Benefits of Reduced Air Pollution in the United States

Dallas Burtraw
Resources for the Future

Presentation to EMEP Conference
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Background materials at
Roadmap

- Integrated Assessment Approach
- 1990 CAAA
- NOx SIP Call
- Multi-pollutant legislation
  - Efficient Emission Fees for SO2, NOx
  - Proposal Targets, Benefits
  - Errors and Uncertainties in Benefit Estimates
  - Guidelines for Hg
  - Architecture for Carbon
Integrated Assessment: Meaning and Method

- Integration of full-form models with “internal” validity
- Emphasis on “external” integrity
- Account for correlated uncertainty
- Include assessment
- Value of additional information

NYSERDA played a path-breaking role in the application of integrated assessment in the early 1990s with co-sponsorship of the ESEERCO externality study.

Benefits of Reduced Air Pollution
TAF Findings: Benefits and Costs of Title IV

“Integrated Assessment” (NAPAP, 97) and “Benefits and Costs of Title IV” (CEP, 98)

Benefits of Reduced Air Pollution
## The Weak Links

<table>
<thead>
<tr>
<th>Expected Benefit:</th>
<th>Short-Term Value of Additional Information:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health: Mortality</td>
<td>●</td>
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<tr>
<td>Health: Morbidity</td>
<td>●</td>
</tr>
<tr>
<td>Visibility</td>
<td>●</td>
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<tr>
<td>Materials and Cultural Resources</td>
<td>●</td>
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<tr>
<td>Nonuse Values: Ecosystem Health</td>
<td>●</td>
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<tr>
<td>Aquatics: Recreation</td>
<td>○</td>
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<tr>
<td>Forests: Recreation</td>
<td>○</td>
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<tr>
<td>Ag / Commercial Forestry</td>
<td>○</td>
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<tr>
<td>Radiative Forcing</td>
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Benefits of Reduced Air Pollution
Spatial Effects of Trading

- In 1993, the NY AG sued EPA to restrict allowance sales.
- NY Assembly, later Senate, voted to constrain trades.
- 1998 agreement with Long Island Lighting Company (LILCO).
- 1998 Senator D’Amato likened long-range transport of acid rain to “airborne terrorism.”
- 2000 Governor Pataki signed into law legislation to monitor and control sale of SO$_2$ allowances.
- 2003 Appeals court strikes down NY law.
Effect of Trading on Emissions

Percent Change in Title IV Baseline Utility Emissions Attributable to Trading for 2005

“Regional Analysis of SO2 Allowance Trading” (EST, 99)
Percent Change in Title IV Baseline Benefits Attributable to Trading for 2005

Effect of Trading on Health

Percent Change in Benefits
-15
-15 to -10
-10 to -0.01
0
0.01 to 10
10 to 15
>15

Benefits of Reduced Air Pollution
Effect of Trading on Deposition

Percent Change in Title IV Baseline Sulfur Deposition Attributable to Trading for 2005

Percent Change in Deposition

-8  
-8 to -4  
-4 to -2  
-2 to -0.01  
0  
0.01 to 2  
2 to 4  
4 to 8  
>8
Baseline Emissions, with Phase I Allocations and Emissions of SO\(_2\) by Region

- **1980 Emissions**
- **Phase I Allowances Annualized**
- **Phase I Emissions Annualized**

### Regions
- **Midwest**
- **Southeast**
- **Northeast**

<table>
<thead>
<tr>
<th>Region</th>
<th>1980 Emissions</th>
<th>Phase I Allowances</th>
<th>Phase I Emissions</th>
</tr>
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<tbody>
<tr>
<td>Midwest</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Southeast</td>
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<td></td>
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<tr>
<td>Northeast</td>
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</tbody>
</table>
Allowances Allocated and Emissions of NO\textsubscript{x} Under OTC Program

Benefits of Reduced Air Pollution
8-hour Ozone change and state shares for 30% NOx Reduction.

Krupnick et al. in preparation, 2003
The Second Grand Experiment: NOx SIP Call

- NO\textsubscript{x} emissions contribute to multiple problems:
  - ozone, particulates, nitrogen deposition, visibility
- Nonattainment of ozone standard provides regulatory handle for EPA NO\textsubscript{x} SIP Call
- Policy aimed at ozone, a seasonal problem
- But, other NO\textsubscript{x}-related effects are realized throughout the year
- Costs of NO\textsubscript{x} control are largely fixed and capital costs.

Annual vs. Seasonal NOx Controls’’ (JAWMA 01; Land 03)
Question: What is the most cost-effective way to achieve NO$_x$ reductions given full set of NO$_x$ related problems?

Three NO$_x$ reduction scenarios:

- Summer cap in 19 state SIP Call region
- Annual cap in the same SIP Call region
- National Annual cap

Benefits of Reduced Air Pollution
Major Uncertainties

- Market Structure
- Epidemiology / Mortality
- Valuation / Mortality
RFF “Haiku” Electricity Model

- Intra-regional market modeling
  - Market equilibrium in 13 regions
  - Demand: 3 customer classes, 4 time periods, 3 seasons
  - Supply constructed using model plants
    - Defined by technology, fuel type, vintage
    - Investment and retirement
    - Emission compliance
    - Fuel market prices adjust

- Inter-regional power trading
  - Equilibrates regional prices, transmission constraints

Benefits of Reduced Air Pollution
Net Benefits for the Nation, 2008

Combinations of assumptions in scenario analysis characterizing market structure, epidemiology and valuation.

Benefits of Reduced Air Pollution
Main Findings Favor Annual NOx Controls

- Under all scenarios **SIP Annual policy** yields greater net benefits than current policy; Ohio Valley included.
- National annual policy is slightly less cost-effective than current under preferred assumptions …but it is more cost-effective under majority of scenarios.
- SIP region always realizes greatest net benefits under National Annual policy.
- Omitted benefits do not change ranking for SIP Annual
State Actions in SIP Call region

Connecticut, Massachusetts, New Hampshire, North Carolina and New York have moved to annual controls on NO$_x$ and SO$_2$.

State actions amplify the challenges to resource planning for electricity generators.
The Clean Air Act’s Requirements

**NSR Permits** for new sources & modifications that increase emissions

**Ozone**
- 1-hr Serious Area Attainment Date
- Designate areas for 8-hr Ozone NAAQS
- 1-hr Severe Area Attainment Date
- Marginal 8-hr Ozone NAAQS Attainment Date
- 8-hr Ozone Attainment Demonstration SIPs due
- Assess Effectiveness of Regional Ozone Strategies
- Possible Regional NOx Reductions? (SIP call II)¹
- Moderate 8-hr Ozone NAAQS Attainment Date

**Note**: Dotted lines indicate a range of possible dates.

¹ Further action on ozone would be considered based on the 2007 assessment.

² The SIP-submittal and attainment dates are keyed off the date of designation; for example, if PM or ozone are designated in 2004, the first attainment date is 2009.

EPA is required to update the new source performance standards (NSPS) for boilers and turbines every 8 years.

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**Benefits of Reduced Air Pollution**

Acid Rain, PM₂.₅, Haze, Toxics
EIA forecasts over time for 2010

Benefits of Reduced Air Pollution
## Percent of Total Generation in the Baseline

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Gas</th>
</tr>
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<tbody>
<tr>
<td><strong>Today</strong></td>
<td>54%</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Forecast for 2020</strong></td>
<td>48%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>106%</td>
</tr>
</tbody>
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Growth

**Benefits of Reduced Air Pollution**
Old generating units have highest emission rates...

Average NOx Emission Rates for Coal-Fired Boilers by Vintage

Benefits of Reduced Air Pollution
But just a small share of emissions

Percent of NO\textsubscript{x} Emissions for Coal-Fired Boilers by Vintage

<table>
<thead>
<tr>
<th>Vintage</th>
<th>NO\textsubscript{x} Emissions (lb./MWh)</th>
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<tbody>
<tr>
<td>&lt;1950</td>
<td>6.0%</td>
</tr>
<tr>
<td>1950-1959</td>
<td>14.9%</td>
</tr>
<tr>
<td>1960-1969</td>
<td>21.6%</td>
</tr>
<tr>
<td>1970-1979</td>
<td>40.1%</td>
</tr>
<tr>
<td>1980-1989</td>
<td>21.1%</td>
</tr>
<tr>
<td>&gt;1989</td>
<td>1.8%</td>
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</tbody>
</table>

Share of 1999 Generation by Vintage

Benefits of Reduced Air Pollution
### Legislative Comparison of Multipollutant Proposals: S. 366, S. 485, and S. 843.

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<tr>
<td><strong>Sulfur Dioxide (SO₂)</strong> Million Tons</td>
<td>2.25 in 2009. Two regions.</td>
<td>4.5 in 2010. 3.0 in 2018.</td>
<td>4.5 in 2008. 3.5 in 2013. 2.25 in 2016.</td>
</tr>
<tr>
<td><strong>Carbon Dioxide (CO₂) Billion Tons</strong></td>
<td>2.05 in 2009.</td>
<td>No CO₂ policy.</td>
<td>2.57+ in 2009. 2.47+ in 2013. + Sequestration increases CO₂ cap.</td>
</tr>
</tbody>
</table>
Efficient Emission Levels for SO2 and NOx

Scenario and Key Assumptions

- PM-health modeled only; no ozone benefits
- Examine SO2 and NOx emission fees
- No CO2 or mercury requirements
- Results for 2010
- Title IV SO2, SIP Call NOx baseline
- Pope et al. (1995) for sulfates
- Nitrates as ordinary PM$_{10}$
- VSL=$2.25$ million (Mrozek and Taylor, 2001)
Marginal Benefits and Costs: SO₂

Benefits of Reduced Air Pollution
Value of SO$_2$ Emission Reductions by State

Benefits per Ton ($1999)

- 0 - 1444
- 1460 - 2694
- 2795 - 3245
- 3336 - 3688
- 3829 - 6062
NO\textsubscript{X} & SO\textsubscript{2} Electricity Sector Emissions in 2020

Source: Banzhaf, Burtraw and Palmer, 2002. *Public Utilities Fortnightly* Benefits of Reduced Air Pollution
Major Research Issues and Uncertainties in Valuation of Health-Related Benefits

**Emissions Modeling**
- Source apportionment: Who is to blame (location and types of sources)?

**Epidemiology**
- Long-term exposures and disease.
- Which particulates matter?

**Valuation**
- Valuation of children and elderly and other vulnerable groups. Evidence suggests:
  - Parents value children’s health > own health.
  - Seniors value selves < younger adults… But far greater than Life-Year-Lost approach suggests.
Acidification Benefits

- Acidification played a leading role in 1990 Clean Air Act Amendments.
- Thin literature on value of improvements in acid-sensitive ecosystems.
- NAPAP/TAF developed limited estimate of recreation benefits, but value of information assessment suggested nonuse values were more important.
Ongoing Study of Adirondacks

**Motivation:** Nonuse values are implicitly zero in B/C analysis until a study shows they are larger. Information on the size of values could guide further policy initiatives.

**Purpose of Study:** Elicit total Willingness to Pay for ecological improvements in the Adirondack State Park region consistent with scenarios for emissions reductions.

**Goals:**
- Laymen’s Summary of the Science Report.
- CVM estimates consistent with the science and state of the art in economics.
This map illustrates one small part of the Adirondack State Park. This part is located where the red dot is on the inset map. Most of the lakes affected by past air pollution are small; they are typically much smaller than Central Park in New York City. The large lakes that you may have heard of (such as Saranac Lake or Lake George) are much bigger than Central Park and are not lakes of concern.
Status

• Numerous focus groups and peer reviewed instrument design.
• Instrument in field currently.
• Mode of administration includes internet and mail. Approximately 2300 responses anticipated.

No results yet… Of responses we can share qualitative result that 44% feel problem is very important, 46% feel problem is somewhat important.
Main Points on Criteria Pollutants

- SO$_2$ and NO$_x$ caps for all of the proposals appear justified... there is room for more SO$_2$ reductions; NO$_x$ reductions about right.
  - Efficient SO$_2$ fee ($4,700 - $1,800 per ton) would yield 0.9 – 3.1 million tons.
  - Efficient NO$_x$ fee ($1,200 - $700 per ton) would yield 1.0 – 2.8 million tons.

- Evidence supporting regional caps.
- Ancillary CO$_2$ reductions.
Benefits of Reducing Mercury Emissions

- Estimates linking health benefits to mercury emission reductions are needed.
- One study used Chesapeake Bay angler population to account for:
  - Change in averting behavior among anglers under fish consumption advisory implies a change in mercury exposure.
  - Commercial market behavior.
  - Using epidemiological and economic literature, estimate changes in health endpoints and value where possible.

Paul Jakus, Meghan McGuinness, and Alan Krupnick, 2002
Results

- Health benefits of Fish Consumption Advisories: $0-$13-$71 million
- Utility loss to recreation from FCA: $9 million
- Commercial fisheries loss: $0.5 million

⇒ These results apply to a narrow population. General results for benefit-cost analysis are still needed.
Target:
What does benefit literature say?
MACT~7.4 tons/yr to Ancillary~28 tons/yr
(current levels in coal burned for electricity: ~75 tons/yr)

Design:
Trading enables tougher goals. Perhaps with…
- Maximum emission rate constraint
  (not minimum emission rate reduction), and
- State opt out of trading for local protection
Key Ingredients to Multipollutant Policy

- **SO$_2$ and NO$_x$ caps** are justified on benefit-cost.
- **Mercury trading**, with constraints, can lower costs; benefits not well quantified.
- Architecture is very important for carbon policy.
  - Start soon rather than start large.
  - Auction is less costly to society, and preserves asset values better than output-based allocation.
  - The auction institution is expandable beyond electricity.
  - A hybrid allocation approach to balance compensation and efficiency.