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Performance of the Clean Air Act and its Amendments

**Testimony prepared for Presentation to Subcommittee on Energy and Air Quality, Committee on Energy and Commerce
U.S. House of Representatives
May 1, 2002**

**By Alan Krupnick, Senior Fellow and Director
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Summary

Whether viewed through the lens of cost-benefit analysis or through comparing emissions and air quality trends to trends in economic activity, the Clean Air Act and its Amendments appears to have successfully delivered net benefits to the American people, although there are significant uncertainties surrounding the cost and benefit estimates in the U.S. Environmental Protection Agency's retrospective and prospective studies of the Clean Air Act and its Amendments. In addition, because these studies did not disaggregate the benefits by pollutant, sector, or subsection of the Act, it is difficult to tell which parts are performing well and which are not.

From other analyses, it appears that federal measures for mobile source controls and the sulfur dioxide (SO_2) allowance trading program for electric utilities are particular bright spots, albeit ones that can be made brighter. Viewed pollutant by pollutant, reductions in particulate emissions and SO_2 as a fine particulate precursor appear to be particularly beneficial on net.

Less effective segments of the act and its amendments include: the SIP process, which is not well suited to address issues of long-range pollution transport; inspection and maintenance programs, which poorly target the older and dirtiest vehicles; and New Source Review, which has led to much litigation and is redundant to a cap-and-trade system. In light of the apparent lack of a concentration threshold for the criteria pollutants, the criteria by which the National Ambient Air Quality Standards are to be set remains too vague, in spite of the recent Supreme Court ruling against use of cost-benefit analysis.

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Thank you Chairman Barton and other members of the subcommittee for the opportunity to testify on the performance of the Clean Air Act. I am Alan J. Krupnick, senior fellow and director, at Resources for the Future (RFF), a nonprofit, nonadvocacy research and educational organization specializing in problems of natural resources and the environment since 1952. The views I express today are my own, not those of RFF.

The performance of the Clean Air Act (CAA) can be measured in two general ways:

(1) by how much better off the American people are with the act than without it, in other words, by the excess of the benefits of the act compared to the costs; and

(2) by whether these benefits and costs are distributed throughout the population in a way that we as a society find acceptable or advantageous.

The former may be termed an efficiency measure; the latter is an equity measure. I will offer some thoughts on the former only.

Economic Versus Environmental Performance Measures

There are several ways in which efficiency can be measured. One revealing, but nonrigorous approach is simply to compare how well the economy has performed since the Clean Air Act was implemented to the performance of various indicators of emissions and air quality. If economic activities are going up while pollution is going

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down, this is an indicator that something in the act is going well. It is an incomplete indicator, to be sure. For example, as the economy grows, the composition of its output changes. If by accident this change results in lower emissions, such changes should not be counted as a benefit of the act.

The attached chart presents some of these comparisons. Measures of general economic activity include gross domestic product, megawatt hours of electricity generated, fuel used, and vehicle miles traveled.

These activities are compared to the U.S. Environmental Protection Agency's (EPA) emissions and air quality trends data for each of the criteria pollutants, except lead. Lead is an obvious, major success story for the Clean Air Act as it is a highly toxic pollutant that was largely removed from environmental concern through EPA's phase-out of lead from gasoline, using authority conferred to the agency by the act. Even the policy used to implement the phase-out was well conceived from a cost-effectiveness perspective, as the lead phase-down rule was an early version of tradable permit programs, which have turned out to be so successful.

From Figure 1, with each trend line indexed to 1970, it is clear that measures of general economic activity, as well as activities more or less directly leading to emissions, are trending strongly upward while emissions are either flat (NOx emissions) or falling. The flat or downward trend in emissions is also mirrored in the air quality data (not shown) where the number of nonattainment areas has been falling, although not steadily.

Cost-Benefit Analyses of Performance[1]

A more rigorous approach to measuring the efficiency of the act is to simply refer to the results of the Section 812 studies that Congress required in the 1990 Clean Air Act Amendments (CAAA) EPA to do: *The Benefits and Costs of the Clean Air Act: 1970 to 1990* (EPA, 1997a) and *The Benefits and Costs of the Clean Air Act, 1990 to 2010* (EPA, 1999). Because the first of these studies began after 1990, it is called the retrospective study, while the latter, tracking the effects of the 1990 Amendments, is called the prospective study.

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[1] Much of the discussion in this section is taken from Krupnick and Morgenstern (2002).

These studies are probably the most intensive and expensive cost-benefit analyses ever done at the agency. Under the auspices of the agency's Science Advisory Board, both studies were scrutinized throughout the decade-long preparation by at least three expert committees of outside economists, air quality modelers, epidemiologists, and other health experts.

Although both the retrospective and the prospective studies involve many controversial policy and technical issues, they clearly show that, *taken as whole*, the nation has received high returns on its investment in improved air quality over the past three decades. The estimates indicate that, for the early years, benefits exceed costs by a factor of 40 or more. Prospectively to the 1990 Amendments, benefits still exceeded costs, although by a far smaller margin.

Table 1 presents the annualized (central) estimates for both benefits and costs developed in the two studies. Each of the two (aggregate) scenarios is evaluated by a sequence of economic, emissions, air quality, physical effect, economic valuation, and uncertainty models to measure the differences between the scenarios in economic, human health and environmental outcomes. Both studies examine the benefits and costs of reducing volatile organic compounds (VOCs), nitrogen oxides (NO_x), sulfur dioxide ($S0_2$), carbon monoxide (CO), coarse particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$).[2]

These results indicate that aggregate benefits of air pollution control exceed costs by more than an order of magnitude for the period 1970–1990. Note that this conclusion is robust with respect to alternative assumptions about age-adjusted mortality. Also note that the costs were treated as if the were certain, when, in fact, there is much uncertainty about such costs.

[2] Although the incremental effects of the 1990 Amendments on primary particulate matter (PM) emissions is relatively small, PM in the atmosphere is comprised of both directly emitted primary particles and particles that form in the atmosphere through secondary processes as a result of emissions of $S0_2$, NO_x, and organic compounds. These PM species, formed by the conversion of gaseous pollutants emissions, are referred to collectively as "secondary" PM. Because the Clean Air Act, especially the 1990 Amendments, achieve substantial reductions in these gaseous precursor emissions, it has a much larger effect on PM_{10} and $PM_{2.5}$ than might be apparent if only the changes in directly emitted particles are considered. Also, the retrospective analysis assessed the effect of CAA provisions governing lead in the environment. However, since the 1990 Amendments do not include new provisions for the control of lead, it is not considered in the prospective analysis.

Table 1: Central Estimates of Total Annual Monetized Benefits and Costs of Environmental Regulations

(Billions of 1996 dollars as of 1999)

	Benefits	Costs
EPA retrospective report, 1990	$960[a/] to $1450	$54
EPA prospective report, 2000	$55[a/] to $96	$20

Source: OMB (2000)

[a/]Age-adjusted mortality estimate.

While benefits still exceed costs for the prospective study, the ratio of benefits to costs is considerably lower than in the retrospective analysis, suggesting that the "truly low-hanging fruit" may have been picked in the early years.[3]

Table 2, taken directly from the prospective study, summarizes the central estimates on a present value basis by title of the Clean Air Act. For Titles I–V, present value estimates of benefits exceed those of costs by a factor of four. About 90% of these benefits are associated with avoided mortality. The remainder are associated with avoided morbidity and with ecological and welfare benefits. On the cost side, the prospective analysis finds that Title I accounts for almost half of the total cost of the first five titles. Title II accounts for another third, with the balance distributed among Titles III-V. Because of the long-term nature of the benefits of Title VI (stratospheric ozone), the results for this title are not fully integrated into the overall findings. However, the present value benefits of this title exceed costs by a factor of 20.

Overall, as the Agency has written in the prospective study, the conclusion of the 812 analysis is clear:

"While alternative choices for data, models, modeling assumptions, and valuation paradigms may yield results outside the range projected in our primary analysis, we believe based on the magnitude of the difference between the estimated benefits and costs that it is unlikely that eliminating uncertainties or adopting reasonable alternative assumptions would change the fundamental conclusion of…[the] study: the Clean Air Act(s')…total benefits to society exceed its costs." (page v)

[3] In one of the scenarios presented in the prospective study (low benefits) costs actually exceed benefits by $1 billion per year.

How much stock should we put in these overall results? The Science Advisory Board's general endorsement is certainly good reason for trusting the results. However, there were some important and acknowledged shortcomings, including the lack of disaggregation of benefits, difficulty in defining a baseline, difficulties in measuring the willingness to pay for mortality risk reductions, omissions of important benefit categories, and poorly estimated costs.

Not Enough Disaggregation. Both studies were conducted at a highly aggregate, economy-wide level. The retrospective study did not estimate either the benefits or the costs of individual regulations, pollutants, or of any subcategories (for example, stationary versus mobile sources) of the federal air pollution program. The prospective study estimated costs but not benefits by title of the 1990 Amendments, but there were no further disaggregations.

From a policy perspective, an analysis of total costs and total benefits represents a very simple approach to a complex issue. Arguably, few propose abandoning all federal air pollution control. The more policy-relevant question concerns the costs and benefits of individual regulations and, even more relevant, the costs and benefits of marginal changes to individual regulations on individual pollutants. The principle rationale offered by the agency for this highly aggregate analysis is that while costs can be reliably attributed to individual regulations or programs, the broad-scale methodology used for the benefits analysis precludes reliable estimation of the benefits by regulation or program, especially since some pollutants, such as NOx, show up in multiple titles and affect multiple criteria pollutants (NO2, ozone, and particulates).

Yet, others have analyzed disaggregated pollutants by title, taking EPA's aggregate benefit estimate (and cost estimates by title) as given (Smith and Ross, 1999), and for Title IV alone (Chestnut, 1995, Burtraw et al, 1998), which applied only to the electricity generation sector. In addition, EPA was able to develop separate benefit estimates for their new ozone and fine particulate National Ambient Air Quality Standards (NAAQS) (USEPA, 1997b). The findings from these studies are presented in table 3. This table shows that some titles deliver more net benefits than others and that the new fine particulate NAAQS is likely to be a much better buy for society than the new 8-hour ambient ozone standard.

Difficulty Defining the Baseline. The so-called baseline issue is another knotty problem for judging the reliability of these studies. In both studies the Agency analyzed air pollution programs by comparing specific policy and baseline scenarios. The retrospective study contrasted a scenario reflecting historical economic and environmental conditions observed with the Clean Air Act in place to a hypothetical scenario projecting the economic and environmental conditions which would have existed on the assumption that the stringency and effectiveness of air pollution control technologies were frozen at their 1970 levels. In the prospective study, all rules promulgated or expected to be promulgated pursuant to the 1990 Act were contrasted to a scenario that essentially freezes federal, state, and local air pollution controls at the levels of stringency and effectiveness prevailing in 1990. Both studies hold constant the geographic distributions of populations and economic activities across the scenarios.[4]

The frozen technology assumption – an obvious simplification – is central to the overall results. Arguably, in the absence of new federal regulation, one would expect to see some air pollution abatement activity, due to state or local regulation or, possibly, on a voluntary basis. As Davies (1970) has reported, nonfederal air pollution efforts date back to 1881 when the city of Chicago adopted an ordinance that declared: "the emission of dense smoke from the smokestack of any boat or locomotive or from any chimney anywhere within the city shall be…a public nuisance." Davies reports that other cities followed Chicago's example. More recently, some states have imposed particularly stringent controls, especially California. If one assumed that state and local regulations would have been equivalent to federal regulations, then a cost-benefit analysis of the Clean Air Act would be a meaningless exercise: both benefits and costs would equal zero. For both studies, EPA and the outside experts wrestled with the possibility of developing more realistic baseline scenarios. In the end, they decided that any attempt to

[4] Although the scenarios do reflect the basic trends in population and economic growth across the country over the relevant time periods, they do not allow for the possibility that people would respond to pollution by moving away from the dirtiest areas.

predict how states' and localities' regulations or voluntary efforts would have differed from the Clean Air Act is too speculative.

Difficulty Measuring Values for Mortality Risk Reductions. The monetized benefits reflect interpretations of the available science and economic literature made by the Agency in consultation with its outside experts. As a form of sensitivity analysis, a number of alternative interpretations of the literature also were examined. The quantitatively most important concern the valuation of premature mortality. In both the retrospective and prospective analyses, the Agency developed an alternative scenario based on the loss-of-life-years approach to reflect the greater susceptibility of older individuals to air pollution-induced mortality. In both studies, this scenario yielded significantly lower benefits. The prospective study also examined alternative assumptions about the incidence of mortality, the incidence and valuation of chronic bronchitis, as well as certain other effects. For Title VI, sensitivity analysis reflected potential averting behaviors, such as remaining indoors or increasing use of sunscreen or hats.

Since these studies were published, two distinct elements of the health valuation literature have been expanded. The first is a more systematic evaluation of the main body of the literature, which is associated with using wage rate differentials reflecting differential workplace risks. Mrozek and Taylor (2002) have performed a meta-analysis of 38 labor market studies contributing 203 estimates of the value of a statistical life (VSL). They find that EPA's best estimate for VSL ($6 million of 1998 dollars) is three times too large (that is, their best estimate is $2 million), owing to a number of factors. The most important is a false attribution of wage rate differentials to mortality rate differences, when in fact, much of this variation is due to inter-industry differences in wage rates that occur for other reasons.

The second is some new studies in the mortality risk valuation literature (for example, Hammitt and Graham, 1999; Krupnick et al, 2002; Strand, 2001; Johannesson and Johansson, 1996) that are specifically designed to reflect the mortality risks associated with air pollution using survey techniques, rather than using estimates from labor markets, a context and population far different than that appropriate to air pollution. Much of this literature also suggests that EPA's $6 million estimate for VSL is too high (a factor of three to six too high would not be out of line) with the appropriate adjustment being quite uncertain, as this literature needs to mature. Additional context adjustments, say for the dread associated with cancer or other diseases and deaths caused by air pollution, could result in higher VSLs, however.

Omissions. Although both studies attempt broad coverage, there are some notable omissions, largely because of data or modeling limitations. Emissions of hazardous air pollutants are not extensively considered in either study.[5] Estimates for Title VI of the 1990 Amendments regarding stratospheric ozone depletion are developed in the prospective study but they are not fully integrated into the main analysis.

Despite efforts to characterize the impacts of air pollution on natural systems, the inability to quantify and/or monetize the damages precluded the development of benefits estimates for ecosystem impacts (except for a supplementary calculation for avoided costs of nitrate reductions associated with NOx emissions). A similar story applies to potential carcinogenic and certain other health effects associated with criteria pollutants.

Poorly Estimated Costs. Costs are estimated as increases in expenditures by different entities to meet the additional control requirements of the 1990 Amendments, including operation and maintenance expenditures plus amortized capital costs (that is, depreciation plus interest costs associated with the existing capital stock).[6] Changes in employment and prices as well as impacts that might be experienced among customers of the firms that must incur these costs were partially examined in the retrospective analysis but omitted in the prospective study. In limiting consideration of these so-called general equilibrium effects, the EPA reports effectively preclude analysis of the tax interaction effect, which reflects the economy-wide result of imposing additional costs in the context of existing (distortionary) taxes.

This effect was extensively discussed by the expert review committee of the prospective study, and is mentioned in the study, but is not incorporated quantitatively.

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[5] Some pilot analyses of hazardous air pollutants were conducted but it was determined that the poor quality of the available information precluded comprehensive quantification of the effects.

The tax interaction effect (Parry and Oates, 2000) refers to the effect of increased control costs on the deadweight loss associated with our existing system of labor and other taxes. The slight rise in the cost of living slightly lowers real wages, with aggregate losses being quite large because there are so many people affected.[7] Costs may be significantly underestimated on this account. At the same, the difficulties of forecasting future technological changes (and EPA's current practice of fixing technology) probably leads to an overestimate of costs (Harrington, Morgenstern, and Nelson, 2000).

In summary, while significant challenges remain to estimate the cost and benefit performance of the Clean Air Act and its Amendments, there are as many reasons for expecting that net benefits will be higher than estimated as lower than estimated, with the net effect awaiting further research. Clearly, new benefits will be larger in some elements of the act than in others, a discussion to which I now turn.

Performance of Specific Elements of the Clean Air Act

A final approach to examining performance of the Clean Air Act is to consider some of the evidence on individual elements of the act. This examination will be highly selective, mostly choosing topics about which I have some expertise.

SO_2 Allowance Trading. The SO2 Allowance Trading Program in Title IV is an unmitigated net benefit and has lead the way to a revolution in thinking about the use of market-based instruments for pollution control. Research at RFF and elsewhere has examined the workings of this program in great detail.

We find that the lion's share of benefits results from reduced risk of premature mortality, especially through reduced exposure to sulfates, and these expected benefits measure several times the expected costs of the program (Burtraw et al, 1998). Although emission trading in theory could have environmental impacts, "the geographic consequences are not consistent with the fears of the program's critics…pollutant concentrations decrease and health benefits actually increase in the East and Northeast

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[6] Costs for meeting Title IV through the SO_2 trading program were estimated by a model that allocates emissions reductions cost effectively in a context of responding to market signals in the electric power and tradable allowance markets.
[7] One committee member estimated that costs of implemented the 1990 Amendments could be 30% higher than shown in the report.

due to trading...Deposition of sulfur in the eastern regions also decreases.” (Burtraw and Mansur, 1999). Meanwhile, “allowance trading may achieve cost savings of $700-$800 million per year compared to ‘enlightened’ command-and-control...(and) annual savings of almost $1.6 billion” compared with a less enlightened command-and-control alternative of forced scrubbing. “Innovation accounts for a large portion of these cost savings…” involving “…organizational innovation at the firm, market and regulatory level and process innovation by electricity generators and upstream fuel suppliers.” (Carlson et al, 2000). Although some of these innovations were already in the works prior to the program, the allowance trading program deserves significant credit for providing the incentive and flexibility to accelerate and to fully realize exogenous technical changes that were occurring in the industry.

Based on these good results, it is fair to say that EPA considers trading programs at least equally with traditional command-and-control methods when it considers new regulations. The best recent example is the NOx trading program, designed to help states implement the NOx SIP call. Other agencies and stakeholders also think of trading as a cost-effective and politically palatable means of reducing pollution, witness the enthusiasm in some quarters outside of those inhabited by economists, for CO_2 trading, tradable CAFE credits, and the like. The success of Title IV has made this popularity and even “faith” possible.

Yet, the SO2 trading program and other trading programs could have been made better in hindsight, and could be made better in the future. In particular, the level of the cap could be tied to an economic index, such as allowance prices (Burtraw, 2002). As allowance prices fall, the pace of reduction in emissions could be accelerated to capture low-cost benefits for the environment and public health. Conversely, if allowance prices rise to unanticipated or unjustified levels, the pace of emission reductions could be slowed.

Federal Measures for Mobile Source Emissions Reductions. Another success is the federal measures called for in Title II to reduce emissions of hydrocarbons, CO_2 and NOx from mobile sources. These measures, such as reformulated gasoline and tailpipe emissions standards, are generally believed to have contributed the dominant share of the emissions-reduction benefits from mobile sources. Reformulated gasoline has the advantage of being relatively low cost and of being applicable to the entire vehicle stock, whereas the tailpipe standards affect only new vehicles. Further, by making new cars more expensive relative to used cars, the tailpipe standards may have contributed some to the dramatic increase in the lifetime of used cars, whose emissions tend to be larger than newer cars. Cost-effectiveness of gasoline reformulated to reduce VOC emissions, for instance, has been estimated to be in the range of $1,900 to $3,900 per ton (Harrington, Walls, and McConnell, 1995). These estimates do not capture the environmental costs associated with MTBE additives nor the subsidies associated with using ethanol. Thus, only some reformulations come this cheaply.

More problematic has been the vehicle inspection and maintenance programs required of some nonattainment areas by the act (Title II). A detailed RFF study of Arizona's enhanced I/M program finds its cost-effectiveness is about $5,500 per ton of NOx plus VOCs (Harrington, McConnell, and Ando, 2000). Further, the recent NAS study (2001) found that such programs have "generally achieved less emissions than originally projected" (p. 2) and quoted estimates of cost-effectiveness ranging from $4,400 to $9,000 per ton of NOx plus VOCs. Providing effective and efficient means of finding and repairing dirty vehicles should be a top priority for the future. The near elimination of tailpipe emissions of new cars leaves the maintenance of vehicles as they age the last potentially low-cost area for on-road mobile source emissions reductions. One approach is to rethink the allocation of responsibility for in-use emissions in a more fundamental way, putting more of the emission liability on vehicle manufacturers, through extended warranties, emission repair liability, or expanded use of vehicle leasing. Such alternative assignments of liability can perhaps reduce the cost of monitoring and enforcement of I/M, reduce the incentives of motorists to avoid maintenance and repair, and, by providing more flexibility about which vehicles to repair, increase the efficiency of I/M as well.

More problematic still in terms of cost-effectiveness are the various programs to mandate or otherwise promote the use of low-emitting, alternate-fueled vehicles. As shown in a new report (NRC, 2002, appendix F), projected costs per ton of reductions from these vehicles range from a low of $6,000 up to nearly $100,000 per ton of VOCs plus NOx reductions. Of course, to meet the NAAQS may require implementation of measures with large costs-per-ton reduction and, specifically referring to alternate-fueled vehicles, these costs are likely to come down significantly with technological change and mass production. Nevertheless, what is important is whether cheaper means for such reductions are left unimplemented and whether changes in program design for the implemented programs could reduce costs, raise effectiveness, or both.

Federal Measures for Point-Source Emissions Reductions. Aside from SO_2 trading and the future NOx trading program, the regulation of point source emissions has been effected by the New Source Review (NSR) program and nonattainment level permit activities related to the SIP. While the NSR program has undoubtedly spurred new abatement and low-polluting process technology, as was intended, these emissions reductions have come at a high cost. As with mobile sources, tighter standards applied to new sources relative to old sources create a bias against capital turnover, leaving possibly dirtier capital in place for far longer than it would have been with a more balanced treatment of sources. Further, with cap-and-trade programs in place, such as those for SO_2 nationally, RECLAIM in Los Angeles, and NOx in the northeastern United States, NSR is simply redundant. Forcing new sources to meet a tight technology-based standard will only reduce the demand for allowances, lowering their price below what they would otherwise be. While the individual new sources will have lower emissions with NSR than without it, other sources will have greater emissions, since total emissions are capped. On net, exposures over time and space will be different, but not clearly higher or lower.

The SIP Process. The SIP process has probably not worked very well. This is not necessarily the fault of the Clean Air Act. At the time the Act and its Amendments were passed, the magnitude of long-range pollution transport was not known and was assumed to be small. Now we understand that ozone and its precursors, as well as the finer particulates and their precursors can travel many hundreds of miles (or more) making the process of placing responsibility for attainment on the shoulders of individual nonattainment areas (even with all the federal measures in place) problematic. Figures 2 and 3 show some recent results from a state-of-the-art air quality model (Mendoza-Dominguez, and Russell, 2000; Yang, Wilkenson, and Russell, 1997) that integrates ozone and aerosol chemistry into a highly spatially and temporally disaggregated model of ozone and fine particulate concentrations. These figures show how much population-weighted particulate and ozone concentrations in a state can be cut by reductions of SO_2 and NOx emissions, respectively, in each of the states.[8] The figures clearly show that several nearby states are substantially involved in other states' pollution and that the local (own-state) share of concentrations is only around 20 to 25%.

The lawsuits that have resulted to get long-range sources under control are another indication of the problems with the SIP process. A Federal Advisory Act Committee (USEPA, May 1998), which John Seitz at OAQPS and I co-chaired, spent many hours trying to develop alternatives to this process, recognizing that there were areas of violation and areas of influence, that needed to form the basis for a new way of reaching attainment.

The National Ambient Air Quality Standards. Of course, the centerpiece of Clean Air legislation from 1970 onwards has been the National Ambient Air Quality Standards. By meaning such standards to be enforceable, Congress tagged them as the driving force in air quality regulation. As such, it is perhaps unsurprising that they have come under so much criticism, both on the basis of the criteria for setting them and for the criteria that may not be used. In spite of the recent Supreme Court ruling against the use of cost-benefit analysis and economic efficiency as a criterion for standard setting, it still remains the case that the criteria for setting standards in the absence of a threshold are not defined, if not indefinable. Tighter and tighter standards are not necessarily in the

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[8] In our study area of the eastern U.S., NOx emission reductions also reduce PM2.5 concentrations, but only about $1/10^{th}$ to $1/20^{th}$ as much as SO2 on a ton for ton basis. These estimates and those in Figures 2 and 3 are for an often-studied meteorological episode in July 1995. These figures result from simulating a 1,000 ton reduction of either SO2 or NOx emissions in each state and examining the reduction in 24-hour PM2.5 and 8-hour ozone concentrations for a given state. The height of the bars gives the concentration reduction that results from this case. These very large reductions in NOx cause at most a 12.7 ppb reduction in ozone concentrations, for instance.

country’s best interests. Arguably, as EPA’s Regulatory Impact Analysis for Ozone and Particulate Matter shows, it might have been better to have a new ozone standard no tighter than the current one and a fine particulate standard even tighter than the new one.

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Table 2: Summary of Quantified Primary Central Estimate Benefits and Costs (Estimates in million $1990s)

Cost or Benefit Category	Annual Estimates 2000	2010	Present Value
Costs:			
Title I	$8,600	$14,500	$85,000
Title II	$7,400	$9,000	$65,000
Title III	$780	$840	$6,600
Title IV	$2,300	$2,000	$18,000
Title V	$300	$300	$2,500
Total Costs, Title I–V	$19,000	$27,000	$180,000
Title VI	$1,400*		$27,000*
Monetized Benefits:			
Avoided Mortality	$63,000	$100,000	$610,000
Avoided Morbidity	$5,100	$7,900	$49,000
Ecological and Welfare Effects	$3,000	$4,800	$29,000
Total Benefits, Title I–V	$71,000	**$110,000**	$690,000
Stratospheric Ozone	$25,000*		$530,000*

* Annual estimates for Title VI stratospheric ozone protection provisions are annualized equivalents of the net present value of costs from 1990 to 2075 (for costs) or 1990 to 2165 (for benefits). The difference in time scales for costs and benefits reflects the persistence of ozone-depleting substances in the atmosphere, the slow processes of ozone formation and depletion, and the accumulation of physical effects in response to elevated UV-b radiation levels.

Source: EPA, 1999. *The Benefits and Costs of the Clean Air Act, 19902010*.

Table 3. Summary of Cost-Benefit Studies of the 1990 Clean Air Act Amendments for 2010 (estimates in million $1990).

Study	Benefits	Costs
Title IV		
Burtraw et al (1998)[1]	$25, 000	$800
Chestnut (1995)	$35,277	NA
New NAAQS (EPA, 1997)[2]		
Ozone (8-hr.), partial attainment	$400-$2,100	$1,100
Ozone (8-hr.), full attainment	$1,500-$8,500	$9,600
Fine Particulates, partial attainment	$19,000-$104,000	$8,600
Fine Particulates, full attainment	$20,000-$110,000	$37,000
Clean Air Act Amendments (Smith, 1999)[3]		
Title I	$26,564	$14,500
Title II	$14,968	$9,000
Title III	$1,925	$840
Title IV	$69,297	$2,000

[1] While this estimate is specific to the eastern United States, these benefits are expected to account for 98% of total U.S. benefits.
[2] Partial attainment costs are incremental to partial attainment of current standards, and reflect partial attainment of promulgated standards. EPA estimates 17 potential residual nonattainment areas for ozone, and 30 potential residual nonattainment counties for fine particulates as of 2010. Full attainment costs, however, are incremental to full attainment of current standards.
[3] Total 1990 Amendments benefit estimate ($110 billion; see table 2 above, in bold) and cost estimates by title (see table 2, above) are from EPA (1999).

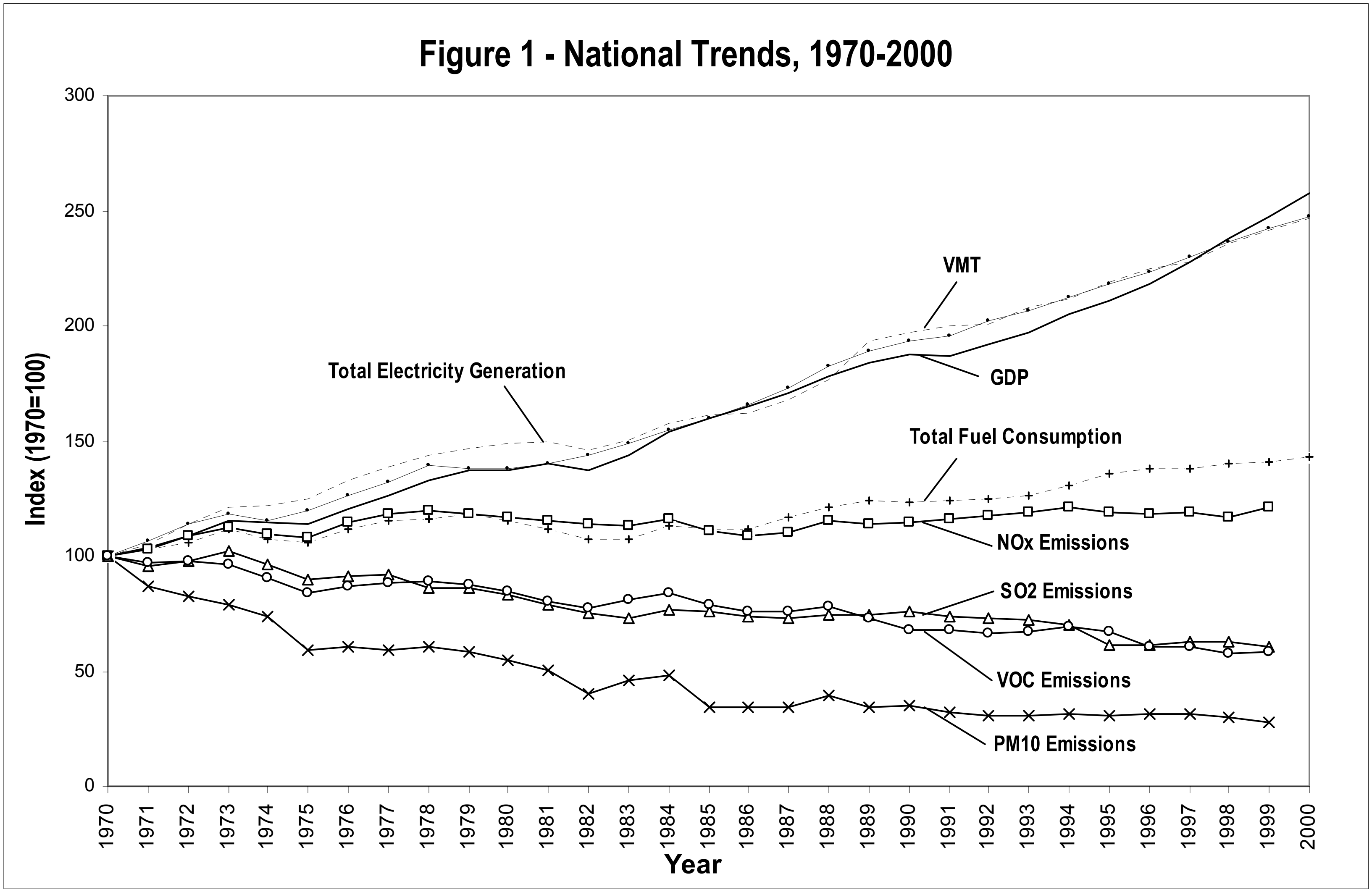


Figure 1 - National Trends, 1970-2000
Index (1970=100)
300
250
200
150
100
50
0
VMT
GDP
Total Electricity Generation
Total Fuel Consumption
NOx Emissions
SO2 Emissions
VOC Emissions
PM10 Emissions
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Year

Figure 2

Interstate Effects of Reductions in SO2 Emissions on Fine Particulate Matter Concentrations

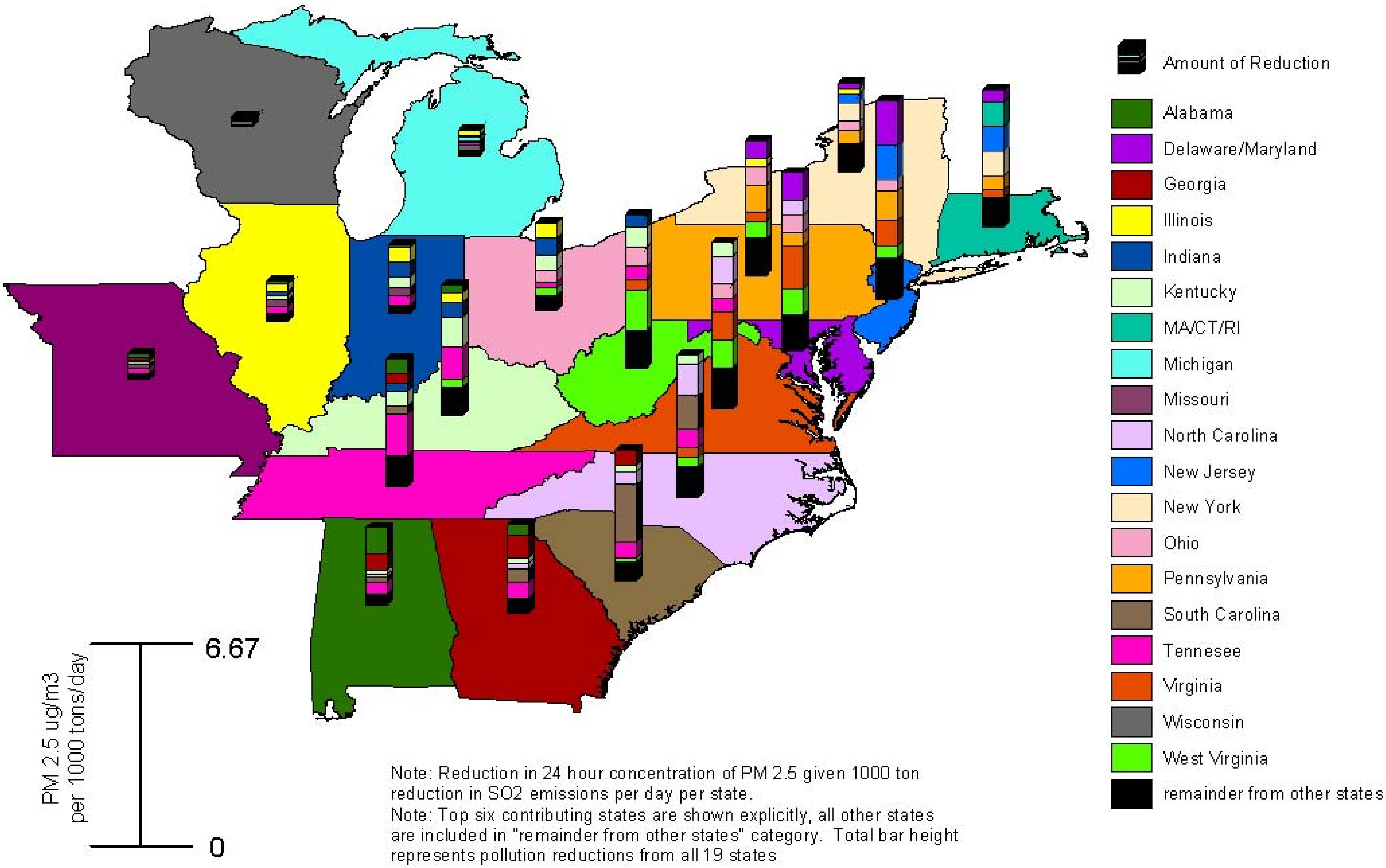
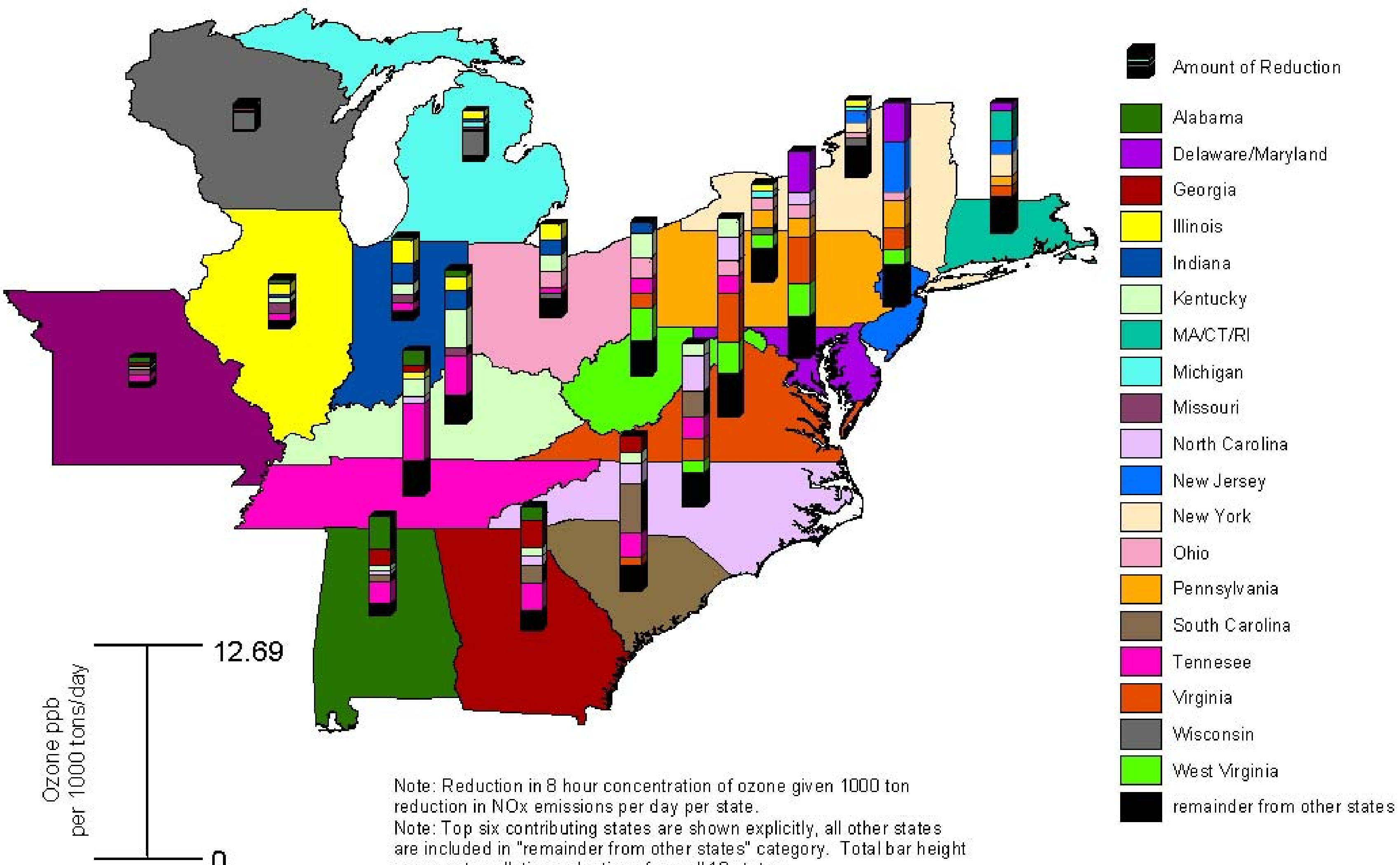


Figure 3

Interstate Effects of Reductions in NOx Emissions on Ozone Concentrations



Note: Reduction in 8 hour concentration of ozone given 1000 ton reduction in NOx emissions per day per state.
Note: Top six contributing states are shown explicitly, all other states are included in "remainder from other states" category. Total bar height represents pollution reductions from all 19 states