

A fresh look at the benefits and costs of the US acid rain program

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Abstract

The US Acid Rain Program (Title IV of the 1990 Clean Air Act Amendments) has achieved substantial reductions in emissions of sulfur dioxide (SO₂) and nitrogen oxides (NO_x) from power plants in the United States. We compare new estimates of the benefits and costs of Title IV to those made in 1990. Important changes in our understanding of and ability to quantify the benefits of Title IV have occurred. Benefits to human health now take a much higher profile because the contribution of SO₂ and NO_x emissions to the formation of fine particulate (PM_{2.5}) is substantial, and evidence of the harmful human health effects of PM_{2.5} has emerged in the last 15 years. New estimates of the health benefits of PM_{2.5} reductions are the largest category of quantified health and environmental benefits and total over US\$100 billion annually for 2010 when the program is expected to be fully implemented. Although important uncertainties exist in any specific estimate of the benefits, even if the estimates were calculated using more limiting assumptions and interpretations of the literature they would still substantially exceed the costs. Estimates of annualized costs for 2010 are about US\$3 billion, which is less than half of what was estimated in 1990. Research since 1990 also suggests that environmental problems associated with acid deposition and nitrogen deposition are more challenging to resolve than originally thought and will require larger reductions in emissions to reverse. The greater than expected benefits to human health, the greater vulnerability of natural resources and ecosystems, and the lower than expected costs all point to the conclusion that further reductions in SO₂ and NO_x emissions from power plants beyond those currently required by Title IV are warranted.

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1. Introduction

Title IV of the 1990 Clean Air Act Amendments (CAAA), also known as the Acid Rain Program, has achieved substantial reductions in US electric power industry emissions of sulfur dioxide (SO₂) and nitrogen oxides (NO_x) at lower costs than originally predicted. New estimates of the human health and environmental benefits of Title IV are calculated and contrasted with the US Environmental Protection Agency's (US EPA's) most recent estimates of the costs of Title IV. The benefits are estimated using the US EPA's most recent projections of emissions of SO₂ and NO_x from power plants in 2010, after Title IV is fully implemented, in comparison to projections

of what emissions would have been in 2010 without the Title IV regulations.

Congress passed Title IV of the 1990 CAAA to reduce emissions of SO₂ and NO_x from fossil fuel-fired power plants. The SO₂ program is a departure from previous regulatory approaches because it sets an overall emissions cap and allows trading of emissions allowances between facilities, thereby creating flexibility for the regulated entities to find the lowest cost approach to reducing total emissions. The permanent cap on total annual SO₂ emissions to be reached in 2010 is 8.95 million tons, which is about half the amount emitted by power plants in 1980. The Title IV NO_x provisions are emission rate limits based on available control technologies. NO_x emissions from power plants are also being reduced by Title I, under which the National Ambient Air Quality Standards (NAAQS) are implemented. Since proposals to reduce power plant emissions beyond the Title IV requirements are under consideration by the Administration and by Congress, it is timely to reassess what Title IV has accomplished.

The Acid Precipitation Act of 1980 (PL 96-294, Title VII) established a federal interagency task force that

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instituted the National Acid Precipitation Assessment Program (NAPAP). NAPAP provides information for policy and regulatory decisions on acid deposition, and to this end NAPAP conducted a 10-year scientific, technological, and economic study of the relationships among fossil fuel combustion, acids, and other air pollutants formed by combustion emissions, and the effects of these pollutants on the environment, the economy, and human health. NAPAP (1991) then issued the 1990 Integrated Assessment, which summarized the technical information and its implications regarding the environmental and economic costs and benefits of alternative control options.

NAPAP's assessment work was path breaking, but considerable research and analysis has been done since 1990 and much has changed in how we assess Title IV. Improved air pollution fate and transport modeling tools and new published research on the human health and environmental effects from power plant emissions are now being widely used by federal and state agencies to assess the expected effectiveness of proposed regulations. The focus of the 1990 NAPAP assessment was on SO₂ emissions and resulting acid aerosols and acid deposition. Some consideration of NO_x emissions was included because they contribute to the formation of acid aerosols, acid deposition, and ozone. However, very little attention was given to the effects of nitrogen deposition and fine particulate matter (PM_{2.5}, for which SO₂ and NO_x emissions are important precursors). Estimated benefits of PM_{2.5} reductions are now the largest category of quantified benefits.

The most important change in the assessment of Title IV benefits is for human health. Studies published in the last 15 years have shifted the focus of expected health benefits from acid aerosols to PM_{2.5} (of which acid aerosols are one component). The evidence of an effect of PM_{2.5} on mortality and morbidity is the basis of the 1997 NAAQS for PM_{2.5}, and implies substantial health benefits from Title IV required reductions in SO₂ and NO_x emissions. Research since 1990 has also revealed that some of the environmental problems associated with SO₂ and NO_x emissions are more challenging to resolve than originally thought. It will take substantially more reductions in emissions to achieve the desired environmental benefits, especially with regard to the effects of acid deposition and nitrogen deposition. Given the lower than expected costs of Title IV and the higher than expected benefits, further reductions in emissions of SO₂ and NO_x from the electric power sector are justified.

2. Emissions reductions

SO₂ and NO_x emissions from power plants have declined as expected with the implementation of Title IV. The US EPA estimated emissions and costs using the 2002 Integrated Planning Model (IPM), which is a multiregional

model of the US electric power sector.¹ The IPM provides forecasts of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints. The IPM evaluates the cost and emissions impacts of proposed policies to limit emissions. The scenario for 2010 without Title IV includes all existing and new source emission control standards for SO₂ and NO_x set before 1990, and a less efficient NO_x control technology option for future Title I compliance. The scenario with Title IV imposes a system-wide SO₂ emissions cap with trading and banking and includes several available fuel switching and emission control options. Retrofit combustion control options available for Title IV NO_x compliance are also included.

Fig. 1 shows annual SO₂ emissions by region for 1990 and 2000, and estimates for 2010 'with Title IV' and 'without Title IV' scenarios. In all regions, emissions are expected to be lower in 2010 than they would have been without Title IV, and lower in most regions in 2010 than they were in 1990. A similar regional pattern exists for NO_x emissions from power plants. Although there has been concern that the trading program might allow emissions to remain high or to increase in some locations, power plant emissions have remained low in regions where they were low in 1990, and the largest reductions have occurred in regions where emissions were the highest.

A key uncertainty in estimating Title IV benefits is projecting what levels of emissions would have been in the absence of Title IV. Benefits derive not just from reductions but also from prevention of increases. The 1990 assessment projections of SO₂ emissions in 2010 without a new control program ranged from an increase from 1990 levels to a reduction in emissions as large as that expected with a control program. The key uncertainties in this prediction were the remaining facility life for existing facilities not required to meet new source performance standards until major modification or replacement, rates of adoption of clean power production technologies, and expected growth in demand for electricity. The scenarios that predicted a large reduction in emissions by 2010 without Title IV assumed a more rapid replacement rate for older facilities, which would be retired or retrofitted with new control technology as required under New Source Review (NSR) when major modifications were made. Experience since 1990 has shown that most of these facilities have managed operations to avoid triggering NSR, resulting in facility life

¹ IPM was developed by ICF Consulting, Inc. For more information, see <http://www.epa.gov/airmarkets/epa-ipm>. IPM results reported here are based on model runs made in 2003 using the 2002 version of the model, which is documented in the US EPA publication, Documentation of EPA Modeling Applications Using IPM (V.2.1), March 2002. Adaptations were made to the 2002 base case assumptions for these model runs to calculate the counterfactual case for 2010 without Title IV and to estimate the emissions and costs for the Title IV case.

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