment insurance programs. Most provide assistance to workers either unemployed or underemployed as a result of a Federal action or policy. Several of these programs are ongoing; for example, the Trade Act of 1974 provides assistance to workers adversely affected by foreign competition. Others have been established to help workers so affected by one-time Federal actions. These include temporary benefits for airline employees under the Airline Deregulation Act of 1978, for loggers affected by the expansion of the Redwoods National Park, and for railroad employees affected by the establishment of Amtrak and Conrail.

The largest special worker-assistance program, the Trade Adjustment Assistance program to help workers hurt by foreign competition, paid $1.6 billion to more than 500,000 workers during 1980. Most of the others are much smaller.

Benefits provided by these programs range from relocation, training, and job search benefits (but no direct monetary payments) to monetary benefits ranging from 60 to 100 percent of the worker's salary. Some programs are funded through congressional appropriations, while others receive funds from the public or private corporations involved (e.g., the railroads absorbed by Amtrak). Most of the programs provide benefits for between 1 and 6 years. Two programs provide benefits until age 65.

To assist coal miners adversely affected by acid rain legislation, Congress could establish a special worker-assistance program similar to those described above. The program could provide special retraining to help workers find jobs in other industries in their communities and assist workers that desire to move to other areas where greater employment opportunities may be available. It should be noted, however, that during past fluctuations in coal production, workers in the Appalachian area have tended to remain in their home communities without jobs rather than relocate to areas where employment opportunities may be greater.

Congress could also provide for direct payments to unemployed workers either for a set period (e. g., 1 to 6 years) or until retirement age. Funds for the program could come from congressional appropriations or through a trust fund established from a tax on electricity generation, pollution emissions, or coal sulfur content.

Measures for reducing economic incentives to switch to lower sulfur fuels, or for prohibiting the use of nonlocal fuel, would increase scrubber-related capital requirements for the utility industry. One method available to Congress to minimize the capital burden on utilities, and the subsequent cost to consumers, was discussed under the previous policy question, "Who Should Pay the Cost of Emis-

[2]46 Fed. Reg. 8109.

sions Reductions? A tax on electricity generation or pollution emissions could be used to reimburse utilities for all or part of the capital costs of pollution control technology. Annual operating and maintenance costs—about half the total costs of controls— might still be paid by each utility's consumers, but the burden of raising construction capital would be reduced.

Modifications to the Federal tax code have been proposed as another means of reducing the capital costs of pollution control. The Economic Recovery Tax Act of 1981 (Public Law 97-84) allows utilities to use accelerated depreciation to recover investment costs. This provides tax benefits to utilities, creating more favorable cash-flow conditions.[3] The availability of tax-exempt industrial development bonds to finance pollution control hardware (thereby allowing utilities to raise capital at lower interest rates) is another means by which the Federal Government currently offsets the additional capital costs of pollution control.

Additional changes to the tax laws—e. g., increasing tax deductions for pollution control investment —would help some, but not all, utilities to finance pollution control technology. About 20 percent of major privately owned utilities paid no Federal income tax in 1981. Over 50 percent paid some tax, but took the maximum allowable investment tax credit (85 percent of a company's tax liability).[4]

Another approach to reducing capital requirements for pollution control is to encourage development of potentially lower cost control technologies, such as LIMB (Limestone Injection Multistage Burners) or regenerable processes. At present, government and industry support for new pollution control technologies tends to emphasize technologies for sources yet unbuilt. Current law does not require existing plants to use technology-based pollution control for meeting ambient air quality standards.

Investments in research and development for pollution control technologies to retrofit existing sources are subject to both: 1) the risks inherent in any R&D program and, 2) the unpredictable demand for these technologies, given uncertainties about future pollution control regulations. Federal cost-sharing of R&D for retrofitting existing sources would reduce investment risks and might encourage research on innovative, and potentially new, cost-saving technologies. The Federal Government could also increase its own research activities in this area.

Conclusions and Options

In addition to the direct costs of control, acid deposition control legislation could have undesirable secondary consequences. Three options are presented to minimize economic hardship to miners of high-sulfur coal. Two options are presented to help ease potential difficulties the utility industry might face in raising capital to pay for pollution control technology.

Options available to Congress to mitigate undesirable effects of a control policy are described below,

Option 8a: Require Sources To Reduce Emissions by Technological Means

Congress could mandate emissions reductions by technological means, to minimize potential production shifts within the U.S. coal industry and thereby minimize adverse regional employment and economic changes. For large-scale reductions, Congress could mandate control requirements similar to NSPS. Requiring emitters to remove a high percentage of potential sulfur dioxide emissions through such control technologies as scrubbers would minimize the economic advantage of switching to lower sulfur coal.

For smaller reductions—up to about 2.5 million tons of sulfur dioxide per year—Congress could direct EPA to require washing for particular coals. To minimize the costs of this option, Congress could direct EPA to exempt those coals for which washing is not cost effective.

Mandating emissions reductions through technological means would minimize unemployment in high-sulfur coal areas and stimulate the pollution control and construction industries. This approach, however, would also increase overall con-

[3] For a discussion of how this law benefits utilties, see D. W. Kiefer, "The Impact of the Economic Recovery Tax Act of 1981 on the Public Utility Industry, " Congressional Research Service, 1982.

[4] D. W. Kiefer, "Tax Credits: Their Efficacy in Helping the Utility Industry Finance Retrofitting to Reduce Sulfur Dioxide Emissions, Congressional Research Service, 1983.

trol costs, limit the potential economic gains to areas that produce low-sulk- coal, and increase electricity costs to consumers.

Option 8b: Strengthen and Clarify the Local Coal Protection Provision of the Clean Air Act, Section 125

Section 125 of the Clean Air Act allows States or EPA to prohibit the use of coals that are not produced "locally or regionally, " if such an action would ' 'prevent or minimize significant local or regional economic disruption or unemployment. Congress provided no guidance, however, on the meaning of these terms, and no ruling has been made under the section to allow policymakers to determine its effectiveness.

Congress could enhance the section's effectiveness by defining ' 'significant" economic disruption or unemployment (e. g., a threshold of projected increased unemployment of 10 percent, 20 percent, etc.). In addition, Congress could provide guidance on defining a region for use in implementing the section.

Assuming that the provision could be implemented effectively, it would achieve the same goal as option 8a— minimizing unemployment in high-sulfur coal regions—but would increase overall control costs. EPA has stated, however, that its ' 'experience with Section 125 casts considerable doubt on the workability of this portion of the statute.

Option 8c: Establish a Special Worker-Assistance Program for Affected Coal Miners

Congress has established many special worker-assistance laws to help people that are either unemployed or underemployed as a result of a Federal action. A similar program could be established to assist high-sulfur coal miners adversely affected by acid rain legislation.

Such a program could provide direct monetary benefits or relocation, training, and job-search assistance, Funding for the program could come from either general tax revenues or a tax on electricity, sulfur dioxide emissions, or coal sulfur content.

Option 8d: Reduce Utility Capital-Raising Requirements for Pollution Control Equipment

Additional pollution control regulations would increase the capital requirements of the utility industry at a time when some utilities are in poor financial condition. Adopting either option 8a or 8b as part of an emissions reduction program would increase the use of control technology, thereby increasing capital requirements even further.

Several means are available to Congress to aid utilities in raising the necessary capital. Two measures already in use are industrial development bonds to finance pollution control equipment and tax breaks under the Economic Recovery Tax Act of 1981 (Public Law 97-84). Ensuring the continued availability of low-cost industrial development bonds can lower the costs of pollution control equipment to both utilities and consumers. Additional tax breaks, similar to the accelerated method of depreciation permitted by the Economic Recovery Tax Act of 1981, but specific to pollution control equipment, could also be provided. Because many utilities already pay little or no Federal income tax, however, such a policy would assist some, but not all, utilities that might choose technology-based controls.

A more direct approach to reducing the capital requirements of the utility industry was presented under Decision 7. Congress could establish a tax on electricity or pollutant emissions to pay for all or part of the capital costs of pollution control equipment.

Option 8e: Provide Federal Support for R&D on Pollution Control Technologies for Existing Sources

Congress could increase FederaI research and development activities or take measures to encourage private-sector R&D. More specifically, Congress could establish a cost-sharing program for research on innovative methods of retrofitting existing sources with pollution control technologies. Focusing the program on retrofit technologies would direct limited Federal funds to pollution control methods for sources most affected by possible acid rain control legislation-existing sources that do not currently use pollution control technologies. A program to assume some or all of the risks of R&D might encourage development of cost-saving technologies that could reduce utility capital requirements and minimize production shifts within the coal industry.