# A Guide to Economic and Policy Analysis of EPA's Transport Rule

**Richard Schmalensee**

**Robert N. Stavins**

**March 2011**

This White Paper was commissioned by the Exelon Corporation. It represents the views of the authors, not necessarily those of Exelon.

# A Guide to Economic and Policy Analysis of EPA's Transport Rule

**Richard Schmalensee and Robert N. Stavins**[1]

**March 2011**

## Executive Summary

The U.S. Environmental Protection Agency (EPA) is developing new rules to regulate the interstate transport of sulfur dioxide ($SO_2$) and nitrogen oxides ($NO_X$) emitted from electric power generation facilities. EPA's regulatory proposal – the Clean Air Transport Rule (Transport Rule) – is designed to help communities that are generally downwind of major emissions sources comply with air quality standards and, in the process, provide health and environmental benefits to upwind and downwind communities alike. The Transport Rule is one in a series of rules being developed by EPA that will affect the electric power sector, including regulation of GHG emissions, hazardous air pollutants, cooling water intake structures, and waste disposal for coal combustion bi-products.[2]

As EPA undertakes this series of rulemakings, we believe the public interest requires the Agency to carefully assess decisions about the stringency, design, and timing of proposed rules in a holistic framework that appropriately accounts for the regulation's likely effects. This framework is grounded in "benefit-cost analysis," a key element of regulatory impact assessments required through Executive Orders spanning the past five Presidential administrations, and is complemented by distributional assessment of the economic impacts to regions, sectors and populations. Using this lens, several important points about the Transport Rule emerge:

- **Existing studies providing estimates of the Transport Rule's benefits and costs consistently find that benefits outweigh costs on a national basis, often by a wide margin.**

  EPA estimates that benefits of the Transport Rule are 25 to 130 times greater than the corresponding estimated costs. The benefits come in many forms, with the largest coming

---

[1] Schmalensee is Howard W. Johnson Professor of Economics and Management at the Massachusetts Institute of Technology and John C Head III Dean Emeritus of the MIT Sloan School of Management. He served as the Member of the Council of Economic Advisers with primary responsibility for environmental and energy policy from 1989 through 1991. He is a Research Associate of the National Bureau of Economic Research and a Fellow of the Econometric Society and the American Academy of Arts and Sciences. He has served as a member of the U.S. EPA's Environmental Economics Advisory Committee and as Chairman of its Clean Air Act Compliance Analysis Committee. Stavins is Albert Pratt Professor of Business and Government, John F. Kennedy School of Government, Harvard University; University Fellow, Resources for the Future; and Research Associate, National Bureau of Economic Research. He is an elected Fellow of the Association of Environmental and Resource Economists, was Chairman of the U.S. EPA's Environmental Economics Advisory Committee, and served as Lead Author of the Second and Third Assessment Reports, and Coordinating Leading Author of the Fifth Assessment Report, Intergovernmental Panel on Climate Change. These comments are not submitted on behalf of any of these institutions, which are listed only for purposes of identification. The authors are grateful to Todd Schatzki for invaluable assistance in the preparation of this paper, but retain full responsibility for its content.

[2] EPA is also reconsidering recently revised National Ambient Air Quality Standards (NAAQS) for ozone that would likely require additional seasonal $NO_x$ reductions beyond those required by the Transport Rule. EPA is also expected to propose new $PM_{2.5}$ NAAQS later in 2011 that would potentially require additional annual $SO_2$ and $NO_X$ reductions.

from reduced premature mortality. Reduced morbidity, especially lower incidence of respiratory and heart disease, improved visibility, enhanced agricultural and forestry yields, environmental amenities, and improved ecosystem services would also be achieved. The billions of dollars in savings expected from reduced health care expenditures and improved worker productivity alone may more than offset the Transport Rule's compliance costs.

- **The net positive benefits of the Transport Rule estimated by these studies are robust to changes in certain key modeling assumptions.**

  Differences in key assumptions used to estimate the benefits of reduced premature mortality largely drive the wide variation in estimated benefits of the Transport Rule, which accounts for the vast majority (80 to 96 percent) of total estimated benefits. These studies' findings of positive net benefits continue to hold with changes to several key modeling assumptions.

- **Actions taken to achieve regulatory benefits also create social costs. The proposed timing of the Transport Rule's requirements appear unlikely, however, to raise the national costs of implementation significantly.**

  Given the anticipated quantity of required pollution control retrofits, and the limited quantity of coal-fired capacity expected to retire under Transport Rule, and excess capacity in many regions, we should be able to easily avoid substantial transition costs.

- **Expanded supplies of low-cost natural gas and currently underutilized labor supply to help install pollution control equipment may well lower the social cost of the Transport Rule and mitigate any impact on electric rates.**

  Although coal prices have risen over the past decade, technological advances in natural gas extraction have greatly expanded economically viable supplies of unconventional sources. By making natural gas-fired generation more competitive with coal-fired generation, these price trends can not only lower the cost of reducing emissions through fuel substitution, but also contribute independently to coal-fired plant retirement decisions along with other market factors, such as EPA regulation.

  Similarly, in difficult economic times, such as today's, when unemployment is high, some workers used to meet new regulatory requirements may otherwise have been unemployed or underemployed. Thus, using their labor to implement the regulation imposes a lower social cost. Consequently, implementing the Transport Rule during periods of high unemployment may lower the Rule's social costs.

- **"Upwind" states, in addition to "downwind" states, will receive substantial benefits from the Transport Rule.**

  Although designed to address "upwind" states' power plant pollution impacts on "downwind" states, this characterization may misrepresent the geographic distribution of the Transport Rule's benefits and costs. While the Rule's economic costs most likely will be borne in upwind states relying heavily on coal-fired power, because of reduced emissions, these states also would likely receive substantial benefits from the Rule, largely in the form of improved health outcomes. The benefits will include reductions in health care expenditures and improved worker productivity, as well as improvements in well-being.

- **Employment will likely rise in the short run as a consequence of the Transport Rule, due largely to investment in new pollution controls.**

  In the short run, the installation and operation of new pollution control equipment and construction of new generation to replace retired coal-fired generation under the Transport Rule are likely to outweigh any reduced employment at retiring coal-fired facilities. In the long run, given the many adjustments within and outside the electric sector, the Transport Rule's impact on net employment could be positive or negative.

In sum, while imposing incremental costs to achieve reductions in $SO_2$ and $NO_X$ emissions, the Transport Rule would produce significant benefits in terms of improved health outcomes, and better environmental amenities and services, which studies estimate significantly outweigh the costs.

## I. EPA's Transport Rule and Other Rulemakings Affecting the Electric Power Sector

The Transport Rule is being developed to satisfy the "good neighbor" provision of the Clean Air Act (CAA), which requires that upwind states reduce emissions that "contribute significantly" to downwind states' nonattainment with (or maintenance of) National Ambient Air Quality Standards (NAAQS) for two key pollutants: ozone and fine particulate matter ($PM_{2.5}$).[3] Because $SO_2$ and $NO_X$ are "precursors" to ozone (i.e., smog) and $PM_{2.5}$,[4] reductions in upwind $SO_2$ and $NO_X$ emissions can help reduce ambient ozone and $PM_{2.5}$ concentrations in downwind regions.[5]

The Transport Rule is EPA's second effort to satisfy these "good neighbor" provisions. Because of "legal flaws", the U.S. Court of Appeals (the Court) remanded EPA's first effort, the Clean Air Interstate Rule (CAIR), but required that CAIR remain in effect until a rule addressing the Court's concerns was promulgated. Under the Transport Rule, power plants will need to comply with Phase I state-specific emissions targets in 2012 and more stringent Phase II emission targets in 2014. As shown in Table 1 below, these targets represent reductions of between 30 to 60 percent below anticipated (Baseline) emissions in 2012 absent the Transport Rule. Notably, however, because of industry over-compliance with existing $SO_2$ and $NO_X$ emission requirements,[6] 2009 emissions already were substantially below the Baseline level. Indeed, $NO_X$ emissions in Transport Rule states in 2009 were below aggregate emissions under both 2012 and 2014 Transport Rule requirements, whereas achieving aggregate $SO_2$ 2014 targets will require about a 40 percent reduction relative to 2009 emissions.[7]

In its ruling, the Court invalidated the core of prior $SO_2$ and $NO_X$ regulation, a cap-and-trade system with unlimited trading across states, which had afforded maximum compliance flexibility.[8] While fixing the spatial distribution of emissions may provide greater assurance that upwind emission reductions will help downwind regions achieve and maintain NAAQS compliance, it also limits the opportunity to shift emission reduction efforts to locations where they are least costly. Therefore, the proposed Transport Rule has the potential to raise the costs of

[3] US EPA, 2010. "Federal Implementation Plans To Reduce Interstate Transport of Fine Particulate Matter and Ozone, Proposed Rule." *Federal Register* 75(147):45210-45465. CAA Section 110(a)(2)(D). EPA has previously promulgated rules to satisfy the "good neighbor" provision, including the $NO_X$ SIP Call in 1998, which reduced $NO_X$ emissions to assist downwind states' compliance with the ozone NAAQS.

[4] Through chemical reactions in the atmosphere, both $SO_2$ and $NO_X$ emissions can lead to atmospheric ozone and fine particulates, both of which have adverse health consequences. ($PM_{2.5}$ refers to fine particulates smaller than 2.5 micrometers which can be inhaled deeply causing serious respiratory problems.) Ozone, commonly known as smog, is formed in the atmosphere when hydrocarbon vapors react with nitrogen oxides in the presence of sunlight. Both $SO_2$ and $NO_X$ can be transformed through atmospheric chemical reactions into small particulates.

[5] The Transport Rule would limit annual $SO_2$ and $NO_x$ emissions in 28 states, and seasonal $NO_x$ emissions in 26 states.

[6] $SO_2$ emissions are currently capped at 8.95 million tons in 2010 annually under Title IV of the 1990 CAA. Many factors have contributed to over-compliance, including the banking of allowances to comply with future requirements.

[7] Because the Transport Rule will require compliance with individual state budgets, the reductions necessary for each state to meet its state budgets will vary.

[8] Prior regulations include the Title IV $SO_2$ Trading Program, the Ozone Transport Commission $NO_X$ Budget Program, and the $NO_X$ SIP Call.

achieving aggregate reductions in $SO_2$ and $NO_X$ emissions.[9] Notably, however, EPA's preferred design for the proposed rule establishes state-specific emissions caps or budgets for power plant $SO_2$ and $NO_X$ emissions, and allows intra-state emissions trading and limited inter-state emissions trading.[10] As such, to help lower compliance costs, EPA's proposal provides some compliance flexibility while also addressing the Court's concerns regarding CAIR.[11]

**Table 1**
**$SO_2$ and $NO_X$ Emissions: Actual and Projected Compared to Transport Rule Targets For Transport Rule States (Million Tons)**

| | | | 2012 | | 2014 | |
|---|---|---|---|---|---|---|
| | 2008 | 2009 | Baseline | Transport Rule | Baseline | Transport Rule |
| $SO_2$ | 8.9 | 4.7 | 8.5 | 3.6 | 7.4 | 2.8 |
| percent reduction relative to 2009 | | | | 23% | | 40% |
| percent reduction relative to baseline | | | | 58% | | 62% |
| $NO_X$ (annual) | 2.2 | 1.3 | 2.2 | 1.4 | 2.1 | 1.4 |
| percent reduction relative to 2009 | | | | -6% | | -6% |
| percent reduction relative to baseline | | | | 36% | | 33% |
| $NO_X$ (summer) | | | 0.7 | 0.6 | 0.7 | 0.6 |

Note: Baseline emissions are EPA's estimate of future emissions assuming pre-existing regulatory requirements (e.g., Title IV $SO_2$ trading) and economic factors affecting the operation of pollution control equipment.
Source: EPA, June 2010; EPA, Acid Rain Program Progress Reports, for 2008 and 2009.

Given the potential for flexibility to lower compliance costs, as it develops other power sector rules, EPA should endeavor to continue to allow as much compliance flexibility as is feasible. Flexibility can emerge in various ways in the different EPA rule-makings. For example, future regulations of cooling water intake structures, designed to reduce fish impingement and entrainment, could provide flexibility by allowing consideration of site-specific circumstances, and by including the potential for restoration at other locations to offset impacts from the intake structure.[12]

---

[9] The Court's decision on CAIR has effectively ended the nationwide $SO_2$ allowance trading system created by Title IV of the 1990 CAA. That system embodied the assumption that all $SO_2$ emissions are environmentally equivalent, regardless of their location, thus achieving some reduction in compliance costs at the expense of a more certain distribution of benefits.

[10] The Transport Rule proposes state-specific caps, based on each state's contribution to downwind nonattainment, in response to the Court's concern that CAIR's cap-and-trade program did not sufficiently assure elimination of upwind sources' "significant contribution" to downwind nonattainment.

[11] EPA is also considering two alternatives to its preferred design. Both options limit trading flexibility and thus would raise the costs. One alternative prohibits inter-state trading entirely, while allowing intra-state trading. The other "direct control" option would cap state-level emissions, impose emission rate standards on all facilities, and allow averaging across each company's facilities within each state.

[12] In some respects, EPA's proposed rule for cooling water intake structures embodies such flexibility. EPA, Proposed Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities, March 28, 2011.

## II. Fundamentals of Economic and Policy Evaluation of Environmental Regulations

Economic analysis of proposed regulations is a critical element of the regulatory process. When performed properly, such analysis can contribute valuable information for constructive public deliberations on new policies and can help ensure that regulations provide positive net benefits to society.[13] Benefit-cost analysis is the core element of a sound economic assessment of a proposed regulation. Within the benefit-cost framework, the full benefits and costs of proposed policies are estimated and aggregated to determine which regulatory approach (including the option not to regulate) is likely to provide the greatest net benefits (benefits minus costs).[14] When benefits and/or costs occur over time, as they typically do, discounting is performed to aggregate over different time periods. To the extent possible, both benefits and costs are estimated in monetary terms, to enable direct comparisons. Applying benefit-cost methods to alternative policies – including different stringency levels, implementation schedules, and/or policy instruments – can help identify which alternative provides the greatest net benefits to society.

Environmental regulations can provide a range of benefits associated with human health (including enhanced well-being, lower health expenditures, and increased worker productivity), greater public and workspace safety, better recreational experiences, improved visibility, enhanced aesthetic amenities, and improved ecological services. Due to the lack of markets for many of these benefits, monetizing their values raises many challenges. However, available empirical methods can reliably determine individuals' willingness-to-pay for improvements in health, recreational experiences and environmental conditions, while other methods can provide proxies for benefits when such estimates are not available.

Actions taken to achieve regulatory benefits also create social costs.[15] While the availability of relevant markets simplifies certain aspects of cost analysis, accurately capturing the economic impacts of new rules, particularly under uncertain future conditions, raises many challenges. These impacts reflect actions taken to comply with the regulation (compliance costs), plant shutdowns, job losses, and production disruptions arising in the transition to new regulations (transition costs), and the impact of higher prices on the broader economy (general equilibrium costs).

Assessment of a regulation's distributional impacts complements benefit-cost analysis. Even though a regulation creates net gains for society as a whole, it may nonetheless make some groups worse off. Distributional assessments focus on whether certain industries, income groups, or geographic regions are likely to experience particularly positive or negative net impacts from the proposed regulation. Such analysis can provide policymakers with an opportunity to modify the regulation or supplement it with additional measures to address these distributional impacts.

Given the many benefits of comprehensive regulatory impact assessments, administrations dating back to the Reagan era have required such assessments for all proposed "major" federal

---

[13] *See*, Arrow, Kenneth, Maureen Cropper, George Eads, Robert Hahn, Lester Lave, Roger Noll, Paul Portney, Milton Russell, Richard Schmalensee, Kerry Smith, and Robert Stavins. "Is There a Role for Benefit-Cost Analysis in Environmental, Health, and Safety Regulation?" *Science*, April 12, 1996.

[14] Even when statutory requirements limit agency discretion to design regulations to maximize net benefits (such as the setting of NAAQS), agencies are still required to analyze benefits and costs.

[15] For a more complete taxonomy of regulatory costs, see: Jaffe, Adam B., Steven R. Peterson, Paul R. Portney, and Robert N. Stavins. "Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tells Us?" *Journal of Economic Literature* 33(1995):132-163

regulations.[16] To this end, the White House Office of Management and Budget (OMB)[17] and EPA itself[18] developed guidance documents to define more formally the scope and methods that analysts should use to create rigorous, balanced, and ultimately informative analyses.

## III. Analyzing the Benefits and Costs of EPA's Transport Rule

The Transport Rule would lead to both new benefits – incremental to those achieved by existing Federal and state emission requirements – and new costs, as the electricity sector takes additional steps to meet stricter limits on power plant emissions. However, studies estimating the Transport Rule's benefits and costs have consistently found that benefits outweigh costs, on a national basis, often by a wide margin. In this section we enumerate some of the benefits and costs that would be created under the Transport Rule and discuss important issues for their proper assessment.

### A. Benefits

Existing EPA regulations to limit emissions of $SO_2$, $NO_X$ and other criteria pollutants have created significant benefits in terms of health improvements, aesthetic amenities, recreational benefits, and ecosystem enhancements. OMB estimates that EPA air rules in place as of 2010 account for \$93 billion to \$629 billion (2009\$)[19] in annual benefits, reflecting the vast majority (94 to 97 percent) of the benefits from all EPA regulations and a large share (60 to 84 percent) of the benefits from all federal regulation.[20] Most of these air quality benefits are attributable to rules that target reductions in $PM_{2.5}$ pre-cursor emissions of $SO_2$ and $NO_X$. EPA estimates even larger annual benefits – \$1.3 trillion annually in 2010 – from the CAA than those estimated by OMB.[21]

The electric power sector currently accounts for roughly 75 percent of national $SO_2$ emissions and 20 percent of national $NO_X$ emissions.[22] Further reductions in $SO_2$ and $NO_X$ power

---

[16] E.O. 12866, signed by President Clinton in 1993, outlines the rationale, goals and requirements of federal regulatory review. This was preceded by related Executive Orders, notably E.O. 12291, signed by President Reagan in 1982. E.O. 12866 has been subsequently amended, but its primary provisions remain intact. The Obama administration recently issues E.O. 13563, which "adds and amplifies" to E.O. 12866.

[17] Office of Management and Budget, Circular A-4, September 17, 2003. OMB Circular A-4 outlines "best practices" that agencies should use in conducting regulatory analyses.

[18] EPA's Guidelines were revised and re-released in 2000. Revisions were made in collaboration with outside experts and its Science Advisory Board. One of the authors chaired the SAB's Environmental Economics Advisory Committee at that time. EPA, "Guidelines for Preparing Economic Analyses," EPA 240-R-00-03, September 2000.

[19] Throughout the paper, values from other studies are converted into 2009 dollar values using the GDP price deflator. Bureau of Economic Analysis, "Price Indexes for Gross Domestic Product," 2010.

[20] These aggregate figures generally reflect benefits as estimated by EPA. OMB, Office of Information and Regulatory Affairs. "2010 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities." 2010, pp. 10-14.

[21] This estimate includes reductions from CAIR and the Clean Air Mercury Rule, which has since been vacated. "The Benefits and Costs of the Clean Air Act from 1990 to 2020," Office or Air and Radiation, March 2011.

[22] EPA, Nitrogen Oxide and Sulfur Dioxide Emissions by Sector, 2005.

plant emissions can potentially yield a wide variety of benefits, including reduced mortality, reduced incidence of respiratory and heart disease, improved visibility, enhanced agricultural and forestry yields, greater environmental amenities, and improved ecosystem services.[23] Moreover, these benefits come in many forms, including improved well-being, reduced health-care expenditures, and improved work-productivity from reduced sick days. The magnitude of these health benefits will depend upon the size and location of emission reductions, the resulting improvements in air quality, and the valuation of health benefits that arise from these air quality improvements.

As shown in Table 2, estimates of the benefits from further reducing $SO_2$ and $NO_X$ power plant emissions vary widely across studies. [See end of draft – will be embedded in text in final draft.] Estimates of total benefits range from a low of $20 billion annually to a high of $310 billion annually. The sizable variation in estimated total benefits is driven largely by differences in key assumptions used in estimating the benefits of reduced premature mortality, which accounts for the vast majority (80 to 96 percent) of total estimated benefits.[24] These key assumptions include air transport and health effects modeling, and the value of a statistical life (VSL), which measures the benefits of reduced mortality risk. We examine the sensitivity of total benefits to these key assumptions by holding constant assumptions related to either VSL or health effects across studies. As shown in column [f] of Table 2, VSL estimates used in recent studies range from $2.8 million to $8.3 million.[25] Table 2, column [g] shows that using a $7.3 million VSL, as recommended in EPA's most recent economic guidelines and endorsed by EPA's Science Advisory Board's Environmental Economics Advisory Committee, substantially narrows the range of total benefits across studies, producing a minimum value of $48 billion in benefits.[26]

[23] For example, reductions in nitrogen and acid deposition may improve agricultural and forestry yields.

[24] Our assessment of Transport Rule also considers studies of CAIR, given certain similarity in the policies' requirements. Differences in the quantity and geographic distribution of emission reductions from each policy will likely lead to differences in estimated and actual benefits and costs.

[25] VSL methods typically rely upon either differences in wages between more and less risky jobs or survey methods to determine people's willingness to pay for reductions in mortality risk. Even in economic terms, VSL is not intended to capture the "value of a life." Rather, VSL reflects the aggregate value that a large number of individuals would be willing to pay in exchange for a small reduction in mortality risk.

[26] One of the authors was chair of the Committee at the time of this review.

## Table 2
## Summary of the Economic Benefits of Reduced Electric Power $SO_2$ & $NO_x$ Emissions from Various Studies

| | | | | | | | | | | Total Benefits with Fixed Values for: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | VSL | Health Effects | |
| Source | Year / Case | Policy [a] | Benefits [b] | Mortality Benefits [c] | Costs [d] | | Net Benefits [e] | | VSL [f] | EPA SAB Value [g] | Pope et al. Effects [h] | Palmer et al. Effects [i] |
| EPA [1] | 2014 / 3% + Pope | Transport Rule | $128.9 | $116.8 | $2.4 | $4.3 | $126.6 | $124.6 | $8.3 | $114.9 | $118.3 | $75.0 |
| | 2014 / 3% + Laden | Transport Rule | $309.4 | $297.2 | $2.4 | $4.3 | $307.0 | $305.0 | $8.3 | $273.7 | $118.3 | $75.0 |
| | 2014 / 7% + Pope | Transport Rule | $118.3 | $106.2 | $2.4 | $4.3 | $115.9 | $114.0 | $8.3 | $105.6 | $118.3 | $75.0 |
| | 2014 / 7% + Laden | Transport Rule | $277.5 | $265.4 | $2.4 | $4.3 | $275.2 | $273.2 | $8.3 | $245.7 | $118.3 | $75.0 |
| EPA [2] | 2010, 3% discount | CAIR | $92.6 | $85.0 | $2.4 | | $90.2 | | $7.6 | $89.3 | $87.5 | $54.9 |
| | 2010, 7% discount | CAIR | $79.1 | $71.5 | $2.7 | | $76.4 | | $7.6 | $76.3 | $87.5 | $54.9 |
| | 2015, 3% discount | CAIR | $127.6 | $117.2 | $3.2 | | $124.4 | | $8.1 | $116.0 | $103.2 | $65.4 |
| | 2015, 7% discount | CAIR | $109.0 | $98.7 | $3.9 | | $105.2 | | $8.1 | $99.3 | $103.2 | $65.4 |
| Burtraw et al. [3] | 2010 | CAIR (with Mercury CAP) | $20.6 | $17.2 | $3.7 | | $17.0 | | $2.8 | $47.6 | $32.5 | $20.6 |
| | 2020 | CAIR (with Mercury CAP) | $29.5 | $23.7 | $7.1 | | $22.4 | | $2.8 | $66.6 | $44.3 | $28.6 |
| National Research Council [4] | 2005 | Full Damages | $63.9 | $60.1 | | | | | $6.2 | $74.6 | | |

Adjusted benefits estimates are calculated as follows:

- EPA SAB VSL – Assumes a value of statistical life of $7.3 million in $2009, based upon the EPA's Guidance for Economic Analysis, which has been reviewed by the EPA's Science Advisory Board Environmental Economics Advisory Committee.
- Pope et al. Health Effects – Assumes levels of avoided premature mortality from reduced $SO_2$ and $NO_X$ emissions as estimated by EPA and based upon health effect coefficients from Pope et al. (2002) for PM and Bell et al. (2004) for ozone, assuming a 7 percent discount rate when discounting future mortality reductions.
- Burtraw et al. Health Effects – Assumes levels of avoided premature mortality from reduced $SO_2$ and $NO_X$ emissions as estimated by Burtraw et al for benefits in 2010. These estimates were the lowest health effects among studies analyzing $SO_2$ and $NO_X$ emissions reductions from eastern states. The NRC study had lower health effects, although this study analyzed national emissions, including emissions from western states that are targeted by the Transport Rule.

Estimates using fixed values for health affects assume an allocation of health effects to $SO_2$ and $NO_X$ emissions based on estimates from the National Research Council study.

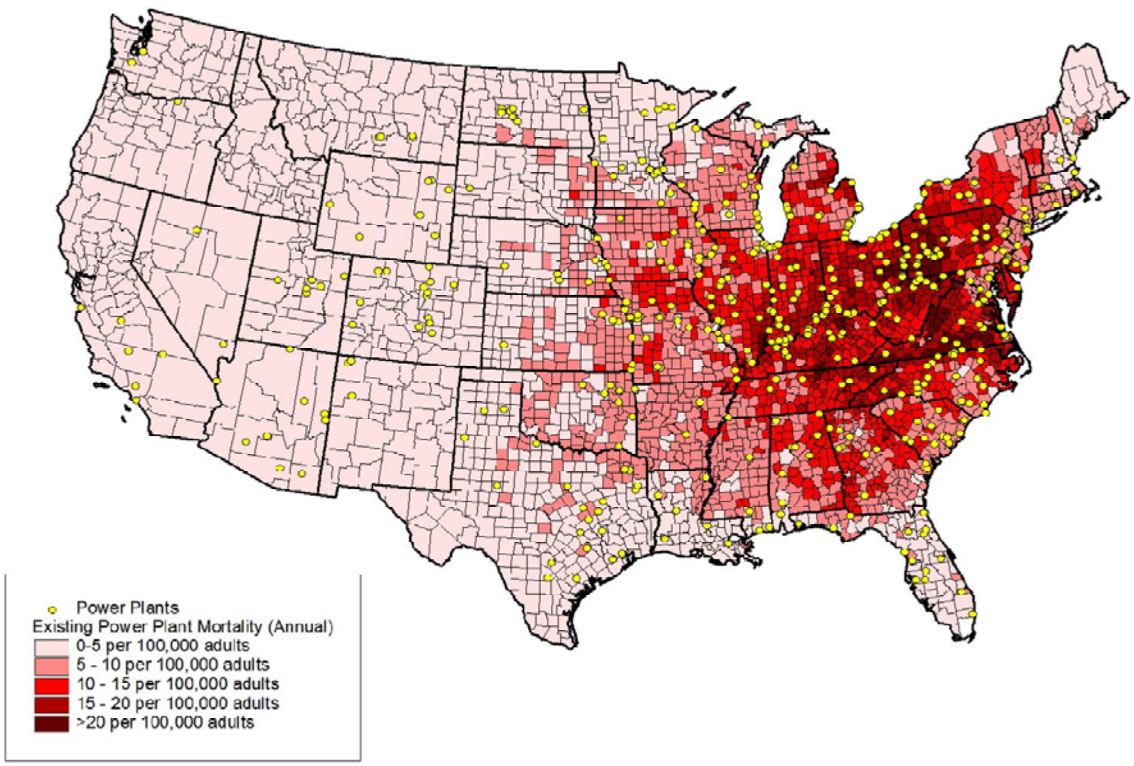
**Table 2 (Continued)**
**Summary of the Economic Benefits of Reduced Electric Power $SO_2$ & $NO_x$ Emissions from Various Studies**

Notes:
All figures in 2009 dollars.
[1] Estimated benefits reflect health and environmental improvements in the eastern United States regardless of whether a community is in compliance with health-based NAAQS standards for ozone and $PM_{2.5}$, Estimates from the National Research Council Reflect benefits from the elimination of *all* emissions from electric power generation.
[2] EPA provides two measures of social cost for Transport Rule. The first measure (reported first) reflects (Hicksian equivalent) economic surplus over future years. The second measure (reported second) reflects direct compliance costs, including the annual cost of CAIR-related capital investment. Palmer et al.'s cost estimate reflects the net change in producer and consumer surplus. Estimates of incremental direct costs (including control and fuel) are $3.0 in 2010 and $6.8 billion in 2020.
[3] Burtraw et al. analyze the costs associated with CAIR, targeting $SO_2$ and $NO_X$ emissions, and a cap on national mercury emissions. However, when estimating benefits, they only consider benefits in reduced $PM_{2.5}$ and ozone associated with CAIR emission reductions.

Sources:
[1] EPA, "Regulatory Impact Analysis for the Final Clean Air Interstate Rule," EPA-452/R-05-002, March 2005.
[2] EPA, "Regulatory Impact Analysis for the Proposed Federal Transport Rule," Docket ID No. EPA-HQ-OAR-2009-0491, June 2010.
[3] Palmer et al., 2005, "Reducing Emissions from the Electricity Sector, The Costs and Benefits Nationwide and for the Empire State," Resources for the Future Discussion paper 05-23, June; Palmer et al., 2007, "The benefits and costs of reducing emissions from the electricity sector," *Journal of Environmental Management*, 83(2007): 115-130.
[4] National Research Council, 2009, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*, Washington, D.C.

Each study's estimated mortality benefits also reflect the complex series of modeling steps needed to translate reductions in upwind $SO_2$ and $NO_X$ emissions first into changes in ambient ozone and $PM_{2.5}$ concentrations, and then into changes in health outcomes. To examine the sensitivity to these modeling assumptions, we assume health effect values (reduced mortality per ton of emissions reduced) from EPA's most conservative Transport Rule scenario.[27] As reported in Table 2, column [h], when these health effects are used, estimated benefits range from $33 to $118 billion. When more conservative health effects are used, as shown in Table 2, column [i], estimated benefits range from $21 to $75 billion.[28] Together, these results suggest that estimated mortality benefits appear fairly robust to reasonable alternative values for these key assumptions.

**Figure 1**
**Mortality Rates from Small Particulates from Coal-fired Power Facilities**




Source: Clean Air Task Force, 2010. Analysis by Abt Associates.

While designed to address downwind non-attainment, the Transport Rule also provides significant benefits to the upwind regions that reduce emissions. As illustrated in Figure 1, premature mortality from coal-fired power plants is most significant in the mid-western and eastern

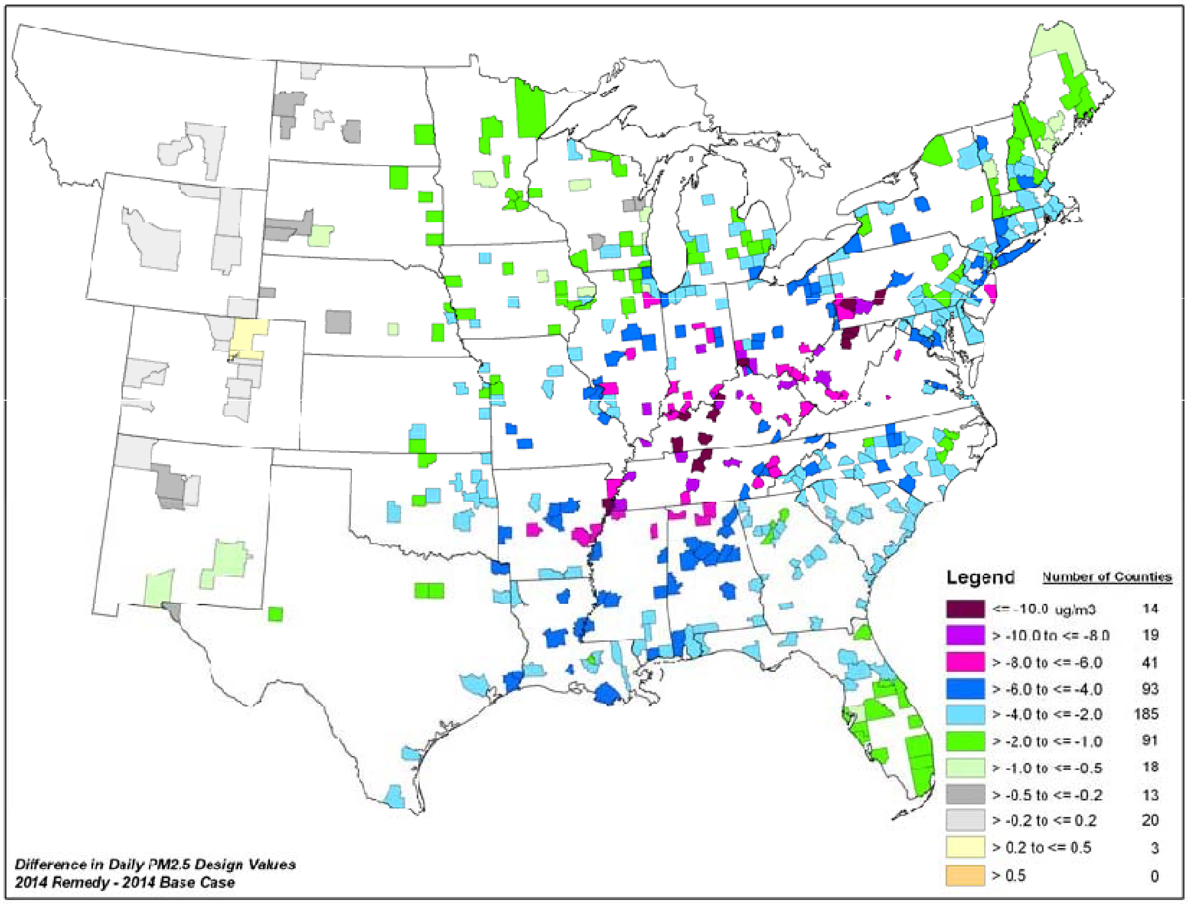
---

[27] This EPA scenario assumes mortality (health) effect coefficients from Pope et al. for PM and from Bell et al. for ozone, and a 7 percent discount rate when valuing future mortality reductions. Bell, M.L. et al., 2004, "Ozone and short-term mortality in 95 US urban communities, 1987-2000," *Journal of American Medical Association*, 292(19): 2372-9; Pope, C.A., 2011, "Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution," *Journal of the American Medical Association*, 287: 1132-1141.

[28] Palmer et al., 2005, "Reducing Emissions from the Electricity Sector, The Costs and Benefits Nationwide and for the Empire State," Resources for the Future Discussion paper 05-23, June; Palmer et al., 2007, "The benefits and costs of reducing emissions from the electricity sector," *Journal of Environmental Management*, 83(2007): 115-130.

states, many of which have such plants, with West Virginia, Pennsylvania, Ohio, Kentucky, and Indiana experiencing the highest mortality rates.[29] In fact, three of these states – Ohio, Pennsylvania and Indiana – are among the top four $SO_2$-emitting states in the country. As shown in Figure 2, which illustrates estimated ambient air quality ($PM_{2.5}$) improvement, Transport Rule benefits would be spread over a similar geographic region as current health impacts from coal-fired generation.

**Figure 2**
**Transport Rule Impacts on 24-hour Small Particulate (PM2.5) concentrations in 2014**




Source: EPA, 2010.

In addition to reducing premature deaths, estimated by EPA to be as high as 36,000 annually, the Transport Rule will also reduce non-fatal illnesses, particularly respiratory and cardiovascular conditions. The EPA estimated that the Transport Rule would reduce over 10 million of these non-fatal illnesses annually. These conditions include chronic and acute bronchitis, non-fatal heart attacks, asthma exacerbations, and other upper and lower respiratory symptoms.[30] While the sheer number of avoided respiratory and cardiovascular conditions would be far greater than the number of avoided premature deaths, the estimated benefit from avoiding

---

[29] These states have the highest mortality rates from coal-fired power generation as estimated by Abt Associates. Clean Air Task Force, "The Toll from Coal, An Updated Assessment of Death and Disease from America's Dirtiest Energy Source," September 2010.

[30] EPA, June 2010, pp. 4-5.

one of these incidents is dramatically smaller than the benefit of a single avoided death. As a result, estimated morbidity benefits account for 4 to 20 percent of total benefits, as opposed to 80 to 96 percent for reduced mortality.[31] However, as illustrated in Table 3, estimates of the morbidity benefits will tend to understate the economic benefit of reducing illnesses to the extent they rely upon "cost-of-illness" methods that only capture reductions in health care expenditures and/or improvements in worker productivity, but do not capture improvements in well-being, such as the value of avoiding pain, discomfort, and other negative effects.

**Table 3**
**Categories of Benefits Estimated in EPA's Transport Rule RIA**

| Benefit Category | | Examples of Health and Other Effects Estimated Use Alternative Approaches | Well-Being | Resource Saving (e.g., reduced health care costs, improved worker productivity) |
|---|---|---|---|---|
| Health | Mortality | Premature | Willingness-to-Pay | |
| | Morbidity | Chronic Bronchitis | Willingness-to-Pay | |
| | Morbidity | Non-fatal Heart Attacks<br>Hospital Admissions (respiratory, cardiovascular)<br>Acute Bronchitis | | Cost of Illness |
| Amenity | Visibility | National Parks & Monuments | Willingness-to-Pay | |

Health improvements not only enhance people's quality of life, but also lead to resource cost savings, through reductions in health care expenditures and greater work-productivity. As shown in Table 3, one estimate of the magnitude of these benefits is the sum of the individual benefits estimated using a cost-of-illness approach – $3.7 billion annually, based on EPA analysis.[32] Similarly, Cicchetti estimates that the Transport Rule would provide benefits (avoided lost income) of $5.92 billion annually due to reductions in lost workdays and health insurance costs.[33] However, as shown in Table 3, these estimates do not include resource savings from the reductions in mortality, chronic bronchitis and other conditions evaluated through willingness-to-pay methods, since these methods do not allow any resources savings to be distinguished from improvements in well-being. As such, any estimate of resource savings that excludes these values would tend to understate the true magnitude of these savings.

### B. Costs

Achieving improvements in air quality under the Transport Rule requires directing resources – capital, labor, and materials – to actions that lower electric sector emissions, while still ensuring the continued reliability of electricity supply – that is, ensuring that there are sufficient generation and demand-response resources to meet customer's loads at all times.

---

[31] EPA estimates that the Transport Rule would create annual benefits of about $8.3 billion from reduced morbidity, while Palmer *et al.* estimate that CAIR, which the Transport Rule will replace, has morbidity benefits of $3.4 billion in 2010 and $4.9 billion in 2020. These estimates reflect benefits associated with ozone and $PM_{2.5}$, but do not include benefits from reductions in coal-related mercury emissions that likely arise as an ancillary benefit of reduced $SO_2$ emissions.

[33] Cicchetti, Charles, "Expensive Neighbors: The Hidden Cost of Harmful Pollution to Downwind Employers and Business," 2010, p. 37.

### 1. Reducing Emissions from Energy Production

The electric sector can achieve $NO_X$ and $SO_2$ emissions reductions through a variety of approaches, including expanded utilization of existing pollution-control equipment,[34] switching to coal with lower sulfur content,[35] installation of new pollution-control equipment, and switching to more efficient and/or lower-emitting generation sources. Most analyses find that each of these approaches would contribute in varying degrees to reducing $SO_2$ and $NO_X$ emissions under the Transport Rule. However, estimates of the extent to which each of these alternatives would be used, and the associated costs of compliance, depend upon many assumptions, such as the cost of pollution control retrofit, the opportunity for higher utilization of existing pollution controls, constraints on further switching to lower sulfur coals, and the relative cost of alternatives to coal-fired power.

Many different post-combustion technologies are available to reduce emissions, with costs and effectiveness varying across these alternatives. Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction, which target $NO_X$ emissions, and wet and dry Flue Gas Desulfurization (FGD), which target $SO_2$ emissions, are the most likely compliance alternatives to be deployed under the Transport Rule. Alternative technology options for smaller coal plants, however, such as dry sorbent injection (DSI) for $SO_2$ control, offer lower capital costs, and shorter construction times, and show promise for Transport Rule compliance.[36] Notably as well, to comply with other CAA regulations or state requirements, many coal-fired power generation facilities are already equipped with pollution-control equipment. Table 4 below shows that 70 percent of coal-fired generation capacity has $NO_X$ or $SO_2$ controls.

**Table 4**
**Existing National Generation Infrastructure**

| Existing Power Generation Capacity | Capacity (GW) | Percent of Total Installed Capacity | Percent of Coal-fired Capacity |
|---|---|---|---|
| Total Installed Capacity | 1,122 | | |
| Total Coal-fired Generation Capacity | 341 | 30% | |
| No control | 103 | 9% | 30% |
| FGD only | 65 | 6% | 19% |
| SCR only | 58 | 5% | 17% |
| FGD & SCR | 115 | 10% | 34% |

Note: Coal-fired capacity figures reflect both existing and planned pollution controls.
Source: Credit Suisse, "Growth from Subtraction," September 23, 2010; Energy Information Administration, *Electric Power Annual, January 4, 2011.*

Installing new pollution controls involves a variety of costs, including labor to install and operate equipment, material inputs to equipment operation and construction, and capital to finance

[34] For example, EPA finds that, under the Transport Rule, an additional 40 GW of coal-fired facilities will choose to operate their FGD scrubbers year-round rather than for only a portion of the year, while year-round operation of SCR for $NO_X$ control will rise by 51 GW. U.S. EPA, Regulatory Impact Analysis for the Proposed Federal Transport Rule, Docket ID No. EPA-HQ-OAR-2009-0491, June 2010, p. 258-259.

[35] The scope for further emission reductions from fuel switching is uncertain. Opportunities for significant cost savings may have largely been exhausted in complying with prior regulations.

[36] These also include low $NO_X$ burners for $NO_X$ control.

investments. In addition, operating pollution control raises the cost of producing power.[37] EPA estimates that 32.8 GW of FGD and 2.4 GW of SCR would be installed by 2020 to meet Transport Rule requirements (relative to a baseline without CAIR).[38]

Although potentially large in absolute terms, pollution control capital expenditures to comply with the Transport Rule would comprise a relatively small fraction of the aggregate capital expenditures anticipated in the coming decades as the industry enters into a new "investment cycle" to modernize grid infrastructure, address declining reserve margins, and adapt to enhanced environmental objectives. Awareness of the growing need for substantial capital investment is not new. For example, a 2008 study found that the electricity industry needs $1.5 trillion in new investment over the next two decades to replace and modernize aging infrastructure and meet growing demand.[39] By contrast, based on EPA estimates, capital expenditures needed to comply with the Transport Rule could range from $10 to $30 billion.[40]

In fact, pollution control investment made to comply with CAIR and pre-existing regulatory requirements, such as New Source Review settlements and state environmental policies, help reduce new investment needed to comply with the Transport Rule in coming years. For example, to comply with Phase I of CAIR and other requirements, between 2007 and 2009, plant owners installed FGDs on 57 GW of coal-fired generation and SCRs on 31 GW.[41] Regulatory requirements are also driving planned retrofits in future years. For example, one study reports that planned installations of 20 GW of FGD and 10 GW of SCR and SNCR between 2012 and 2015.[42]

Switching from coal to lower emitting fuels and alternative technologies can also reduce $SO_2$ and $NO_x$ emissions.[43] If the relative cost of these lower emission alternative sources of

[37] For example, operating costs can increase due to labor requirements for pollution control equipment, materials costs (for example, sorbents injected into plant exhaust), environmental management costs (for example, waste disposal), and "parasitic" load that reduces a plant's effective output.

[38] EPA, IPM v.4.10 Model Runs, September 1, 2010, "TR Base Case v.4.10", and "TR SB Limited Trading v.4.10). Other studies, such as Credit Suisse (2010) and CRA (2010), have analyzed the effect of combinations of different EPA rules, but do not analyze the Transport Rule in isolation. NERC does not report estimated retrofits. North American Electric Reliability Corporation (NERC), "2010 Special Reliability Scenario Assessment: Resource Adequacy Impacts of Potential U.S. Environmental Regulations," Princeton, N.J., October 2010; Credit Suisse, "Growth from Subtraction," Equity Research, September 23, 2010; Charles River Associates (CRA), "The Reliability Implications of EPA's Proposed Transport Rule and Forthcoming Utility MACT," December 16, 2010;

[39] Chupka, Mark, et al., "Transforming America's Power Industry: The Investment Challenge 2010-2030," prepared for the Edison Foundation, November 2008.

[40] This estimate reflects EPA estimates of retrofit quantities and costs. EPA estimates of retrofits needed to comply with the Transport Rule (relative to a pre-CAIR baseline) at 32.8 GW of FGD and 2.4 GW of SCR retrofits. Capital cost estimates for pollution control vary depending upon many factors in EPA's IPM model. Our estimate assumes a range of unit costs: $385 to $817 per kW for FGD, and $147 to $258 per kW for SCR as reported in "illustrative" examples provided in IPM documentation. EPA, "Documentation for EPA Base Case v.4.10, Using the Integrated Planning Model," Office of Air and Radiation, August 2010, Tables 5-4 and 5-8.

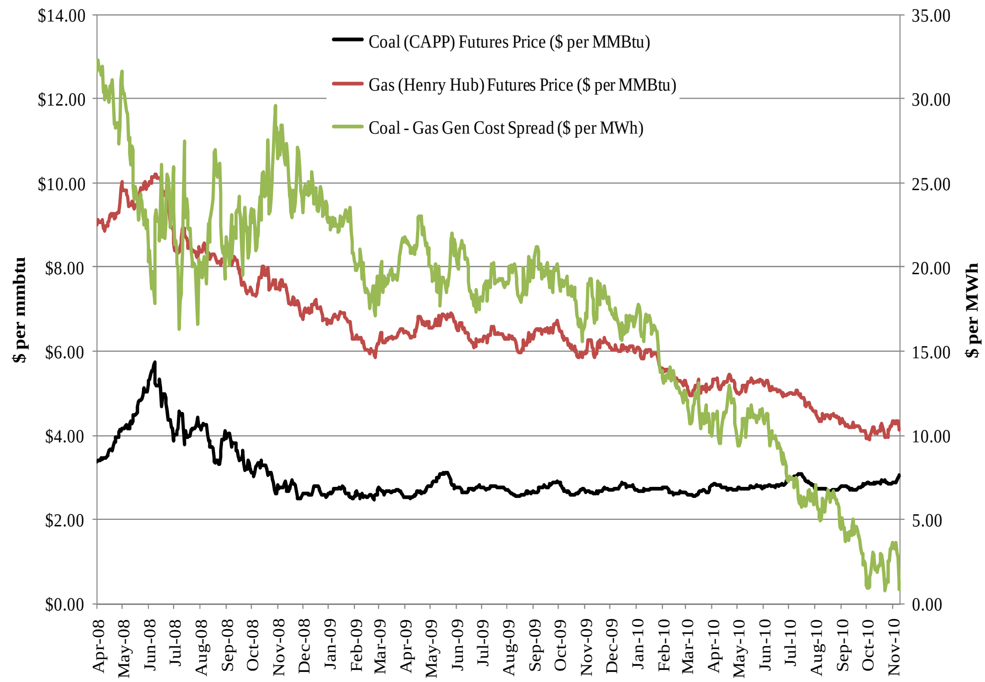
[41] EPA, NEEDS v.4.10 Database.

[42] Credit Suisse, 2010, Exhibit 46.

[43] If Transport Rule investments and responses increase electricity prices, consumers may reduce their energy use. Like substitutions in the electricity supply, these adjustments potentially lower the social cost of complying with new requirements.

electricity is favorable, substituting them for coal-fired generation can cost-effectively reduce emissions.[44]

**Figure 3**
**Coal and Natural Gas 2011 Futures Prices and Coal-Gas Generation Cost Spread**




Notes: Prices are for April 2011 delivery. The Coal-Gas Generation Cost Spread is the difference between the fuel costs needed to generate 1 MWh of power based on EIA heat rates (for new capacity) of 9,200 Btu/kWh for coal and 6,974 Btu/kWh for combined cycle gas.
Sources: SNL Financial - NYMEX Coal Futures, and NYMEX Henry Hub Futures, December 1, 2010.

Recent market trends and technology developments have substantially lowered the cost of transitioning from coal-fired generation to alternative power sources. In particular, technological advances in natural gas extraction have greatly expanded economically viable supplies from unconventional sources, including shale deposits, tight sands, and coal-bed methane.[45] Meanwhile, coal prices have gradually risen over the past decade.[46] As a consequence of these fuel price trends, and as shown in Figure 3, the gap between coal and gas prices has shrunk in recent years, which has made natural gas facilities increasingly competitive with coal-fired facilities.[47] Given these changing fuel price economics and evolving EPA regulations, some less efficient coal-fired

[44] For example, if a coal-fired facility generates power at $35 per MWH before installing and operating pollution-control equipment, and at $40 per MWh with pollution control, the compliance cost would be $5 per MWh. However, if the cost of a combined cycle natural gas facility is $37 per MWh, then increasing output from this plant and decreasing output from the coal plant can save $3 per MWh.

[45] Actual supplies will depend upon many factors, including EPA regulations of natural gas extraction. MIT Energy Initiative, *The Future of Natural Gas, An Interdisciplinary MIT Study*, Interim Report, 2010.

[46] For example, average coal prices rose 86 percent from 2000 to 2008. EIA, Annual Coal Reports.

[47] The competitiveness of particular plants will depend on many specifics, including fuel delivery costs (which are not reflected in Figure 1), plant-specific heat rates, and other operations costs, including pollution control equipment operation.

facilities have already chosen to retire even before full implementation of the Transport Rule.[48] Thus, increasing availability of low-cost natural gas can not only help lower the Transport Rule's compliance costs, but can also directly influence coal plant retirement decisions.

### 2. Maintaining Reliability

The electric industry has a responsibility to provide customers with reliable electric service at all times. To ensure that customers' loads can be met at all hours of the day, utilities must maintain sufficient resources (with appropriate operating characteristics) to meet anticipated peak electricity demands. These resources can include both physical generation capacity and demand response resources.

To account for load growth and retirement of older facilities, in most regions, new generation capacity must be added over time. If new regulatory requirements reduce available installed generation capacity, new resources will have to be added sooner, thereby increasing the discounted cost of maintaining sufficient capacity. Replacing lost resources traditionally required construction of new generation facilities. However, alternative options, particularly demand response, are now available and often cost-effective, and have been widely deployed to help grid operators ensure customer's loads are met without interruption.[49]

Given the combined effect of expanded supplies of low priced natural gas, new air regulations and other factors (e.g., aging facilities), some facilities may retire instead of installing and operating pollution-control equipment, thus reducing available generation capacity. Such a retirement decision may be economically rational if the likely future revenues in the electricity market would provide insufficient return on capital investments in the new equipment. New regulatory requirements could also reduce generation capacity if installing new pollution control equipment reduces a facility's net output (a "derating").[50]

These retirements and deratings do not themselves impose an economic cost; an economic cost is incurred when the lost capacity needs to be replaced earlier than would otherwise be necessary. Consequently, for regions with more resources than are needed to maintain reliability, the cost associated with retired capacity could be deferred for many years into the future. NERC estimates of generation capacity reductions under the Transport Rule, reflecting both potential facility retirement and de-ratings due to pollution-control equipment, suggest that EPA's preferred regulatory approach would lead to less than a three percent reduction in the nation's 341 GW of coal-fired capacity.[51] Furthermore, in many regions with excess capacity (i.e., more resources than needed to maintain reliability), the economic cost of replacing this lost capacity may be deferred for many years. For example, NERC finds that less than 10 percent of total projected reduced

---

[48] Tierney *et al.* report that various utilities have recently announced the retirement of 4.9 GW of coal-fired power generation. Tierney, Susan, Michael J. Bradley, et al., "Ensuring a Clean, Modern Electric Generating Fleet while Maintaining Electric System Reliability," August 2010. Similarly, the most recent *State of the Market Report* from PJM's Independent Market Monitor identified over 11 GW of coal-fired power units at risk for retirements because they "did not recover avoidable costs even with capacity revenues." PJM, *State of the Market Report*, Vol. 1, March 11, 2010.

[49] Demand response includes many mechanisms by which customers decrease their electricity use in response to price or other signals. In recent years, demand response has grown in nearly all regions as system operators have targeted this resource through new programs and markets. ISO/RTO Council, "2009 State of the Markets Report," 2009.

[50] For example, the power demands of pollution control equipment can reduce a facility's effective capacity.

[51] NERC, 2010.

capacity (0.25 GW of 2.9 GW) would occur in regions that will be below their reserve margins in 2015.[52] This would mean that only 250 MW of new capacity would need to be installed between now and 2015 to maintain reliability as a consequence of the Transport Rule.

Moreover, the quantities of reduced capacity contemplated in these analyses are small compared to capacity expansions achieved in prior periods. For example, over the five-year period between 1999 and 2004, 177 GW of new capacity was installed in the U.S., more than 60 times NERC's Transport Rule retirement forecast.[53]

To ensure that reliability can be maintained as regions meet Transport Rule emission targets, planning and market mechanisms exist to develop sufficient resources in a timely and efficient manner to meet customer loads. For example, in many restructured regional electricity markets, utilities are required to obtain sufficient long term capacity obligations to meet their customers' loads. Capacity markets, such as PJM's Reliability Pricing Model and ISO New England's Forward Capacity Market, provide a mechanism for utilities to procure commitments from existing and new resources to meet their customers' needs. Both PJM's and ISO New England's capacity markets create incentives for new entry up to three years in advance of actual need.

Within traditionally regulated markets, to fulfill their legal obligation to serve their customers reliably, vertically-integrated utilities undertake long-range resource planning. Their efforts to develop new generation and demand resources are complemented by grid operators' regional planning, which is designed to identify and undertake transmission investments that mitigate reliability concerns, including those that may arise due to generation retirements.

In addition to these long-term market and regulatory mechanisms, various backstop mechanisms exist to maintain reliability should local or regional reliability concerns arise. In particular, Federal agencies and grid operators can prevent particular generation facilities from retiring if their retirement would create reliability concerns, particularly in localized areas. [54]

### C. Aggregation of Costs and Benefits and General Equilibrium Effects

Calculating the net benefits of the Transport Rule is, in principle, a straightforward exercise of comparing the estimated benefits with the estimated costs. As shown in Table 2, estimates of the annual cost of the Transport Rule or the CAIR range from $2.4 to $7.1 billion.[55] Other studies analyzing the electric industry impacts of the Transport Rule individually or as one of many regulations often do not develop estimates of a key issue before policymakers – the Transport Rule's social costs. To the extent that industry impacts from these studies differ from those estimated by EPA, social costs estimates may similarly differ.[56] By comparison, estimates of Transport Rule or CAIR benefits range from $20 to $309 billion annually (in $2009) – a significant

[52] NERC, 2010.

[53] CRA, 2010; NERC, 2010.

[54] *See* Tierney et al., 2010, p. 22-23.

[55] Many factors contribute to differences in estimates across studies, including differences in Transport Rule and CAIR emission targets. Because cost estimates in Palmer et al. also reflect compliance with a national cap on mercury emissions, they likely reflect costs unrelated to CAIR compliance and thus would tend to over-state the cost of complying with CAIR alone.

[56] For example, *see* NERC, 2010.

multiple of the corresponding cost estimates.[57] Thus, studies to date have concluded that the Transport Rule's benefits far exceed its costs. In fact, estimated Transport Rule costs are lower than estimated benefits even under more conservative assumptions about mortality impacts, as shown in Table 2, column [i].

Estimates of the national benefits and costs of any regulation, as shown in Table 2 for the Transport Rule, may not fully reflect regional differences in a policy's net benefits. Although the benefits of the Transport Rule will be spread across all eastern states (as shown in Figures 1 and 2), the costs are likely to be borne disproportionately in states relying heavily upon coal-fired power generation. Because of the potential for such regional differences, it is important to consider a policy's distributional consequences, as well as the aggregate benefits and costs it creates.

### D. Timing of Regulatory Requirements

Determining the appropriate timing of new regulatory requirements requires an assessment of the economic tradeoffs among alternative compliance dates. Delaying the implementation of new regulatory requirements defers both the benefits created and the costs imposed. If compliance costs were independent of the timing of regulatory requirements (and if aggregate benefits exceed aggregate costs), then delaying the regulation only delays the society's enjoyment of the regulations' net benefits. By contrast, regulations implemented too quickly can raise the industry's transition costs by, for example, elevating equipment prices, creating labor shortages, requiring more costly, less efficient resources to meet near-term requirements, and temporarily reducing reliability.

However, appreciable transition costs from the Transport Rule appear easily avoidable given the anticipated quantity of pollution control retrofits estimated by EPA to comply with the Transport Rule's requirements, the limited quantity of coal-fired capacity expected to retire as a consequence of the Transport Rule, and excess capacity in many regions.[58] EPA's assessment indicates that compliance with the Transport Rule's Phase 1 2012 requirements would require limited, if any, incremental investment in pollution control.[59] While compliance with the Transport Rule's Phase 2 2014 requirements will necessitate installing some incremental pollution controls, the total quantity of retrofits anticipated through 2014, after reflecting already announced retrofits and retrofits needed to comply with the Transport Rule, appears to be no greater than the amounts

[57] All studies evaluated consider the Transport Rule's direct economic impacts. However, the Transport Rule could have broader economic impacts as the changes in prices arising from the compliance costs in the electricity sector, reduced costs in the health care sector, and other effects ripple throughout the economy. Given these potential effects, EPA's Transport Rule analysis also considers social costs within a general equilibrium framework, although these estimates only reflect changes in energy prices and not other price changes (e.g., health care).

[58] For example, Tierney et al. report that the national average utilization of natural gas combined-cycle capacity units was 33 percent in 2008, compared to 56 percent for coal-fired units, with a maximum regional utilization of 42 percent among Transport Rule regions. Tierney et al,, 2010, Table 4.

[59] EPA says that 2012 requirements are set to allow compliance through operation of existing scrubbers at full efficiency and through use of lower sulfur coal. FR Vol. 75, No. 147, August 2, 2010, p. 45281.

of equipment installed in recent years.[60] Moreover, as noted earlier, the industry has already undertaken retrofits to comply with CAIR and other regulatory requirements even as EPA developed the Transport Rule. Thus, it appears unlikely the 2014 requirements would lead to appreciable transition costs driven by the need either to install new pollution control equipment or to replace retired generation capacity.

### E. Accuracy of Estimates of Benefits and Costs

Economic analysis of any major proposed regulation faces the tremendous challenges of forecasting the responses of industry and consumers to new regulatory requirements, the prices of basic resources (fuel, labor, and capital) in future time periods, and the value of future resource savings in, for example, health care.[61] Given these uncertainties, it is not surprising that *ex ante* estimates benefits and costs frequently differ from the actual benefits and costs arising during implementation. A systematic study of 25 environmental regulations in the US and abroad found that estimates of the costs of new regulations developed in *ex ante* economic analyses of proposed regulations have tended to overstate costs.[62]

Any tendency to overstate costs has been driven, in large part, by the emergence of new, unanticipated technologies that lowered compliance costs, particularly for regulations that provide compliance flexibility, including the use of economic incentives or market-based mechanisms. By providing compliance flexibility, regulation can create incentives to develop less costly compliance solutions, since regulated entities can capture the savings from using these more cost-effective technologies. For example, allowing coal-fired generation facilities flexibility in achieving $SO_2$ reductions under the Title IV $SO_2$ cap-and-trade system prompted scrubber and fuel switching innovations, resulting in $SO_2$ compliance costs significantly below original estimates.[63] The potential for DSI to contribute to Transport Rule compliance illustrates how technology choices for $SO_2$ reduction continue to evolve even today.

[60] As noted earlier, from 2007 to 2009, 57 GW of FGD and 31 GW of SCR were installed. EPA, NEEDS v.4.10 database. The pollution control industry appears able to expand its capabilities and labor supply to some degree when there is sufficient demand. For example, Staudt finds that actual installation of pollution control exceeded EPA's assessment of industry capability performed during the CAIR rule-making. Staudt, James. E., "Availability of Resources for Clean Air Projects," Andover Technology Partners, October 1, 2010.

[61] Accounting for these uncertainties is an important part of a well-developed benefit-cost analysis. OMB guidelines during the George W. Bush administration called for explicit analysis of uncertainty (e.g., Monte Carlo analysis) for important regulations. *See*, Jaffe, Judson and Robert Stavins, "On the Value of Formal Assessment of Uncertainty in Regulatory Analysis," *Regulation and Governance* 1(2007): 154-171.

[62] Harrington, Winston, Richard D. Morgenstern, and Peter Nelson, "On the Accuracy of Regulatory Cost Estimates," Resources for the Future Discussion Paper 99-18, January 1999. OMB performed a similar analysis, finding that "… U.S. Federal agencies tend to overestimate both benefits and costs, but they have a significantly greater tendency to overestimate benefits than costs." Office of Information and Regulatory Affairs, "Validating Regulatory Analysis: 2005 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities", OMB, 2005.

[63] For example, *see*, Ellerman, A. Denny, Paul L. Joskow, Richard Schmalensee, Juan-Pablo Montero, and Elizabeth M. Bailey, *Markets for Clean Air: The U.S. Acid Rain Program*, New York: Cambridge University Press, 2000; Carlson, Curtis, et al., "Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?," *Journal of Political Economy* 108(6): 1292-1326.

Although the Transport Rule limits interstate emission trading, it nonetheless continues to provide electricity generators with significant flexibility in $SO_2$ and $NO_X$ compliance. Thus, by its design, the Transport Rule provides incentives for technological innovation that potentially reduce costs below initial estimates.

## IV. Distributional Economic Impacts

Along with the aggregate benefits and costs of a proposed regulation, the regulation's likely economic impact on various groups and locations is an important concern for policy makers, as well as for the affected stakeholders. For the Transport Rule, key impacts include local and regional changes in electricity rates and employment – and in economic growth more generally. Given the great interest in reducing unemployment in the current recession, employment and economic growth are critical to policy discussions.

Understanding the implications of changes in electricity rates, jobs, or other economic factors requires recognition that these changes have different consequences for different participants in the economy. Electric rate increases are generally negative for energy consumers, whether households or businesses, but may be essential for energy companies to recover some of the costs of new regulations. Likewise, increased job opportunities are good for workers, particularly in times when unemployment is high and wages are stagnant.

### A. Impacts on Electricity Rates

By spurring new investment and raising the costs of producing electricity, new environmental regulations can increase retail electricity rates. However, the size of any rate increases will depend upon many factors, including the stringency of new requirements, the costs of available alternative compliance approaches, and the fuel mix in and structure of the markets. Because of the complexity of these interrelated factors, and the importance of details specific to individual regulations and regions, it is very difficult to generalize about how new environmental regulations will affect electricity rates.

While many of the Transport Rule's emission reduction costs will be passed through to customers in the form of higher electricity rates, the actual changes in rates will depend upon two key factors. First, the impacts will depend upon the market and industry structure that serves each customer. Industry restructuring over the past decade has resulted in a patchwork of market and regulatory structures that will produce different outcomes for different consumers. At one extreme, vertically integrated utilities regulated under the traditional cost-of-service regime, which own about three-quarters of coal-fired capacity, will typically be able to pass through all prudently incurred investments and operating costs into their retail rates over an extended period of time.[64] However, the need for such new investment will depend on many factors, including alternatives to retrofitting existing generation or building new generation, such as purchasing replacement power on wholesale markets. Thus, customers served by these utilities are likely to bear the full cost of compliance through rate increases. By contrast, owners of merchant power facilities, whose prices

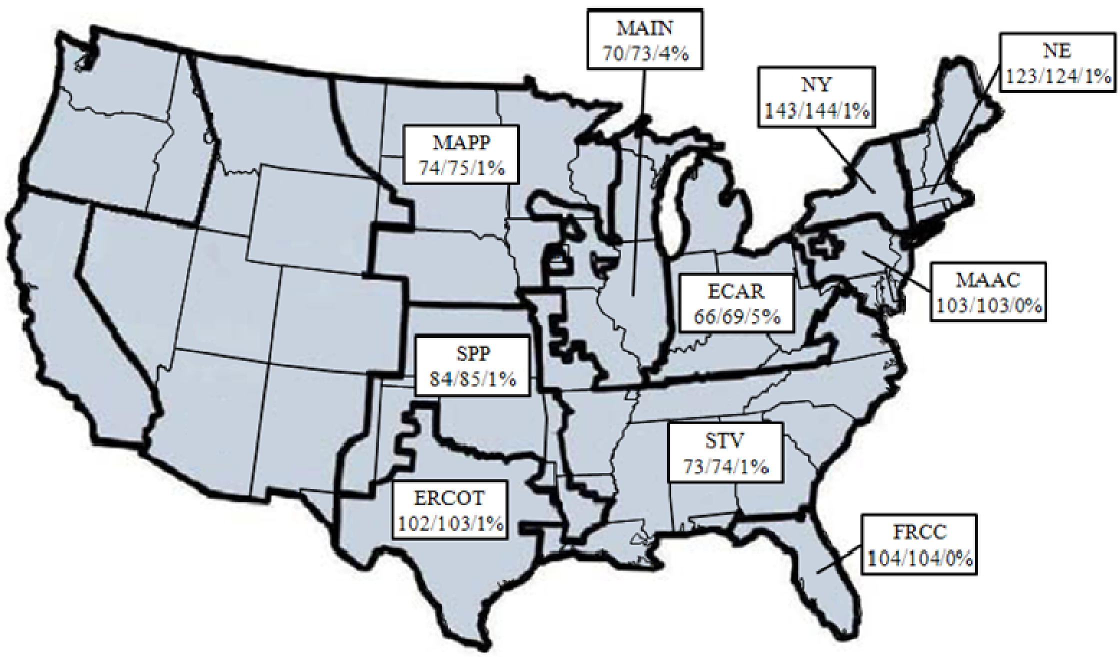
[64] Credit Suisse, p. 25.

are determined in competitive wholesale markets rather than regulated on a cost-of-service basis, will find it more difficult to pass through the costs of regulatory compliance.[65]

The second key factor affecting rate impacts is geography. Because electricity is not a commodity that is easily stored or transported long distances, the costs and resulting rates to customers also depend greatly on the character of the regional system used to serve each customer. Under the Transport Rule, regional variation in rate impacts may arise because of differences in reliance on coal-fired power generation, the extent to which existing facilities have already invested in pollution-control equipment, and the stringency of state emission budgets.

While rate increases are likely to be greatest in the states most reliant upon coal-fired generation, these states now typically enjoy among the lowest electricity prices in the country. As shown in Figure 4, EPA estimates of rate impacts from the Transport Rule, which vary from 0% to 5% of existing rates across the 10 regions analyzed by EPA, tend to be greatest in the regions that currently enjoy the lowest electricity rates.

**Figure 4**
**EPA Estimates of Regional Electricity Rates With and Without the Transport Rule (TR)**
**(Average Rate without TR / Average Rate with TR / Percent Change) (Rates in $ per MWh)**




Source: EPA, 2010.

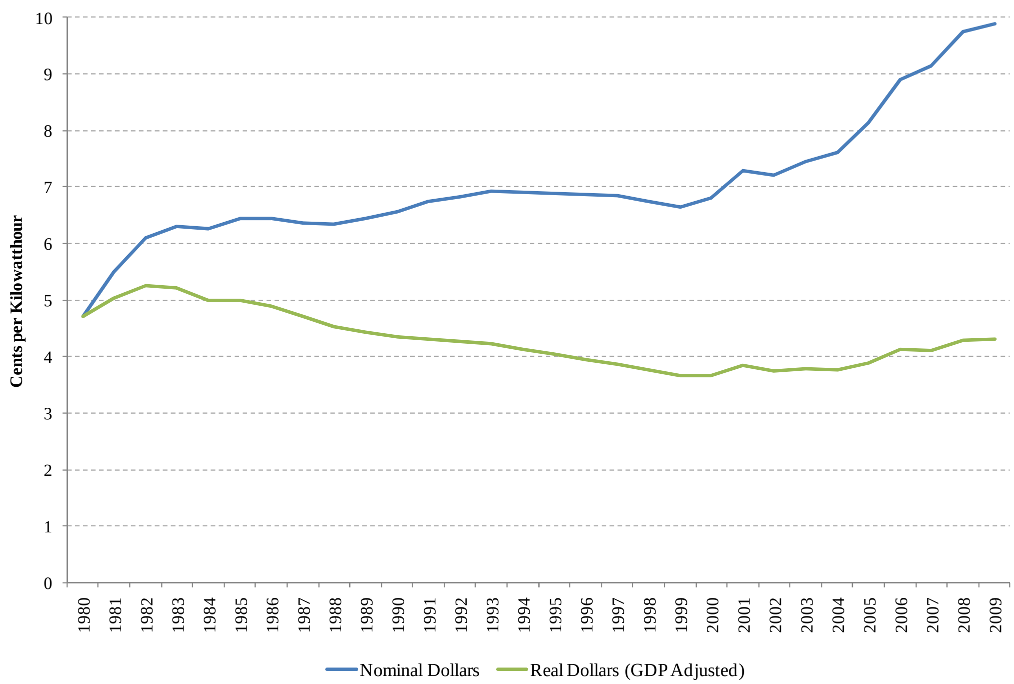
Recent downward trends in wholesale market prices may also help mitigate any Transport Rule rate impacts. Driven in large part by lower natural gas prices and lower demand, wholesale energy prices have fallen recently. For example, load-weighted energy prices in PJM were 45 percent lower in 2009 than in 2008, and remained 31 percent below 2008 averages through the first

[65] The wholesale markets into which these facilities sell their power have no direct mechanism to allow recovery of investments in pollution-control equipment. Further, the cost of operating equipment can only be recovered to the extent that wholesale prices rise to cover new variable costs. However, such price increases will only occur if the marginal price-setting units in wholesale markets are affected by new regulations.

three quarters of 2010.[66] While economic recovery will put upward pressure on wholesale prices, most analysts agree that sustained low natural gas prices are likely to continue to place downward pressure on utility rates for many years. In addition, in regions where coal-fired generation does not set the market price, these declining prices serve as another indicator of the opportunity offered by low-cost natural gas supplies and other power sources to lower the cost of achieving emission reductions.

Changes in energy prices can have adverse consequences for households by increasing the share of household budgets that must be devoted to electric utility bills. These changes in rates can be potentially regressive since low-income households typically spend a larger share of their incomes on electricity.[67] However, even for the lowest income households, electricity bills represent on average less than 5 percent of all household expenditures. In addition, many utilities provide programs that subsidize the electricity rates offered to those in the lowest income brackets and can thus shelter particularly vulnerable families from any rate impacts of new regulations. Moreover, as shown in Figure 5, while electricity prices have been rising in recent years, the real, inflation-adjusted cost of electricity is still lower than in the early 1980s.

**Figure 5**
**Real and Nominal Electricity Prices, National Average**




Note: Inflation-adjusted, real dollar estimates are adjusted based upon the GDP price deflator.
Source: Bureau of Economic Analysis.

Increases in electricity rates also potentially have an adverse effect on businesses by raising their costs of production. Because the Transport Rule affects only electric generating units, any

[66] Monitoring Analytics, *2009 State of the Market Report for PJM*, Volume 1, March 11, 2010; Monitoring Analytics, *Q3 2010 State of the Market Report for PJM*, November 15, 2010.

[67] In 2009, expenditures on electricity were on average 2.8 percent of total household expenditures and 4.2 percent of total expenditures for households with after-tax incomes less than $15,000. Consumer Expenditure Survey, U.S. Bureau of Labor Statistics, October, 2010.

new costs would arise only for businesses that rely heavily on electricity. Moreover, as we discuss below, these rate impacts are only one of many potential ways that new regulations may affect a region's level of economic activity (and jobs). Finally, only small rate impacts are anticipated from the Transport Rule, and these could be partially or more than fully offset by other drivers of regional economic change, including relaxation of regulatory requirements in many noncompliance regions.

### B. Economic Growth and Employment

With today's high unemployment rates and sluggish economic recovery, policymakers and the public are particularly interested in the job effects of new environmental regulations. Will new regulations create or destroy jobs? Where and in what sectors?

In good economic times, when the workforce is fully or almost fully employed, using labor to meet new regulatory requirements both raises the costs of regulated goods and means that fewer workers are available to do other productive things in the economy. By diverting scarce labor resources away from other activities, the use of labor thus imposes an opportunity cost on society, which should be considered alongside the capital costs of pollution reduction.

However, in difficult economic times, such as today's, when unemployment is high, some workers used to meet new regulatory requirements may have otherwise been unemployed or underemployed. Thus, using their labor to implement the regulation imposes lower costs on society. Moreover, through indirect effects, environmental regulation may spur economic activity and job growth in sectors not directly affected by the regulation, but which provide goods and services for those sectors.

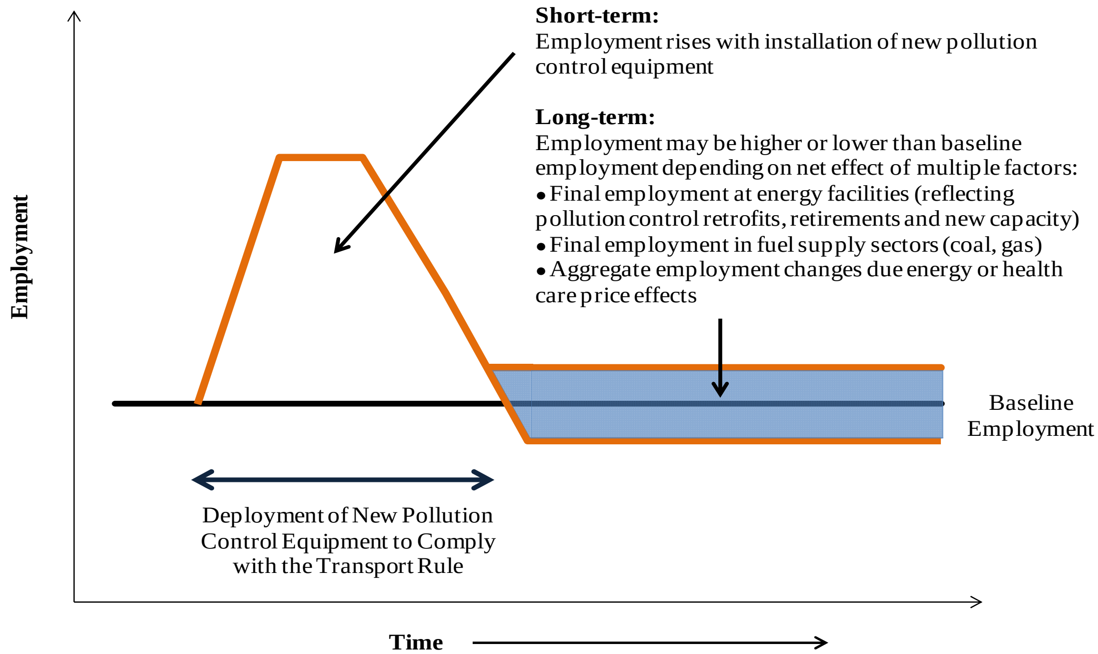
The mechanisms that drive job impacts reflect the various economic adjustments made in response to the new regulations. Direct responses to regulation will lead to short-term job gains from the manufacture and installation of new pollution control equipment to comply with the regulation. In the long run, adjustments in employment will depend upon how the power sector industry adjusts to the new regulatory requirements, as well as the indirect upstream and downstream effects of those adjustments on the rest of the economy. These direct and indirect impacts can vary in their magnitude over time, and across regions and sectors.

The particular nature of the regulation can also affect employment impacts. Since environmental improvements are often achieved through regulations on multiple entities in multiple locations, more stringent regulations in one location potentially may relax regulatory requirements on other entities in other locations. For example, by reducing emissions from upwind sources, and helping downwind regions attain NAAQS compliance, the Transport Rule may relax regulatory requirements on sources in those downwind regions.

Moreover, because these various adjustments can lead to many *offsetting* direct and indirect effects, which can vary across regions and sectors, determining the net employment effect is challenging. Consequently, estimates of partial or localized employment effects can paint an inaccurate picture of net employment impacts if not properly placed in a broader economic context.

Employment impacts from the Transport Rule are also likely to vary significantly over time. In the short run, compliance with the Transport Rule will likely lead to short-term job gains arising from the design, manufacture and installation of pollution controls.[68] Various estimates of the employment impacts associated with infrastructure installation suggest that these impacts could be significant with a large share of these immediate job gains occurring in regions where new equipment is installed. Moreover, while these job impacts would be temporary, they could also stimulate the broader economy and employment.

**Figure 6**
**Illustrative Employment Impacts of the Transport Rule**




Note: The figure provides a stylized depiction of Transport Rule employment impacts and does not reflect a quantitative assessment, such that the relative magnitude of depicted impacts reflects likely impacts.

While employment is likely to rise in the short run, in the long run, employment could either increase or decrease depending on direct changes in electricity generation, indirect effects as these changes ripple through the economy, and the relaxation of regulatory requirements as downwind regions come into NAAQS compliance. These impacts would also vary significantly across regions. In upwind regions subject to the Transport Rule, while some employment may be lost as a consequence of coal-fired generation retirements, these losses will be offset – at least partially and potentially more than fully – by employment gains from operating pollution control equipment and staffing the new generation facilities needed to replace any retired capacity.

---

[68] The installation of pollution-control technology may require a substantial amount of labor relative to the number of employees otherwise working at a power plant. For example, one study estimates that the manufacture and installation of FGD creates employment of 848-1,001 annual full-time equivalents (Industrial Economics, 2010). Assuming two years to install the unit, this means about 400 to 500 jobs. This same study estimates that 103 permanent workers are needed to operate and maintain this equipment. By contrast, the National Commission on Energy Policy found that 1 GW of coal-fired capacity requires 100 to 300 employees. See Price, Jason *et al.*, "Employment Impacts Associated with the Manufacture, Installation, and Operation of Scrubbers," Industrial Economics Memorandum, January 15, 2010; National Commission on Energy Policy's Task Force on America's Future Energy Jobs, Final Report.

In "downwind" regions, employment may rise as the Transport Rule brings these regions into attainment with NAAQS, thus allowing them to relax the more stringent emission standards imposed on non-attainment regions.[69] For example, new stationary sources in noncompliance regions must meet standards based on the Lowest Achievable Emission Rate (LAER), which are more stringent than the alternative Best Available Control Technology (BACT) standards. In addition, new sources in nonattainment regions must offset all (or even more than all) emissions through the purchase of emission offsets. The aggregate and cumulative effect of these more stringent requirements can be significant.[70]

In addition to relaxing existing requirements in noncompliance regions, the Transport Rule can also avoid the need to impose further requirements in these regions to help bring them into compliance. Moreover, the costs of achieving emission reductions through the Transport Rule are generally less costly than alternatives measures targeting non-electricity in-state sources. For example, EPA notes that the cost of $SO_2$ reductions by non-electricity sources ranges from $2,270 to $16,000 per ton of $SO_2$, compared to a maximum of $2,000 per ton for upwind electricity sources.[71] These differences in the cost-effectiveness of alternative means of reducing emissions not only have distributional consequences across regions, but also have consequences for aggregate national costs of bringing all regions into compliance with air quality standards.[72]

In addition to these direct effects on upwind and downwind regions, the Transport Rule could lead to job impacts through the price effects identified in earlier sections. For example, the Transport Rule would likely raise prices for electricity (particularly in regions heavily reliant on coal), and lower prices for health insurance by varying degrees across eastern states. The net impact of these adjustments on any given state is unclear, may vary across industries depending on the intensity of their electricity use, but is likely to be limited given the small price changes anticipated as a consequence of the Transport Rule.

## V. Conclusion

As EPA undertakes the series of rulemakings affecting the electric utility sector, we believe the public interest requires that the Agency carefully assess all of the regulations' economic impacts – both in aggregate and across sectors and regions.

This paper provides a guide to understanding the appropriate analytical framework for considering these impacts, and a lens to assess the economic consequences of the Transport Rule. Through our limited examination of studies assessing various anticipated effects of the Transport Rule, we highlight several important points:

---

[69] *See*, Cicchetti, 2010, pp. 33-35.

[70] Greenstone estimates that counties out of attainment with the CAA lost approximately 590,000 jobs and $127 billion ($2009) in output over the first 15 years of implementation of the CAA (compared to counties in compliance with the CAA.) Greenstone, Michael, "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufacturers," *Journal of Political Economy* 100(6). *See, also* Becker, Randy and Vernon Henderson, "Effects of Air Quality Regulations on Polluting Industries," *Journal of Political Economy* 108(2):379-421.

[71] F.R. Vol. 75, No. 147, p., 45281.

[72] Any conclusions about cost-effectiveness of alternative approaches to emission reductions must reflect differences in the benefits created by reducing emissions from alternative sources given each source's specific geographic location and the air transport of emissions to downwind populations.

1. Existing studies providing estimates of the Transport Rule's benefits and costs consistently find that benefits outweigh costs, on a national basis, often by a wide margin.
2. Existing studies' estimates of the Transport Rule's health benefits and their conclusions that the Transport Rule would likely produce positive net benefits appear robust to changes in several key modeling assumptions.
3. Given electric infrastructure changes forecast by several studies, the proposed timing and requirements in the Transport Rule appear unlikely to raise the national costs of implementation significantly.
4. Expanded supplies of low-cost natural gas and currently underutilized labor supply to help install pollution control equipment may well lower the social cost of the Transport Rule and mitigate the impact on electric rates.
5. Although designed to address "upwind" states' power plant pollution impacts on "downwind" states, this characterization may misrepresent the geographic distribution of the Transport Rule's benefits and costs. While the Rule's economic costs are most likely to be borne in upwind states relying heavily on coal-fired power, because of reduced emissions, these states also would likely receive substantial benefits from the Rule, largely in the form of improved health outcomes.
6. Employment will likely rise in the short run as a consequence of the Transport Rule, due largely to investment in new pollution controls. In the long run, the net employment impacts could be either positive or negative, depending upon a number of economic factors, including potential increases in energy prices, potential declines in health insurance costs, and changes in labor requirements to operate the electric industry's infrastructure, as well as changes in the aggregate level of unemployment.