Economic Benefits of Controls

Dallas Burtraw – Resources for the Future

We heard Representative Sweeney say today that one can perceive a trade-off between economics on the one hand and the environment on the other hand. He suggested that folks may be inclined to approach policy from one camp or the other camp.

The work that I am drawing on links these two areas: economics and the environment. This work is the attempt to estimate the economic cost of environmental degradation (Figure 1).

This body of work is at least two decades old, and to some the work in this area has been frustrating. Richard Ottinger wrote, in the early 1990s, that previous studies aimed at estimating external environmental costs failed to value such a significant portion of externalities as to render the values irrelevant. He went on to suggest that the very small values arrived at in these studies raise a serious question about whether it is worthwhile to pursue further the evaluation of environmental externalities. An environmental advocate may have a feeling that the environmental wars cannot be won on the basis of economic analysis; they can only be lost on the basis of the economic arguments. But that is not the case.

I want to draw on the main findings from the economics and integrated assessment literature about the performance of the acid rain program. This work has involved a large number of coauthors and has appeared in the *Journal of Political Economy, Environmental Science and Technology, Contemporary Economic Policy, Journal of Air & Waste Management*, plus some unpublished discussion papers. Some of the findings are encouraging, with respect to the success of the program, and some of them point the direction for ongoing research.

There are several findings that emerge from this review. One is that there is an adequate basis to value the effect of acid rain on the recreational and consumptive use of resources. This area of economic benefit is characterized as "use value." An unhappy finding from the literature that I will survey is the conclusion that improvements in use values alone do not justify the costs of Title IV emission reductions.

Another important category of value is characterized as "non-use value." These are values individuals hold for the resource even if the individuals do not intend to directly experience or consume the resource. The area of non-use value includes the estimation of broader ecological changes. A second finding in the literature is that the science and economics are still not adequate to value in economic terms most of the ecological effects that we have been hearing about at this

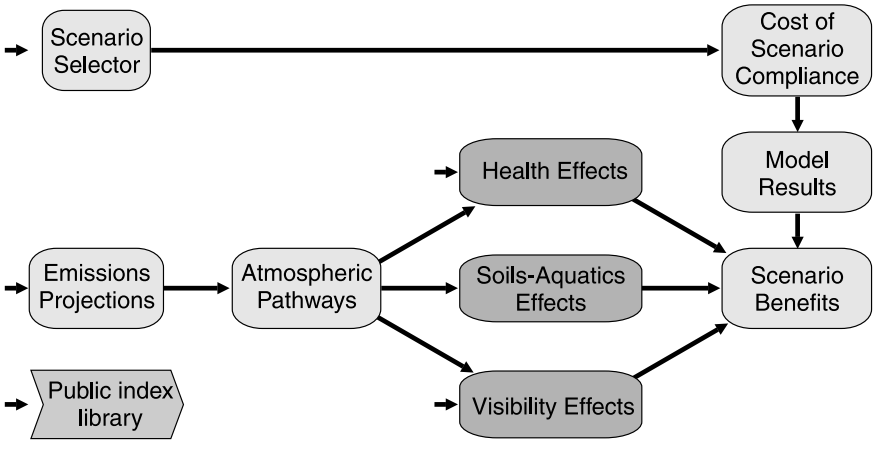

Figure 1. Drawing links between economics and the evnironment.

conference. However, there is evidence in the literature that suggests that the relative magnitude of non-use values and the value of ecological improvements viewed in this way could be very large.

A third and very important finding in the literature is that values associated with improvements in human health, which Dr. Lippmann talked about yesterday, provide the lion's share of quantifiable benefits. Taken alone, the value of improvement in human health is an order of magnitude greater than costs. These estimates, independent of the assessment of ecological improvements, appear to justify in and of themselves further reductions in the emissions cap.

A fourth finding that I will touch on is that trading of SO_2 emission allowances has not undercut the benefits of the emission reductions and may have added to those benefits slightly.

Finally, I want to look forward to a contemporary policy issue, which is the design for a regional NO_x trading program now expected to be implemented in 2004 in the eastern states.

In an important sense, my topic – the economic valuation of environmental improvements – has come late in the ball game. It has been considered largely after the SO_2 policy was designed and implemented. Indeed, the topic comes late in this panel and at the tail end of this conference. Rather, it is at the beginning when, as an economist, I might like to organize an assessment to identify where the greatest benefits are. It is also when one might want to use such an assessment to prioritize the expenditure of research dollars and public efforts to improve the environment. For obvious reasons, that is not the way that NAPAP unfolded in the 1980s. Extensive resources were spent to characterize airborne transport of emissions, and terrestrial and aquatic effects of acidification, but other processes omitted from this analysis proved to be equally critical drivers in calculating benefits and costs. We have heard about these other drivers in the last day and a half. They include the epidemiology of health effects, the economic valuation of health effects, the change in coal transportation costs (Carlson, et al. 2000; Burtraw et al. 1998), among other topics. These were not studied in adequate economic terms before implementation of the SO_2 trading program, and since the implementation of the program there have been significant contributions to the academic literature that improve the type of assessments that can be made. That is why, at the conclusion of my talk, I want to draw attention to the NO_x trading program as a contemporary policy issue that should be considered in light of what environmental economics can contribute to future policy.

I am going to begin by summarizing the results of an integrated assessment effort that involved 30 researchers from about a dozen different institutions. The result was a public domain integrated assessment model called the Tracking and Analysis Framework (TAF) (Bloyd et al., 1996). Figure 1 provides an illustration of the model, which is publicly available at www.lumina.com\taflist. One publication based on this effort appeared in *Contemporary Economic Policy* (Burtraw et al., 1998), and it was one of the few publications independent of federal agencies that attempted to estimate benefits and costs of the Title IV SO_2 and NO_x programs. The integrated assessment model linked changes in emissions to changes in transport, to changes in concentrations and deposition, to changes in a number of environmental end points, including lake acidity, and then to use values associated with lake acidities in the Adirondack Park region. The concentrations were estimated on a state-by-state basis across the nation with respect to changes in sulfates and nitrates. Human health as well as visibility effects were quantified and valued in monetary terms.

The midpoint estimates resulting from the study are reported in Table 1. I want to emphasize two important caveats. First, note that the numbers in the table are reported "per affected person." The populations affected by changes in the environment vary with the nature of the environmental change. In the case of health benefits, the population of the nation are included. In the case of recreation or visibility changes, only regional populations are included. Hence, the numbers in the table are not additive.

A second caveat is illustrated in Figure 2. The integrated assessment gave projections through 2030 for a number of environmental end points, as illustrated. Notice that the vertical axis displays the estimates on a log scale. This is appropriate when

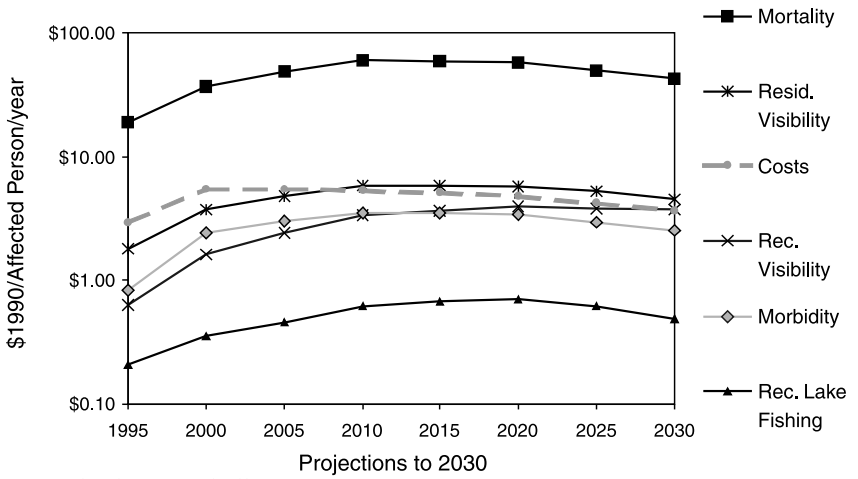

Figure 2. Benefits for assessed effects.

you look at the magnitude of uncertainty through the entire valuation pathways. The log scale is a useful visual tool for comparing the benefits and costs while retaining a flavor of the uncertainty associated with the midpoint estimates.

Costs are estimated to be about $6 per person for electricity consumers across the nation. The benefits of improvements in recreational lake fishing are substantially less than this cost (Table 1). This benefit estimate is achieved using a reduced form model that was calibrated to the Magic model and only considers effects in lakes in the Adirondack Park region. Although there are a lot of other lakes and streams that are going to be affected around the rest of the nation, there are also going to be different user populations that will be affected at these locations. So, on a per-affected capita basis, the estimate we obtained for the Adirondacks is a useful estimate of the benefits of environmental improvements pertaining to recreational fishing. What the study finds is that it would be difficult to justify the costs of the program from a benefit-cost perspective when considering improvements in recreational fishing alone.

Table 1. Comparing benefits and costs.

Effect	$ per *affected* person from expected emissions reductions in 2010 (1995$)
Morbidity	4
Mortality	69
Lake Fishing	1
Recreational Visibility	4
Residential Visibility	7
Costs	*6*

Happily, one does not have to justify the cost of the program on the basis of any one of the environmental pathways taken alone.

A number of benefit categories individually weigh in at about the same level as cost, including recreational and residential visibility improvements per affected person, and morbidity health effects on a nationwide basis. However, mortality health effects on a nationwide basis weigh in at about an order of magnitude greater.

I want to focus a moment longer on the mortality estimate because of what Dr. Lippmann said yesterday. Part of the theme that has emerged in the last day and a half is what we have learned since 1990. Dr. Lippmann pointed out that as of 1990, the research was not firmly in place to convincingly establish the benefits associated with premature mortality from changes in nitrates and sulfates. Since that time, there has been a growth in the epidemiology literature. The integrated assessment estimates I have been citing relied on epidemiology in Schwartz and Dockery (1992). Subsequently, the Pope et al. (1995) study and the Krewski et al. (2000) re-analysis of this study suggest that the dose response coefficients are about three times what they were when we

calculated the numbers based on Schwartz and Dockery in the work I have presented.

Another important development in environmental economics goes to valuing changes in premature mortality. The way valuation of mortality effects was done circa 1990 was to look at compensating wage differentials in the work place, for example the wage premium for coal miners or for police officers, as compensation for the extra risk associated with those professions. That approach is the basis for the value of statistical life that has been the underpinning of benefit-cost analysis for most of this decade.

There are philosophical and conceptual problems with the compensating wage approach. So, in the middle part of the decade there began efforts to try to, on an ad hoc basis, see if we could improve on this, paying attention to factors such as evidence that infirm or older populations are perhaps most at risk from poor air quality. Yesterday, Dr. Lippmann mentioned the attempt to look at life years lost as being sort of an ad hoc adjustment. Those ad hoc adjustments were already reflected in the integrated assessment estimates I reported.

More recently, however, there has been a series of studies that have tried to match the nature of the change in risk from PM exposure to the valuation of that risk (Krupnick et al., 2000; Mrozek and Taylor, 2002). This work suggests changes in values that go in the opposite direction of those from the new epidemiology, reducing the estimate of benefits from reduced mortality, and they largely off-set the changes in the epidemiology since the benefit estimates are the product of these two values.

There could be two or three reasons that the valuation of premature mortality associated with PM exposure might be less than suggested by the compensating wage approach. One reason that is often suggested, and which I mentioned previously, has to do with the age of individuals who are exposed. However, the literature does not find this to be statistically important. Instead, what does have an effect on the estimate is the delay between exposure and response. A subject's willingness to pay at the time of exposure is higher when the response is immediate than when it is postponed (that is, when the exposure shortens one's life because of changes in health status when one becomes elderly). The willingness to pay to avoid such exposures differs when health effects are realized immediately versus when there are changes in life expectancy that are realized 20 or 30 years from now.

In summary, considering changes in the health epidemiology and the valuation of changes in health status in the last decade, these changes head in offsetting directions with respect to the economic valuation of mortality health effects. So, developments in the 1990s suggest the health benefits from the reductions in emissions achieved due to the 1990 Clean Air Act Amendments are an order of magnitude greater than the cost of the program, as suggested originally by the studies done in the middle of the decade.

Another question of interest is the regional effect of emission allowance trading. We have used a simulation model that embodies the economic logic of trading with plants trading on the basis of relative marginal costs of emission reductions. This is used to find the expected location of changes in emissions, which is then coupled with other aspects of the integrated assessment framework to evaluate those changes (Burtraw and Mansur, 1999). Figure 3 illustrates the finding that trading leads to an increase in emissions in the Midwest and a decrease in the East and Northeast. However, what follows from this change in the location of emissions is that health status in the aggregate is

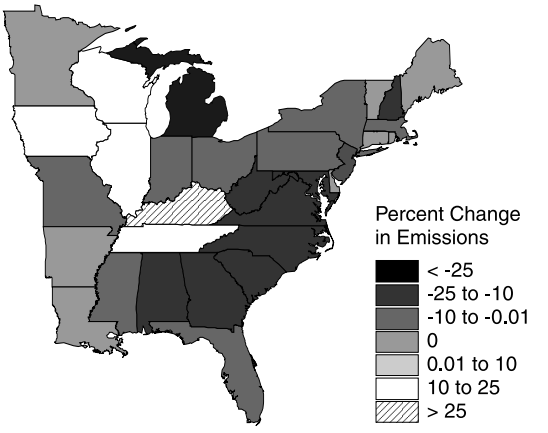

Figure 3. Effect of trading on emissions. Percent change in Title IV baseline utility emissions attributable to trading for 2005.

not degraded by trading, and may actually be improved, as illustrated in Figure 4. Many observers have objected to the fact that the northeastern states are affected by long-range transport of emissions from the Midwest. This is true, but this effect is overshadowed by the fact that residents of northeastern states suffer less from a unit of emission in the Midwest than when the emission is more proximate to where they live. The change in health benefits is most unfavorable in the regions where emissions increased. This view runs contrary to the intuition formed from studies about acidic deposition, which falls, of course, at the end of the atmospheric transport pathway, presumably many hundred miles from the emission source. Changes in concentration occur all along the transport pathway and are greater relatively close to the emission source rather than at the end of the transport pathway. It is in the Midwest that there are the greatest changes in health status as a consequence of the slightly greater emissions there as a result of the trading process.

We find that health effects vary slightly due to emission trading, but it is so trivial in magnitude that one could probably say the effect is zero. However, where there is an effect with respect to changes in health status or with respect to deposition, we find an improvement in aggregate public health due to the trading process. In some states there is an increase in exposure and in some states there is a decrease in exposure due to trading, but on net the effect of trading is to improve the aggregate measure of health status. The map in Figure 4 illustrates the expected percent change in monetized health benefits as a consequence of the geographic pattern of trading. Let me emphasize that this illustrates changes that come in addition to the large changes resulting from the decrease in aggregate emissions. The map indicates that the whole eastern seaboard will realize a slight improvement in health status as a result of the pattern of trading that we identify in the model.

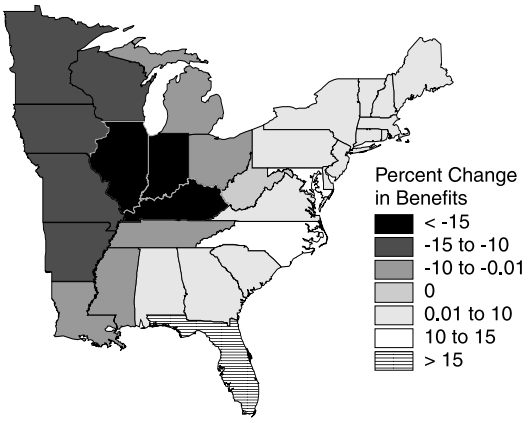

Figure 4. Effect of trading on health. Percent change in Title IV baseline benefits attributable to trading for 2005.

The measure of improvement in deposition that we have estimated is focused on the northeastern states including the State of New York. The improvement from the trading process is small and not important. Again, however, it comes on top of the large and very important improvement that results from the aggregate reduction in emissions under the emissions cap.

There has also been work by others that has examined the actual location of emissions in the first few years of the program, compared to the location of allocation of emission allowances. Yesterday we heard about the EPA's look at current allowance usage and where allowances were allocated compared to where allowances have been surrendered for compliance. That is a problematic measure because firms can bank an allowance, firms can buy one from Peter and buy one from Paul and use one and not use the other. So, it is not entirely meaningful to track the origin of an allowance used for compliance under the program. Nonetheless the EPA empirical assessment (EPA, 1998) and others (Swift, 2000; Solomon and Lee, 2000) are pretty much the same as the findings from the integrated assessment simulation model. The pattern of trading has had very little effect on the ultimate location of emissions.

Nonetheless, I want to validate the concern that there could be a geographic effect due to trading. The idea that the geographic pattern of trading could be undoing the benefits to the environment or human health, or in some other sense be fundamentally unfair, might strike one as an exciting potential piece of investigative journalism (Figure 4). It is a legitimate concern, and indeed it is found throughout the underpinnings of the economics literature about trading. To

address this issue in public policy involves potentially complex institutions that are designed to accommodate concerns about the geographic or temporal patterns of emission trading. As the EPA escorts us towards a new NO_X trading program in the eastern 19 states, the same question may be relevant to the design of the NO_X trading program.

The institutional design of a trading program that would be necessary to accommodate this concern would come at a significant cost, which would be realized through greater transaction costs, less trading and greater costs of emission reductions in the aggregate. The simplicity, transparency and flexibility of the SO_2 trading program is one of the primary reasons for why costs have been low and it has been such a success. These virtues would be sacrificed if we had to design a complex program to accommodate the geographic concerns. Doing so would raise the cost of a trading program substantially, so it should only be done when evidence suggests that these conceptual possible problems are likely to be manifest in an important way.

In the case of the SO_2 trading program, it is serendipity that the evidence indicates the pattern of trading has not harmed health or the environment, and it may actually have contributed to an improvement. The concern in New York State is to the contrary. I want to validate that concern as a conceptual point, but in the case of the SO_2 trading program I cannot support it as an empirical point.

Perhaps the overarching point from the perspective of New York State, however, comes out of the concern about where the emissions cap is set and whether or not we are achieving sufficient reductions. That is a very good question, and I encourage that as a focus for ongoing dialogue.

In conclusion, the effects of trading are very small compared to the effects of the overall emission reductions, as summarized in Table 2 and Table 3. Yes, there are positive health benefits in the aggregate associated with trading according to our modeling, but they are only about $100 million a year, compared to health benefits due to the overall reduction in SO_2 emissions of over $17 billion per year, in the year 2005. I am comparing

Table 2. Effects of Title IV are small.

	1995	2005
Change in SO_2 Emissions	-152 thousand tons Nationally	-53 thousand tons Nationally
Change in Sulfur Deposition	-0.1 kilograms/hectare New York	-0.2 kilograms/hectare New York
Change in Health Benefits	566 million (1995 $) Nationally	124 million (1995 $) Nationally

Table 3. Effects of Title IV are large.

	1995	2005
Change in SO_2 Emmissions	-1287 thousand tons Nationally	-3213 thousand tons Nationally
Change in Sulfur Deposition	-1.3 kilograms/hectar New York	-3.1 kilograms/hectar New York
Change in Health Benefits	5998 million (1995 $) Nationally	17,400 million (1995 $) Nationally

$100 million versus $17 billion when I conclude that the main point is that the overall cap is what was really important in achieving the benefits that have resulted from the program. Trading underneath that cap has been important to realizing cost savings, flexibility for the industry, and it has had close to a trivial effect in terms of the benefit estimations.

As a final observation about the SO_2 trading program, I want to report on an effort to identify the weak links in the existing science and economics as identified by the integrative assessment. We did a number of value of information and value of uncertainty analyses. We extended the quantitative analysis through an expert solicitation process to obtain judgments about the value of additional information for a number of environmental and health end points, including health, visibility, cultural material uses, and non-use values. As I indicated previously, use values stem from changes in well being through direct exposure or experience with an environmental end point, such as swimming, boating, fishing, angling, bird watching or what have you.

An idea emerged in the economics literature 25 or 30 years ago, at first heretical, but one that now has gained widespread acceptance and legitimacy. This is the idea that individuals may be willing to pay for environmental improvement, even if the individual never plans to visit the resource, never plans on having his or her children visit the environmental resource, etc. Even in this case, it is possible that the individual is willing to sacrifice something in terms of monetary well being in order to see that resource preserved. This willingness to sacrifice forms a basis for estimating what are called nonuse values. Today, even among the most conservative economists, the concept of non-use values has legitimate standing. It has been shown in some very careful studies to be sometimes quite significant. The issue that divides the economics profession is whether non-use values can be reliably and consistently estimated in a fashion sufficient for use in the policy process. It is all too easy to come up with totally fictional estimates by just asking your neighbors and friends what they would be willing to pay for something like healthier air. The scholarly research in estimating non-use values is much more sophisticated, and it has broken out of economics. It is now a subject of interdisciplinary studies linking social science, economics and physical sciences.

Anyway, the end points that we looked at are indicated in the rows in Table 4. We solicited judgments from experts about the questions indicated at the tops of the first four columns in

Table 4.

Categories ● high ◎ high-mid ◒ mid ⊙ low-mid ○ low	1. Link Between Science and Economics: Are benefit endpoints well established? Does science provide infomation needed for economic analysis?	2. Economic Methods: Are economic methods adequately developed?	3. Data Availability: Is data available from science and from economics for an assessment of benefits?	4. Expected Benefit: Are expected benefits large?	5. Value of Additional Information: With the goal of improving benefit estimates, what is the relative short-term return on investment?
Health: Mortality	◎	◎	◎	●	●
Health: Morbidity	◎	◎	◎	◎	◎
Visibility	◎	◒	⊙	◎	◎
Materials / Cultural	⊙	◒	○	◎	◎
Nonuse Value: Ecosystem	⊙	⊙	⊙	●	◒
Aquatics: Recreation	◎	●	⊙	⊙	◒
Forests: Recreation	⊙	◎	○	⊙	◒
Ag. / Comm. Forestry	◎	●	◒	◒	⊙
Radiative Forcing	⊙	○	○	⊙	○

the table. Are the links between science and economics firm enough to support a benefit estimation? Are the economic methods in place? Is the data available on both the science and economic fronts? Are the expected benefits large? The last column of the table indicates the expected benefit, or in other words the value of additional information, in terms of qualitative order of magnitude from a short-term research agenda to improve the links between science and economics.

We find that health mortality is the driving question here, because of its overall magnitude of expected benefit. The other issue which has high expected benefits from additional research is non-use value for ecosystem health. The problem with that research area is that it is a long-term research project. I wouldn't be too discouraged about that, however. If we were in this room 25 years ago asking the same questions, we would have been talking about valuing health effects with comparable uncertainty and many at that time would have felt that the ability to do so was ill founded, not reliable, and certainly not robust to repeated inquiry coming to study the same question to see if they could come up with the same answer. Twenty-five years ago, the estimation of health effects was nowhere near where it is today. Now, in the 1990s, we find dozens of epidemiological and health valuation studies that are robust, and stand up to repeated inquiries by various scholars. I think we can be optimistic that although non-use values are probably a decade or two away from the same level of rigor, the research is well along the way in that regard. However, although research has started in the academic community, the funding for it, as funding for anything we have talked about in the last two days, is not necessarily evident.

As we look forward to issues of the greatest contemporary policy interest, the one that stands out is the proposed NO_XSIP Call and regional summertime NO_X emission trading program for the 19 eastern states and the District of Columbia. The program is expected to take effect in 2004.

We have heard that NO_X emissions contribute to multiple problems. However, the regulatory handle for the NO_XSIP Call cap and trade program is limited to non-attainment of the ozone health standard. Consequently the program is designed at achieving reductions in ozone, which is a summer seasonal problem, but other NO_X-related effects are realized throughout the year. Our recent research is motivated by the observation that about 75% or 80% of the costs of NO_X control that is going to be realized at these power plants are one-time capital costs, and a relatively small proportion is variable costs. Consequently, the overall magnitude of costs would not change by much if the emission reductions were achieved on an annual basis. How would the benefits change, and would it be cost-effective to reduce emissions throughout the year?

To investigate this we looked at two scenarios (Burtraw et al., 2001; Palmer et al. 2001). One was a summer cap in 19 states. The other is an annual cap, where the cap was determined by an average emission rate that was kept the same as for the summer cap scenario. We looked at two scenarios with respect to the status of restructuring in the electricity industry. Limited restructuring characterizes current commitments to implementing competitive pricing at the state level. National restructuring is a scenario in which the entire country is assumed to implement competitive pricing by 2008. The regulatory structure of the electricity industry has big effects because restructuring, we think, is going to lead to greater NO_X emissions in the baseline (that is, in the absence of the NO_X SIP Call cap and trade program).

The results are illustrated in Table 5 for the limited restructuring case (Burtraw et al., 2001). The SIP seasonal policy would cause a reduction of about a million short tons of NO_X from the power sector. However, if implemented on an annual basis, the policy would more than double the emission reductions. Paying attention to the particulate matter health pathway, we calculate more than a doubling of improvement in health benefits from particulate matter that would result, while the compliance costs increase only by roughly about 20 percent.

The good news from a political perspective is that, for reasons that are quite interesting to an economist and would bore the rest of you, the change in electricity prices could be expected to be less under a SIP annual policy than under a SIP seasonal policy. We find that extending the NO_x SIP Call trading program to an annual program would lead to $200 million to $600 million per

Table 5. Nationwide, annual particulate related health benefits and costs for 2008.

	Benefits/Costs in Aggregate (million 1997$)			(thousand short tons)	Benefits/Costs per Ton (1997$ per short ton)		
	Particulate Related Health Benefits Only (from Table 3)	**Post Combustion Control Costs** (from Table 5)	**(Partial) Net Benefits** (Particulate Health Benefits minus Costs)	**NO_X Emissions** (from Table 2)	**(Partial) Average Benefit**	**Average Cost**	**Marginal Cost**
Baseline	-	30	-	5,533	-	-	1,356
SIP Seasonal	+749	+2,146	-1,397	-992	755	2,163	3,401
SIP Annual	+1,777	+2,728	-951	-2,378	747	1,147	1,985
National Annual	+2,564	+4,434	-1,870	-3,962	647	1,119	3,884

year in additional net benefits (additional benefits less additional costs). This estimate is based only on the value of particulate-related health effects. But, the finding is robust to all the omitted benefits, including changes in ozone, which are the driver for the SIP Call policy in the first place.

Looking forward, our conclusion is that the EPA and the eastern states, many of whom are represented here today, should consider revising the SIP Call initiative to aim at annual reductions. Thank you.

REFERENCES:

Bloyd, Cary, et al. 1996. *Tracking and Analysis Framework (TAF) Model Documentation and User's Guide*, ANL/DIS/TM-36, Argonne National Laboratory, December.

Burtraw, Dallas, Alan Krupnick, Erin Mansur, David Austin, and Deirdre Farrell. 1998. "The Costs and Benefits of Reducing Acid Rain," *Contemporary Economic Policy*, vol. 16 (October), pp. 379-400.

Burtraw, Dallas and Erin Mansur, 1999. "The Environmental Effects of SO_2 Trading and Banking." *Environmental Science and Technology*, Vol. 33, No. 20, (October 15), 3489-3494.

Burtraw, Dallas, Karen Palmer, Ranjit Bharvirkar, and Anthony Paul), 2001. "Cost-Effective Reduction of NO_X Emissions from Electricity Generation," *Journal of Air & Waste Management*, Vol. 51, 1476-1489.

Carlson, Curtis, Dallas Burtraw, Maureen Cropper, and Karen Palmer. 2000. SO_2 Control by Electric Utilities: What are the Gains from Trade?" *Journal of Political Economy*, 108 (6), 1292-1326.

Environmental Protection Agency, 1998. "The Environmental Impacts of SO_2 Allowance Trading," Acid Rain Program, (December); http://www.epa.gov/acidrain/effects/tradefx.htm

Krewski, D., R.T. Burnett, M.S. Goldberg, K. Hoover, J. Siemiatycki, M. Jerrett, M. Abrahamowicz, and W.H. White. 2000. "Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality. A Special Report of the Institute's Particle Epidemiology Reanalysis Project." Cambridge, MA: Health Effects Institute.

Krupnick, Alan, Anna Alberini, Maureen Cropper, Nathalie Simon, Bernie O'Brien, Ron Goeree, and Martin Heintzelman. 2000. "Age, Health, and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey of Ontario Residents," Discussion Paper 00–37. Washington, DC: Resources for the Future (September).

Mrozek, Janusz R., and Laura O. Taylor, 2002. "What Determines the Value of Live? A Meta-Analysis," *Journal of Policy Analysis and Management,* forthcoming.Palmer, Karen, Dallas Burtraw, Ranjit Bharvirkar, and Anthony Paul, 2001. "Restructuring and the Cost of Reducing NO_X Emissions in Electricity Generation," Resources for the Future Discussion Paper 01–10 (March).

Palmer, Karen, Dallas Burtraw, Ranjit Bharvirkar, and Anthony Paul, 2001. "Restructuring and the Cost of Reducing NO_X Emissions in Electricity Generation," Resources for the Future Discussion Paper 01–10 (March).

Pope, C. A. III, M. J. Thun, M. M. Namboodiri, D. W. Dockery, J. S. Evans, F. E. Speizer, and C. W. Heath, Jr. 1995. "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of US Adults," *American Journal of Respiratory and Critical Care Medicine*, vol. 151, pp. 669-674.

Schwartz, J., and D.W. Dockery. 1992. "Particulate Air Pollution and Daily Mortality in Steubenville, Ohio," *American Journal of Epidemiology*, vol. 135, no. 1, pp. 12–19.

Solomon, Barry D., and Russell Lee, 2000. "Emissions Trading systems and Environmental Justice," *Environment,* vol. 42, no. 8 (December), 32-45.

Swift, Byron, 2000. "Allowance Trading and SO_2 Hot Spots – Good News From the Acid Rain Program," *Environmental Reporter,* vol. 31, no. 19 (May 12), 954-959.

QUESTION

AUDIENCE: NO_X is a worse contributor to deposition and damage in the winter. I wanted to bring that up.

MR. BURTRAW: I'll accept that as an observation rather than a question. I agree, that if we look at the omitted benefits, an annual NO_X reduction program would dominate a seasonal NO_X reduction program, not just because of health benefits, but also because of the non-health benefits, which we did not model thoroughly.