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How Environmental Laws Work: An Analysis of the Utility Sector's Response to Regulation of Nitrogen Oxides and Sulfur Dioxide Under the Clean Air Act

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I. INTRODUCTION

Many people have voiced concerns about our environmental regulatory system. Businesses express concern about the cost and complexity of regulation and slow governmental approvals. These concerns have added to industry resistance to efforts to tighten environmental standards or to address new problems such as global climate change. Environmental advocates are concerned about the effectiveness of regulations, their enforcement, and the need to tighten standards to increase social benefits. Policy analysts have drawn attention to the lack of common sense results and the inflexibility in many current regulatory systems, together with the lack of appropriate incentives for continuous improvement and innovation.

This study is designed to examine the actual performance of environmental regulations and the compliance behavior of regulated businesses in a real-world setting. It focuses on business compliance with regulatory standards for nitrogen oxides (NO_X) and sulfur dioxide (SO_2) in the electric power industry from 1995 through 1999. The selected time period permits evaluation of Phase I of Title IV of the federal Clean Air Act (CAA), enacted in 1990 to regulate utility emissions of SO_2 and NO_X. This allows comparison of the two contrasting regulatory approaches Title IV imposed on electricity-generating facilities: an emissions cap and allowance trading program for SO_2, the most ambitious such program operating in the United States, and a more traditional technology-based emission rate standard to control NO_X emissions. The study also compares these standards to the new source standards for NO_X and SO_2 in effect during the 1995-1999 period, providing findings about business behavior in the face of varied regulatory standards.

A. Methodology

A principal methodological approach of the study was the analysis of applicable environmental laws and polices, together with the extensive data compiled by governmental and private sources on the power generation industry. Particular use was made of the emissions and generation data compiled by the United States Environmental Protection Agency (EPA) and the Department of Energy's Energy Information Administration (EIA),[1] together with private sources such as the Center for Energy and Environmental Policy Research of the Massachusetts Institute of Technology (MIT) and Resources for the Future.

A second major methodological approach of the study was to conduct confidential interviews with representatives of power-generating firms, federal and state regulators, public interest and citizen organizations, and technology manufacturers and consulting organizations providing equipment and advice to the electricity generating industry. This included detailed, often on-site interviews with environmental program managers for most of the electricity-generating firms affected under Phase I.[2]

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[1]. Prominent among these are the annual publications EPA, PUB. NO. EPA-430/R-00-007, ACID RAIN PROGRAM: 1999 COMPLIANCE REPORT (2000), *available at* http://www.epa.gov/airmarkets/cmprpt/arp99 (last updated Dec. 11, 2000) [hereinafter EPA 1999 COMPLIANCE REPORT]; EPA, ACID RAIN PROGRAM: 1999 EMISSIONS SCORECARD (2000), *available at* http://www.epa.gov/airmarkets/ emissions/score99 (last updated Dec. 11, 2000) [hereinafter EPA 1999 EMISSIONS SCORECARD]; U.S. ENERGY INFORMATION ADMINISTRATION (EIA), U.S. DEP'T OF ENERGY, PUB. NO. DOE/EIA-0383, ANNUAL ENERGY OUTLOOK 2001: WITH PROJECTIONS TO 2020 (2000), *available at* http://www.eia.doe.gov/oiaf/aeo/index.html (last modified Jan. 30, 2001) [hereinafter DOE ANNUAL ENERGY OUTLOOK].

[2]. The interviews were confidential, and covered a wide range of topics about the effect of the regulations and firms' compliance strategies and behavior.

B. Background of Title IV

Acid precipitation, which forms as a result of SO_2 emissions and to a lesser extent NO_X emissions, emerged as a significant environmental and political issue in the late 1970s. The problem was caused primarily by electricity-generating plants in the east-central part of the United States, extending from Missouri east to West Virginia and south to Georgia, which burned the high-sulfur coal from this region.[3] The issue pitted these midwestern states and coal interests against environmentalists and the downwind northeastern states, and the acrimonious debate produced a ten-year stalemate in Congress during the 1980s.[4] Title IV of the Clean Air Act Amendments of 1990, which enacted the Acid Rain Program to address both SO_2 and NO_X emissions, ultimately broke this stalemate.[5]

Title IV's emissions cap and allowance trading system for SO_2 was designed to reduce 1980 SO_2 emission levels by 10 million tons, while promising lower costs than typically associated with traditional rate-based standards.[6] The law also imposed rate-based standards designed to lower NO_X emissions by about 2 million tons from baseline levels.[7] Both programs required significant reductions from the larger, dirtier utility units during Phase I, which lasted from 1995 until 1999.[8] Phase

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[3]. Acid precipitation occurs when sulfur dioxide and nitrogen oxides react in the upper atmosphere with water, oxygen, and other chemicals to form sulfuric acid and nitric acid. These acids adhere to rain drops or snow, damaging forests and acidifying lakes and limiting their ability to support aquatic life. Acid precipitation damage has been most pronounced in the northern tier and northeastern United States and Canada because the forests and lakes in these areas are more sensitive to acidic deposition. NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM, 1990 INTEGRATED ASSESSMENT REPORT (1991) [hereinafter NAPAP INTEGRATED ASSESSMENT]; JAMES L. REGENS & ROBERT RYCROFT, THE ACID RAIN CONTROVERSY 35-58 (1989).

[4]. *See generally* RICHARD COHEN, WASHINGTON AT WORK, BACK ROOMS AND CLEAN AIR (1990) (discussing congressional debates); BRUCE A. ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL AND DIRTY AIR (1981) (discussing competing interests regarding coal industry, environmentalists, CAA regulation, and various states).

[5]. Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 104 Stat. 2399 (1990) (codified at 42 U.S.C. §§ 7401-7700 (1994)).

[6]. Ian M. Torrens et al., *The 1990 Clean Air Act Amendments: Overview, Utility Industry Responses, and Strategic Implications*, 17 ANN. REV. ENERGY & ENV'T 211, 213 (1992). Today, it is understood that the reductions required by Title IV benefit not only acid deposition, but also human health in reducing the formation of fine particulates and of urban ozone.

[7]. 42 U.S.C. § 4651(b) (1994). Because the standards were rate-based, they never achieved the reduction from the 1980 baseline, but did slow the growth of NO_X emissions to 3% between 1990 and 1999, compared to a 28% increase in plant utilization. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 2.

[8]. Title IV only covers electric generation units that sell electricity, loosely termed "utility units," although in today's deregulated environment, independent power providers may sell power without being a regulated utility. *See* 42 U.S.C. § 7651a(17) (1994). Title IV excludes from its coverage industrial producers of electricity, even though in 1990 they emitted 3.6 million

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II commenced in 2000, and imposed stricter standards on virtually all utility units.[9]

II. REGULATORY PROGRAM FOR SULFUR DIOXIDE (SO_2)

The centerpiece of Title IV was the emissions cap and allowance trading program for SO_2, designed to reduce utility emissions by 10 million tons, or roughly 50% from 1980 levels. The program's record of over-achieving this goal at very low compliance cost has prompted many to regard it as one of the most successful environmental regulatory programs.[10]

The emissions cap sets a mass performance standard very unlike traditional rate standards. The cap is the most important element of Title IV because it establishes the program's environmental integrity and much of its economic efficiency by allowing regulated firms to choose any effective compliance method, leading to significant cost savings.[11] The emissions trading system also helped to lower compliance costs by allowing firms to reduce emissions at the generating units where their costs were lowest, and resulted in establishing a market price per ton of emission reductions.

The combination of a cap-and-trade system makes every ton of reductions count and exerts continuous economic pressure on firms to improve performance, transforming business compliance behavior as compared to a traditional rate-based approach.[12] Overall, this unique

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tons of SO_2 compared to utility emissions of 15.9 million, and 3.0 million tons of NO_X compared to utility emissions of 6.7 million. EPA, NATIONAL AIR POLLUTANT EMISSION TRENDS 1900-1998, PUB. NO. EPA-454/R-00-002, at 3-10, 3-12 (Mar. 2000), *available at* http://www.epa.gov/ttnchie1/trends/index.html [hereinafter EPA EMISSIONS TRENDS]. Note that industrial sources may voluntarily opt into the SO_2 program. 42 U.S.C. § 7651i(a) (1994).

[9]. Phase I of the program includes only larger units with emissions greater than 2.5 pounds per million Btu of fuel burned (lb/mmBtu) during the baseline period of 1985-1987 (known as "Table A" units, as they are listed in Table A in the statute), together with any substitution or compensating units that were voluntarily entered into Phase I. *See* 42 U.S.C. § 7651c (1994). The 265 units included in Phase I of the SO_2 program as of January 1, 1995, also are affected by the Phase I NO_X program. *See id.* § 7651f. All utility units larger than 25 MW in size are included in Phase II of the program, which began in 2000. *See id.* §§ 7651d(a), 7651f(a).

[10]. *See generally* EMISSIONS TRADING (Richard F. Kosobud et al. eds., 2000) (discussing economic, environmental, and regulatory issues surrounding emissions trading); A. DENNY ELLERMAN ET AL., MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM (2000) (evaluating the impact of Title IV on SO_2 emissions).

[11]. 42 U.S.C. § 7651a-c (1994).

[12]. Emission rate systems, especially if differentiated by technologies, exert few incentives to use cleaner base technologies, and promote an "equal effort" approach based on reasonable or best efforts. They also create no incentives to go beyond the standard. In contrast, emissions cap and allowance trading approaches, together with other potential market mechanisms, create an equal "cost per ton" approach that allows greater flexibility in compliance

regulatory design resulted in major emissions reductions, industry compliance costs below the lowest predictions, significant and unexpected innovation, relatively little litigation during program implementation, very low ongoing transaction costs, and 100% compliance.

The environmental effects of the sulfur reductions have also been significant. Compliance with Title IV has already reduced acid deposition in northeastern states.[13] The EPA has also estimated the health benefits from reduced SO_2 emissions at over $10 billion.[14]

A. Background and History of SO_2 Regulation: Traditional Rate-Based Standards

Prior to Title IV, existing power plants were primarily affected by state-based legislation aimed at attaining national ambient environmental standards.[15] The federal Clean Air Act of 1970 established the first national ambient air standards for SO_2, designed to protect health and welfare,[16] and required states to develop "state implementation plans"

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choices and exerts continuous pressure on businesses to reduce tons of pollution. These issues are discussed *infra* Part V.

[13] James A. Lynch et al., *Changes in Sulfate Deposition in Eastern USA Following Implementation of Phase I of Title IV of the Clean Air Act Amendments of 1990*, 34 ATMOSPHERIC ENV'T 1665 (2000) (finding a 25% reduction by 1998).

[14] EPA, PUB. NO. EPA-430/R-95-010, HUMAN HEALTH BENEFITS FROM SULFATE REDUCTIONS UNDER TITLE IV OF THE 1990 CLEAN AIR ACT AMENDMENTS 6-4 (1995) (calculating annual benefits for sulfate aerosol reductions at $10 billion in Phase I, rising to $40 billion by 2010, with 88% of benefits from reduced premature mortality). The EPA also estimates the benefits of additional NO_X reductions at $1262 to $4786 per ton in 1999. EPA, PUB. NO. EPA-452/R-98-003B, 2 REGULATORY IMPACT ANALYSIS FOR THE NO_X SIP CALL, FIP, AND SECTION 126 PETITIONS ES-6 (1998) [hereinafter EPA 1998 RIA]; *see generally* ENVTL. LAW INST., CLEANER POWER: THE BENEFITS AND COSTS OF MOVING AWAY FROM COAL TO NATURAL GAS POWER GENERATION (Nov. 2000) (calculating NO_X, SO_2 and CO_2 benefits from reduced coal generation) [hereinafter ELI CLEANER POWER]; CLEAN AIR TASK FORCE, DEATH, DISEASE & DIRTY POWER: MORTALITY AND HEALTH DAMAGE DUE TO AIR POLLUTION FROM POWER PLANTS 4-5 (2000) [hereinafter CLEAN AIR TASK FORCE] (calculating annual benefits of bringing power plants into compliance with modern pollution standards for SO_2 and NO_X at over $100 billion).

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[15] National legislation affecting SO_2 dates back to the Clean Air Act of 1963, which restricted interstate air pollution. Clean Air Act of 1963, Pub. L. No. 88-206, 77 Stat. 392 (1963). This law failed to have great effect, as its cumbersome procedures required intergovernmental conferences to address specific instances of interstate pollution, as well as multiple requests for remedial action. Several cases did, however, result in reductions of SO_2 and particulate deposition. *See* SENATE COMM. ON PUBLIC WORKS, 93D CONG., 2D SESS., A LEGISLATIVE HISTORY OF THE CLEAN AIR ACT AMENDMENTS OF 1970, at 1346 (COMM. PRINT 1974). The Air Quality Act of 1967 later initiated a system for air-quality planning based on ambient air-quality standards to supplement these abatement procedures, a precursor to the 1970 legislation. *See* Air Quality Act of 1967, Pub. L. No. 90-148, 81 Stat. 485 (1967); Vickie L. Patton, *The New Air Quality Standards, Regional Haze, and Interstate Air Pollution Transport*, 28 ENVTL. L. REP. 10,155 (1998).

[16] Clean Air Act, 40 C.F.R. 50.2(b) (2000).

(SIPs) to achieve these standards.[17] The primary standard for SO_2 was set at 0.030 parts per million (ppm), to be achieved on a calendar-year basis, and the secondary standard was 0.5 ppm, set on a three-hour basis.[18] An unintended consequence of these new ambient standards was the dispersion of SO_2 through tall stacks. The EPA permitted over a dozen states to adopt SIPs allowing sources to meet the new standard by building tall stacks to disperse the SO_2 instead of reducing emissions.[19] This practice injected SO_2 into the higher atmosphere where it remained longer, facilitating the chemical reactions that produce sulfuric acid and aggravating acid precipitation. In the 1977 CAA Amendments Congress subsequently prohibited the use of tall stacks to achieve ambient standards.[20] It is important to note that these ambient standards still exist and protect against plants emitting SO_2 at levels that would exceed local health-based limits.

In contrast to the lenient standards and relative lack of regulation of existing plants, the CAA established stringent standards for new sources or major modifications of existing sources, based on "new source performance standards" (NSPS).[21] The first NSPS established in 1971 limited emission rates to 1.2 pounds of SO_2 per million BTU of fuel burned (lb/mmBtu) for coal-fired plants.[22] To meet this standard, new sources either had to use scrubbers to reduce emissions or use so-called "compliance coal" with a sulfur content equivalent to the NSPS rate. The effect on the industry was dramatic because emission rates from existing sources were far higher. Because of the disparity between standards for existing and new plants, electric utilities began to focus their research and operational efforts on extending the operating life of the older, "grandfathered" facilities.[23]

In the Clean Air Act Amendments of 1977, Congress created the New Source Review process and a stricter new source performance

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[17]. 42 U.S.C. § 7410 (1994).

[18]. Clean Air Act, 40 C.F.R. §§ 50.4, 50.5 (2000). *See* National Ambient Air Quality Standards for Sulfur Oxides (Sulfur Dioxide)—Final Decision, 66 Fed. Reg. 1665-01 (May 22, 1996).

[19]. *See* Patton, *supra* note 15, at 10,162; Richard L. Revesz, *Federalism and Interstate Environmental Externalities*, 144 U. PA. L. REV. 2341, 2351-52 (1996); *see generally* REGENS & RYCROFT, *supra* note 3 (discussing history of efforts to control acid rain).

[20]. The 1977 Amendments added section 123 to the Act, which states that the "control of any air pollutant under an applicable implementation plan under this title shall not be affected in any manner by—(1) so much of the stack height of any source as exceeds good engineering practice . . . or (2) any other dispersion technique." 42 U.S.C. § 7423 (1994).

[21]. *Id.* § 7411.

[22]. Clean Air Act, 40 C.F.R. § 60.43 (2000) (applying the standard to plants built between 1971 and 1978).

[23]. *See infra* Part III.D.3.a.

standard that retained the former 1.2 lb/mmBtu standard but also required new sources to reduce potential stack SO_2 emissions by 70% or 90%, depending on the coal quality.[24] This standard required utilities to install scrubbers at all new generating units, removing much of the incentive to use low-sulfur coal and favoring powerful eastern high-sulfur coal interests.[25] By thus increasing the cost of new coal-fired plants, the scrubbing requirement added incentives to extend the life of the older, dirtier plants.

Both the ambient and new source SO_2 standards were based principally on human health concerns, and proved inadequate to address the broader regional effects of acid deposition on ecosystems. By the late 1970s, Canada, several states, and national and state environmental organizations were raising serious concerns about acid precipitation. In 1980, Congress created the National Acid Precipitation Assessment Program to address disagreements over the cause of acid precipitation.[26]

Throughout the 1980s, legislators introduced bills in Congress to reduce acid precipitation.[27] These typically focused on requiring the older, dirtier coal plants to meet the 1.2 lb/mmBtu standard used for new sources since 1970, or to require scrubbing, with annual costs estimated at $4 to $7 billion.[28] Eastern coal interests and electric utilities blocked

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[24] 42 U.S.C. § 7411; Clean Air Act, 40 C.F.R. § 60.43a (2000).

[25] In *Sierra Club v. Costle*, the court held that a utility could not use low-sulfur coal to create equivalent reductions. 657 F.2d 298, 320-21 (D.C. Cir. 1981). It interpreted the rate-based standard and held that "[i]n no instance, however, can a plant reduce emissions less than 70% of potential uncontrolled emissions . . . . There is no dispute that the 70% floor in the standard necessarily means that, given the present state of pollution control technology, utilities will have to employ some form of flue gas desulfurization ('FGD' or 'scrubbing') technology." *Id.* at 316 & n.38. Later, in *Wisconsin Electric Power v. Reilly*, the court held that use of low-sulfur coal was also not permissible to avoid the threshold for imposition of strict New Source Performance Standards. 893 F.2d 901, 919 (7th Cir. 1990).

[26] 42 U.S.C. §§ 8901-8912 (1994).

[27] *See generally* COHEN, *supra* note 4 (discussing congressional debates).

[28] For instance, the Mitchell Compromise negotiated between Senator Mitchell, then-Chairman of the Environment Subcommittee of the Senate Environment and Public Works Committee, and Majority Leader Senator Byrd, would have initially required scrubbing at 33 MW of "cost-effective" plants, and required all utility coal-fired plants not already meeting a 1.2 lb/mmBtu emissions rate standard to meet a 1.0 lb/mmBtu standard beginning in 2003. The annualized costs of fully implementing this were estimated at $4.4 to $6.1 billion. The Waxman-Sikorski bill of the 98th Congress, co-sponsored by over 80 House members, would have mandated scrubbing on the 50 largest utility plants with an estimated cost of as much as $7 billion annually. Paul R. Portney, *Policy Watch: Economics and the Clean Air Act*, 4 J. ECON. PERSP. 173, 175 (1990); *see also* H.R. 3400, 98th Cong. (2d Sess.1984). *See generally* Dallas Burtraw, *Appraisal of the* SO_2 *Cap-and-Trade Market, in* EMISSIONS TRADING 133 (Richard F. Kosobud et al. eds., 2000) (discussing costs and benefits of alternative regulatory methods).

these efforts, arguing that they were too costly and would cause dramatic increases in electricity rates in many states.[29]

In mid-1989, the Bush Administration broke the deadlock on acid precipitation with a proposal to cap emissions at a level 10 million tons below 1980 levels and to allow emissions trading under the cap.[30] This proposal, which became Title IV, was designed to achieve significant emissions reductions at substantially lower cost than earlier proposals.

B. Title IV

Title IV was passed in 1990 to substantially reduce the SO_2 emissions of electric utilities, which were then responsible for 70% of national emissions.[31] Title IV is unlike traditional regulations that impose source-specific rate limits, and instead implements an industry-wide mass standard—a permanent cap on utility SO_2 emissions at 8.95 million tons per year, or roughly half their 1980 baseline emissions.[32] Phase I of the program began in 1995, and required the 263 dirtiest coal-fired electricity-generating units (referred to as "Table A" units) to reduce their SO_2 emissions to a base level of 5.7 million tons per year.[33] Phase II commenced in 2000, and requires all generating units larger than 25 megawatts to reduce their emissions to reach the final cap amount of 8.95 million tons.[34]

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[29] Paul L. Joskow & Richard Schmalensee, *The Political Economy of Market-Based Environmental Policy: The U.S. Acid Rain Program*, 41 J.L. & ECON. 37, 47 (Apr. 1998); Arnold W. Reitze, Jr., *The Legislative History of U.S. Air Pollution Control*, 36 HOUS. L. REV. 679, 715 (1999).

[30] The Bush Administration bill as originally presented on June 15, 1989, would have created a two-pronged regulatory approach: power generation units that emitted over 1.2 lb/mmBtu of SO_2 in the baseline year (1985) would be subject to an emissions cap of 5.1 million tons, combined with an allowance trading system; those emitting less than 1.2 lb/mmBtu would be required to maintain that emissions rate. The latter group, known as "the class of '85," came to perceive inclusion in the allowance system as preferable, and the debate began to center on how many allowances to provide to these "clean" utilities and to various sub-groups within this group. The overall choice of a 10 million ton reduction was slightly in excess of the estimated reductions required by other bills recently proposed in Congress, and was based in part on a perceived "knee" in the cost of compliance curve at the 10 million ton reduction level. *See, e.g.*, Nancy Kete, The Politics of Markets: The Acid Rain Control Policy in the 1990 Clean Air Act Amendments 182-3, 251-2 (1993) (unpublished Ph.D. dissertation, Johns Hopkins University) (on file with author) (outlining costs of four bills as presented to the Bush Administration).

[31] EPA EMISSIONS TRENDS, *supra* note 8, § 2.2, at 3-4.

[32] 42 U.S.C. § 7651c (1994); *see also* Torrens et al., *supra* note 6, at 213.

[33] 42 U.S.C. § 7651c. The level of the Phase I cap was reached by multiplying an emissions rate of 2.5 lb/mmBtu SO_2 (about double the Phase II standard) times utilization in the baseline years. *Id.*; *see also* ELLERMAN ET AL., *supra* note 10, at 39-41 (detailing precise Phase I allocation rules).

[34] The level of the Phase II cap is reached by multiplying an emissions rate of 1.2 lb/mmBtu SO_2 times baseline utilization. The 1.2 lb/mmBtu emission rate has historical

To implement the cap, the law assigned allowances, each equivalent to one ton of SO_2 emissions, to each affected generating unit based on its historic base period (1985-1987) generation rates, but scaled down so that the aggregate emissions equaled the target emissions cap.[35] Title IV therefore effectively implements a new source standard of zero because any new generating source must purchase all its needed allowances from other sources, and total emissions do not grow.[36]

In addition to these baseline allowance allocations, Title IV provided almost 4 million bonus allowances over the first years of the program, primarily to encourage the use of scrubbers;[37] together with a small number for renewable energy and small diesel refineries producing desulfurized fuel.[38] Both the annual allowances and the bonus allowances were allocated without charge to existing sources. Finally, to help establish a market and to counter fears of allowance hoarding, the law requires the EPA to hold back and auction roughly 3% of the allowances allocated to units each year, and to make available a limited amount of allowances at $1500 through a Direct Sales Reserve.[39]

In another departure from traditional regulation, Title IV allows individual sources to trade their unused allowances to other sources, or bank them for future use.[40] The design of Title IV therefore creates several compliance options for a generating source:

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significance, as it is the rate standard which has been required for new coal-fired power plants since 1970.

[35]. Congress was trying to achieve a reduction of 10 million tons from 1980 emissions, but the individual source information for 1980 was poor, so Title IV established the baseline period based on emissions from 1985 through 1987, proportionately reduced to equal estimated 1980 emissions. 42 U.S.C. § 7651a(4) (1994).

[36]. *See* 42 U.S.C. § 7651b(e) (1994).

[37]. By far the largest quantity of bonus allowances was the 3.5 million extension allowances, allocated primarily (2.1 million) to units that installed scrubbers. The origin of these 3.5 million bonus allowances was a shift forward of one year in the effective date of the Act, in moving from the Senate bill to the Administration bill. During Phase I, this achieved an added 3.5 million ton reduction, redistributed as bonus allowances to firms choosing to install scrubbers, which was in the interest of states with high-sulfur coal deposits. 42 U.S.C. § 7651c(d) (1994); Torrens et al., *supra* note 6, at 215. A similar advance of one year for Phase II led to the allocation of an additional 530,000 allowances for the years 2000 through 2009. *Id.* at 213 n.1.

[38]. Although 300,000 bonus allowances were authorized to reward efforts to develop alternative energy sources, only 30,377 were allocated during Phase I. 42 U.S.C. § 7651c(g) (1994). In addition, up to 35,000 allowances a year were authorized for small diesel refineries producing low-sulfur fuel, of which 147,820 were allocated in Phase I. *Id.* § 7651i(h). Allocation data from EPA COMPLIANCE REPORTS.

[39]. 42 U.S.C. § 7651o(b)-(d). The auction and Direct Sales Reserve provisions were added to Title IV to counter "fears that market imperfections, such as irrational hoarding of allowances by utilities or anti-market behavior by state public utility regulators, might make it impossible for new entrants to acquire allowances necessary to construct and operate new generating capacity." ELLERMAN ET AL., *supra* note 10, at 169 & n.5.

[40]. *See id.* § 7651b(b).

- emit *at* the unit’s annual baseline tonnage limit;
- emit *below* the limit and generate unused allowances that can be banked for later use, used by other units within the company, or sold or traded to other firms; or
- emit *above* the limit and obtain allowances to cover the additional emissions.[41]

In order to guard against the transfer of generation from Phase I units to noncovered Phase II units, Title IV required firms to maintain their average heat input from their baseline period, or suffer the loss of allowances.[42] However, another flexibility mechanism allowed them to designate non-Table A units that would otherwise not be covered until Phase II as “substitution units” during Phase I.[43] Once a firm elected to do so, the EPA determined a baseline for the units and provided them with allowances just like Table A units, allowing firms to use the emissions reductions (or exceedances) from these plants as part of their overall compliance strategy.[44]

Finally, Title IV incorporates an extremely strict monitoring and compliance system. Continuous Emissions Monitoring Devices (CEMS) must record data every fifteen minutes and regularly report consolidated data to the EPA, including data that indicates that the monitor is functioning properly.[45] The CEMS cost almost $1 million per stack.[46] At year end, following a two-month period for “true-up,” each company must show that it has sufficient allowances to cover all emissions for that year.[47] If not, firms automatically receive a $2000 fine per ton of exceedances, and must restore each excess ton plus a penalty ton that is

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[41]. Such allowances can come from the allowance market or from other units owned by the company, whether generated contemporaneously or banked in previous years. *Id.*

[42]. *See id.* §§ 7651c, 7651g(c)(1); Clean Air Act, 40 C.F.R. § 72.43 (2000).

[43]. *Id.* § 7651c(b).

[44]. *Id.* § 7651c(b), (c).

[45]. Clean Air Act, 40 C.F.R. § 75.1 (2000). This is more stringent than the new source provisions, which require only two data points per hour. Clean Air Act, 40 C.F.R. § 60.47a(g) (2000). It has been noted that predictive emissions monitors are far cheaper and may be as accurate as CEMS, since sulfur emissions can be accurately predicted from fuel sulfur content and boiler characteristics, but these are rarely allowed. C. Foster Knight, *How Regulations Impact Innovative Environmental Technologies: A Recent Case Study*, TOTAL QUALITY ENVTL. MGMT. 119 (Spring 1995) (discussing predictive emissions monitoring systems).

[46]. ELLERMAN ET AL., *supra* note 10, at 248-50.

[47]. At the end of the year, utilities are granted a sixty-day “true-up,” or grace period, during which SO_2 allowances may be purchased, if necessary, to cover each unit’s emissions for the year. At the end of the grace period, the allowances that a unit holds in its compliance account must equal or exceed the annual SO_2 emissions recorded by the unit’s monitoring system. Any remaining allowances may be sold or banked for use in future years. Clean Air Act, 40 C.F.R. § 77.3 (2000).

deducted from the firm's allotment for the following year.[48] This system has resulted in 100% compliance over the five years of the Phase I program.[49]

This cap-and-trade system is both more rigid and more flexible than traditional regulation. The emissions cap is more rigid because it creates zero growth of emissions, which benefits the environment. The monitoring rules and compliance system are also extremely strict, with severe and automatic penalties. However, the system provides great flexibility to firms in choosing compliance options. Due to the true performance standard established by the emissions cap, together with trading, a utility is free to choose among competing compliance approaches, including scrubbing, switching to lower sulfur coal, blending coals with different sulfur contents, and shifting load to units that emit less sulfur. In addition, government regulators are not involved in decisions about technology choice, as they are in application of technology-based standards like BACT, RACT, and LAER.[50] The government role is that of strict compliance monitoring, not supervising the choice of technology, which greatly lowers transaction costs and allows firms to rapidly change their compliance approaches.

C. Industry Response

The electric industry's response to Title IV can be characterized in three overlapping stages. In the earliest years of the program, firms significantly over-invested in compliance, including constructing scrubbers for twenty-seven Phase I units.[51] These actions were driven by predictions of relatively high allowance prices in the $300 to $1000 range, and uncertainty as to whether additional allowances would be available on the market.[52] In the second stage, firms began to recognize and react to the lower cost of compliance represented by lower allowance prices in the $150 range, which first became evident in the

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[48]. 42 U.S.C. § 7651(j) (1994); Clean Air Act, 40 C.F.R. § 77.6 (2000).

[49]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 2.

[50]. 42 U.S.C. §§ 7479(3), 7501(3), 7502(c)(1) (1994).

[51]. *See infra* note 91.

[52]. When the cap-and-trade system was first proposed in 1990, the EPA's marginal cost estimates for Phase I were between $290 and $410 per ton, and $580 to $815 for Phase II in constant 1995 dollars. ICF RESOURCES, INC., COMPARISON OF THE ECONOMIC IMPACTS OF THE ACID RAIN PROVISIONS OF THE SENATE BILL (S.1630) AND THE HOUSE BILL (H. 1630) (July 1990) [hereinafter ICF RESOURCES]. The National Acid Precipitation Assessment Program (NAPAP) estimated that only modest SO_2 reductions could be made at under $200 per ton, and that the marginal cost of a 10 million ton reduction by 2000 would be $700 to $900 per ton. NAPAP INTEGRATED ASSESSMENT, *supra* note 3, at 411.

period from 1992 to 1993.[53] These price signals led some firms to cancel scrubber contracts, and led to a growing use of low-sulfur coal to reach compliance.[54] In this stage, and continuing throughout Phase I, the trading provisions were used by many firms to bank allowances for future use and for intra-firm averaging among different units, with only a handful of firms using inter-firm trading as a compliance strategy.[55]

A third stage became evident toward the end of Phase I, in which many firms increased their participation in the allowance market, trading directly with other firms and increasing trading for arbitrage or profit-making purposes.[56] However, this third stage did not represent any change in compliance strategies. Virtually all firms continued essentially autarkic or self-reliant compliance strategies throughout Phase I, emitting well below their limits and banking allowances for future use.[57]

The following sections describe firms' observed compliance behavior, and assess how the legal provisions or other aspects of Title IV have acted to influence this behavior.

1. Price Signals, Coupled with the Flexibility of Title IV, Drove Major Shifts in Businesses' Compliance Strategy

One of the most interesting aspects of the early years of Title IV was firms' relatively rapid response to price signals generated by the allowance market that reflected the underlying cost of compliance. Initial industry expectations in 1991 were for prices between $300 and $1000 per allowance.[58] In 1992 and 1993, the earliest signals began to reveal that prices would be substantially lower. The first trades took place in 1992 at $265 and $300,[59] and the EPA's first auction of

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[53]. ELLERMAN ET AL., *supra* note 10, at 231-35 (discussing estimates of Phase I costs prior to implementation).

[54]. U.S. GENERAL ACCOUNTING OFFICE, PUB. NO. GAO/RCED-95-30, AIR POLLUTION: ALLOWANCE TRADING OFFERS AN OPPORTUNITY TO REDUCE EMISSIONS AT LESS COST 29 (1994) [hereinafter GAO 1994 TRADING]; Burtraw, *supra* note 28, at 133-67.

[55]. *See* Figure 2-3. *See generally* A. Denny Ellerman, *From Autarkic to Market-Based Compliance: Learning from Our Mistakes, in* EMISSIONS TRADING (Richard F. Kosobud et al., eds. 2000) (discussing utility emphasis on self-reliance and Phase I over-compliance).

[56]. *See id.* at 12.

[57]. *See* Figures 2-3 A, B.

[58]. An industry poll showed widespread expectations of allowance prices on the order of $300 to $725 for Phase I and $500 to $1000 for Phase II in June-July 1991, falling to $200 to $550 for Phase I and $300 to $700 for Phase II by October/November 1991. Torrens et al., *supra* note 6, at 220. Similarly, the EPA and other economic studies predicted that allowances would cost $290 to $410 during Phase I, and $580 to $815 in Phase II. *See* ICF RESOURCES, *supra* note 52. *See generally* Burtraw, *supra* note 28, at 152 (setting forth long-run cost estimates).

[59]. The first trade was of 10,000 allowances at $265 per allowance from Wisconsin Power & Light Company to the Tennessee Valley Authority. Frank Edward Allen, *Tennessee*

allowances in March of 1993 revealed prices at $131.[60] As shown below, private transactions continued for almost a year to be somewhat above the price set by the 1993 auction, but by mid-1994 they fell to the $150 level set by the EPA auction in March of 1994, and continued in the $100 range through Phase I, until they began to climb towards $200 as Phase II approached.[61]

See Figure 2-1: SO_2 Allowance Prices[62]

Since allowance prices are closely tied to the cost of compliance, the low allowance prices reflect a very positive development: a low cost of compliance.[63] The major drivers of the lower costs in Phase I were innovation and investment relating to low-sulfur coal, as well as increased scrubbing efficiency.[64] These responses were prompted in large part by the design of Title IV, although unrelated market forces, such as increased rail competition, also contributed.[65]

The ability of firms to shift compliance strategies in response to the changing costs of different compliance options is directly related to the cap-and-trade standard. Title IV allowed firms to respond to the unexpectedly low price of low-sulfur coals; several firms cancelled scrubber contracts and many switched to low-sulfur coal. Altogether, scrubbers were built for only twenty-seven Phase I units, significantly fewer than were anticipated at the time the 1990 CAA Amendments were adopted.[66] Title IV is therefore unlike the previous rate-based NSPS standards that limited compliance technologies to scrubbing or the use of

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Valley Authority Is Buying Pollution Rights From Wisconsin Power, WALL ST. J., May 11, 1992, at A12. The second was a trade of 25,000 allowances from ALCOA to Ohio Edison for $300 per allowance. Joan E. Rigdon, *Alcoa Unit Arranges $7.5 Million Sale of Pollution Allowances to Ohio Edison*, WALL ST. J., July 1, 1992, at A6.

[60]. *See* Ellerman, *supra* note 55, fig. 1, at 6.

[61]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 10.

[62]. EPA, PUB. NO. EPA-430/R-00-0007, ACID RAIN PROGRAM: 1999 COMPLIANCE REPORT (2000).

[63]. Researchers, however, have pointed out that allowance prices may be lower than expected because they may reflect the marginal cost of compliance, and be less than the average cost due to the “lumpy” nature of certain investments in compliance technologies, such as scrubbers. *See* ELLERMAN ET AL., *supra* note 10, at 297-302; Dallas Burtraw & Byron Swift, *A New Standard of Performance: An Analysis of the Clean Air Act’s Acid Rain Program*, 26 ENVTL. L. REP. 10,411 (1996).

[64]. *See infra* Part II.C.5.a-d.

[65]. Richard Schmalensee et al., *An Interim Evaluation of Sulfur Dioxide Emissions Trading*, 12 J. ECON. PERSP. 53, 57 (1998).

[66]. GAO 1994 TRADING, *supra* note 54, at 29; Burtraw, *supra* note 28, at 133-67; *see also infra* Part II.C.5.

"compliance coal."[67] It also differs markedly from traditional regulation by not requiring regulatory approval of changes in compliance choices, thus avoiding delay and transaction costs.

2. Over-Compliance and Banking

Title IV required firms to reduce emissions at Phase I units to a base level of approximately 6.7 million tons per year (including both Table A and substitution units),[68] but the addition of bonus allowances distributed primarily in the first years of the program meant that the annual cap was between 8.7 and 7 million tons during Phase I, as shown in Figure 2-2.

See Figure 2-2: Phase I Sulfur Dioxide
Emissions and Allowance Cap (1990-1999)[69]

Utilities responded to the Title IV program by over-complying and reducing SO_2 emissions to 5.2 million tons, or approximately 30% below the cap.[70] This over-compliance in part reflects a conservative business tendency to leave a margin of safety when complying with environmental regulations. However, two aspects of Title IV provided firms additional impetus to over-comply. The first was the significant allocation of almost 4 million bonus allowances in Phase I, mostly for construction of scrubbers as a concession to coal mining interests.[71] Second, the ability to bank allowances under Title IV added value to early reductions because allowances would become more valuable in Phase II when allocations to Table A units would be reduced and all other

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[67]. The design of Title IV prompted both innovation and investment in low-sulfur coal, as firms actively began to experiment with fuel blending as a compliance strategy. *See infra* Parts II.C.4, II.C.6.a; *see also* ELLERMAN ET AL., *supra* note 10, at 244. Previous industry experience in reducing SO_2 was under the New Source Performance Standards (NSPS), which were rate standards and strongly limited compliance options. *See supra* text accompanying notes 21-25.

[68]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 7, exh. 3. Approximately 5.7 million were allocated to Table A units, and 1 million per year to substitution units.

[69]. EPA, PUB. NO. EPA-430/R-00-0007, ACID RAIN PROGRAM: 1999 COMPLIANCE REPORT (2000), at 7, 9. The 1990 emissions level of 9,720,466 tons is the average of the 1995-1999 units' emissions in 1990, and was derived from data in EPA, ACID RAIN PROGRAM: 1999 EMISSIONS SCORECARD (2000).

[70]. *Id.* at 7, 9. If the 4 million tons of bonus allowances are not counted, the over-compliance falls to 22% below the cap amount. *See* ENVIRONMENTAL DEFENSE, FROM OBSTACLE TO OPPORTUNITY: HOW ACID RAIN EMISSIONS TRADING IS DELIVERING CLEANER AIR 22 (2000).

[71]. *See supra* note 37. Interviews with government regulators and utility representatives indicate that the bonus allowances motivated the construction of an additional five to six scrubbers, generating additional reductions.

units would enter the program.[72] Together these factors created significant motivation towards over-compliance in Phase I.[73]

The net result in Phase I was that 38.1 million allowances were issued over all five years and net emissions were only 26.5 million tons. This created a bank of 11.6 million allowances saved for use in Phase II that is not expected to be depleted until 2010.[74] Overall, a principal effect of banking may simply be to smooth the transition between Phases I and II, as it promotes a more gradual decline in emissions. The banking behavior also has minor positive environmental significance because it achieved early reductions during Phase I, although the saved tons may be expected to be emitted in later years.[75]

Banking may be considered a form of trading, as it shifts the use of allowances from one year to another. If so, the extensive banking behavior becomes the principal use of Title IV's trading mechanisms. Overall, 14,031,943 tons of emission reductions were created by units that emitted below their allowance allocations. Of this amount, 10,518,211, or fully 75%, were banked for later use, and only 3,541,045 were "traded" in the more traditional sense to offset emissions of other units during Phase I.[76]

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[72] 42 U.S.C. § 7651d (1994).

[73] Analysis by Resources for the Future shows that banking helped to drive over-investment in scrubbers. Dallas Burtraw & Erin Mansur, *The Effects of Trading and Banking in the SO_2 Allowance Market*, DISCUSSION PAPER NO. 99-25, at 19, *at* http://www.rff.org/environment/air.htm (Mar. 1999).

> In theory, allowing for banking should decrease costs. However, we find that the opportunity for banking actually led compliance costs to be higher by $651 million in 1995 and $339 million in 2005 in our model. Banking encouraged the construction of scrubbers that appear *ex post* to be cost-inefficient. Given changes in fuel markets subsequent to the planning and construction of these facilities, we calculate that none of the 21 scrubbers that were built in Phase I would have been built if there had not been banking.

Id.

[74] The 11.6 million ton bank includes the net 10.5 million allowances created by over-compliance at utility units during Phase I, plus other allowance pools not directly allocated to those units, i.e., the 750,000 auctioned allowances, 339,705 allowances to industrial opt-in sources and the 147,820 allowances issued to small diesel refineries. These figures are derived from ELI analysis of EPA COMPLIANCE REPORTS, 1995-1999.

[75] Since acid deposition creates cumulative impacts, early reductions are beneficial as they may prevent threshold effects for acid deposition that harm ecosystems. One analysis shows banking may also slightly improve health effects over time, primarily by displacing emissions out of highly populated areas in the northeast, but that this effect may be countered by future population growth. Burtraw & Mansur, *supra* note 73, at 15.

[76] *See* Figure 2-5. Figures derived through ELI analysis of EPA COMPLIANCE REPORTS.

3. Autarkic Compliance

Compliance responses in Phase I revealed a strong tendency for firms to adopt an autarkic or "comply on your own" strategy. Most of the fifty-one affected firms made extensive use of the flexibility mechanisms to achieve emission reductions within their own firm, but as shown in Figures 2-3, A and B, only three firms (Illinois Power, Tampa Electric, and Duquesne Power) used inter-firm trading as a compliance option over the full period of Phase I. All other firms achieved compliance through actions taken within the firms themselves.

See Figure 2-3A: SO_2 Allowances and Emissions of Top 10 Phase I Utilities by Total Allowances Allocated (1995-1999) and Figure 2-3B: SO_2 Allowances and Emissions, Phase I Utilities (except 10 largest) (1995-1999)[77]

This finding of minimal inter-firm allowance trading is significant because most economic analyses reveal substantial differences in compliance costs among the Phase I units. Those differences should have driven greater use of the inter-firm trading option.[78] The discussion in Part II(C)(9) provides some reasons why firms did not use inter-firm trading to the full extent that it may have been economically justified.

Another aspect of autarkic compliance is the unequal burden placed on smaller firms with few units. When firms primarily use the trading provisions for intra-firm averaging, large firms are able to lower their cost of compliance due to the variability among their own multiple units and may be little affected by the lack of inter-firm trading. On the other hand, absent the ability to trade with other firms, a firm with only one or two units would be limited to compliance options that could achieve the needed reductions at those particular units. Indeed, a few of these smaller firms chose to install scrubbers, a relatively expensive compliance option for a small plant.[79]

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[77]. Figures derived from analysis of EPA COMPLIANCE REPORTS, 1995-1999. *See also* figure 2-5. Data shows the sum of all emissions and allowance allocations to Phase I-affected units for each firm in the years 1995-1999.

[78]. GAO 1994 TRADING, *supra* note 54, at 72-73; Ellerman, *supra* note 55, at 190-91; Douglas R. Bohi & Dallas Burtraw, *SO_2 Allowance Trading: How Do Expectations and Experience Measure Up?*, 10:7 ELEC. J. 67 (1997) (noting that many utilities have failed to take advantage of allowance trading as a method of reducing compliance costs).

[79]. These firms included small municipal utilities for the City of Owensboro, and Atlantic City. *See* Figure 2-5. *See generally* Todd J. Zywicki, *Environmental Externalities and Political Externalities: The Economy of Environmental Regulation and Reform*, 75 TULANE L. REV. 845, 864 (1999) (finding that the fixed cost of scrubber installation falls harder on small businesses).

4. Strategies for Compliance

As noted above, Title IV provides firms with a very wide scope of compliance options that include:

1. scrubbing;
2. fuel switching to lower-sulfur coals;
3. shifting to natural gas or renewable energy;
4. optimization, or increasing the efficiency of the unit;
5. load shifting to lower-emitting units;
6. use of substitution provisions;
7. allowance trading;
8. allowance banking;
9. demand-side management;[80] and
10. retirement.[81]

The emissions cap (as opposed to the trading provisions) is the primary aspect of Title IV that allows firms the flexibility to choose among the first four compliance options. Traditional emissions rate standards would be more restrictive because they tend to reward technologies that reduce end-of-pipe emission rates, which may not allow firms to achieve pollutant reductions through cleaner processes, increased efficiency, or reduced demand.[82] The greater flexibility afforded by the emissions cap approach is supplemented by the trading and substitution mechanisms in Title IV that allow firms added flexibility in the locus of emissions reductions. The trading provisions allow intra-firm averaging, trading with other firms, and banking allowances, and the substitution provisions allow for greater inclusiveness of units.

The table below shows that firms achieved the major share of SO_2 reductions by two methods. Scrubbing, an end-of-pipe control

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[80] Demand-side measures are those taken to improve the efficiency of consumer power use, or to reduce consumption. Clean Air Act, 40 C.F.R. § 72.2 (2000). Note that while demand-side management is a compliance mechanism under a cap-and-trade approach, the phased nature of Title IV required firms in Phase I to not reduce their overall utilization. Therefore, special rules were needed in Phase I to encourage demand-side management. *See, e.g., id.* §§ 72.43, 73.80.

[81] Again, as with demand-side management, the retirement of inefficient or obsolete units is a compliance mechanism generally under a cap-and-trade approach, but the phased nature of Title IV required firms in Phase I to not reduce utilization. 42 U.S.C. § 7651g(c)(1) (1994).

[82] Rate standards limit or restrict compliance technologies. In the SO_2 context, the New Source Performance Standard adopted in 1977 only allowed scrubbing, and the 1971 NSPS standard limited compliance choice to scrubbing or a particular quality of coal. In the NO_X context, standards such as BACT are interpreted by some states to only recognize reductions made through end-of-pipe control equipment, not through process change. *See infra* Part IV.E.1. Rate standards thus often do not recognize or reward reductions made upstream, such as those made through the use of cleaner processes or fuels.

technology that reduces SO_2 to a solid waste,[83] contributed 35% of the total emission reductions made during Phase I (not counting bonus allowances). Fuel switching by firms that blended or switched to low-sulfur or medium-sulfur coal contributed 59% of reductions. Retiring units contributed another 6% of reductions although their output was generally made up at other units.

Figure 2-4. Source of Reduction for Plants
that Reduced Emissions Below Allocations
(Total Reductions Made in Phase I, 1995-1999)[84]

		units	Reductions with Bonus	%	Reductions w/o Bonus	%
Table A Units	scrubbing total	26	5,856,376	42	3,665,433	32
	switching total	126	5,526,657	39	5,178,540	45
	retired/not util.	7	283,905	2	283,905	2
Substitution Units	scrubbed	16	292,469	2	292,469	3
	unscrubbed	113	1,712,075	12	1,712,075	15
	retired/not util.	44	360,461	3	360,461	3
Total			14,031,943	100	11,492,883	100

Figure 2-5 reveals individual firms' compliance strategies. The first column shows firms' net allowance savings or withdrawals during Phase I. The second column shows the allowance savings made by unscrubbed Table A firms that emitted below their allowance allocation. The third shows the allowance withdrawals used by units that emitted above their allocations. Subsequent columns show the reductions achieved through scrubbed, retired, or substitution units. Bonus allowances allocated to firms are shown for information purposes, but these allowances are also included in the other columns since they formed part of firms' compliance strategies.

See Figure 2-5. Compliance Methods of Fifty-One Companies
in Phase I (1995-1999)[85]

Several compliance strategies are evident:

(a) Sixteen utilities scrubbed at one plant and used the excess allowances for all or a substantial part of their allowance needs at their other units. Firms such as American Electric Power, TVA, and Allegheny Power scrubbed a single large plant to create over a million excess allowances in each case.

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[83] *See* REGENS & RYCROFT, *supra* note 3, at 59-74.

[84] Data derived from analysis of EPA COMPLIANCE REPORTS, 1995-1999. Note that only plants that reduced emissions below allocations are included.

[85] Data derived from analysis of EPA COMPLIANCE REPORTS, 1995-1999.

(b) Thirty-four firms adopted a primary strategy of switching to lower-sulfur coals at some units to create excess allowances for all or a substantial part of their needs at their other units. The large Southern Company achieved net reductions at all of its forty-nine units primarily by switching to lower-sulfur coal.

(c) Only one firm, Illinois Power, purchased allowances as its principal compliance strategy.

5. The Scrubbing Story: Fewer Scrubbers than Expected but Lower Costs Due to Economics, Innovation, and Regulatory Design

Scrubbing, or flue gas desulfurization,[86] was the principal compliance strategy for sixteen utilities, and scrubbed plants achieved 35% of all emissions reductions.[87] Scrubbing was clearly the central compliance strategy of major firms such as American Electric Power, the TVA, and Allegheny Power. These firms' scrubbing strategies not only offset excess emissions at other units, but allowed each firm to build up a banked supply of over 1 million allowances for Phase II.[88] In addition to these larger firms, some small firms, such as municipally owned entities, chose scrubbing despite the relatively high per-ton compliance costs to install scrubbers at smaller units. These firms did so because it was an available compliance option that allowed each firm to comply on its own.[89]

Contrary to initial expectations, scrubbing turned out to be the more expensive of the two principal compliance methods, and the actual number of scrubbers built was substantially less than expected, as firms turned to low-sulfur coals as a cheaper compliance option. A 1994 Government Accounting Office report found that scrubber vendors expected to complete thirty-five or forty contracts in Phase I, though some vendors claim that they expected a need for as much as 100,000

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[86]. Scrubbing essentially replicates the chemical reaction that gives rise to acid precipitation, but is contained within the scrubbing vessel. This technology sprays limestone or another calcium source into the fuel chamber, causing a chemical reaction with the flue gas that turns the SO_2 gas into a solid. The resulting slugs are then disposed of in landfills or, if calcium sulfite is used, employed in the production of wallboard. *Id.*

[87]. Phase I scrubbers cost $249 per kilowatt to install, or $150 million for a 600 MW plant. *See* Figure 2-7. They also use about 1.5% of the electric power generated by the plant to run, consume significant lime or limestone, and generate solid wastes that over the lifetime of a 300 MW plant would fill 1000 acres, unless alternative uses of the wastes can be found, such as for gypsum or landfill. Interviews with scrubber manufacturers.

[88]. Each of these companies generated over a million allowances at a single scrubbed plant, Cumberland (TVA), Harrison (Allegheny Power), and Gavin (AEP). *See* Figure 2-11.

[89]. Interviews with smaller firms show that most never seriously considered allowance purchases for compliance.

MW of installed or retrofit scrubber capacity.[90] Ultimately, only twenty-seven scrubbers were installed for Table A plants, with a capacity of 16,167 MW.[91] Most utilities that installed scrubbers did so in part due to the need for early implementation of compliance options. A retrofit scrubber requires from eighteen to thirty months of advance planning, so commitments to scrubbing vendors had to be made as early as 1992, when estimates of the cost of compliance and of allowances still ranged from $300 to $700.[92] Had these early projections of compliance costs proven to be accurate, scrubbing, especially at larger plants, would have been a cost-effective compliance strategy.[93] However, economic analysis shows that in retrospect, few or none of these scrubbers would now be considered to have been an economic investment.[94]

The bonus allowance provisions in Title IV also contributed to the early over-investment in scrubbers. As a concession to high-sulfur coal mining interests, Congress allocated about 2.1 million of the 3.5 million extension allowances awarded during Phase I to utilities that committed to install scrubbers.[95] These bonus allowances provided subsidies regarded as worth $200 to $400 million based on the value of

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[90] GAO 1994 TRADING, *supra* note 54, at 29. An MIT Center for Energy and Environmental Policy Research (MIT/CEEPR) survey of respondents who represented about half of the retrofitted scrubbing capacity also identified 3600 MW where scrubbing was the initial option but not the last. A.D. ELLERMAN ET AL., EMISSIONS TRADING UNDER THE U.S. ACID RAIN PROGRAM: EVALUATION OF COMPLIANCE COSTS AND ALLOWANCE MARKET PERFORMANCE 50 (M.I.T. Center for Energy and Envtl. Policy Research, 1997); *cf.* ICF RESOURCES, *supra* note 52 (predicting lower need for scrubbed capacity).

[91] The scrubbers for these twenty-seven units were constructed in the early to mid-1990s in response to Title IV. In addition, a scrubber was installed at one Table A plant in 1985, which was therefore part of its baseline and not a compliance strategy. Another Table A unit, Big Bend Unit 1, installed a scrubber in December 1999, which was the last month of Phase I, and relevant only for Phase II compliance. In addition to the Table A units, substitution units had installed fifteen pre-1990 NSPS scrubbers, with a capacity of 6056 MW, making a grand total of 21,223 MW scrubbed capacity for units in Phase I for all five years. However, the reductions at substitution units made before 1990 do not count as Phase I reductions, but instead are part of their baseline emissions. *See* Clean Air Act, 40 C.F.R. § 72.41(c)(3) (2000).

[92] *See* Torrens et al., *supra* note 6, tbl.1, at 220. In a survey conducted by the MIT/CEEPR, 75% of respondents, representing about half of the retrofitted scrubbing capacity, "indicated that expectations of allowance prices of $300 to $400 were 'very important' in decisions to scrub." ELLERMAN ET AL., *supra* note 90, at 50. The long lead time to install a retrofit scrubber was needed so the equipment could be installed during planned outages in 1994 or 1995.

[93] Economic estimations are that few scrubbers would have been built during Phase I had firms been able to accurately predict the lower costs of switching. *See* Burtraw, *supra* note 28.

[94] Burtraw & Mansur, *supra* note 73.

[95] These 3.5 million allowances represent the savings made by moving up the effective date of the legislation one year, from 1996 to 1995.

allowances, and were a significant factor that motivated several utilities to install Phase I scrubbers at an estimated five or six units.[96]

See Figure 2-6. Scrubbers Installed by Year and Type[97]

One of the significant stories of Phase I was the declining cost of scrubbing over the course of Phase I. ICF Resources projected in 1990 that scrubber costs for Phase I units would amount to $455 per ton of SO_2 removed.[98] Actual costs calculated by MIT were $282 per ton, caused not by a decline capital costs, but major reductions in operating costs, as shown in Figure 2-7. By 2000, scrubbing costs had declined yet again, this time due to a precipitous drop in capital costs to the $100/kW level, less than half the $249/kW cost in 1995.[99]

Figure 2-7. Phase I Scrubber Cost Components
(in 1994 dollars)[100]

	Predicted 1995 (ICF Resources, 1990)	Actual 1995 (MIT, 2000)
Initial Capital cost ($/KW)	$249	$249
Fixed O&M ($/KW-yr)	$6.55	$2.00
Variable O&M (per kWh)	1.81 mills	1.26 mills
Removal efficiency	90%	95%
Utilization	65%	82%
Cost per ton SO2:	$455	$282
Capital charge (@11.33%)	$285	$206

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[96]. *See* Interviews with state regulatory officials and utility companies. States such as Illinois also attempted to protect their high-sulfur coal mining industries by providing subsidies for scrubber installation. Even these incentives were insufficient to tilt the balance in favor of scrubbing. One utility spent $35 million to begin construction of a scrubber, received approval for a subsidy from the state for the scrubber, but opted instead to achieve compliance by first purchasing allowances in Phase I, and subsequently by switching to low-sulfur coal in Phase II, thus foregoing a substantial subsidy for the scrubber installation. *See* American Bar Association, *New Strategies for New Market: The Electric Industry's Response to the Environmental Protection Agency's Sulfur Dioxide Emission Allowance Trading Program*, 47 ADMIN. L. REV. 469, 480-81 (1995) (describing Illinois Power's decision to cancel "its plan to install scrubbers" in favor of purchasing allowances to comply with Phase I).

[97]. U.S. ENERGY INFORMATION AGENCY, PUB. NO. EIA-0348(99)12. FLUE GAS DESULFURIZATION (FGD) CAPACITY IN OPERATION AT U.S. ELECTRIC UTILITY PLANTS AS OF DECEMBER 1999, 2 ELEC. POWER ANNUAL, tbl. 30 (October 2000). The type of scrubber was determined through interviews with plant managers and scrubber manufacturers, and also by reference to data compiled by MIT's Center for Energy and Environmental Policy Research.

[98]. *See* Figure 2-7.

[99]. *See* Interviews with scrubber manufacturers.

[100]. ICF RESOURCES, INC. COMPARISON OF THE ECONOMIC IMPACTS OF THE ACID RAIN PROVISIONS OF THE SENATE BILL (S.1630) AND THE HOUSE BILL (H.1630[sic]) (July 1990); A.D. ELLERMAN ET AL., MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM, tbl. 9.3, 240 (2000).

Fixed Overhead and Maintenance	$66	$15
Variable Overhead and Maintenance	$104	$65

These major cost reductions were due to several factors: technological innovation in scrubber design, economic factors that led firms to increase utilization at scrubbed plants in Phase I, and Title IV's flexible design that allowed more efficient scrubbers to be built. The innovation and rapid decline in scrubber costs during Phase I stand in marked contrast to the previous two decades, during which scrubbing vendors enjoyed a monopoly in SO_2 compliance technology for new firms. During that time relatively little innovation in scrubber design had taken place.[101]

a. Increased Scrubber Utilization

One factor that led to decreased per-ton costs of scrubbing was the unexpectedly high utilization rate of scrubbed units during Phase I, which spread the capital costs over a larger number of tons. The increased utilization can be explained by the relatively low variable costs of scrubbing, at about $65 per ton of SO_2, once the significant capital investment is made.[102] Operating an existing scrubber was therefore profitable as long as the variable cost was lower than the price of allowances. This cost savings created an impetus for firms to shift power generation, or "load," away from Phase I unscrubbed units to scrubbed units.[103]

b. Innovation in Scrubber Design

Design improvements also lowered scrubbing costs. Interviews with scrubber manufacturers revealed that significant innovation in scrubbers has occurred since the first Phase I scrubbers were installed in

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[101] ELLERMAN ET AL., *supra* note 10, at 241 ("A recent study of the advances in scrubber technology in the United States through 1992 found 'no significant progress . . . in abatement technology' and attributes this result to the 'small incentives for innovation [associated with] the form of regulation typically used in the U.S.'"); *see also* Allen Bellas, *Empirical Evidence of Advances in Scrubber Technology*, 20 RESOURCES & ENERGY ECON. 327 (1998); Paul A Ireland et al., *A Review of Phase I Retrofit FGD Cost Experience—New Benchmarks for the Future*, Presentation at AMWA Mega Symposium sponsored by EPRI-DOE-EPA (1995) (notes on file with author).

[102] *See* Figure 2-7.

[103] ELLERMAN ET AL., *supra* note 10, at 235-42.

1995.[104] The major advance that led to price reductions was eliminating redundancy. Modern scrubbers typically have a single vessel that serves multiple units, greatly reducing costs. Redundancy has been reduced in other components as well. Another advance has been higher-speed flue gas streams that increase the rate at which the reaction between flue gas and the reagent slurry occurs.[105] Other advances include using less expensive ceramic materials in scrubbing vessels and sourcing materials worldwide.

In addition to these design improvements, innovation has taken place in waste disposal practices. Since the solid wastes from a scrubber may cover 1000 acres over the life of a large plant, waste disposal is a significant part of scrubbing cost.[106] Utilities have worked to enhance cost-effective ways to recover saleable, commercial-quality gypsum from scrubbing waste by using a different reagent, or by further processing.[107]

c. Title IV's Design

A third factor in reducing scrubbing expense is that Title IV's design allowed more efficient scrubbers to be built. Until 1992, most utilities installed scrubbers to meet New Source Performance Standards, although a few utilities had installed scrubbers to meet state SO_2 emission or ambient standards.[108] Under NSPS, sources had to achieve a 90% or 70% reduction on a continuous basis.[109] NSPS scrubbers therefore had to be very reliable to ensure strict compliance with this rate limit, as any deviation would lead to a violation and potentially require shutting down the plant while the scrubber was repaired. As a consequence, the scrubber built for NSPS required significant redundancy and typically an entire backup scrubber module in case the

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[104]. In one case, scrubbers being built at two units of the Mount Storm plant today will cost 30% to 40% less than the scrubber built at an identical unit of that plant in 1995. *See* Interviews with industry representatives; Pollution Engineering Online, *Marshley Wins $88 Million Scrubber Contract*, *at* http://www.pollutionengineering.com (Apr. 1999).

[105]. This has made it possible to achieve the same amount of SO_2 emissions reduction with a smaller scrubbing vessel, thereby lowering capital costs and maintenance costs by 15% to 20%.

[106]. *See* Interviews with scrubber manufacturers.

[107]. An increase in the demand for gypsum has helped fuel research and development in refining this process, with the result that by-product gypsum production has become highly economical for some utilities. Gypsum companies are now building facilities close to some generating units. The use of gypsum obtained from scrubbers increased from 1.5 million tons to 2.5 million tons between 1996 and 1998. R.F. BALAZIK, U.S. GEOLOGICAL SURVEY, MINERALS INFORMATION—1998: ANNUAL REVIEW FOR GYPSUM 35.1 (1999).

[108]. *See* Interviews with electric utilities; ELLERMAN ET AL., *supra* note 10, at 235-42.

[109]. *See supra* note 25.

first one failed, causing costs to be far higher than needed to reduce sulfur emissions efficiently. Title IV adopted a mass limit with an annual averaging period, allowing a utility to average its emissions over a year and even to purchase allowances if needed to compensate for scrubber down time. As a result, scrubbers built to comply with Title IV do not have to be over-built, nor include backup modules, significantly lowering their capital and operating costs.[110]

Another aspect of Title IV's design that promoted innovation was its flexibility, which introduced competition into the SO_2 reduction field. For the first time scrubbers had to compete with other compliance methods, thus spurring innovation. A second factor of Title IV's design is that every ton of reductions counts, creating incentives for businesses to raise scrubber efficiencies. The NSPS rate standard, on the other hand, created no incentives for achieving removal efficiency greater than the established rate limits.[111]

6. The Low-Sulfur Coal Story—Regulatory Design and Economic Choices

The widespread use of low-sulfur coal has been a major compliance strategy during Phase I, accounting for 59% of actual reductions.[112] Firms such as the Southern Company switched to lower-sulfur coals as the centerpiece of their compliance strategies, characterized by the company as "BUBA," or "Bank, Use and Buy Allowances." All forty-nine of Southern's units emitted below their allowance allocation, allowing the company to build a 1 million ton bank of allowances for Phase II.[113] Many other firms were also able to switch to low-sulfur coal at relatively low cost, although geographic location in relation to low-sulfur coal fields, and the availability of low-cost transportation from these fields, were important factors.[114]

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[110]. *See* Figure 2-7.

[111]. Some firms reported that some public utility commissions prohibited over-compliance with the 90% reduction new source standard for scrubbing, as any overcompliance was not in accordance with a "prudent investment" policy. This represents an extreme example of the limitations caused by rate-based standards.

[112]. *See* Figure 2-4.

[113]. Gary R. Hart, *Southern Company's BUBA Strategy in the SO_2 Allowance Market, in* EMISSIONS TRADING 204, 205 (Richard F. Kosobud ed., 2000) ("Our plan was to procure a substantial supply of this low-sulfur coal for our affected units during Phase I while at the same time paying little or no premium for this 1% coal [emitting SO_2 at 1.67 lb/mmBtu] as opposed to a coal that emitted the 2.5 lb/mmBtu rate.").

[114]. *See* Jeffrey M. Hirsch, *Emission Allowance Trading Under the Clean Air Act: A Model for Future Environmental Regulations?*, 7 N.Y.U. ENVTL. L.J. 352, 381-82 (1999).

The use of low-sulfur coal was catalyzed by the flexibility afforded by Title IV, which unlike any of the NSPS standards did not place constraints on the use of low-sulfur coal for compliance.[115] This led to experimentation and innovation in fuel blending techniques that facilitated greater use of low-sulfur western coals, and provided incentives to use eastern low- and medium-sulfur coals, as described below. These innovations, together with investment prompted by Title IV, lowered the expected cost premium for low-sulfur coals and increased their use.[116]

a. Low-Sulfur Western Coal

Coal from the Powder River Basin (PRB) in Wyoming and Montana has a very low sulfur content at or below 0.6 lb/mmBtu.[117] The market for western coal was growing even before Title IV was enacted because of its low cost to mine, lower shipping prices produced by rail deregulation, and state acid precipitation regulatory programs in states such as Minnesota and Wisconsin.[118] Following the enactment of Title IV several utilities, especially those within 1000 miles of the PRB, moved rapidly to adapt their coal handling and milling equipment to accommodate PRB coal.[119] Use of PRB coal has now penetrated east to West Virginia and south to Georgia.[120]

Despite its low sulfur content, the use of PRB coal presents problems: it is subbituminous, and has both higher ash content and lower heat value than harder eastern bituminous coals, which can cause derating (or loss of generating capacity) and interfere with boiler operation.[121] Prior to the enactment of Title IV, many utilities believed that western coals would not perform well in their generating units, especially the large cyclone boilers in the midwest built to handle eastern coals.[122] Available options therefore were believed to be scrubbing or switching to relatively expensive eastern low-sulfur coals.

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[115]. 42 U.S.C. § 7651b (1994).

[116]. *See* ELLERMAN ET AL., *supra* note 10, at 82-89; *infra* text accompanying note 131.

[117]. EIA, COAL INDUSTRY ANNUAL, PUB. NO. DOE/EIA-0584(98) (1999).

[118]. Utility emissions of SO_2 had already begun to fall before Phase I, with 1993 levels 7% below 1985 levels. EPA 1999 EMISSIONS SCORECARD, *supra* note 1.

[119]. *See* ELLERMAN ET AL., *supra* note 10, at 82-88. "[T]he consequence of competition and productivity improvements has been the halving of the rail rate for long-distance shipments of coal out of the PRB." *Id.*

[120]. *See* Interviews with utility companies.

[121]. *See* ELLERMAN ET AL., *supra* note 10, at 244.

[122]. *See* Interviews with utility companies; Burtraw & Swift, *supra* note 63.

In response to the impetus provided by Title IV's design, which credits any emission reductions, utilities began experimenting with blending inexpensive low-sulfur PRB coal with traditionally higher-sulfur midwestern coal to reduce total SO_2 emissions.[123] Early on, typical blends were 40% low-sulfur PRB coal and 60% higher-sulfur bituminous coal, a combination firms believed would prevent or minimize the operational and derating problems. Experimentation allowed utilities to steadily increase the percentage of PRB coal through reengineering their plants.[124] Today, blends of up to 80% PRB coal are not uncommon, and a number of plants have been modified in ways that permit using 100% PRB coal.[125]

PRB-related innovation is closely tied to Title IV's mass standard because firms initially did not think they could blend PRB coal to reach rate values such as 1.2 lb/mmBtu.[126] Because, unlike a rate standard, Title IV rewarded any reduction, such as moving from high emissions to medium emissions, firms began to experiment with blending PRB, with the positive results outlined above.

b. Low- and Medium-Sulfur Eastern Coals

As Phase I continued, eastern low- and medium-sulfur coals also began to compete with western coal for new market share. The greater distance from western coal fields and the operating issues with PRB coal increased the attractiveness of Appalachian low-sulfur coal, with sulfur content at about 1.2 lb/mmBtu. A study by MIT of the early years of Phase I showed this coal was able to capture a significant part of the market, accounting for 44% of SO_2 reductions from fuel switching, with the medium sulfur coal accounting for another 35% of reductions from fuel switching.[127]

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[123]. ELLERMAN ET AL., *supra* note 10, at 250.

[124]. *Id.* at 244. "[I]n what must be considered a triumph of tinkering and continuous tinkering, it was found that subbituminous coal could be blended with the local bituminous coal up to a point without incurring significant derating." *Id.*

[125]. *See* Interviews with utility firm representatives. *See also* ELLERMAN ET AL., *supra* note 10, at 129 (noting that PRB coal accounts for about 15% of the SO_2 emissions reductions from fuel switching under Title IV and 10% of the overall SO_2 emissions reductions under Title IV).

[126]. The rate value of 1.2 lb/mmBtu has significance as it is the rate standard new plants have to achieve under NSPS, and is the rate standard on which the Phase II cap was established. Most units would need to reach such a rate level by Phase II.

[127]. ELLERMAN ET AL., *supra* note 10, at 128-29.

c. Economic Considerations in Switching to Low-Sulfur Coals

In considering switching from higher-sulfur to low-sulfur coals, firms considered three primary cost elements: mine-mouth cost, transportation cost, and the premium paid for the lower sulfur content of the coal.[128] All three costs can vary considerably between coals.[129] For example, PRB coal from large open-pit mines costs only $0.20 per mmBtu to mine, or one quarter of the cost of mining eastern coals, but transportation costs are higher due to the greater distance to eastern generating units.[130]

A major element affecting Title IV implementation has been the lower than expected sulfur premium, which has led to greater use of low-sulfur coal. One factor contributing to the lower price was rail deregulation in the 1980s, which lowered shipping cost and made PRB coal more competitive.[131] Title IV itself promoted major investment by utilities. One study identified $12 billion in added investment associated with Title IV by mid-1995: $6 billion for development of low-sulfur coal fields, $3 billion for scrubbers and modifications, $2 billion in coal-related rail investment, and over $1 billion in allowance purchases.[132] This spurred rail industry innovations in the design of cars and infrastructure,[133] and some utilities also invested in transportation infrastructure, including barges and rail cars, to ensure access to PRB coal at competitive prices.[134] These investments in assets and infrastructure addressed bottlenecks and barriers to the use of low-sulfur coal, and contributed to the observed reduction in compliance cost.

The second factor leading to greater than expected use of low-sulfur coal was the lower than expected capital cost of retrofitting boilers so they could use low-sulfur coal, which included the cost of boiler modifications, coal-handling equipment, and particulate controls.[135] Here, there is an important distinction between eastern and western coals. Most boilers built for the bituminous coal prevalent in the eastern part of the country can switch to low-sulfur bituminous coal at low

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[128] *See* Ireland, *supra* note 101.

[129] ELLERMAN ET AL., *supra* note 10, at 129-30.

[130] *Id.*

[131] *See id.* at 128-30; EIA, THE EFFECTS OF TITLE IV OF THE CLEAN AIR ACT AMENDMENTS OF 1990 ON ELECTRIC UTILITIES: AN UPDATE, PUB. NO. DOE/EIA-0528(97), at 23-25 (1997).

[132] Clean Air Capital Markets, Research (1995) (unpublished data, Washington, D.C.) (on file with author).

[133] Burtraw & Swift, *supra* note 63, at 10,419.

[134] *See* Interviews with utility representatives.

[135] *Id.*

capital expense, around $5 to $10 per kW of capacity for most units.[136] It costs more to retrofit these boilers to burn sub-bituminous coals from the western United States, which have higher ash and moisture content, and hence different combustion characteristics. The magnitude of this expenditure depends on the plant, but typically is in the range of $50 to $75 per kW.[137] Although significant, these costs are far less than the $249/kW in capital costs to install scrubbers.

A third factor related to the use of low-sulfur coal was the concern about the use of PRB coal potentially resulting in derating and operational problems. These concerns failed to materialize.

d. Effect of Title IV on Coal Pricing

Title IV significantly changed coal prices. Prior to Title IV, the principle added value was for coal with a sulfur content of 1.2 pounds or less of sulfur per million Btu of heat content. Often referred to as "compliance coal," it allowed firms built between 1971 and 1978 to meet the New Source Performance Standard in effect at that time, or similar state standards.[138] The sulfur content of coal made little difference to other plants: plants built before 1971 were essentially unregulated, and plants subject to the new source standard imposed after 1978 were required to scrub, making them apt to buy the cheapest coal regardless of its sulfur content.[139] Title IV dramatically changed this situation by making any reduction in SO_2 valuable. This introduced more price competition among fuels and created a uniform gradient in the price of coals based on sulfur content.

7. Retirement

Normally, retirement of a unit would be an effective compliance strategy under a cap-and-trade program, as it would result in allowance savings. However, the phased nature of Title IV required that firms

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[136]. *See* Ireland et al., *supra* note 101; *see also* ELLERMAN ET AL., *supra* note 10, at 224 (switching to PRB cost $15 to $75 per kW; switching to other bituminous coals cost $0 to $15 per kW).

[137]. *See* Ireland et al., *supra* note 101; *see also* ELLERMAN ET AL., *supra* note 10, at 224. Added particulate controls were also needed because western coal is "dustier" than most eastern coal, increasing explosion danger as well.

[138]. Clean Air Act, 40 C.F.R. § 60.43 (2000); *see also supra* text accompanying note 22.

[139]. *See supra* text accompanying note 25. If a utility had to install a scrubber in order to meet ambient air quality standards or if a plant subject to NSPS opted for the 90% removal standard, the principle consideration in the choice of coal was price, not sulfur content, since there was no regulatory or economic advantage to using lower sulfur coal. Many of the utilities in the central part of the country chose to use lower priced high sulfur coal mined in the region. *See* Interviews with utility representatives.

maintain their baseline utilization during Phase I, although they could average the utilization of all their units.[140] For the most part, this precluded retirement as an independent compliance strategy in Phase I, since the reduced utilization would need to be made up at other units. Overall, only seven Table A units (1343 MW) in the midwest with short remaining lives were shut down, with lost generation made up at other units.[141] Approximately forty substitution units, or more than 3000 MW, also were retired, reducing the emissions of these units by 383,587 tons, but again with offsetting generation at other units.[142]

8. Substitution Units

Firms made significant use of substitution units, confirming their readiness to make use of a flexibility mechanism with low transaction costs. Almost three-quarters of all firms, thirty-six in all, designated substitution units, and substitution was a significant method of compliance for a dozen firms.[143] Overall, 195 units were included as substitution units for at least one year, and net reductions from substitution units were 2,365,005 tons, about 20% of the total reductions achieved during Phase I.[144]

The substitution provisions were intended to allow greater flexibility in meeting the reduction requirements, as firms found it cheaper to achieve the needed reductions at another of their units rather than the ones designated under Table A. For example, it might make more economic sense to scrub a newer Phase II unit, or switch to low-sulfur coal at a Phase II unit that was located nearer to a transportation route such as a river or railway. However, analysis conducted at MIT shows that allowing firms to voluntarily choose which units to include led in part to "gaming," with firms choosing to include units that would have decreased their emissions anyway.[145] Again, this is a problem with the phased structure of Title IV, and will not be an issue once all firms are included in Phase II.

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[140]. 42 U.S.C. § 7651g(c)(1) (1994).

[141]. Four of the units were Wisconsin Electric Power's old North Oak Creek plant, and the lost utilization was made up at the South Oak Creek plant owned by the same utility. The other retired units were Avon Lake 11 in Ohio, Breed 1 in Indiana and Des Moines 11 in Iowa. EPA 1999 COMPLIANCE REPORT, *supra* note 1, app. B-4. *See generally* Ireland et al., *supra* note 101 (citing POWER ENGINEERING UPDATE, Mar. 1993).

[142]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, app. B-4.

[143]. Eleven companies with three or more units achieved roughly half or more of their compliance through substitution units. In addition, two smaller firms participated in Phase I only because their units were chosen as substitution units. *See* Figure 2-5.

[144]. *See id.*

[145]. ELLERMAN ET AL., *supra* note 10, at 197-220.

The use of the substitution provision could have been even greater had not the environmental community and certain elements of the industry litigated in response to initial rules promulgated by the EPA that would have allowed firms to count the reductions made at substitution units that installed scrubbers between 1985 and 1990.[146] Although advocates of this approach argued that the scrubbers were installed in anticipation of the legislation, and thus that their reductions should be counted, the plaintiffs argued against retroactively counting any reductions achieved before 1990. The EPA settled the case by agreeing with the plaintiffs, and providing that baseline emissions would be the lower of 1985 or 1990 levels.[147] These events left a searing memory in many of the firms interviewed, who view the lesson learned as "early compliers lose." They also partly attribute industry's reluctance to voluntarily reduce CO_2 emissions before passage of final legislation to these earlier events.[148]

9. Trading

The trading mechanisms under Title IV represent the most significant use of emissions trading in our environmental laws, and so have received a great deal of attention. Although not as critical as the emissions cap, trading is an important element of Title IV, as it contributed to cost reductions by allowing firms to bank allowances, shift load between their units as a compliance strategy, and to benefit from inter-firm trading.

Allowance trading climbed steadily throughout Phase I as firms became more accustomed to its use, and as movement toward a deregulated energy policy placed greater emphasis on marketing and trading in general. EPA data from the Allowance Tracking System shows that at least 81.5 million allowances were traded during Phase I.[149] However, most of these consisted simply of internal reallocation within a firm, and the extent of trading is better reflected in the 30.8 million allowances traded between economically unrelated entities, as shown in Figure 2-8.[150]

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[146]. *See* Acid Rain Program: Permits, 59 Fed. Reg. 60,218 (Nov. 22, 1994).

[147]. *See* Clean Air Act, 40 C.F.R. § 72.41(c)(3) (2000).

[148]. *See* Interviews with utility representatives.

[149]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 10-11. These figures include trades of both Phase I and Phase II allowances, which are not reported separately by the EPA.

[150]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 11.

See Figure 2-8. Allowance Transactions Between
Unrelated Entities (1995-2000)[151]

The experience of Phase I reveals a number of interesting contrasts and findings regarding trading. One was its increased importance and use for arbitrage and profit-making purposes, contrasting with firms' conservative use of trading for compliance. Aside from banking, only 3.5 million of the traded allowances, or 13% of total emissions, were used for compliance purposes during Phase I.[152] Most of these were used internally by firms to average the emissions of their own units, and inter-firm trading for compliance comprised only 577,583 allowances, or 2% of total emissions.[153] Another was that early fears about market power in trading, or the creation of emissions hot spots, never materialized. Finally, the effect of trading in creating a price for a ton of emissions reduction allowed the greater integration of an environmental parameter into the economic decision-making of firms.

Before examining the use of trading in Phase I, it is important to note the relationship of trading to the emissions cap. The cap is arguably the more important element of Title IV, as it creates the environmental integrity and much of the economic efficiency in the program. The cap also creates the context in which trading can take place through allowances, which combine far greater opportunity for trading, lower transaction costs, and greater environmental integrity than the previous forms of credit trading. This commodity-like nature of allowances allows trades to be made without government presence, and creates some of the important environmental and economic benefits of allowance trading.

a. Establishment of the Trading System

The growth of trading has been influenced by the annual EPA auction of allowances and the role of an independent community of allowance brokers who facilitate allowance transactions. The initial 1993-1994 period of trading was marked by relatively little trading and uncertainty in the market.[154] Roughly 50% of allowance transactions were made through the official EPA auctions, which provided an early

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[151]. *Id.*

[152]. 3.5 million was the total number of allowances needed by individual units to cover emissions that exceeded their allowance allocations. *See* Figure 2-5.

[153]. Only three firms emitted more allowances than they were allocated, requiring their use of 577,583 allowances. *See* Figure 2-5. A slightly higher number is reached if one adds the 130,789 allowances used by other firms that exceeded their allowance allocation for only one or two years. *See infra* note 171.

[154]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 11.

signal of the unexpectedly low price of compliance. Allowance prices, however, varied between the auction and private deals, indicating an immature market.[155] Confirming firms' lack of familiarity with the market, most trades were made through brokers, and different brokers charged commissions of $3.50 to $10 per allowance in this period.[156]

Today, about 6 to 10 million allowances are traded annually between separate entities, largely through private transactions. Only 2% of transactions take place through the EPA auction.[157] However, the EPA helps establish a secure market through its Allowance Tracking System, which records allowance transactions, typically within twenty-four hours.[158] Prices are transparently quoted in several privately maintained indexes, and the consistency of prices is high.[159] One aspect of firms' increased familiarity with trading is the decreased fraction of trades made through brokers today. Direct trades made by utilities have climbed from a negligible amount in 1994-1997 to an amount equal to the total made through brokers. This trend is also reflected in the commission charged by brokers, which has steadily declined to $1 per ton in 1995, $0.50 per ton in 1997, and $0.20 per ton in 1999.[160]

One of the early concerns during the creation of Title IV was that allowances simply would not be available, due to hoarding or other market power problems. This concern led to inclusion of the provisions for an allowance auction and a guaranteed reserve of allowances priced at $1500.[161] However, there has been widespread liquidity throughout Phase I, assisted by the independent community of emissions brokers.[162]

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[155]. Ellerman, *supra* note 55, fig. 1, at 6.

[156]. *See* Interviews with emissions brokers. One firm charged $10 per allowance in this early period, and sold a significant share of the early allowances, but provided considerable technical and strategic advice along with the allowance sale.

[157]. Only 150,000 allowances are traded in the EPA auction, which was about 2% of the 10 million allowances traded in 1999. *See* Figure 2-8.

[158]. Clean Air Act, 40 C.F.R. § 73.30 (2000). *See* Joseph A. Kruger et al., *A Tale of Two Revolutions: Administration of the SO_2 Trading Program, in* EMISSIONS TRADING 115, 121 (Richard F. Kosobud ed., 2000) (noting that the "EPA processes about 90% of allowance transactions within 24 hours of receipt, using just two Acid Rain staff.").

[159]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 10 (showing allowance price indexes of Fieldston Publications and Cantor Fitzgerald).

[160]. Carlton J. Bartels, *Turning Gas into Cash*, ENVTL. FIN. 32 (Nov. 1999); ELLERMAN ET AL., *supra* note 10, at 167 n.4.

[161]. Each year approximately 3% of allowances are withheld from units to be auctioned, and a limited reserve of allowances are guaranteed to be available at a price of $1500, to ensure the availability of at least a small number of allowances. 42 U.S.C. § 7651o (1994); *see also* ELLERMAN ET AL., *supra* note 10, at 169 n.5.

[162]. *See* Interviews with emissions brokers; *see also* Bartels, *supra* note 160.

b. Use of Trading

Allowance trading encouraged utilities to seek out "least-cost" compliance options among their plants in order to minimize the cost of compliance. Such strategies can be clearly seen in firms' decisions to install scrubbers on the largest plants, where the cost per ton of emission reductions would be the lowest; or to switch those plants closest to existing rail or water transportation to low-sulfur coal, thereby minimizing the cost of the transported coal.[163] The benefits of trading have the potential to be significant, as most studies have shown great variability in the cost per ton of emissions reductions at various plants.[164]

The extent of trading depends greatly on the definition of trading. As shown in Figure 2-8, over 30 million allowances were traded between discrete entities, but in contrast only 3.5 million allowances were used for compliance purposes by units to emit above their allowance allocation.[165] Almost all of this use was for averaging, or trading between units owned by the same firm, and only 708,372 allowances were used over all of Phase I to allow firms to exceed their allowance allocation in any one year.[166]

The use of the trading provisions at the unit level is shown by Figure 2-9, which compares actual emissions of the 372 units in the program all five years with their allowance allocations. The figure shows that a majority, or 244 units, emitted lower than their allocated level and banked allowances, while 128 units emitted over their allocated level and used excess allowances generated by other units for compliance.

See Figure 2-9: Difference Between SO_2 Emissions and Allowances, Phase I Units (1995-1999)[167]

c. Compliance Trading

Notwithstanding the greatly increased use of trading, firms' use of trading for compliance purposes was relatively unchanged throughout Phase I, and remained conservative. Firms made major use of only two potential compliance uses of trading, those of banking and intrafirm

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[163]. *See* Interviews with utility representatives; *see also* ELLERMAN ET AL., *supra* note 10, at 129-36.

[164]. GAO 1994 TRADING, *supra* note 54.

[165]. *See* Figure 2-5 (showing that only 3,541,045 allowances were used by units to emit over their allowance allocations).

[166]. *See infra* note 171.

[167]. Data derived from analysis of EPA COMPLIANCE REPORTS, 1995-1999.

averaging, and made less use of interfirm trading than may have been dictated by purely economic factors.

i. Banking

The most extensive use of the trading provisions in Title IV was inter-temporal trading or banking, described earlier. Banking, or saving allowances, accounted for almost 75%, or 10,518,211, of the 14,031,943 allowances created by the 244 units that emitted below their allowance allocations.[168]

ii. Averaging

Firms made considerable use of the opportunity to trade allowances between different units for the purpose of intra-firm averaging. Almost 60%, or thirty of the fifty-one firms, used averaging to achieve compliance over the five years of the program, and even more used averaging to allow a unit to emit over its allowance total for at least one year.[169] For instance, all of the forty-nine units owned by the Southern Company emitted below their allocations over the five year period, but a few required allowances to meet their compliance obligations in one or more years.[170]

iii. Inter-firm Trading for Compliance

Inter-firm trading of allowances for compliance purposes totaled only 708,372 allowances during Phase I, or less than 3% of total emissions.[171] Despite the growing level of trading, only one utility, Illinois Power, relied extensively on allowances to meet its compliance obligations in Phase I, emitting 44% over its allocation.[172] Only two

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[168]. *See* Figure 2-4.

[169]. *See* Figure 2-5 (showing ELI analysis of unit data in EPA 1999 COMPLIANCE REPORT, *supra* note 1).

[170]. *Id.*

[171]. The total use of allowances by firms to emit more than their allowances in any one year was: Illinois Power, 503,208; Tampa Electric, 60,138; Duquesne 14,237, and all others 130,789. *Id.* These 708,372 allowances used by firms to cover their allowance deficit during Phase I is 2.6% of Phase I's 26.5 million tons of total emissions. Data from ELI analysis of EPA COMPLIANCE REPORTS 1995-1999.

[172]. This situation occurred primarily due to political, and not economic, considerations concerning the 1900 MW Baldwin Plant, responsible for most of Illinois Power's emissions. The Baldwin plant burned local high-sulfur coal, with emissions over 5 lb/mmBtu. There was political opposition from coal miners and the legislature to closing these mines and allowing the plant to switch to low-sulfur coal. Illinois Power initially started to build a scrubber at Baldwin, although according to some sources this was simply to appease the local legislature and in-state coal miners. Ultimately, Illinois Power stopped building the scrubber, and instead used allowances for compliance throughout Phase I. *See* Interviews with government regulators and

other firms made net allowance purchases during Phase I: Tampa Electric emitted 14% over its allocation, and Duquesne Power emitted 4% over.[173] An additional twelve firms used inter-firm trading to emit more than their allowances in a given year, but in all cases only did so for one or two years, and emitted below their allocation for Phase I as a whole.[174]

In large part, the limited interutility trading reveals a bias towards autarkic behavior by firms in their environmental strategies. However, several specific problems discouraged such trading. The most important involved state public utility regulations, which typically required that gains or losses generated by trading be refunded to ratepayers as an element of fuel cost.[175] A second disincentive is the tax treatment of allowances. The Internal Revenue Service considers allowances to have a zero cost basis, since they are allocated for free.[176] This imposes a large tax on the first seller of an allowance, creating a significant disincentive. Discussions with several utilities showed that this was a serious constraint for some firms, but not for others that had offsetting tax credits or other special situations that avoided tax consequences.[177] Thirdly, public opposition to trading in the early years of the program led some utilities, such as TVA, to limit buying or selling allowances for compliance.[178]

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environmental groups. Illinois Power has now achieved a 90% reduction in SO_2 at Baldwin by shifting to low-sulfur coal at the advent of Phase II. ST. LOUIS POST-DISPATCH, Nov. 13, 1998.

[173]. The excess emissions were: Illinois Power, 503,208; Tampa Electric, 60,138; Duquesne 14,237. *See* Figure 2-5.

[174]. *See supra* note 171.

[175]. ELLERMAN ET AL., *supra* note 10, at 193 ("[A]cross all states issuing regulations, public utility commission regulations on allowance-trading activity largely require that 100% of both expense and revenues be returned to the ratepayers."). *See generally* Elizabeth M. Bailey, *Allowance Trading Activity and State Regulatory Rulings: Evidence from the U. S. Acid Rain Program*, *at* web.mit.edu/afs/Athena.mit.edu/org/c/ceepr/www/workingpapers.htm (Mar. 1998) (analyzing public utility trading in response to state regulation).

[176]. *See* Gary Hart, *Roadblocks to an Optimal Trading System*, ENVTL. FIN. 26, 26 (May 2000), *available at* http://www.emissions.org/publications/member_articles/index.html. "The potential tax policy consequences coupled with the direct refunding of the remaining proceeds to customers . . . . have led many utilities to hold, or bank, allowances for future compliance and not participate fully in the allowance market." *Id.*

[177]. *Id.*; *see also* Interviews with utility representatives. One practice of utilities was to make a six-month loan of allowances to brokers or other utilities to trade, which is tax-free. The allowances would be repaid by the broker with interest in an additional amount of allowances, such as 5%. *See* Hart, *supra* note 176, at 26. Although this was a way of making profits from allowances holdings, it has little relevance to compliance.

[178]. TVA's board of directors adopted a no-trading policy after negative publicity on its participation in one of the very first SO_2 allowance trades in 1992. *See* Matthew L. Wald, *Utility Is Selling the Right to Pollute*, N.Y. TIMES, May 12, 1992, at A1 (criticizing the firm's participation in the allowance trade).

d. New Paradigm of Trading and Arbitrage Trading

Trading of energy-related commodities such as power, fuels, and emissions has been at the center of the revolution in the power sector as many states have initiated deregulation to a market-based system for the generation and marketing of power.[179] In this new, competitive era, firms' use of trading has also evolved, with many firms commencing to trade for arbitrage or profit-making purposes as well as compliance.[180] The increased emphasis on marketing and trading in many firms has led to a major realignment in which the generation division within a firm may no longer dictate terms to the traders, but vice-versa.[181]

Arbitrage trading by some firms has become significant, with allowances regarded as an asset that can lead to profits through trading, especially if combined with fuel and energy trading.[182] This new attitude toward trading has been assisted by practices such as six-month tax-free loans of allowances between utilities and brokers that the broker uses for trading, and then repays to the utility with additional allowances as interest.[183] Such arbitrage trading is neutral in terms of the environment, and helps to explain the difference between the 30.8 million allowances traded between distinct entities in Phase I, and the only 3.5 million traded for actual compliance purposes.

The enormous importance of trading to some firms is reflected in the placement of emissions trading authority in the corporate structure. The allowance trading function was traditionally located in the company's environmental department, after which it was shifted in some firms to the fuel-purchasing department where allowances are bought and sold along with other commodities like coal. Today, many electricity-generating companies have established a division or separate corporate entity for trading energy-related commodities.[184] Some smaller firms with particularly active programs may generate as much gross revenue from such trading as they do selling electricity.[185]

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[179] *See Energy Survey*, THE ECONOMIST, Feb. 10, 2001, at 11.

[180] *See* Interviews with emissions brokers and utility representatives.

[181] *See* Vito Stagliano & Sarah Emerson, *Energy Trading: The Market's Response to Deregulation*, RESOURCES 127 (Spring 1997); *see also* Interviews with utility representatives.

[182] *See* Interviews with utility representatives.

[183] *Id.*; *see also* ELLERMAN ET AL., *supra* note 10, at 178 (discussing allowance swapping).

[184] *See* Interviews with utility representatives

[185] *See* Interviews with emission trading representatives of utility companies. Cinergy, a larger firm, reported revenues of $640 million from its trading subsidiary, about 11% of its total 1998 revenues. CINERGY CORP., 1998 FINANCIAL REPORT & 1999 PROXY STATEMENT C-20, C-26 (1999).

e. Trading Helped to Integrate Environmental and Economic Issues

A potentially profound influence of trading on compliance behavior is its effect in establishing a market price for a ton of reductions. This has allowed a greater integration of environmental and certain economic aspects of the industry and, some claim, allowed far greater integration of environmental considerations into overall business decision-making.[186]

The most evident example of this integration is that allowance prices are today fully integrated into the price of coal: the sulfur premium for coal tracks the allowance price, and coal suppliers now bundle allowances with their coal.[187] This integrates the environmental effects of coal into its price, and hence into all firm decisions about fuel cost and efficiency. It also creates an even cline in the sulfur premium that contributes to a competitive coal market. A second example is that allowance prices are regularly updated in the dispatch models that dictate which of a firm's plants will operate at any time.[188] Again, this fully integrates an environmental parameter into one of a firm's key ongoing economic decisions. Neither of these integrations would be possible under rate standards, and both show how cap-and-trade systems continue to exert dynamic effects on a continuing basis long after the effective date of the regulations.

Some argue further that creating a price for pollution causes a revolution in compliance behavior because it broadly moves consideration of pollution effects into mainstream company decisions.[189] By allowing companies to profit from trading allowances, they argue that firms begin to view environmental compliance as another arena for competition, lowering resistance to regulation by firms that perceive they may out-compete other firms in this arena. Achieving these positive effects is assisted if the company's accounts reflect the market value of

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[186]. *See* Interviews with emission trading representatives of utility companies and indepen-dent emissions brokers.

[187]. The allowance system allows coal suppliers to "bundle" allowances with their coal to meet emissions limits or utilities' demands. The opportunity to profit through arbitrage trading if coal prices are out of line with allowance prices ensures a relatively high degree of consistency between allowance prices and the sulfur premium. Coal suppliers have opened accounts in the EPA's Allowance Tracking System and trade allowances to bundle them with coal supplies. These practices tie in the price of coal with other compliance strategies, and so achieve economic efficiency and least-cost compliance. *See* ELLERMAN ET AL., *supra* note 10, at 255-57.

[188]. *See* Interviews with environmental compliance representatives of power generation firms. Many update allowance prices on a monthly basis.

[189]. The discussion in the following paragraphs is derived from confidential interviews with industry sources.

allowances, instead of carrying them at zero basis if they are allocated for free. Once the cost of allowances is reflected in the accounts, the pollution consequences of actions may affect all economic decisions made by a firm.

One regulatory factor that appears to be critical in achieving this integration is the ability to freely trade allowances with minimal transaction costs or delay. This creates a market price through a competitive and transparent trading market that is national in scope with no restrictions or limits on trades. Because of the cap-and-trade system, this can be done while maintaining very high environmental integrity.[190]

10. Phased Structure Caused Problems

Title IV created a two-phased structure that regulated only certain generating units in Phase I. However, because of the interconnected nature of the electricity grid, this created the potential for these units to transfer generation and therefore emissions to other units not included in Phase I.[191] Title IV's rules partially prevent this practice by requiring firms to utilize their Phase I plants at least to the level at which they were operated during the baseline period.[192] However, they did not prevent firms from meeting the increased demand for energy that occurred during Phase I by increasing the use of Phase II generating units proportionally more than Phase I units.

The MIT Center for Energy and Environmental Policy Research analyzed utilization levels in the years 1995-1997, and concluded that firms did indeed shift some utilization due to growth from Phase I to Phase II units, leading to greater SO_2 emissions over time.[193] These actions actually reduced Phase I emissions by a total of 427,590 tons, as

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[190]. The cap assures environmental quality, while the strict monitoring and penalty provisions assure the integrity of trading. The allowance method, unlike credit trades, also means that no government pre-approvals are needed that would slow trades and add significant transaction costs.

[191]. While Phase I achieved early reductions, it created a problem due to the interconnectedness of all electricity generating firms. Firms could potentially reduce emissions at Phase I units simply by generating more electricity at other units that would not be covered until Phase II. *See* BRIAN MCLEAN, EPA, PUB. NO. EPA 95-RA12004, LESSONS LEARNED IMPLEMENTING TITLE IV OF THE CLEAN AIR ACT 7 (1995). Further, as described *infra* in Part II.C.8, the substitution provisions also likely resulted in excess Phase I emissions.

[192]. *See* 42 U.S.C. § 7651g(c)(1) (1994); Clean Air Act, 40 C.F.R. § 72.2 (2000).

[193]. Susanne Schennach, *The Effect of Title IV on SO_2 Emission and Heat Input*, *in* MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM 323 (Ellerman et al. eds., 2000); ELLERMAN ET AL., *supra* note 90, at 50; E-mail from A. Denny Ellerman, Executive Director, MIT Center for Energy and Environmental Policy Research, to Byron Swift, Environmental Law Institute (Dec. 29, 1999) (on file with author) (calculating that 7% of heat input was transferred from Phase I unscrubbed units to Phase II units, and the emissions transferred to Phase II less the emissions reductions in Phase I).

the Phase II units were generally cleaner.[194] However, it allowed the Phase I units to bank an additional 1,159,995 allowances, potentially creating a net difference of 732,404 additional tons of emissions over time.[195] These problems indicate that phasing of power plants in a regulatory system is difficult at best, and if done again, more sophisticated rules need to be developed.

11. Environmental Effects or "Hot Spots" from Trading

Concern has been expressed that Title IV's allowance trading system could result in "hot spots," or areas of localized high pollution levels, by allowing heavily emitting units simply to buy allowances instead of reducing emissions.[196] The results of Phase I reveal that allowance trading had a relatively small effect in shifting emissions, with a slight tendency towards cooling hot spots, not creating them.[197] Since local pollutant levels depend primarily on the overall stringency of regulation, together with economic factors such as plant siting, size, and utilization, it appears that rate-based systems may allow greater hot spots than cap-and-trade systems.

Before examining the results of trading in Phase I, it is important to note that Title IV requires reductions in addition to the existing ambient standards for SO_2 that are designed to protect public health in the vicinity of a plant.[198] As noted before, many plants met these ambient standards through tall stacks and not emissions reduction, but these ambient standards still exist and serve as a check against SO_2 trading ever causing significant hot spots.[199]

Phase I data indicates there has been relatively little shifting of emissions due to trading. First, as shown in the figure below, emissions were fairly evenly below authorized allocations in virtually all states.

See Figure 2-10: SO_2 Allowances Allocated
and Emissions by State (1995-1999)[200]

A second indication of the lack of effect of trading in causing hot spots during Phase I is an EPA analysis of the origin of all allowances

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[194] *See supra* note 193.

[195] *Id.*

[196] Byron Swift, *Allowance Trading and SO_2 Hot Spots—Good News from the Acid Rain Program*, 31 ENV'T REP. 954 (May 12, 2000), *available at* http://www.epa.gov/airmarkets/articles/so2trading-hotspots_charts.pdf.

[197] *Id.*

[198] *See* 42 U.S.C. § 7651 (1994).

[199] *See supra* text accompanying notes 17-20.

[200] Data derived from analysis of EPA COMPLIANCE REPORTS, 1995-1999.

actually used at units to offset emissions in the years 1995-1998.[201] This study revealed that 81% of allowances actually used originated in the same state as the source, and that net inter-regional trading only constituted 3% of all allowances used.[202]

A third way to look at the effects of trading is to review the reductions made at individual plants during Phase I. The data confirms a general prediction made about cap-and-trade programs that they will tend to create incentives for the dirtiest plants to clean up the most, as the per-ton cost of emissions reductions should be lowest where the capital costs of control are spread over the largest number of tons. Figure 2-11 reveals that the largest emitters have reduced emissions the most, with the result of cooling hot spots rather than creating them.

See Figure 2-11: Allowances vs. Emissions of the
Twenty Largest Phase I Plants[203]

Overall, it appears that localized levels of pollution are determined overwhelmingly by economic factors, notably plant location, size, and utilization. To the extent that regulation has any effect on localized levels of pollution, it is the overall stringency of the regulation that matters, not whether it is achieved by a rate or cap-and-trade system.

III. REGULATORY PROGRAMS FOR NO_X

This Part discusses the standard for nitrogen oxides (NO_X) established under Title IV, with reference to other NO_X regulations applicable to sources in northeastern states and to new sources. Title IV's Phase I NO_X program has succeeded in many respects. Although litigation delayed the program one year, firms achieved 100% compliance with the standards in every year thereafter.[204] In other ways, however, the program failed to achieve noteworthy results. The standards were relatively weak, and exempted major groups of boilers

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[201] EPA, Clean Air Markets Div. (unpublished data, on file with author) (2000).

[202] Even the 3% of interregional trading showed little directionality, often consisting of transfers between neighboring states that happened to cross a regional boundary. *See* Swift, *supra* note 196, at 954-55, 957; U.S. GENERAL ACCOUNTING OFFICE, PUB. NO. GAO/RCED-00-47 ACID RAIN: EMISSIONS TRENDS AND EFFECTS IN THE EASTERN UNITED STATES (Mar. 2000), *available at* http://www.gao.gov/archive/2000/re00047.pdf [hereinafter GAO 2000 EFFECTS].

[203] Data derived from analysis of EPA COMPLIANCE REPORTS 1995-1999. Emissions and allowance totals were calculated by summing the emissions and allocations to Phase I affected units within each plant.

[204] EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 2; EPA, OTC NO_X BUDGET PROGRAM: 1999 COMPLIANCE REPORT 2 (2000), *available at* http://www.epa.gov/airmarkets/cmprpt/otc99/index.html (last updated Dec. 11, 2000) [hereinafter EPA 1999 OTC NO_X COMPLIANCE REPORT].

from coverage. As contemplated by Congress, the standards led firms to do little more than install retrofits of low-NO_X burners on most boilers, limiting innovation to one point in time and to methods that reduced the cost of making the retrofits.

Title IV established the first regulation of NO_X faced by many existing power plants. Most coal-fired power plants were built before the Clean Air Act of 1970, and so faced few restrictions on NO_X emissions, as Clean Air Act regulation focused on new sources.[205] Although states were authorized to regulate existing sources in areas that had not attained the national ambient standards, these tended to be large urban centers; since most coal plants were located outside such areas, few states imposed significant restrictions.[206] Major state-level regulatory activity on NO_X did not commence until the 1990s, when scientists began to emphasize the role of NO_X in the formation of urban ozone.[207]

During the period studied, incentives to firms to make added NO_X reductions came primarily from the Ozone Transport Commission (OTC) cap-and-trade program established in 1999,[208] and from new source NO_X standards that apply primarily to gas-fired turbines.[209] The OTC program led firms to use a variety of additional technologies to make further NO_X reductions, but innovation under the new source standards has focused primarily on end-of-pipe control technologies.[210] The regulatory system for NO_X therefore creates a fragmented set of rate standards that impose different limits and compliance burdens on

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[205]. *See* Figure 3-4 for data on age of plants. The 1970 Clean Air Act established federal performance standards for new or modified sources, initially establishing New Source Performance Standards, followed by the more complex New Source Review process in the 1977 Amendments. 42 U.S.C. §§ 7411, 7503 (1994). New Source Performance Standards for NO_X for boilers and turbines are found at 40 C.F.R § 61 (2000). In contrast, existing power plants were not subject to direct federal regulation until Title IV was passed in 1990.

[206]. Illinois, for example, only regulated larger existing plants in the Chicago or St. Louis (IL) major metropolitan areas, and imposed fairly lenient NO_x standards. These were 0.46 kg/MW/hr (0.3 lbs/mmBtu) for gas or liquid fossil fuels, and 1.39 kg/MW/hr (0.9 lbs/mmBtu) for coal. *See* Existing Emission Sources in Major Metropolitan Areas, ILL. ADMIN. CODE tit. 35, § 217.141 (2001). Many other states simply did not develop any standards for existing power plants. *See, e.g.*, 41 KY. ADMIN. REGS. 61 (1981). Compare with standards set for new electric utility steam generating units. 41 KY. ADMIN. REGS. 59:016 (1981). States in the Ozone Transport Region typically did not impose NO_X standards on existing plants until March 15, 1994. *See, e.g.*, N.Y. COMP. CODES R. & REGS., tit. 6 § 227-2 (2001). Earlier standards for stationary sources focused on particulates and opacity. *See id.* § 227-1.

[207]. *See generally* NAT'L RESEARCH COUNCIL, RETHINKING THE OZONE PROBLEM IN URBAN AND REGIONAL AIR POLLUTION (1991) (discussing national policy on the effect of NO_x in urban areas).

[208]. *See infra* Part III.E.1; 42 U.S.C. § 7511c (1994).

[209]. *See infra* Part III.E.2.

[210]. *See* Figure 4-2.

different technologies and far more lenient standards on old versus new sources. This is very unlike the SO_2 program in which all sources faced the uniform emissions cap and allowance-trading system.[211]

A. Background

Nitrogen oxide (NO_X) is a criteria pollutant regulated under the Clean Air Act,[212] and plays a major role in a variety of environmental problems, including acid precipitation, the formation of particulates and ozone dangerous to human health, and damage to plants and agricultural productivity.[213] Electricity-generating facilities emitted 6.1 million tons of NO_X in 1998, 25% of national emissions, with 88% of these emissions from coal-fired generation.[214]

The combustion process produces NO_X in two principal ways. Fuel NO_X is created through oxidization of nitrogen in the fuel, with combustion conditions determining the extent of NO_X formation. Thermal NO_X is created by the reaction of molecular nitrogen and oxygen in the combustion air, and increases with combustion temperature and oxygen content. Fuel NO_X can be controlled to a small degree by burning coal with lower nitrogen content, but thermal NO_X must be controlled by lowering flame temperature and creating oxygen-lean conditions in the combustion process to reduce NO_X formation.

Low-NO_X burners control fuel and air mixing to reduce peak flame temperatures, and are an economical way to limit the formation of NO_X in electricity-generating units.[215] Installing low-NO_X burners, however, is more difficult in some boiler types than others, and achieves different levels of emissions reductions in different boilers.[216] Because low-NO_X burners may increase unburned carbon levels, they typically lower boiler

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[211] *See infra* Part III.E.3.

[212] 42 U.S.C. § 7409(c) (1994).

[213] *See* EPA, PUB. NO. EPA-456/F-99-006R, TECHNICAL BULLETIN, NITROGEN OXIDES (NO_X), WHY AND HOW THEY ARE CONTROLLED (Nov. 1999), *available at* http://www.epa.gov/ttn/catc/dir1/fnoxdoc/pdf.

[214] EPA EMISSIONS TRENDS, *supra* note 8, at 2-2, 3-4. Vehicles contributed 53% of national emissions, while other fuel combustion contributed 17%. *Id.*

[215] Normally, "[r]etrofitting low-NO_X burners in wall-fired boilers . . . involves removing the existing burners and providing more space for the installation of the low-NO_X burners" together with modifications to the waterwall and windbox. "For small furnaces, installation of low-NO_X burners may cause flames to impinge on the opposite wall of the furnace," causing derating of the unit load and corrosion of the waterwalls. EIA, *Reducing Nitrogen Oxide Emissions: 1996 Compliance with Title IV Limits*, ELEC. POWER MONTHLY, at xv (May 1998), *available at* http://www.eia.doe.gov/cneaf/electricity/nox_emissions/contents.html.

[216] *Id.*

efficiency by a few percentage points.[217] In addition to these "combustion controls" that limit NO_X formation, NO_X emissions can be destroyed after formation by control technologies.

Our research found that utilities struggled with the alternatives available for reducing NO_X emissions. Most had limited experience with most of the later generation low-NO_X burner technology, and there were major concerns over detrimental impacts of low-NO_X burners on boiler tubes and overall efficiency. Control technologies like Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR) at the time were not well proven on a commercial scale nor for large coal-fired units. Also, deregulation was on the horizon and some companies were hesitant to invest capital with a lengthy recovery period. Changing to lower emitting fuels could possibly trigger New Source Review (NSR) requirements and could adversely affect unit efficiency, driving up production cost and making the unit less competitive. These uncertainties caused firms to delay and minimize expenditures to the extent possible while maintaining their obligation to serve load.[218]

B. Title IV NO_X Standard and Its Legislative History

Title IV was designed to cut NO_X emissions from utility boilers by 2 million tons from 1980 levels by the year 2000.[219] However, instead of using an emissions cap and allowance-trading system as with SO_2, Congress established annual average emission limits for coal-fired electric utility units based on the use of "low-NO_X burner technology."[220]

Phase I of the NO_X program lasted from 1996 through 1999, and applied to the 265 wall-fired and tangentially-fired boilers[221] included in the Acid Rain Program as Table A units, or substitution units active on January 1, 1995.[222] The legislation exempts other boiler types from

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[217] Low-NO_X burners may increase carbon monoxide and unburned carbon levels, contributing to imbalances in the distribution of air and fuel. Operating low-NO_X burners with systems that accurately regulate the fuel and air supplies can alleviate these problems. STATE AND TERRITORIAL AIR POLLUTION PROGRAM ADMINISTRATORS & ASSOCIATION OF LOCAL AIR POLLUTION OFFICIALS (STAPPA/ALAPCO), CONTROLLING NITROGEN OXIDES UNDER THE CLEAN AIR ACT: A MENU OF OPTIONS 18 (July 1994) [hereinafter STAPPA/ALAPCO 1994]; Acid Rain Program; Nitrogen Oxides Emission Reduction Program, 57 Fed. Reg. 55,632, 55,639 (Nov. 25, 1992).

[218] *See* Interviews with utility representatives.

[219] 42 U.S.C. § 7651(b) (1994).

[220] *Id.* § 7651f(b).

[221] Most boilers firing pulverized coal are wall-fired or tangentially fired. Wall-fired boilers produce discrete flames from burners mounted in the boiler wall, or in opposing walls. Tangentially-fired boilers have burners at the four corners of the furnace to create a single rotating fireball in the center. *See* STAPPA/ALAPCO 1994, *supra* note 217, at 14.

[222] 42 U.S.C. § 7651f(b) (1994).

Phase I because low-cost combustion controls such as low-NO_X burner technology were not known to be available for these boilers at the time of passage of the Act.[223] Phase II of the program started in 2000, and includes all other units affected by Title IV.[224] Since the units included in Phase I have already made their boiler modifications, they are permanently grandfathered at the lower Phase I standards and not the more stringent Phase II standards.[225]

Figure 3-1 shows the emissions limits applicable to different boiler types in Phase I and Phase II of the program. Phase I limits for wall-fired and tangentially-fired boilers were 0.50 and 0.45 lb/mmBtu, a significant reduction from their average uncontrolled emission level of 0.95 and 0.65 lb/mmBtu respectively.[226]

Figure 3-1. Title IV NO_X Standards by Boiler Type (lb/mmBtu)[227]

	Phase I		Phase II	
Boiler Type	*# of Units*	*Standard*	*# of Units*	*Standard*
Tangentially-fired	135	0.45	308	0.40
Dry bottom wall-fired	130	0.50	299	0.46
Cell burners			36	0.63
Cyclones (>155 MW)			55	0.86
Vertically fired			28	0.84
Wet-bottom (>65 MW)			26	0.84

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[223]. These units, known as Group 2 boilers, include cell, cyclone, and wet-bottom boilers. *Id.* § 7651f(b)(2).

[224]. Phase II includes both wall- and tangentially-fired (Group 1) boilers not covered in Phase I and other types of boilers (Group 2). Congress authorized the EPA to establish a lower limit for these remaining Group 1 boilers "if the Administrator determines that more effective Low-NO_X burner technology is available." The EPA made such a finding, and in 1996 established slightly lower limits for Group 1 boilers in Phase II. Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112, 67,113 (Dec. 19, 1996).

[225]. 42 U.S.C. § 7651f(b)(2) (1994).

[226]. EPA, PUB. NO. AP-42, COMPILATION OF AIR POLLUTANT EMISSION FACTORS (1995); *see also* ICF CONSULTING, INC., REGULATORY IMPACT ANALYSIS OF THE PROPOSED INTERVENTION LEVEL PROGRAM FOR SULFUR DIOXIDE: FINAL REPORT, PUB. NO. EPA-452/R-96-14 (1996) [hereinafter ICF RIA 1996].

[227]. *See* Clean Air Act, 40 C.F.R. §§ 76.5, 76.6 (2000); Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112, 67,112-18 (Dec. 19, 1996).

In contrast to the intense debate on sulfur standards, there is relatively little legislative history on the NO_X standard adopted in Title IV. The NO_X reductions were perceived to be an adjunct to SO_2 regulation, as the contribution of NO_X to acid deposition was confined mostly to western states, and NO_X controls were expected to cost far less than SO_2 controls.[228] Although the motives for regulating NO_X included its contribution to nutrient loading in sensitive waters and in ozone formation, at that time the role of NO_X in ozone formation was not perceived to be as important as it is today.[229]

The manner in which NO_X would be regulated shifted dramatically during the legislative process. As introduced, the NO_X provisions required affected units to meet an annual tonnage limit for NO_X and provided an allowance trading provision, similar to the SO_2 cap-and-trade program.[230] However, this was changed radically upon adoption of a substitute provision introduced by Senator Trent Lott of Mississippi that established emission rate standards for NO_X set in the traditional manner for each boiler type.[231] The final rate standard was based on what could be achieved using low-NO_X burner technology, with an explicit recognition by Congress that this would not lead to major costs.[232]

Subsequently, Congress added a number of flexibility provisions designed to reduce the costs to affected firms. First, the rate standard is an annual standard, which allows more flexibility in technology use than a daily or monthly standard.[233] Second, companies are allowed to average their units to meet the rate standard, an important tool that most companies would use.[234] Third, the law allows an individual unit to

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[228] S. REP. NO. 101-228, at 333 (1989).

[229] *See* Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase I; Final Rule, 59 Fed. Reg. 13,538 (Mar. 22, 1994); NAPAP INTEGRATED ASSESSMENT, *supra* note 3, at 2-4.

[230] S. 1630, 101st Cong. § 407 (1990).

[231] Senator Lott stated that under his amendment, "utilities will not be forced to install unreasonably expensive equipment" and NO_X emission limits will be based on "the application of low-NO_X burner technology, a much more reasonable and cost-effective method proven to successfully achieve significant NO_X reductions." 136 Cong. Rec. 5044 (1990).

[232] 42 U.S.C. § 7401(a)(4) (1990) (current version at 42 U.S.C. § 7401 (2000)); S. 1630 101st Cong. § 401(a)(4) (1990). Together with Senator Lott, Senator Lincoln Chafee asserted that the provisions that became section 407 would not force the installation of "unreasonably expensive equipment" and added that "reasonable and cost-effective methods have proven to be successful in achieving significant NO_X reductions." 136 Cong. Rec. 5044 (1990); *see also* MCLEAN, *supra* note 191, at 9. "It seems that through the legislative process, the goal shifted from a specific emissions reduction target to specific performance standards to a requirement to use 1 or more technologies. . . ." *Id.*

[233] *See* 42 U.S.C. § 7651f (1994).

[234] *See id.*

obtain an Alternate Emission Limit (AEL) if it could not meet the standard even after installing a low-NO_X burner.[235] A final flexibility provision created through the regulations was the Early Election Program that allowed Phase II units an exemption from Phase II standards until 2008 if they voluntarily met Phase I standards by 1997.[236] The end result was a rate standard with both flexibility and a waiver provision that ensured firms would not need to do more than install known, relatively inexpensive combustion controls on their units.

The limitations of this mandate became apparent when the Court of Appeals for the District of Columbia Circuit subsequently determined that the EPA's initial regulation, which would have required both low-NO_X burners and "overfire air" (a related combustion control), exceeded the agency's authority.[237] The court held that only low-NO_X burners were required.[238] In this sense, Title IV was almost as much a limitation on the EPA's power to regulate NO_X emitted by electricity-generating units as it was an authorization.

C. *Results of Title IV*

1. Initial Litigation and Delay

The initial result of the Title IV NO_X standard was controversy over the meaning of low-NO_X boiler technology. After much debate, the EPA promulgated regulations establishing NO_X emission limits for Phase I units to begin in 1995, based on the combined effect of low-NO_X burner and overfire air technology.[239] However, industry sued and the United States Court of Appeals for the D.C. Circuit vacated the rule, holding that low-NO_X burners do not incorporate the combination of low-NO_X burners and overfire air.[240] Consequently, the EPA reissued a revised final rule in April of 1995 that eliminated the incorporation of overfire air, and delayed the effective date of Phase I by one year to 1996.[241]

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[235] *Id.* § 7651f(d).

[236] Clean Air Act, 40 C.F.R. § 76.8 (2000).

[237] Al. Power Co. v. EPA, 40 F.3d 450, 456 (D.C. Cir. 1994).

[238] *Id.*

[239] Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase I; Final Rule, 59 Fed. Reg. 13,538, 13,540 (Mar. 22, 1994).

[240] *Al. Power*, 40 F.3d at 451 (vacating Phase I NO_X final rule).

[241] Acid Rain Program; Nitrogen Oxides Emission Reduction Program: Direct Final Rule, 60 Fed. Reg. 18,751, 18753, 18757 (Apr. 13, 1995).

2. Implementation

Following the lawsuit, implementation of the NO_X program was relatively straightforward, and all 265 coal-fired units affected under Phase I met the legal requirements in each year.[242] Most, or 175 units, met the emissions rate limits as expected through the installation of low-NO_X burners.[243]

The rate and tonnage reductions resulting from Phase I are shown graphically in Figures 3-2 and 3-3. Overall, units lowered their average NO_X emissions rates to 0.40 lb/mmBtu during Phase I, 43% below the 1990 average of 0.70 lb/mmBtu.[244] This reduced NO_X emissions by approximately 400,000 tons per year, or 32% below 1990 levels, with overall reductions projected to rise to 2,060,000 tons per year during Phase II, which started in 2000.[245] There is less reduction in total tons than in rates because economic growth led to higher utilization of generating units. Unlike the SO_2 program, in which emissions are capped, the rate-based NO_X program will allow NO_X emissions to rise with increased utilization.[246]

See Figure 3-2. NO_X Rate Reductions During Phase I[247]

See Figure 3-3. NO_X Tonnage Reductions During Phase I[248]

Most of the 265 Phase I units achieved compliance in a straightforward manner, by retrofitting low-NO_X burners. Overall, 175 units (66%) installed low-NO_X burner technologies for compliance, with most (114) of these units coupling the low-NO_X burners with overfire

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[242] EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 2.

[243] Data derived from ELI analysis of EPA, ACID RAIN PROGRAM: 1998 EMISSIONS SCORECARD (1999), *available at* http://www.epa.gov/airmarkets/emissions/score98 (last updated Dec. 11, 2000) [hereinafter EPA 1998 EMISSIONS SCORECARD]. This 1998 EMISSIONS SCORECARD was used because the 1999 EMISSIONS SCORECARD, *supra* note 1, was found to contain errors, notably in recording that 28 Phase I units had switched from low-NO_X burners to an uncontrolled state, which upon investigation by ELI turned out to be inaccurate.

[244] EPA 1999 COMPLIANCE REPORT, *supra* note 1, app. C-2. The range of emissions rates for the affected boilers also has been reduced, from 1990 baseline emissions ranging from 0.26 to 1.41 lb/mmBtu to a range from 0.13 to 0.81 lb/mmBtu in 1999.

[245] EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 12. These 2 million tons are a reduction in what would have been emitted without regulation, as the rate-based standard allowed overall emissions to grow with economic growth and increased utilization. *See id.* at 2.

[246] EPA, ACID RAIN PROGRAM: 1998 COMPLIANCE REPORT 13-15 (1999), *available at* http://www.epa.gov/airmarkets/cmprpt/arp98 (last updated Dec. 11, 2000). Note the slight reduction in emissions observed from 1998 to 1999 was caused in part by the initiation of the cap-and-trade NO_X budget program for sources in northeastern states. *See infra* Part III.E.1.

[247] EPA 1999 COMPLIANCE REPORT, *supra* note 1, exh. 9, at 14.

[248] *Id.* exh. 10, at 15.

air.[249] Many firms also used the ability to average emissions among their plants, creating twenty-two averaging plans covering 204 of the 265 units in Phase I.[250] This allowed fifty-two uncontrolled units to continue to emit above the limit, and comply by averaging; of the remaining units, twenty-three already met the Phase I limits, seven were not operating, and eight used other compliance technologies, principally independent overfire air.[251] Figure 3-4 shows the use of compliance technologies according to the decade in which the plant was built.

See Figure 3-4. Phase I NO_X Control Technologies by Age of Plant[252]

Overall, flexibility provisions in the law, including the annual rate standard and the ability to average emissions among a firm's units, allowed relatively economical compliance. Only ten received interim Alternate Emissions Limits from the EPA when they could not meet their rate limits even after installing low-NO_X burners.[253] Overall, the EPA estimated that the cost of the Phase I NO_X reduction program to the electric power industry was $267 million per year.[254] Analysis of the cost of the burner retrofits in Phase I reveal an average per-ton reduction cost of $412, with an average capital cost of $19.75/kW in 1990 dollars.[255] The two types of boilers represented in Phase I, however, experienced markedly differing costs. Wall-fired boilers achieved reduction at $161/ton, whereas tangentially-fired boilers cost $631/ton.[256]

D. Business Behavior and Title IV

The following Subparts discuss business responses to Title IV's NO_X program and relate findings to Title IV's regulatory structure. Subsequent sections discuss other NO_X regulations affecting electricity generators in the 1990s. Finally, Part IV compares the results of the regulatory programs for NO_X with those for SO_2.

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[249]. EPA 1998 EMISSIONS SCORECARD, *supra* note 243.

[250]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, exh. 8, at 13, app. C-1.

[251]. *See* EPA 1998 EMISSIONS SCORECARD, *supra* note 243.

[252]. Data derived from analysis of EPA report. *Id.* tbl. B1.

[253]. *See id.*

[254]. EIA, *supra* note 215, at 4.

[255]. Acid Rain Program; Nitrogen Oxides Emission Reduction Program, 61 Fed. Reg. 67,112, 67142-43 (Dec. 19, 1996).

[256]. *Id.* at 67,141-42. Of the boilers assessed, wall-fired boiler retrofits averaged $161 per ton of NO_X reductions, with a high of $382 and a low of $37, whereas tangentially-fired boilers achieved average costs of $631 with a high of $2625 and a low of $312. The unweighted average of all boilers is $282, but a weighted average is $412. *Id.*; *see also* EIA, *supra* note 215, at 10 (noting that capital cost for twenty-one wall-fired plants varied between $9 and $44 per kilowatt).

1. Rate Standards Led to One-Time Compliance Using the Expected Technology

As can be seen from Figure 3-4, the principal effect of the Title IV rate standards was the one-time retrofit of a known compliance technology. Although these standards significantly reduced NO_X emissions from baseline levels, thereafter firms made little effort or progress in reducing NO_X. This reveals one of the intransigent problems with rate-based limits, as they do not encourage continuous efforts by firms to reduce emissions, or provide incentives to go beyond the standard.

2. In Making Pollutant Reductions, Firms Sought First to Optimize Their Process Efficiency, as Regulations Were Sufficiently Flexible to Create Benefits Through Doing So

The initial response of plant operators subject to the Phase I NO_X program was to optimize boilers by addressing such parameters as air/fuel mixtures and temperatures to assure the lowest possible NO_X emissions prior to investing in additional control technology.[257] Optimization can increase efficiency, and so reduce not only NO_X but all other pollutants emitted by the plant as well. Since most units had not been subject to NO_X requirements before,[258] the results of optimization were generally positive. Plant operators report that the optimization process achieved NO_X reductions of several percent, although some reported gains of 10% to 20%.[259] Vendors of the services and software products involved in optimization claim greater reductions of up to 30%, especially in plants that were previously poorly maintained.[260]

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[257]. Note the difference between optimization, or fine-tuning boiler process to achieve maximum efficiency, and compliance options that involve purely operational modifications. While the latter may not involve any additional NO_X controls, they represent compliance alternatives that reduce NO_X further but involve costs or a loss of efficiency. As the OTC cap-and-trade program shows, many firms discovered low-cost reductions through operational modifications when subject to a broad and flexible regulatory standard that made them "look everywhere" for reductions, but this differs from optimization.

[258]. The exceptions were plants built after 1971, and thus already subject to new source standards under the Clean Air Act. *See* 42 U.S.C. § 7411 (1994); *see also supra* Part III.A.

[259]. *See* Interviews with utility representatives; *see also* ELEC. POWER RESEARCH INST., EPRI PLANT MAINTENANCE OPTIMIZATION SERVICES, Document SO-113427 (July 1999) [hereinafter EPRI PLANT MAINTENANCE]; Elec. Power Research Inst., *Overhauling the Plant Maintenance Process*, EPRI FOSSIL PLANT NEWS (Winter, 1999).

[260]. The optimization process has been greatly assisted by the development of new optimization software programs that monitor and develop correlations between parameters, allowing operators to better understand the combustion process and adjust the parameters to yield optimal results (i.e., low levels of NO_X and carbon monoxide, together with best efficiency). The developers of one such program, Boiler Op, report NO_x reductions averaging between 20% and 30% at a dozen units implementing their system, with minimum deterioration of heat rate and

The availability of flexibility mechanisms in Title IV, such as averaging and the Early Election Program, prompted widespread use of optimization in the Phase I NO_X program. Regulatory design strongly affects the use of optimization, as less flexible rate standards may create few incentives for optimization. For example, a percentage rate reduction standard, like the 1977 SO_2 New Source Performance Standard, creates no incentives for efficiency or optimization because it only measures reductions achieved within the stack. Concentration rate standards provide incentives to optimize only to those units that previously exceeded the rate limit by a small amount. All others must install control technology. However, more flexible regulatory systems, such as those that allow averaging or trading, make optimization important for most or all affected units, and thereby promote efficiency as well as lower-cost compliance.

3. Firms Heavily Used Flexibility Mechanisms with Low Transaction Costs, Such as Averaging

Firms heavily used the two flexibility provisions in the law that provided significant economic benefits with relatively simple procedures. One was the averaging provision, which allowed firms to average the emissions rates of various units under their control.[261] The second was the Early Election Program, which allowed firms to include Phase II units in Phase I, giving them a seven-year grace period from more stringent Phase II limits.[262] Both had low transaction costs because they could be implemented through a simple designation by a firm.[263] In contrast to these, the AEL exemption process was complex and could be used only if a unit could not reach the standard even after installing a low-NO_X burner; it was used for only ten units.[264]

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other operating parameters. Carlos Romero et al., *Field Results from Application of Boiler Op to Utility Boilers*, Presentation at EPRI-DOE-EPA Mega Symposium (August 1999) (notes on file with author). Another program uses a sequential optimization process that maintains boiler performance while achieving reduction in NO_X. Using this program, without any other add-on reduction equipment, reductions in NO_X of between 5% and 20% from historical levels were achieved at one unit. Another similar program, GNOCIS, an EPRI collaborative project, monitored twenty-five to fifty parameters and achieved about a 10% reduction in NO_X. *See* EPRI PLANT MAINTENANCE, *supra* note 259; Elec. Power Research Inst., *supra* note 259.

[261]. 42 U.S.C. § 7651f(e) (1994).

[262]. Clean Air Act, 40 C.F.R. § 76.8.

[263]. *Id.* §§ 76.8, 76.11.

[264]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 12.

a. Averaging and Uncontrolled Units

The Clean Air Act allowed utilities to comply with applicable rate standards by averaging the heat-input-weighted annual emissions rate of two or more units to meet the applicable rate standard.[265] This allowed large firms with many units to shift the burden of compliance between units, providing flexibility almost equivalent to that of trading.

Averaging was a widely used compliance strategy, and twenty-two firms included 204, or 80%, of the 265 affected units in averaging plans in a typical year.[266] Averaging plans allowed larger firms to avoid installing low-NO_X burner technology in some units, and helped to lower compliance costs while maintaining the overall emissions reduction goal. As evident in Figure 3-4, it also allowed a shift in investment to newer facilities, as units built before 1954 were more likely to be uncontrolled than controlled. Interviews addressed the question whether the averaging provision may have allowed firms to extend the life of older facilities, but respondents generally reported using averaging as a flexibility provision, to save on costs they would have otherwise incurred in installing low-NO_X burners in these plants.[267]

Despite allowing greater flexibility, most averaging plans surprisingly resulted in a significant level of over-compliance, with the average emissions rates 10% or more below the applicable limits.[268] The results also show that some firms were overly cautious in creating averaging plans, as nine plans, including thirty-seven units, actually did not need to average at all since all units met the standard.[269] However, even for these units, inclusion in an averaging plan may have provided firms with greater operational security during the year, providing compliance assurance even if one unit were to fail to meet its rate limit.

Averaging allowed fifty-two units, typically older ones, to remain uncontrolled despite exceeding the emissions standard.[270] With average emissions of 0.61 lb/mmBtu, still above the statutory limits, these units

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[265]. 42 U.S.C. § 7651f(e).

[266]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, exh. 8, at 13, app. C-1. The list of units included in averaging plans shows that most (seventeen plans or 77%) involved units in only a single state.

[267]. TVA, for example, averaged six units of its Johnston plant that marginally exceeded their limit, avoiding a major capital outlay for a small NO_X reduction. EPA 1999 COMPLIANCE REPORT, *supra* note 1, app. C-1, C-4.

[268]. *Id.* app. C-1.

[269]. *See* EPA 1999 COMPLIANCE REPORT, *supra* note 1.

[270]. Fifty-two plants are listed as uncontrolled in EPA 1998 EMISSIONS SCORECARD, *supra* note 243.

can remain uncontrolled due to the flexibility afforded by averaging.[271] Although they remain uncontrolled, the averaging provisions still create an incentive for reductions, such as through optimization, as any emissions reduction helps the overall average. Therefore, these units have reduced their emissions rate from 0.67 lb/mmBtu in 1990, and the rates of the highest emitters have been reduced from 1.41 lb/mmBtu in 1990 to 0.81 lb/mmBtu in 1999. An additional twenty-three units, mostly substitution units, are relatively clean plants that are uncontrolled because they meet the required emissions limits anyway, totaling seventy-two uncontrolled units in all. Because of averaging incentives, even these plants reduced their emissions, from an average of from 0.45 lb/mmBtu in 1990 to 0.35 lb/mmBtu in 1999.[272]

b. Early Election Units

Another widely used flexibility provision designed to promote early NO_X reductions was the Early Election compliance option created by the EPA.[273] Under this regulatory program, wall- or tangentially fired boilers that would normally not be regulated until Phase II could elect to comply with Phase I emissions limits starting in 1997, and would not be required to meet the more stringent Phase II limits until 2008.[274]

Two hundred seventy-four units in thirty-six states participated in the EPA's Early Election Program for NO_X, almost half of the 614 eligible units.[275] These participating units reduced their NO_X emissions rates by 20%, from an average of 0.46 lb/mmBtu in 1990 to 0.37 lb/mmBtu in 1999.[276] The Early Election Program resulted in environmental results by achieving net emissions reductions of 435,790 tons, or the difference between additional reductions of 557,491 tons

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[271]. In this paragraph, emissions rate figures are derived from ELI analysis of unit emissions data of these fifty-two units using EPA 1999 EMISSIONS SCORECARD, *supra* note 1.

[272]. *Id.* app. C-2.

[273]. Clean Air Act, 40 C.F.R. § 76.8 (2000).

[274]. There was vigorous debate between the EPA, environmentalists, and industry as to the appropriate number of years of exemption from Phase II limits. The goal was to provide early election units so there would be an incentive for firms to join, but also guarantee net environmental benefits. The final result was a seven year exemption. *See id.* If a utility failed to meet this annual limit for a boiler during any year, the unit was subject to the more stringent Phase II limit for Group 1 boilers beginning in 2000, or the year following the exceedance, whichever was later. *Id.*

[275]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 16.

[276]. *Id.* 1990 emission rates for these units ranged from 0.17 to 1.15 lb/mmBtu. Ten units in the Early Election Program were not operating in 1990: Cliffside 1, 2, 3, and 4; Riverbend 9 and 10; W.H. Zimmer 1; Cross 1; J.K. Spruce 1; and Glen Lyn 52. Reductions for these units were calculated by ELI from their 1995 emissions rates.

achieved in 1997-1999,[277] and the expected higher emissions of 121,701 tons during the period 2000-2007.[278] Another environmental benefit was the added value in achieving earlier reductions, which helped ecosystem recovery.

Firms also benefited economically from the Early Election Program because it allowed operators to use less expensive compliance methods at certain units that could meet Phase I standards at low cost, and to avoid more costly investments, such as burner retrofits, that would be needed to meet the more stringent Phase II limits. Typical Early Election units had emissions rates slightly above the Phase I standard, and could meet that standard through optimization or other compliance methods that were low in cost, but could only achieve limited reductions.[279]

Another business benefit of the program was that it provided greater regulatory certainty over a longer planning horizon for firms. Indeed, many units appeared to have been entered into the early election program as a precaution, as one-third, or ninety, of the early election units were already below Phase II limits in 1990, and two-thirds, or 201, below them in 1999.[280]

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[277]. The net benefits total is given for 118 units using unit data presented in EPA COMPLIANCE REPORTS from 1997-1999. The calculations do not include any reductions made by units that were already operating at or below Phase I limits in 1990, nor by the thirty-three units located in OTC states that had to comply with lower limits under state law. Early election units in OTC states were located in Connecticut (one), New York (nine), Pennsylvania (seventeen), and northern Virginia (six), and were required to meet OTC RACT requirements at least as stringent as those of Title IV by 1995. It was also assumed that emissions rates of units emitting at or below Phase I limits in 1990 reflect either unit design or changes made to the unit prior to the development of the Early Election Program, and so would not have risen above Phase I limits during Phase I.

[278]. Detriments were calculated for seventy-two units using unit data presented in EPA COMPLIANCE REPORTS from 1997-1999. The calculations exclude the OTC units and all those whose average 1997-1999 emissions were at or below Phase II levels. The added emissions from these seventy-two units in 2000-2007 is the difference between the actual emissions rate achieved during Phase I and the more stringent Phase II emissions rate, multiplied by seven years. However, if it is assumed that these plants would have emitted at a rate 10% below Phase II levels as a typical margin of safety, detriments increase to 483,783 tons, creating net benefits of only 73,708 tons from the program.

[279]. EPA 1999 COMPLIANCE REPORT, *supra* note 1. Low-cost compliance methods include low excess air and burners out of service, which can achieve only 10% to 20% NO_X reduction but cost very little. STAPPA/ALAPCO 1994, *supra* note 217, at 16-17. Some operators interviewed report they had never optimized their boilers until Title IV provided the incentive through the Early Election Program.

[280]. Analysis derived from EPA 1999 COMPLIANCE REPORT, *supra* note 1, app. C-2. The lateness of the promulgation of Phase II rules may have been a factor that led some firms to designate units that already met the Phase II standard. Although firms had until January 1, 1997, to identify the units they would enter into the Early Election Program, most firms practically had to do so before the Phase II rules were finalized on December 19, 1996. *See* Clean Air Act, 40 C.F.R. § 76.8 (2000) (Early election for Group 1, Phase II boilers); Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112 (Dec. 19, 1996).

c. Alternative Emissions Limits (AELs)

In contrast to the simple procedures for averaging and early election units, a third flexibility option, Alternative Emissions Limits (AELs), required high transaction costs and was little used. In order to qualify for an AEL, firms had to compile a detailed justification demonstrating that they attempted to install a low-NO_X burner in a unit and that it still failed to meet the emissions rate limit.[281] Firms filed for AELs for ten units in Phase I. These requests have only been approved on an interim status by the EPA, and are still involved in administrative proceedings four years after the start of the program.[282]

4. Businesses Faced with Rate Standards Can Be Expected to Over-Comply by 10%

One of the evident characteristics of firm behavior was over-compliance with the NO_X standards. For Table A units, average emissions were 0.435 lb/mmBtu during the four years of the program, 11% below the average limitation of 0.49 lb/mmBtu.[283] Substitution unit emissions were even lower, averaging 0.37 lb/mmBtu, partly because many of the substitution units were newer and were therefore already lower NO_X emitters.[284]

This over-control represents several factors. Most firm representatives indicated that 10% over-compliance represents a reasonable operating margin to ensure that a particular limit is not exceeded.[285] Since exceeding the limit would bring about a $2000 per ton fine and potential criminal penalties,[286] firms tend to design compliance technology that would slightly surpass the limit in case the technology does not perform quite as well as predicted, and operate the equipment to

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[281] *See* Clean Air Act, 40 C.F.R. § 76.10 (2000). The firm must show that it installed a low-NO_X burner or equivalent at the unit that was designed to meet, but then could not meet, the applicable emissions limitation, and provide operating data showing it was properly installed and operated in accordance with the design specifications.

[282] *See* Interview with Brian McLean, Director of EPA Clean Air Markets Division, in Washington, D.C. (July 18, 2000).

[283] EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 14. Emissions rates of Table A units gradually moved lower during Phase I, from 0.45 lb/mmBtu in 1996, 9% below the average emissions limit, to 0.42 lb/mmBtu in 1999, 14% below the average limit. *Id.*

[284] *Id.* Many substitution units had already met New Source Performance Standards that are only moderately higher than the Phase I limits. As a group, the substitution units collectively emitted only 0.52 lb/mmBtu NO_X in 1990, well below the 0.77 lb/mmBtu emitted by Table A units. *Id.*

[285] *See* Interviews with utility representatives.

[286] Title IV provides for an excess emissions penalty of $2000 for each ton emitted in excess of a unit's emissions limitations requirement. 42 U.S.C. § 7651j(a) (1994). The Act also provides civil and potential criminal penalties for each violation. *Id.* § 7413.

slightly over-comply in case a malfunction reduces its efficiency towards the year's end.[287]

However, over-compliance is also the result of expected business behavior in the face of regulatory uncertainty, which was exacerbated in this case by the delay in promulgating proposed regulations, the subsequent lawsuit, and revisions to the standard.[288] The effects of uncertainty are pronounced in the case of NO_X combustion controls, as every low-NO_X burner must be designed for a specific boiler, and eighteen to twenty-four months are needed to design and install the burners.[289] Therefore, during the early stages of the planning process, when the NO_X rules were not final, some firms opted to install overfire air technology (OFA) as called for by the initial regulation, achieving slightly higher levels of emissions reductions.[290]

5. Innovation under Title IV's Moderate Rate Standards Was Limited in Scope and Extent

A retrospective view reveals that the Title IV NO_X standards had only limited effects in leading firms to develop new solutions. The sections below describe technical innovation for the three main boiler types and for overfire air. This assessment also reveals that the Title IV rate standards led firms to identify better or cheaper ways of compliance only at the time the standard took effect, and did not drive continuous improvement.

a. Wall-Fired Boilers

Innovation significantly reduced the costs of compliance for wall-fired boilers. The initial assumption was that Title IV would require firms to replace existing burners with low-NO_X burners, which was the basis of the EPA's cost estimates in its regulatory analysis.[291] However, manufacturers and users of wall-fired boilers found that if the burners were in good condition and of sufficient capacity, removing a line of burners near but not at the top of the boiler would distribute air in a way

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[287]. *See* Interviews with utility representatives.

[288]. *See supra* Part III.C.

[289]. *See* Interviews with utility representatives.

[290]. There are also business reasons to install OFA simultaneously with low-NO_X burners during the same unit outage, to preclude having to take the unit off-line for another extended period of time for installation of the OFA system alone. Simultaneous installation would yield revenue savings and could avoid system reliability problems for the purchaser of the power. *See* Interviews with utility representatives.

[291]. *See* 1992 Acid Rain Program: Nitrogen Oxides Emission Reduction Program; Proposed Rule, 57 Fed. Reg. 55,632 (Nov. 25, 1992).

that replicates a new low-NO_X burner. This innovation reduced cost to a small fraction of the cost of installing a new burner, with capital costs on the order of only 25% to 50% of the cost of low-NO_X burners for comparable NO_X control.[292] Some vendors report even lower numbers for some units, with capital cost about $1 per kilowatt, compared to the $10 to $20 per kW cost of a new low NO_X burner.[293]

b. Tangentially Fired Boilers

Low-NO_X burner technology for tangentially-fired boilers differs from that for wall-fired boilers, with overfire air playing a more integrated role.[294] Retrofit applications of low-NO_X burners significantly reduce NO_X emissions from tangentially-fired boilers, with reductions in emissions between 10% and 48% in one study, and controlled levels ranging from 0.34 to 0.55 lb/mmBtu.[295] However, contrary to the findings for wall-fired and cyclone boilers, no significant innovation reduced the costs for low-NO_X burner retrofits for tangentially-fired boilers. The cost of reductions averaged $631 per ton, and capital costs ranged from $6 to $42 per kilowatt.[296]

c. Cyclone Boilers

Although cyclone boilers were not included in Phase I, the reasons for this exclusion and the circumstances of their inclusion in Phase II present a good example of business behavior and innovation when

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[292]. Research by General Electric Energy and Environmental Research Corporation and others have found that

> rather than completely replacing a burner, it may be possible to modify a conventional circular burner to effectively control fuel air mixing . . . . [S]ince the hardware changes are simple, the retrofit costs for Low-NO_X Burner Modifications are much lower than for new Low-NO_X Burners. Usually there is no need to change flame scanning and ignition equipment, electric actuator drives or registers, and no need to modify coal conduits or the windbox. As a result the capital cost is typically on the order of only 25% to 50% of the cost of Low-NO_X Burners

for comparable NO_X control. Todd Melick & Roy Payne, *Low NO_x Burner Modifications for Cost Effective NO_x Control*, Presentation at EPRI-EPA-DOE Combined Utility Air Pollutant Control Symposium (Aug. 1999) (notes on file with author).

[293]. Interviews with technology vendors.

[294]. A commonly applied low-NO_X burner technology in United States coal-fired boilers, the low-NO_X concentric firing system is specifically designed for tangentially-fired boilers. These require the replacement of all fuel and air nozzles; however, no major changes in the structure, windbox, or waterwall are needed. Most of these systems include overfire air. EIA, REDUCING NITROGEN OXIDE EMISSIONS: 1996 COMPLIANCE WITH TITLE IV LIMITS (1998), *at* http://www.eia.doe.gov/cneaf/electricity/nox_emissions/ (last modified Dec. 14, 2000).

[295]. *See* Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112, 67,142 (Dec. 19, 1996).

[296]. *Id.*; *see also* EIA, *supra* note 215, tbl. 3, at 10.

confronted with rate standards. Cyclone burners are quite different from wall- and tangentially-fired boilers, firing chunk rather than pulverized coal. Because no low-NO_X burner technology was known to be applicable to cyclone boilers in 1990, they were exempted from regulation under Phase I.[297] The law did provide, however, that if technology "comparable to the costs" of low-NO_X burner technology became available, the EPA could issue standards for cyclones and other boilers for Phase II starting in the year 2000.[298]

The industry made few efforts to identify NO_X reduction methods for cyclones until 1995, when the EPA indicated it would regulate them in Phase II because the cost of downstream technologies such as reburn and SCR had become "comparable" to the cost of low-NO_X burners.[299] The EPA promulgated regulations in 1996 permitting relatively high emissions (0.86 lb/mmBtu), and exempting cyclones less than 155 MW altogether, based on the cost-effectiveness of these technologies.[300]

The industry then formed the Cyclone NO_X Control Interest Group (CNCIG) under the auspices of the Electric Power Research Institute (EPRI) in 1995 to commence research and development.[301] This group achieved spectacular results, and by 1997 demonstrated that applying overfire air technology to cyclones could achieve significant NO_X reductions, on the order of 50%, at very low cost.[302] This result was

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[297]. 42 U.S.C. § 7651f (1994).

[298]. *Id.* § 7651f(b)(2).

[299]. Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112, 67,114 (Dec. 19, 1996). "For cyclone fired boilers, gas reburning and SCR are the best continuous control systems that are available and meet the cost comparability criteria." *Id.*

[300]. *Id.* at 67,142-43.

[301]. Elec. Power Research Inst., *First Demonstration of Overfire Air on Cyclone Steam Generator Reduces Costs of NOx Compliance*, EPRI INNOVATORS 1 (Oct. 1998) (on file with author) [hereinafter EPRI, *First Demonstration*]; E-mail from David O'Connor, Electric Power Research Institute, to Byron Swift, Environmental Law Institute (Nov. 29, 1999) (on file with author).

[302]. The first models were completed in early 1996, and the first successful demonstration of overfire air technology began in 1997. *See* E-mail from David O'Connor, *supra* note 301; David O'Connor et al., *The State of the Art in Cyclone Boiler NO_x Reduction*, Presentation at EPRI-EPA-DOE Combined Utility Air Pollutant Control Sympos. (Elec. Power Research Inst.) (Aug. 1999) (notes on file with author); EPRI, *First Demonstration*, *supra* note 301.

> The results have clearly demonstrated the technical and operational feasibility of OFA as a commercially viable NO_X control approach for cyclones. The application of the technology on 5 cyclone furnaces . . . showed maximum NO_X reductions reaching 50- to 75% from uncontrolled levels using combustion air staging techniques. Preliminary observations and tests . . ., showed no substantial impacts from slagging, fouling, or corrosion of waterwall tubes when fueled by western coal.

Elec. Power Research Inst., Report No. TR-113643, *NO_x Control Field Test Results on Coal-Fired Cyclone Boilers—CNCIG Programs* (Sept. 1999) (on file with author). These articles unanticipated, as the attempts made in the 1980s to use overfire air were failures, and had led to unacceptable wall wastage or carbon loss. The R&D investment in CNCIG was relatively modest, less than $2 million, including full scale demonstrations, and the payback saved the industry a minimum of $250 million in the cost of retrofitting cyclone boilers to meet Title IV requirements.[303] Once this group achieved its objective in meeting the Title IV rate limits, however, the research effort was scaled back.[304]

Although this technology innovation is now available, it is underused because the regulations do not require reductions beyond the rate limit even if they are inexpensive, and they also exempt cyclone units under 155 MW, which may continue to emit NO_X at uncontrolled levels over 1.5 lb/mmBtu, higher than that of any other boiler type.[305] This example illustrates the problems with rate standards when government regulators fail to accurately predict technology innovation, as well as the sporadic nature of technology research they motivate.

d. Overfire Air

Overfire air technology can be combined with low-NO_X burners to divert about 20% of combustion air at the burner level to air ports above the burner zone, reducing the oxygen availability at the burners.[306] However, although overfire air decreases NO_X formation during combustion, it can inadvertently promote waterwall wastage by creating reducing conditions within the burner zone. Wastage has appeared mostly in high-temperature supercritical boilers, and in some cases was severe enough to instigate tube failures and forced outages.[307] These

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indicate that many cyclones could achieve the 0.86 lb/mmBtu standard using overfire air, especially those firing PRB coal, with baseline emissions of 1.1 to 1.2 lb/mmBtu.

[303]. *See* E-mail from David O'Connor, Electric Power Research Institute, to Byron Swift, Environmental Law Institute (Jan. 15, 2001) (on file with author).

[304]. *Id.* (noting that current R&D projects for cyclones continue on two fronts: (1) further NO_X reduction, using a technique called Rich Reagent Injection, and (2) improving the operability and results from using overfire air with cyclones, including ongoing corrosion assessments and controls issues).

[305]. Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112, 67,164 (Dec. 19, 1996).

[306]. This system results in more complete burnout of the fuel and formation of N_2 rather than NO_X. Many firms added overfire air technologies to low-NO_X burners to achieve further NO_X reductions. Some did this to gain benefits due to averaging their units, and others did it to comply with the EPA's initial Phase I rule, which would have required the use of overfire air but was later overturned in court. Interviews with utility representatives.

[307]. EPRI reports that nearly a third of those with overfire air ports initially suffered post-retrofit waterwall wastage:

> Early retrofits of low-NO_X burners without OFA generally did not increase waterwall wastage, but when low-NO_X burner systems with OFA ports were introduced to reduce

problems made many operators reluctant to use the technology in their boilers. An EPRI team discovered that low-cost changes in burner settings and operating practices appeared able to cut waterwall wastage significantly in many boilers by reducing the area covered by damaging iron sulfide deposits.[308]

E. Other NO_X Regulation in the 1990s

Title IV applied to both old and new power generation sources, but was significant principally in its effects on older units, most of which had never been subject to NO_X regulation. In order to evaluate firm behavior with regard to NO_X regulation, ELI reviewed the other major NO_X regulations affecting utility plants in the 1990s. These include the Ozone Transportation Commission (OTC) program for summertime NO_X reductions in northeastern states,[309] and the new source standards that affect new plants or major modification of existing plants. Additional reductions of NO_X emissions from power plants in eastern states has been proposed by the EPA under its NO_X SIP call regulation, but this will not take effect until 2004.[310]

1. OTC Cap-and-Trade in 1999 Forced Further Reductions at Existing Plants

In the twelve northeast and mid-Atlantic states,[311] NO_X emissions from large power plants have been controlled not by Title IV, but by

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> NO_X emissions further, wastage began showing up throughout the power industry. . . . Of some 150 boilers retrofitted with low-NO_X burners featuring OFA, as many as 40 have reported increased waterwall wastage, or discovered wastage where there was none before.

Elec. Power Research Inst., *Guidelines to Ward off Boiler Waterwall Wastage*, EPRI FOSSIL PLANT NEWS (Winter 1999).

[308] *Id.*

[309] *See infra* Part III.E.1.

[310] The EPA has relied on its authority to address the transport of ozone between states to promulgate a "SIP call" that requires a group of at least nineteen eastern states to reduce summertime NO_X emissions by 2004. Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone, 63 Fed. Reg. 57,356, 57,380, 57,401 (Oct. 27, 1998) (covering twenty-two states, and achieving reductions equivalent to a 0.15 lb/mmBtu rate standard by 2003); *cf.* Michigan v. EPA, 213 F.3d 663 (D.C. Cir. 2000), *cert. denied*, 121 S. Ct. 1225 (2001) (upholding lower court decision limiting application to nineteen states and extending deadline to 2004). The EPA's rule encourages the states to achieve most of these reductions in the utility sector, through a regional emissions cap and allowance trading program that reduces these emissions from 1.5 to 0.5 million tons. 63 Fed Reg. at 57,434, tbl.III-5.

[311] The OTC comprises the states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Delaware, the northern counties of Virginia, and the District of Columbia.

more stringent state regulations to reduce summertime NO_X emissions coordinated under the OTC. The OTC was created under the Clean Air Act Amendments of 1990 to facilitate regional planning of states' efforts to attain the National Ambient Air Quality Standard (NAAQS) for ground level ozone.[312] In September of 1994, all OTC states but Virginia adopted a Memorandum of Understanding to achieve regional reductions of NO_X from power generators starting in 1995.[313]

In Phase I of the OTC program, states required sources to install Reasonably Available Control Technology (RACT), a standard roughly equivalent to the Title IV NO_X standards but applying almost one year earlier.[314] Pennsylvania required sources to install low-NO_X burners with separate overfire air, and other states such as New York and New Jersey defined rate standards that were slightly more stringent than the Title IV standards.[315] Most states also allowed averaging among a firm's facilities, creating standards slightly more stringent but similar in nature to Title IV.[316] The result was also similar, with most firms adding combustion controls such as low-NO_X burners and/or overfire air to most units.

For Phase II, starting in 1999, nine OTC states established a NO_X Budget Program creating an emissions cap and allowance-trading system similar to the EPA's SO_2 Acid Rain Program.[317] The emissions cap

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[312] *See* 42 U.S.C. § 7511(c) (1994).

[313] *See* Memorandum of Understanding Among the States of the Ozone Transport Commission on Development of a Regional Strategy Concerning the Control of Stationary Source Nitrogen Oxide Emissions (Sept. 27, 1994), *at* http://www.sso.org/otc/att2.htm [hereinafter Memorandum of Understanding]. Phase I included the installation of reasonably available control technology (RACT). In Phase II, starting in 1999, states adopted an emissions cap and allowance-trading program to reduce region-wide NO_X emissions. The OTC states plan another cut in NO_X emissions in 2003. *Id.* This is consistent with the EPA's plan, generally referred to as the "NO_X SIP call," that affects a broader group of at least nineteen states. *See* Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone, 63 Fed. Reg. 57,356 (Oct. 27, 1998).

[314] *See* Memorandum of Understanding, *supra* note 313.

[315] Pennsylvania law defines RACT for large coal-fired units as "the installation of low NO_X burners with separate overfire air." 25 PA. CODE § 129.93(b)(1) (2001). New Jersey requires utility boilers to meet the following standards: Tangentially-fired burners: 0.38 lb/mmBtu; wall-fired: 0.45 lb/mmBtu; and cyclone 0.55 lb/mmBtu. N.J. ADMIN. CODE tit. 7, § 27-19.4 (2000). New York State RACT regulations set standards for dry-bottom coal-fired tangential plants at 0.42 lbs./mmBtu, wet-bottom coal-fired tangential plants at 1.0 lbs./mmBtu, wall-fired dry bottom plants at 0.45 lbs./mmBtu, and for wall-fired wet bottom plants at 1.0 lbs./mmBtu. N.Y. COMP CODES R. & REGS., tit. 6 § 227-2.4 (1997).

[316] *See supra* note 315.

[317] *See* Memorandum of Understanding, *supra* note 313. The OTC NO_X Budget Program was developed in collaboration with the EPA, industry, utilities, and environmental groups. Under the OTC program, budget sources were allocated allowances by their state government. Each allowance permits a source to emit one ton of NO_X during the summer period

required 912 electricity-generating units to reduce NO_X emissions by 55% to 65% from their 1990 baseline of 417,444 tons.[318] Despite the stringency of the standard, sources over-complied, reducing emissions 20% below the cap level in 1999.[319] Compliance levels were also very high, with only one source failing to meet its standard by one ton, therefore subjecting it to an automatic penalty.[320]

Despite initial expectations that many sources would need to use expensive end-of-pipe controls such as Selective Catalytic Reduction (SCR) to achieve these deep reductions, the flexibility afforded by the cap-and-trade approach led to unexpected results. One was that 126 of the 142 affected coal-fired units achieved up to 30% NO_X reductions through operational changes alone, without significant capital additions.[321] The cap approach allowed compliance through a number of technologies, described in Figure 3-5, and not only SCR. As a consequence, allowance costs, after initial volatility at the program's start in which prices ranged from $3000 to $7000 per ton, have settled down to $500 to $1000, significantly lower than originally estimated.[322]

(May through September). Allowances may be bought, sold, or banked. However, regardless of the number of allowances a source holds, it cannot emit at levels that would violate other federal or state limits (e.g., federal NSPS, Title IV, or state NO_X RACT rules). *See* EPA 1999 OTC NO_X COMPLIANCE REPORT, *supra* note 204.

[318] State Allocations And Emissions in 1999 under the OTC NO_X Budget Program (in tons) were:

State	1990 Baseline Emissions	1999 Allocation*	1999 Emissions
Connecticut	11,130	6,312	5,830
Delaware	13,510	6,142	6,160
Massachusetts	41,330	19,680	17,293
New Hampshire	14,589	6,788	3,463
New Jersey	46,963	21,292	15,390
New York	85,642	54,276	47,267
Pennsylvania	203,181	103,668	79,166
Rhode Island	1,099	580	274
Total	417,444	218,738	174,843

*Includes early reduction credit allowances of 24,635. *See* EPA 1999 OTC NO_X COMPLIANCE REPORT, *supra* note 204, exh. 1, at 2, *available at* http://www.epa.gov/airmarkets/cmprpt/otc99/index.html (last updated Dec. 11, 2000).

[319] *Id.* at 1.

[320] *Id.* at 2.

[321] Joel Bluestein, Energy and Environmental Analysis, Inc., *OTR NO_X Market: Lessons Learned* (1999) (unpublished report presented at missions Marketing Associates in Oct. 1999) (cited in Byron Swift, *Command Without Control: Why Cap-and-Trade Should Replace Rate Standards for Regional Pollutants,* 31 ENVTL. L. REP. 10,330 (Mar. 2001)); GAS RESEARCH INSTITUTE, LOW COST OPTIONS FOR ACHIEVING DEEP NO_X REDUCTIONS, *at* http://www.gri.org (Apr. 2000).

[322] The EPA estimated the average cost of reductions in the electric power sector to be $1468 per ton of NO_X. EPA 1998 RIA, *supra* note 14, at ES-2. Compliance cost is reflected in the price of an allowance, and during the year 2000, allowance prices for 1999 or 2000 tons for

Figure 3-5: Technology Options Available to Existing Coal-Fired Plants to Meet Stringent NO_x Standards[323]

Combustion controls are boiler modifications that minimize the formation of NO_x in the boiler. In addition to the direct burner modifications required for Title IV, advanced combustion controls can include overfire air and computer controls that enhance mixing of coal and air in the boiler.

Gas Reburn technologies reduce NO_x by injecting natural gas above the coal combustion zone. Gas reburn may achieve up to 55% NO_x reduction using 15% gas injection, with capital costs of $12 to $25 per kW and additional operating costs for the relatively more expensive natural gas fuel. Enhanced forms of gas reburn can use reagents such as amine injection to increase NO_X reductions to 60%, although these are slightly more expensive.

Selective Non-Catalytic Reduction (SNCR) injects a urea-based reagent in the upper furnace to reduce NO_X. SNCR achieves about a 35% NO_X reduction at a capital cost of $5 to $20 per kW. Combining re-burn with SNCR can get over 70% reductions.

Selective Catalytic Reduction (SCR) injects ammonia into the boiler, which catalytically reduces the NO_X. SCR has the greatest NO_X reducing potential, achieving 70% to 90% reductions, but is also the most expensive, with capital costs of $50-100 per kW. In addition, SCR has substantial operating costs, uses toxic catalysts that must be replaced, releases ammonia and entails a 0.5% efficiency loss.

It is interesting to view firms' response to the OTC cap, since the affected units were previously subject to rate standards set at levels similar to Title IV standards. Figure 3-6, developed by the Gas Research Institute, shows emissions levels for coal-fired units subject to the OTC cap in 1999.

See Figure 3-6: 1999 Ozone Season NO_X Emission Rates for OTR Coal Boilers Without Post-Combustion Controls[324]

Deleted: NO_x

These results show how different units emit at different levels under a cap-and-trade system that creates a uniform cost per ton for emissions reductions. This is due to the "step-wise" nature of technology choice. In other words, at a given moment in time some firms may find it inexpensive to achieve, for example, a 56% reduction, but very expensive to reach 57% because that would require major new

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the Ozone Transport Region were in the $500 to $1,000 range. *See, e.g.*, Cantor Fitzgerald Environmental Brokerage Services Website, *at* www.cantor.com/ebs (last modified Apr. 5, 2001).

[323]. STATE AND TERRITORIAL AIR POLLUTION PROGRAM ADMINISTRATORS & ASSOCIATION OF LOCAL AIR POLLUTION OFFICIALS (STAPPA/ALAPCO), CONTROLLING NITROGEN OXIDES UNDER THE CLEAN AIR ACT: A MENU OF OPTIONS 18 (July, 1994); GAS RESEARCH INSTITUTE, *supra* note 321.

[324]. GAS RESEARCH INSTITUTE, *supra* note 321, at Fig. 1.

equipment. Another firm may face this "cost knee" at a higher or lower level. So at an equal cost, firms will want to operate units to emit at slightly different levels. However, over time, firms may find ways to incrementally improve processes or operations to achieve greater reductions, typically at low cost.[325] Systems like a cap-and-trade approach encourage such differential behavior and the seeking of continuous reductions. A rate standard sets one limit that must be achieved at a certain date, and so eliminates both these possibilities, restricting firm behavior, raising costs, and eliminating incentives for continued incremental improvements.

2. New Source Standards

In contrast to existing plants, new plants or significant modifications of existing plants have been subject to NO_X standards since the initiation of the Clean Air Act in 1971.[326] Today, new sources are subject to a stringent federal New Source Review process, which requires at a minimum compliance with NSPS.[327] Traditional NSPSs establish emissions rate standards for each power-generation technology; e.g., coal-fired boilers are allowed to emit twice the NO_X as oil-fired boilers, and three times that of gas-fired.[328]

In 1998, the EPA established a new, fuel-neutral NSPS of 0.15 lb/mmBtu for major modifications of existing sources, and 1.6 lb/MWh of electricity generated for new sources, the latter an innovative output-based standard that provides a benefit to efficient producers.[329] However, this fuel-neutral NSPS rarely applies, as the standards created under the New Source Review process are more stringent and therefore control.[330]

New Source Review establishes an emissions rate standard set by regulators on a case-by-case basis based on the specific plant and power-generation technology, such that more lenient standards are applied to

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[325] *See* Nicholas Ashford, *An Innovation Based Strategy for the Environment*, *in* WORST THINGS FIRST? THE DEBATE OVER RISK-BASED NATIONAL ENVIRONMENTAL PRIORITIES (A.M. Finkle & D. Golding eds., 1994).

[326] 42 U.S.C. § 7411 (1994).

[327] *Id.*

[328] The initial NSPS for power plant boilers built prior to 1998 established NO_X emissions limits of 0.50-0.80 lb/mmBtu for coal-fired boilers, 0.30 lb/mmBtu for oil-fired boilers, and 0.20 lb/mmBtu for gas-fired boilers. Clean Air Act, 40 C.F.R. § 60.44a (2000).

[329] *Id.* § 60.44a(d); *see also* Revision of Standards of Performance for Nitrogen Oxide Emissions from New Fossil-Fuel Fired Steam Generating Units, 63 Fed. Reg. 49,442, 49,448-49 (Sept. 16, 1998).

[330] The New Source Review standards, BACT and LAER, establish more stringent requirements that specify NSPS only as a floor. *See, e.g.*, 42 U.S.C. §§ 7479(3) (describing the standard for Best Available Control Technology), 7501(3) (describing the standard for Lowest Achievable Emissions Rate).

dirtier technologies.[331] Sources built after August 7, 1977, in areas that have attained the federal ambient ozone standard set by the EPA must prevent significant deterioration of air quality, and install the Best Available Control Technology (BACT) for the type of plant proposed considering "energy, environmental, and economic impacts and other costs."[332] New plants in nonattainment areas must meet the even more stringent Lowest Achievable Emissions Rate (LAER) standard, which excludes considerations of cost.[333] These strict standards are meant to achieve ambient standards, prevent airshed deterioration, and be used as mechanisms to spur the development and application of new technologies.

3. Technology-Based Rate Standards for NO_X in the 1990s Created an Uneven Regulatory Framework and Varied Economic Signals for Most Business Units

As shown in Figure 3-7, power plant NO_X regulation in the 1990s created a highly uneven regulatory framework that sent different economic signals to the owners of different technologies. Because rate standards were set at differing levels for the different base technologies, they created a progression in which the dirtier a power-generating technology was in terms of NO_X emissions, the more lenient the rate standard. This created highly differential costs for NO_X reductions for different technologies, in the hundreds of dollars per ton of reductions for higher-emitting coal-fired units, and up to $10,000 per ton for clean gas turbines.

Figure 3-7: Differential Standards for NO_X Emissions and Costs from Generating Technologies (1996-1999)[334]

	Old Sources (Title IV/RACT)			New Sources (BACT/LAER)		
	Cyclone coal	Wall-fired coal	T-fired coal	New coal	New gas large	New gas small

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[331] 42 U.S.C. § 7479.

[332] *Id.* §§ 7475(a)(4), 7479(3).

[333] *Id.* § 7503(a)(2).

[334] Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112, 67,113 (Dec. 19, 1996); STAPPA/ALAPCO 1994, *supra* note 217, at 24-29; Marvin Schorr & Joel Chalfin, *Gas Turbine* NO_X *Emissions Approaching Zero—Is It Worth the Price?*, Presentation at Air & Waste Mgmt. Ass'n 92d Annual Meeting, St. Louis, MO (June 20, 1999) (notes on file with author); Leslie Witherspoon & Ken Smith, NO_X *Control Technology Options and Development Activity for Mid-Range Natural Gas Fired Turbines* (1999), Unpublished Presentation (notes on file with author).

Uncontrolled NO$_x$ (lb/mmBtu)	1.50	0.95	0.65	0.50	0.05	0.10
Legal standard (lb/mmBtu)	none	0.50	0.45	0.15	0.02+	0.02+
Cost per ton of NO$_x$ reduction	none	$161	$631	$565 (SCR)	$2,500	$10,000+

The disparities in the regulation of NO$_X$ emissions from different technologies, as well as between old and new plants, created strong economic incentives for the use of dirtier technologies and against the installation of new plants. They also imposed high costs on new technologies, despite creating few, if any, net ambient environmental benefits. These standards create a situation in which regulation of NO$_X$ may frustrate the economic drivers leading firms to use cleaner energy sources, and fail to capture multi-pollutant reductions created by switching to such sources.[335]

IV. GENERAL FINDINGS

The design of Title IV and other regulatory programs to reduce NO$_X$ and SO$_2$ emissions in the electricity-generating sector led to dramatically different industry responses. ELI's review of business responses to these programs provides a foundation for looking at how regulatory design affects environmental results, compliance decisions, and innovation.

Key distinctions between the programs examined include the difference in the standards (an equal effort approach using rates versus an equal cost per ton approach using cap-and-trade); the degree of flexibility allowed in compliance technology; the degree of governmental involvement in firm decision-making about compliance; and whether the systems created continuous or one-time incentives for firms to reduce their pollution levels. The mass-based standards such as cap-and-trade systems worked better than rate systems in these regards, as they imposed stringent environmental standards while allowing greater integration of environmental parameters into business decision-making.

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[335]. *See generally* Tina Kaarsburg & Julie F. Gorte, *Promoting Productivity and Clean Air with Innovative Electric Technologies*, NORTHEAST MIDWEST ECON. REV (Nov./Dec. 1999).

A. *Environmental Standards Have Been Essential to Drive Businesses to Reduce NO_X and SO_2 Emissions*

Although economic forces may also lead firms to cleaner production, regulatory standards have clearly been necessary in order to ensure that firms reduced NO_X and SO_2 emissions. Title IV led firms to make major additional SO_2 reductions by building scrubbers and increasing their use of lower-sulfur coals.[336] Regulation was even more important in making firms reduce NO_X emissions, as NO_X controls for coal-fired boilers generally involve a loss of efficiency or additional costs. Therefore, virtually no firms reduced NO_X emissions at existing boilers before the advent of regulatory standards, and exempted units continue to emit NO_X at uncontrolled levels.[337] This indicates the importance of setting standards to regulate firm behavior.

The record also shows that economic forces have also played an important independent role in leading firms to lower emissions of both SO_2 and NO_X. Prior to the advent of Title IV's SO_2 standard, firms near the Powder River Basin began to switch to cheaper lower-sulfur coals for economic reasons.[338] An analysis by MIT shows that a portion of SO_2 reductions in Phase I can be attributed to this economic trend.[339] Regarding NO_X, economic forces have cut both ways. Although there are few economic incentives for owners of existing coal boilers to reduce NO_X emissions, the situation for new plants is completely different. New combined cycle gas turbines, which emit no SO_2 and about a tenth of the NO_X of older plants, are more efficient and cheaper than new coal plants, and are forecast to capture over 90% of the market for new plants.[340] Because economic forces also can lead to major pollutant reductions, in some cases to a greater extent than regulatory mandates, good environmental regulation should enhance rather than interfere with such positive economic drivers.

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[336] *See supra* Part II.D.5.

[337] *See supra* Part III.D.

[338] ELLERMAN ET AL., *supra* note 10, at 228-29.

[339] *Id.* (noting that no-cost reductions made by businesses switching to lower-sulfur coal that was also cheaper than what they formerly used amounted to approximately 425,000 tons of SO_2 reductions per year, out of a total annual reduction of 3,888,000 tons).

[340] DOE ANNUAL ENERGY OUTLOOK 2001, *supra* note 1, at 75, 78 (noting that advanced natural gas combined cycle technology generates electricity at lower cost than advanced coal). Dramatic technology innovation in developing the dry low-NO_X turbine has meant that new gas plants both cost less and are far cleaner than coal boilers or older gas technologies, emitting NO_X at or below 0.05 lb/mmBtu (uncontrolled coal boilers emit at 0.65 to 1.50 lb/mmBtu); *see also* Schorr & Chalfin, *supra* note 334; STAPPA/ALAPCO 1994, *supra* note 217, at 22.

B. *It Has Proven Difficult to Set Standards That Properly Align Private with Social Costs, and Both* NO_X *and* SO_2 *Standards Were in Retrospect Too Lenient*

While standards appear necessary, it has proven difficult to set standards that properly align firms' private costs with social benefits.[341] Ideally, environmental standards should create an economic context that makes private sources perceive costs that reflect a broader social context of costs and benefits. In retrospect, Congress in 1990 both overestimated the costs of compliance with Title IV,[342] and underestimated the harm stemming from NO_X and SO_2 emissions.[343]

For both the NO_X and SO_2 programs, the cost of control has remained well below current estimates of the social benefits of additional reductions. For NO_X, the cost of retrofitting boilers with low-NO_X burners in Phase I averaged $412 per ton, and the results of the OTC NO_X cap show that significant added reductions could be made at a cost of around $500 to $1000 per ton.[344] In comparison, the benefit of added NO_X reductions in eastern states is estimated by the EPA to be between

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[341] Sources would then clean up pollution to the point at which the marginal cost of removing a ton of pollution equals the social benefit from having that ton removed. In this situation, the economic costs perceived by private firms reflect the overall social and economic value of pollution reduction, creating efficiency in attaining social welfare.

[342] Although the political process grappled with the cost of the programs in both cases, actual costs of compliance turned out to be far lower than predicted. For the SO_2 program, information at the time of the Act's passage in 1990 indicated that costs would be $300 to $1000 per ton, far higher than the observed cost of allowances at around $150. Also, the Direct Sales Reserve provision of Title IV that authorizes sales of allowances at $1500 is another indication of the perceived value of additional reductions, and again far higher than the actual costs. *See* 42 U.S.C. § 7651o (1994). Had an accurate understanding of the costs been available, it is quite likely that Congress would have set the SO_2 cap lower, suggesting that the current cap is set too high to align private costs with social benefits.

[343] Seven northeastern states have petitioned the EPA to strengthen the secondary NAAQS for NO_X, SO_2 and PM 2.5. The petitioners "suggest that the acid rain provisions in title IV of the CAA do not go far enough to ensure full recovery of sensitive ecosystems." Petition for Secondary National Ambient Air Quality Standards for Nitrogen Dioxide, Sulfur Dioxide, and Fine Particle Matter and Related Request, 65 Fed. Reg. 48,699, 48,700 (Aug. 9, 2000) [hereinafter Northeastern States Petition]. The petition cites in support of its assertions the NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM, BIENNIAL REPORT TO CONGRESS (May 1998), *available at* http://www.nnic.noaa.gov/CENR/NAPAP/NAPAP-96.htm; and EPA, PUB. NO. EPA-452/R-97-002, NITROGEN OXIDES: IMPACTS ON PUBLIC HEALTH AND THE ENVIRONMENT (Aug. 1997), *available at* http://www.epa.gov/ttncaaa1/t1/reports/noxtech.pdf; which "document increasing damage caused by acid deposition to the lakes and forests in the Northeastern States and other environmental effects. . . ." Petition for Secondary National Ambient Air Quality Standards for Nitrogen Dioxide, Sulfur Dioxide, and Fine Particle Matter and Related Request, 65 Fed. Reg. at 48,701.

[344] *See supra* notes 256, 322.

$1262 and $4786 per ton.[345] Similarly, the cost of SO_2 allowances in Phase I averaged $150, far below current estimates of the social benefits of added SO_2 reductions, which exceed $5000 per ton.[346] Therefore, for both pollutants, additional reductions would be fairly inexpensive and very beneficial, but are not forced by the standards-based approach. This shows the indispensable nature of establishing the overall standard at the correct level of stringency, whether it is expressed as a cap or a rate.

Technology-based rate standards, and the new source/old source distinction in the Clean Air Act, both cause an added disadvantage in aligning private with social values because they impose highly differential costs on different technologies.[347] This creates a heterogeneous set of cost signals based on technologies which are not aligned with one another. Under NO_X rate regulation, some of the dirtiest technologies faced lenient or no standards even though some could reduce emissions cheaply at prices under $100 per ton, whereas the cleanest technologies faced the most stringent standards and were forced to pay thousands of dollars per ton. Clearly, the economic drivers faced by these firms result in little consistency or rationality when compared to each other, or to a social optimum. The cap-and-trade programs performed better in equating private and social costs because they created a uniform cost faced by all firms, eliminating the inefficiency caused by multiple rate standards that create different economic signals for different technologies.

The cap-and-trade standard is also better in its environmental result over time, since it permanently caps emissions, whereas rate standards can be expected to allow emissions to grow over time along with economic growth. Therefore, while SO_2 emissions were capped during Phase I despite increased power generation, NO_X emissions grew slightly. The cap-and-trade system is also more dynamic at the firm

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[345]. EPA 1998 RIA, *supra* note 14, at ES-6 (noting that total benefits are between $964 and $3654 per ton of NO_X reductions in 1990, or between $1262 and $4786 in 1999 dollars). In comparison, costs were estimated to be $1468 per ton in 1990. *Id.* at ES-3.

[346]. *See* Figure 2-1. The reduction in sulfate particulate emissions alone is estimated by Resources for the Future to be approximately $5335 per ton of SO_2 reductions. ELI CLEANER POWER, *supra* note 14, at 14 (estimating $24.5 billion in benefits from a 4,592,000 ton reduction in SO_2 emissions); *see also* CLEAN AIR TASK FORCE, *supra* note 14, at 4-5 (noting that a 75% reduction in SO_2 leads to benefits of over $100 billion from particulate reductions, or over $10,000 per ton of reductions).

[347]. Although the EPA set these standards based on its best estimates of technology availability and cost, in retrospect these forecasts were not accurate for most technologies, and in particular failed to include unexpected innovation. This is particularly evident for wall-fired boilers and for cyclone boilers (where no reductions were required because of the perceived high costs). In both cases, it turned out that innovations could have provided inexpensive reductions to and below the standards. On the other hand, reductions at tangentially-fired boilers cost more than predicted. *See supra* Part III.D.5.b.

level, as firms have continuing incentives to reduce pollution to meet their quota or create additional allowances; in contrast, rate standards simply require a firm to install technology once and then maintain it. However, the cap is set at a fixed amount for the industry as a whole, limiting its dynamic aspect over time.[348] Understanding how different regulatory systems will interact with firm behavior over time is an important element of understanding regulatory design.

C. *Standards Based on Rates or an Old Source/New Source Distinction May Create Conflict Rather Than Alignment Between Regulatory and Economic Drivers for Environmental Quality*

A central finding of this study is that traditional environmental regulations fail to align the regulatory and economic drivers that lead firms to improve their environmental performance. The lack of alignment appears to be unintentional, and stems both from the new source/old source distinction in our law, and from the inflexibility inherent in rate-based regulatory methods. Examples of the lack of integration created under traditional regulations follow:

Example 1: A firm is choosing between continuing to operate an existing coal-fired plant, or replacing it with a new gas-fired combined cycle plant with no SO_2 emissions and 90% to 95% lower NO_X emissions. Environmental regulations place few costs or burdens on the firm if it chooses to continue operating the older and dirtier facility, but require the firm to undergo a lengthy New Source Review process and may require it to install expensive controls if it chooses to build the new and cleaner facility. The distinction between new sources and old sources creates economic incentives to firms that strongly favor the older, more polluting technology.

Example 2: A firm is deciding between two new generation technologies, one clean, such as natural gas, and the other with far higher emissions, such as coal. There are large social benefits if the firm chooses the clean technology, as total pollution levels are greatly reduced. The NO_X rate limits treat each technology separately, and impose proportionately equal burdens on each, and so create no incentive for the firm to choose the cleaner one. Firms may even face lower per-ton environmental costs in choosing the dirtier technology.[349]

Example 3: A firm is choosing between building a new single-cycle gas turbine or a combined-cycle gas turbine that achieves greater

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[348]. One can imagine that a very different scenario would have developed had Title IV established an allowance auction with a price floor set at $300, the lower end of most cost estimates in 1990; far less SO_2 would have been released during Phase I.

[349]. *See* Figure 3-7.

efficiency. Since emissions rate standards under BACT or LAER are based on parts per million (ppm), they provide no benefit to the firm in achieving greater efficiency or lowering overall pollution by using the combined-cycle unit.

Example 4: A firm building a new coal plant must decide on what kind of coal to use. The SO_2 cap-and-trade program encourages it to use cleaner, low-sulfur coal. However, the rate-based SO_2 New Source Performance Standard requires it to use scrubbers, regardless of how clean the coal is. In another example, if a firm builds a new gas-fired plant, New Source Review requirements in many states require it to install end-of-pipe controls for NO_X regardless of whether or not it uses very clean process technology. In either case, rate-based New Source Performance Standards dictate the installation of control technologies and preclude compliance through cleaner fuels or processes that may cost less and create less overall pollution.

One root cause of the conflict may be that regulations are developed on a policy basis, with paramount attention paid to broad political and social considerations, whereas business decisions are made on an economic basis, in which small differences in cost and regulatory design make an enormous difference. Because businesses try to find the lowest-cost method to comply with the precise wording of regulatory standards, it makes a huge difference if standards require compliance with rate limits or mass limits (cap-and-trade); whether averaging times are hours, days, or months; whether rate standards are set by concentration limits, inputs, or outputs; and whether regulation focuses upstream or downstream in the process. The dramatic differences in the ways in which the precise nature of a standard will affect businesses' economic behavior are often paid inadequate attention when standards are established.

D. Different Regulatory Designs Greatly Affect the Cost of Compliance for Achieving Equivalent Environmental Results

Many types of environmental regulations fail to harness the strong business drivers that can lower compliance. This is shown in Figure 3-7 for NO_X, where firms are not allowed to pursue least-cost approaches to reducing overall NO_X levels on an industry-wide basis, because each technology is regulated separately. The constraints imposed by environmental laws can be seen even more clearly in SO_2 regulation, where we can benefit from a historical analysis of different types of SO_2 regulations and their costs.

Figure 4-1 shows how the greater flexibility of different environmental regulation of SO_2 leads to significantly lowered cost in achieving a similar environmental result. It compares cost estimates for achieving equivalent environmental reductions via a technology prescription mandating scrubbers; the 1977 NSPS that required a 70% to 90% reduction in potential emissions; the 1971 NSPS concentration rate standard of 1.2 lb/mmBtu; and the Title IV cap-and-trade program with and without the trading element. The Figure shows how different regulatory designs create very different compliance costs, from \$1.2 billion and \$7 billion annually for equivalent reductions.

Figure 4-1: Technologies Permitted and Compliance Costs Under Different SO_2 Regulatory Systems[350]

Regulatory Method	Technology Prescription	Emissions Rate (% Reduction)	Emissions Rate (Concentration)	Emissions Cap Without Trading	Emission Cap With Trading
Technologies Permitted	• scrubbers*	• scrubbers*	• scrubbers* • limited use low-sulfur coal	• more efficient scrubbers • major use low-sulfur coal • fuel blending • demand side management	• more efficient scrubbers • major use low-sulfur coal • fuel blending • demand side management • power shifting • trading
Estimated Compliance Cost in Billions per Year	\$7	\$4.5	–	\$2.5	\$1.2

* In addition to limiting compliance options to scrubbing, the scrubber technology permitted under various standards varied. The 1977 rate standard has short averaging periods, which required scrubbers to be significantly over-built with redundant modules, greatly increasing their cost. Title IV allowed significant innovation and gains in efficiency in scrubber design.

An encouraging result of this study is that the cost of compliance for both cap-and-trade programs were greatly below estimates, and several times lower than the cost of equivalent rate-based regulatory approaches. In the Title IV SO_2 program, allowances cost \$150 during Phase I, far lower than the \$300 to \$1000 initially forecast. Similarly, the OTC NO_X cap resulted in allowance prices of \$500 to \$1000, or one third of most estimates. The cap-and-trade approach is less expensive as it helps align economic and environmental incentives by freeing technology choice and creating a uniform incentive for all sources to reduce pollution.

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[350]. U.S. GENERAL ACCOUNTING OFFICE, AIR POLLUTION: ALLOWANCE TRADING OFFERS AN OPPORTUNITY TO REDUCE EMISSIONS AT LESS COST 37-41 (Dec. 1994); Paul R. Portney, *Economics and the Clean Air Act*, J. ECON. PERSP. 4(4), 173-81 (Fall 1990) (cost estimate of \$7 billion based on the Waxman-Sikorski bill of the 98th Congress (H.R. 3400), mandating scrubbers for fifty plants to gain a 10-million ton reduction).

A final observation is that firms' efforts to achieve lower costs of compliance generally have incidental and positive environmental effects. The reason is that lower economic costs typically reflect a lowered use of resources and energy, which is a positive environmental result. Often, lower costs also represent a shift towards pollution prevention in compliance instead of the use of end-of-pipe controls. Therefore increased flexibility under Title IV led firms to use cleaner coal instead of scrubbing emissions, which wastes about 1.5% of plant energy and creates high waste volumes, and helped to halve the capital cost of scrubbing which represents significant savings in materials used.

E. Rate Standards Were Inflexible, Limiting Businesses' Ability to Develop and Implement Compliance Methods and Technologies

One of the chief findings of this study is that rate standards such as those used in the Title IV NO_X program and new source standards for both NO_X and SO_2 proved to be poor performance standards, as they significantly restricted the range of technology choices available for compliance and provided limited incentives for innovation and improvement. In the past, it has been noted that traditional rate-based standards established on a technology-by-technology basis do not encourage shifts to cleaner technology and tend to freeze innovation.[351]

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[351]. Historically, pollution standards under the CAA have been established as rate standards measuring the concentration or percentage of a pollution in end-of-pipe emissions. See, for example, air standards such as Reasonably Available Control Technology (RACT) for existing sources, Best Available Control Technology (BACT) for new sources, and Maximum Achievable Control Technology (MACT) for hazardous pollutants. 42 U.S.C. §§ 7502(c)(1), 7475(a)(4), 7412(g)(2)(A) (1994). Water standards include Best Available Technology Economically Achievable ("BAT"). *See* 33 U.S.C. § 1311(b)(2)(A) (1994). The use of rate standards is appropriate when addressing the local concentration of a pollutant, which was of concern in the early years of the CAA. However, they become less and less appropriate in addressing total pollutant loadings and regional issues such as urban ozone formation and interstate transport of NO_X. Rate-based standards are a major cause of the inflexibility in current environmental laws that is identified in the National Advisory Council for Environmental Policy and Technology (NACEPT) reports, ELI studies, and other reinvention publications as one of the major environmental regulatory issues. *See, e.g.*, EPA, PUB. NO. EPA-101/N-91/001, PERMITTING AND COMPLIANCE POLICY: BARRIERS TO U.S. ENVIRONMENTAL TECHNOLOGY INNOVATION 39 (1991), *available at* http://www.epa.gov/clariton/clhtml/pubtitle.html (last updated Nov. 30, 2000) [hereinafter EPA PERMITTING].

> Specifically, policy makers should reconsider the way 'best available technology'-based regulations are now developed and applied. Such regulations use agency established technology-based limits and use a technology to demonstrate that the limits are achievable. Even though these are performance-based requirements, they have a strong tendency to lock in the technology that is used to demonstrate achievability. To some extent, reliance on 'best available technology'-based regulations impedes the development and introduction of innovative technologies.

Id.; *see* ENVTL. LAW INST., BARRIERS TO ENVIRONMENTAL TECHNOLOGY INNOVATION AND USE (1998) [hereinafter ELI INNOVATION]; Debra Knopman & Emily Fleschner, *Second Generation of*

The findings of this study reveal four characteristics of rate standards that have limited business ability to develop and implement effective and efficient compliance methods for NO_X and SO_2 in the power sector, as described below.

1. Emissions Rate Standards Limited Technology Choice

As shown in this study, rate-based standards inherently limit technology options compared to mass-based performance standards because of the very language of the standard. By defining performance as a reduction in rates instead of a reduction in tons, rate standards may limit or even preclude technologies that would reduce amounts but not rates of pollution. This included both the 1971 and 1977 NSPS for SO_2, which limited compliance to either a certain quality of coal or to scrubbing.[352] Another is the New Source Review standards for NO_X that are defined in "parts per million" (ppm), and so preclude compliance by increasing efficiency or similar prevention methods.[353] By defining performance as rate reduction, rate standards tend to emphasize end-of-pipe controls instead of cleaner fuels or more efficient processes.

Figure 4-2 shows the actual use of technology under the rate standards reviewed, compared with the technologies used by firms in the cap-and-trade programs for NO_X and SO_2. Technology solutions are divided into the three basic means of compliance: cleaner fuels, cleaner processes, and end-of-pipe controls. They are further characterized as high-tech, low-tech or no-tech to emphasize that compliance responses do not have to be high-tech to create highly effective solutions, since an emissions reduction by any method benefits the environment equally.

The Figure shows how weak NO_X rate standards in this sector have simply led to retrofits of known technologies (combustion controls and averaging), and stringent NO_X rate standards promoted innovation principally in high-tech end-of-pipe controls (SCR and SCONOX).[354] In

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Environmental Stewardship: Improve Environmental Results and Broaden Civic Engagement (Progressive Policy Inst., ed.) (May 1, 1999), *at* http://www.ppionline.org/ndol/print.cfm?contentid=767 (arguing that first generation approaches to environmental problems impede innovation while second generation approaches drive innovation and improve accountability); NAT'L ACADEMY OF PUBLIC ADMIN., SETTING PRIORITIES, GETTING RESULTS: A NEW DIRECTION FOR THE EPA 102 (Apr. 1995); William D. Ruckelshaus & Karl Hausker, Enterprise for the Environment, *The Environmental Protection System in Transition: Toward a More Desirable Future* 3 (Jan. 1998), *available at* http://www.csis.org/pubs/pubse&e.html#env_trans; THINKING ECOLOGICALLY: THE NEXT GENERATION OF ENVIRONMENTAL POLICY (Marian R. Chertow & Daniel C. Esty eds., 1997).

[352] *See supra* Part II.A.

[353] *See infra* note 376.

[354] Stringent rate standards under NO_X New Source Review only allow the use of control technologies such as SCR and SCONOX. "SCONOX" is a trademarked catalytic absorption

contrast, cap-and-trade systems allow the use of any technology that could reduce emissions, and so promote the application of, refinement, and innovation in the broadest set of potential technologies.

Figure 4-2: Technologies Used to Meet NO_X Standards[355]

	High-Tech	Low-Tech	No-Tech
Cleaner Fuels			Shift to gas Low-NO_X coals
Cleaner Processes	Dry Low-NO_X Turbine	Combustion Controls (LNB/OFA)	Averaging Load shifting Burners out of service
End-of-Pipe Controls	*SCR* *SCONOX* SNCR Gas Reburn		

Technologies used for NSPS in italics; for Title IV underlined; all used for OTC cap-and-trade

A key distinction between new source rate standards versus a cap-and-trade approach is in how they treat cleaner new sources. Cap-and-trade approaches created declining costs for plants as their pollution emissions declined and so encouraged the use of any cleaner technology. However, New Source Review standards differentially placed very high burdens and costs on new technologies, even if they were relatively clean. This has proven particularly important for NO_X, as over the past decade, major technological advances in natural gas turbines have reduced uncontrolled NO_X emissions from over 100 ppm to the very low 9 to 15 ppm range, ten to thirty times lower than coal-fired boilers.[356] While this has achieved a 90% pollution reduction, these reductions often may not count when a regulatory body applies a standard like BACT or LAER.[357]

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system developed by Goal Line Environmental Technologies, LLC. *See* California Environmental Technology Certification Program, SCONOX: Goal Line Environmental Technologies, *at* http://www.calepa.ca.gov/calcert/CertifiedTech/GoalLine.htm (last modified Dec. 20, 2000) [hereinafter California Environmental Technology Certification Program]. Many states require SCR even for clean gas plants, and whether or not cleaner fuels or processes such as the dry low-NO_X burner can be used is the subject of current EPA guidance deliberations. *See, e.g.*, Notice of Availability for Draft Guidance on BACT for NO_X Control at Combined Cycle Turbines, 65 Fed. Reg. 50,202 (Aug. 17, 2000).

[355]. EPA, RACT/BACT/LAER Clearinghouse Annual Report for 1998: A Compilation of Control Technology Determinations EPA 456/R-98-0004 (June 1998). Interviews with federal and state air pollution control officials, representatives of utility companies, vendors of pollution abatement technologies, and environmental organizations.

[356]. *See* Byron Swift, *Grandfathering New Source Review and NOx—Making Sense of a Flawed System*, 31 Env't Rep. 1538 (July 21, 2000); STAPPA/ALAPCO 1994, *supra* note 217, at 53-54.

[357]. *See* 42 U.S.C. §§ 7479(3), 7501(3) (1994).

Some states applying these rate standards require end-of-pipe control equipment such as SCR when applying NSR to these very clean sources, and do not count what has been achieved through pollution prevention or process change.[358] The epitome of this tendency may be SCONOX, which doubles the cost of controls to achieve a very small additional reduction.[359] The energy used to run SCONOX itself creates more ancillary pollution than the incremental reductions it achieves,[360] but this may not be able to be considered under a literal interpretation of the inflexible LAER rate standard.[361]

Figure 4-3 shows different technologies used under SO_2 regulations. The percentage reduction standard of the current NSPS limited technology choice to a single method: scrubbing.[362] In contrast, the SO_2 cap-and-trade approach allowed maximum technology choice, and because it did so, led to unexpected innovation in fuel blending that allowed far greater use of low-sulfur coal for compliance, dramatically reducing the cost of compliance. It also created competition for scrubbing that has driven innovation and cost reductions in scrubbing.

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[358] *See, e.g.*, MASS. REGS. CODE tit. 310, §§ 7.00, 7.02 (2001); MASS. DEP'T OF ENVTL. REG., CONDITIONAL COMPREHENSIVE PLAN APPROVAL OF MYSTIC STATION 13 (2000) (requiring end-of-pipe SCR technology to reach 2 ppm in addition to dry low-NO_X burner), http://www.state.ma.us/dep/energy/mystic/mysca.pdf. This problem is addressed in Notice of Availability for Draft Guidance on BACT for NO_x Control at Combined Cycle Turbines, 65 Fed. Reg. 50,202-02 (2000), suggesting that BACT not require the addition of SCRs on low-emitting gas turbines, and arguing that adding costs to such turbines actually increases NO_X because the power from the new generation would be expected to displace power from far dirtier facilities. Environmental groups strongly objected to the proposal. *See* Inside Washington Publishers, *Activists Threaten Litigation on Permit, Turbine Policies*, 11 CLEAN AIR REPORT 4 (Sept. 28, 2000).

[359] Swift, *supra* note 196.

[360] The variable cost of operating SCONOX is almost double that of SCR for gas turbines, yet SCONOX achieves only a very small marginal reduction of NO_X, from 3 ppm to 2 ppm (equivalent to moving from 0.0100 to 0.0072 lb/mmBtu, both extremely low). *See* California Environmental Technology Certification Program, *supra* note 354; MASS. DEP'T OF ENVTL. REG., *supra* note 358. If one compares this 1 ppm to the incremental energy used by SCONOX in comparison to SCR, the energy used, were it taken from the grid, leads to emissions of about 1000 pounds of NO_X, 2 tons of SO_2 and over 100 tons of CO_2 for every ton of NO_X abated. *See* DOE ANNUAL ENERGY OUTLOOK 2001, *supra* note 1, tbl. A8, at 132. If one also considers the embedded energy use in all the other added operating costs of SCONOX, these indirect emissions would be even higher. This example shows how the inflexibility of rate standards leads to perverse environmental results, and prevent cost reductions.

[361] Goal Line Envtl. Technologies, L.L.C., *SCONOX Available for Gas-Fired Boilers*, 1 CATALYTIC SOLUTIONS FOR CLEAN AIR, *at* http://www.glet.com/update_10-99.htm#SCONOx AVAILABLE (Oct. 1999).

[362] This type of rate standard was motivated by political concerns to assure jobs for miners and others whose jobs depended on continued extraction of high-sulfur eastern coals. *See* ACKERMAN & HASSLER, *supra* note 4, at 44-45. The 1971 NSPS was also a rate standard, imposing a concentration limit based on Btu input, which was slightly more flexible. *See supra* Part II.A.

Figure 4-3: Technologies Used to Meet SO_2 Standards[363]

	High-Tech	Low-Tech	No-Tech
Cleaner Fuels		Low Sulfur Coal: sub-bituminous Rail Investment/ Innovation	Shift to gas LSC: bituminous Demand Side Management
Cleaner Processes		Trading	Averaging Load shifting
End-of-pipe Controls	*Scrubbing*		

Allowed under NSPS in italics

2. Emissions Rate Standards Did Not Force a Move Toward Cleaner Technologies

Because emissions rate standards under the CAA are individually set for each specific production technology, they create different standards for the kind of fuel used and the specific boiler or turbine technology.[364] This created no incentive for firms to move towards cleaner technologies. The NO_X study shows how the use of technology-based rate standards may create perverse results under which the dirtiest sources receive the weakest economic signals to reduce pollution, and clean sources the greatest. As shown in Figure 3-7, rate standards have actually placed differentially greater burdens on cleaner technologies, creating economic signals contrary to those needed to promote cleaner production.[365]

3. Rate Standards Promote One-Time Compliance Without Incentives for Further Progress

One of the strongest drivers firms face is the economic incentive to reduce costs. Environmental regulations can harness these drivers by creating economic benefits from pollutant reductions on a continuing basis. However, fixed-rate standards created no incentives for continuous reductions, or for compliance that goes beyond stated limits. Therefore, once firms installed low-NO_X burners as required by the Title

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[363]. EPA, RACT/BACT/LAER CLEARINGHOUSE ANNUAL REPORT FOR 1998: A COMPILATION OF CONTROL TECHNOLOGY DETERMINATIONS EPA 456/R-98-004 (June 1998). *See* Interviews with federal and state air pollution control officials, representatives of utility companies, vendors of pollution abatement technologies, and environmental organizations.

[364]. *See supra* Part III.E.3.

[365]. This situation is further exacerbated by the new source/old source distinction under the NO_X standards, which is discussed in Part III.E.2. This distinction in CAA regulation focuses requirements on new sources that are already so clean that reducing their emissions does not significantly reduce total NO_X pollution, but by placing high burdens on these clean new sources, may perversely provide economic incentives to keep old plants on line.

IV rate limits, they took no further action to reduce pollution under Title IV.[366] This limits compliance options to capital or process choices made at the time a plant is built or modified, and eliminates the possibility of compliance through changes in management practices, fuels, or any other operational decisions after a plant is built. Many NO_X reduction technologies, such as gas reburn and overfire air, are incremental, and can be adjusted to achieve various rates of NO_X control depending on the cost of inputs and other parameters.[367]

In contrast, the first year of application of the OTC NO_X cap-and-trade program revealed that once a market incentive was created to reduce NO_X emissions on a continuing basis, firms found ways to lower NO_X by 20% to 30% at existing units without significant capital additions.[368] Achieving such NO_X reductions through operational changes can be highly effective, and may be essential to reduce NO_X to very low levels. Similarly, the Title IV SO_2 cap-and-trade program has encouraged continuing innovation and improvement that has significantly increased scrubber efficiency and steadily lowered the costs of scrubbing and of low-sulfur coal throughout Phase I.

4. Rate Standards Created High Transaction Costs

Rate-based standards typically require significant government intervention in approving the compliance technology chosen by firms, creating significant transaction costs and delay. This is particularly true of New Source Review standards, which require a case-by-case determination of the required technology by government regulators.[369] However, regulations such as cap-and-trade systems have created very strict standards in allowing zero growth in emissions without government review and with very low transaction cost.

5. The Design of Rate-Based Standards Can Be Marginally Improved

The performance of NO_X and SO_2 regulations also show how the design of rate-based standards can strongly affect business compliance alternatives and costs. Making rate standards uniform, annual, and

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[366]. *See supra* Part III.D.1.

[367]. *See supra* Part III.D.5.

[368]. *See supra* note 321.

[369]. BACT and LAER require a case-by-case assessment and approval of compliance technology. *See, e.g.*, 42 U.S.C. §§ 7479(3), 7501(3) (1994); *see also supra* note 330. For a glimpse of the intensive negotiations about technology choices involved in the application such standards, see Environmental Appeals Board, *Formal Opinions; Clean Air Act Prevention of Significant Deterioration (PSD) Permit Appeals*, *at* http://www.epa.gov/eab/eabpsd.htm (last updated Apr. 23, 2001).

output-based could improve the performance of rate standards, as described below. However, these alternative rate-based approaches do not resolve all of the inflexibilities of rate standards, and would not work as well for the economy or the environment as the cap-and-trade system.

a. Longer Averaging Periods

Short averaging periods, such as the thirty-day average for the SO_2 NSPS, have been shown to limit technology development and increase the cost of compliance.[370] On the other hand, long averaging periods, such as the one-year period for the Title IV NO_X standards, increased flexibility.[371] Longer averaging periods should be used unless the specific characteristics of a pollutant and the resulting health and environmental problems require the use of shorter averaging periods.[372]

b. Uniform Rate Standards

A uniform rate standard that does not discriminate between old and new sources, or between technologies, would address the problems identified above that stem from the variability of rate standards between technologies and the distinction between old and new sources. It could also reduce transaction costs by creating a simple, objective parameter.[373] However, such a standard may be perceived as unfair. It would also still suffer from the problems that rate standards experience in restricting technology and compliance choices, not promoting compliance above the limit, and not creating a continuous driver for improvement and innovation.

c. Output-Based Rate Standards

Another important goal is to change from input-based standards such as lb/mmBtu, or concentration standards such as ppm, to output-based standards such as lb/MWh, to reward efficiency. A breakthrough was made in this regard in the EPA's New Source Performance Standard

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[370]. *See supra* Part II.C.5.c; Clean Air Act, 40 C.F.R. § 60.43a(g) (2000).

[371]. *See supra* text accompanying note 233.

[372]. Rate-based standards and short averaging times work best when there is limited dispersion of a pollutant, and the rate is related to the size and output of the source. Therefore, rate standards are likely to perform better with vehicles than with stationary sources, and with pollutants with highly localized effects. The regional nature of the effects of NO_X and SO_2, and the great variability in size of stationary sources, would indicate the use of long averaging periods for these pollutants.

[373]. *See, e.g.*, Tim Woolf & Bruce Biewald, *Electricity Market Distortions Associated with Inconsistent Air Quality Regulations*, 13 ELECTRICITY J. 42-49 (2000) (analyzing the market distortions that exist partially due to varying rate standards for old and new sources and advocating uniform standards), *available at* http://www.synapse-energy.com/publications.htm.

for boilers adopted in 1998, which established a uniform output-based NO_X standard of 1.6 lb per MWh of electricity generated from new boilers.[374] Unfortunately, NSPS is no longer what determines compliance for new sources, as New Source Review imposes a more stringent standard under BACT or LAER.[375] Currently those standards are based on parts per million, which does not reward efficiency and is a very poor indicator of the actual pollution caused by the plant.[376]

d. More Frequent Updating of Rate Standards by Government

Another way of improving rate standards would be for government to more frequently update the standards. However, there are practical impediments to this approach in the length of time it takes to promulgate rules.[377] Title IV could be considered a laboratory experiment of this approach, as it created a two-phased rate-based rulemaking process for NO_X, with Phase I starting in 1996 and a more stringent Phase II in 2000. However, the Phase II process occasioned the typical response of lawsuits, a lack of industry focus on achieving reductions until the regulations were imminent, and lack of reductions beyond the standards after they were promulgated. Also, in retrospect the standards failed to predict and capture a major opportunity for emissions reductions in cyclone boilers. Only when the OTC cap-and-trade program started did firm behavior reveal that an additional 20% to 30% in NO_X emissions reductions could be achieved through operational changes at plants.[378]

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[374] Clean Air Act, 40 C.F.R. § 60.44a(d) (2000). This final rule was adopted in Revision of Standards of Performance for Nitrogen Oxide Emissions from New Fossil-Fuel Fired Steam Generating Units, 63 Fed. Reg. 49,442, 49,444 (Sept. 16, 1998).

[375] *See* 42 U.S.C. §§ 7479(3), 7501(3); *see also supra* text accompanying note 330.

[376] EPA, PUB. NO. EPA-456/R-98-004, RACT/BACT/LAER CLEARINGHOUSE CLEAN AIR TECHNOLOGY CENTER ANNUAL REPORT FOR 1998: A COMPILATION OF CONTROL TECHNOLOGY DETERMINATIONS (1990 ed., 8th Supp. 1998), *available at* http://www.epa.gov/ttn/catc/dir1/rblc98.pdf. Measurement of ppm varies considerably between technologies due to different test methods, and so is a particularly poor measure of overall pollution. *See* Clean Air Act, 40 C.F.R. § 60, app. A, method 19 (showing that ppm varies greatly depending on percent of oxygen in exhaust air).

[377] It now takes five to ten years between initiation and implementation of a major rulemaking process, which is a far slower pace than the rate of development of technology change.

[378] *See* GAS RESEARCH INSTITUTE, *supra* note 321.

F. Emissions Cap and Allowance-Trading Programs Allow Greater Integration of Environmental Issues into Business Decision-Making Processes, Providing Greater Flexibility and Lowering Costs Without Sacrificing Environmental Integrity

This study shows that technology-neutral performance standards such as emissions cap and allowance-trading systems can rectify the problems caused by rate standards without sacrifice to the environment, by creating more flexible systems and eliminating governmental review of technology choice.[379] Both the Acid Rain Program's SO_2 cap and the OTC NO_X cap create major emissions reductions and a zero new source standard without any lengthy permitting procedures (transactions take less than twenty-four hours) or case-by-case conflicts between regulators and regulated.

The major benefits of a good cap-and-trade system are that it enacts a stringent and permanent cap on emissions, which serves society's interest in pollution reductions, while allowing the widest possible breadth of compliance options, hence allowing firms to reduce costs. Cap-and-trade approaches establish a uniform standard for both old and new plants, and so place no undue burdens on new plants that may be cleaner and more efficient. They also are technology-neutral, helping to move compliance away from the end-of-pipe controls promoted by rate standards toward the use of cleaner technologies. Because any reduction creates economic value to a firm, firms also face a continuous driver to reduce emissions and develop innovative technologies and methods.[380] Cap-and-trade approaches also remove government from making case-by-case decisions about technologies, redirecting business effort away from contesting regulatory authority and towards competing in the marketplace.

A more subtle change created by cap-and-trade programs is that by establishing a price for a ton of additional pollution reduction, they have helped to link environmental with economic decision-making within a

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[379]. Note that rate standards under the CAA could be improved to be uniform and output-based, and then would meet some of these objectives. However, even such improved rate standards would suffer from the problems of restricting technology and compliance choices, not promoting compliance above the rate limit, not creating a continuous driver for improvement, and imposing high transaction costs.

[380]. A system of pollution charges or fees may also provide similar benefits if the charges are set high enough, but such systems have rarely been implemented in the United States. Although such fee-based systems are theoretically attractive, studies have shown that in practice, pollutant fees or taxes have almost never been able to be established at levels high enough to affect behavior. *See* ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, ENVIRONMENTAL TAXES IN OECD COUNTRIES (1995).

firm.[381] One instance of this is that the price of an allowance is regularly entered into firms' dispatching models that determine which generation units are operated. In another, the allowance price has become integrated with the quality of coal so that the price of coal now reflects its sulfur emissions. Both of these create efficiency in merging the environmental quality demanded by society with industry decision-making.

Another reason that flexible systems such as cap-and-trade programs may function effectively is that they provide shared benefits. The environment benefits from the permanent emission reductions created by the emissions cap, together with high levels of compliance and a zero new source mandate. Industry benefits from the lower costs of compliance as well as a greater ability to integrate compliance planning with investment cycles, seek out least-cost solutions, and save or even make money through trading. In a sense, the cap-and-trade approach allows firms to apply their entrepreneurial skills to innovate or reduce the costs of compliance, and retain part of the economic gains that result from these efforts. These shared benefits may allow for more stringent standards to be set, while allowing industry to make the most cost-effective reductions.

G. *Innovation, Investment, and Cleaner Production*

The different regulatory programs controlling NO_X and SO_2 emissions elicited dramatically different responses as to the scope, quality, and timing of innovation. As described above, the Title IV NO_X rate approach elicited only one-time and limited innovation for existing plants, leading principally to the installation of low-NO_X burners.[382] In contrast, Title IV's SO_2 cap-and-trade program created continuous drivers for innovation that lasted throughout Phase I, as well as a broader effort by firms to seek pollution prevention methods.[383] New Source Performance Standards drove innovation, but only for a limited set of primarily end-of-pipe control technologies.[384] The lesson learned is that even when applied at moderate levels such as in Title IV, cap-and-trade

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[381] Traditional rate-based regulations create a dichotomy between environmental compliance and all other aspects of firm behavior that has been referred to as a "green wall" separating environmental compliance from the rest of the firm. *See* ENVIRONMENTAL STRATEGIES FOR INDUSTRY: INTERNATIONAL PERSPECTIVES ON RESEARCH NEEDS AND POLICY IMPLICATIONS 8-12 (Kurt Fischer & Johan Schott eds., 1993); Patricia S. Dillon, *Implications of Industrial Ecology for Firms*, *in* THE GREENING OF INDUSTRIAL ECOSYSTEMS (Braden R. Allenby & Deanna J. Richards eds., 1994). The integration achieved by cap-and-trade programs serves to overcome this division.

[382] *See supra* Part III.C.

[383] *See supra* Part II.C.9.

[384] *See supra* Part IV.E.3.

programs can be expected to create significant innovation, whereas rate-based standards limit both the breadth and extent of innovation.[385]

1. Cap-and-Trade Programs Promote Broader Technology Use and Innovation

Figures 4-2 and 4-3 show that both SO_2 and NO_X cap-and-trade programs promoted broad technology choice, and thereby increased the opportunity for innovation. In particular, the wider breadth of technology choice creates greater opportunity for unexpected innovation to occur that cannot be predicted or captured in a government-controlled, rate-setting exercise. It is also noteworthy that despite their purpose of helping to force innovation, the new source standards principally promoted innovation in high-tech, end-of-pipe technologies, leaving out many potential technologies and solutions used under the cap-and-trade programs that could achieve environmental benefits.[386]

Possibly the best example of how the flexibility of cap-and-trade programs promoted innovation and breakthroughs in compliance was firms' increased use of low-sulfur western coals under the Title IV SO_2 program.[387] Title IV encouraged early experimentation in blending PRB coal precisely because it did not impose a rate-based standard. Initially, most firms believed they could not use sufficient amounts of low-sulfur subbituminous PRB coals in their boilers to meet a particular rate standard such as a 1.2 lb/mmBtu.[388] However, since a rate standard was not involved, and all tons of reductions were rewarded, firms began to experiment with blending coals. Unexpectedly, blending worked far better than believed possible, and at lower cost. By the end of Phase I,

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[385]. In the early 1990s, the EPA's National Advisory Council for Environmental Policy and Technology (NACEPT) recognized that "[e]nvironmental improvements in process and materials-require long-term, continuous investment in the development of new, more economically and environmentally efficient technologies which make it possible to leapfrog to a new level of environmental improvement and economic efficiency." EPA, PUB. NO. EPA-100/R-93-004, TRANSFORMING ENVIRONMENTAL PERMITTING AND COMPLIANCE POLICIES TO PROMOTE POLLUTION PREVENTION 5 (1993), *available at* http://www.epa.gov/clariton/c/html/pubtitle.html. NACEPT also observed that the command-and-control environmental regulatory system severely constrains innovation because government regulators tend to require regulated entities to only use existing technologies that are known to meet the emissions limitations. EPA PERMITTING, *supra* note 351; *see also* ELI INNOVATION, *supra* note 351.

[386]. *See supra* text accompanying notes 382-385; *see also* Figures 4-2, 4-3.

[387]. *See supra* Part II.C.6.a.

[388]. This rate level is significant because the permanent emissions cap in Phase II was based on multiplying baseline emissions by 1.2 lb/mmBtu. Therefore most units by Phase II would, on average, have to meet or exceed this rate.

blends using as high as 80% PRB coal were common, driving low-cost emission reductions.[389]

2. Rate-Based Systems Were Unfriendly to Innovation

Another finding of this study is that rate-based systems are unfriendly to innovation due to the same four characteristics that limit business compliance alternatives, described in Part IV(E). By limiting the kinds of technologies used for compliance, rate standards in turn limit the scope for innovation. By limiting compliance to one point in time, they create no incentives for ongoing improvements in operational techniques.[390] Because technology-based rate standards impose stricter standards on cleaner technologies, they limit the incentives for business to develop or use cleaner technologies.[391] Finally, by failing to create continuous drivers for improvement, they limit research and development efforts.[392] As described below, these barriers have also contributed to declining funding for environmental technology development.

3. While Innovation Can Be Expected to Occur Broadly, It Is Not Guaranteed for Any Specific Technology

One of the reasons that flexible programs such as cap-and-trade approaches encourage innovation is that innovation can be expected to occur broadly over an industry, but cannot be guaranteed to occur for any particular base technology. For example, under the Title IV NO_X program, innovation led to major cost reductions for two of the three major boiler types, wall-fired and cyclone boilers, but not tangentially-

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[389]. *See supra* Part II.C.6.a.

[390]. The lost opportunity is revealed by the OTC NO_X cap, which led some firms to make up to 30% NO_X reductions through operational changes alone, which had not been implemented under the previous rate standards. Although New Source Review standards theoretically apply again to a plant if it undergoes a major modification, this happens infrequently. In practice, NSR can result in perverse incentives for firms to not improve plant performance or make operational changes that might trigger the costs of New Source Review.

[391]. As Figure 3-7, describing NO_X regulations, shows, dirtier plants may in practice actually face much lower costs, giving no incentive to move towards cleaner technologies. The "equal effort" approach embodied in current standards creates weak drivers for firms to innovate through developing newer, cleaner technologies.

[392]. This was evident in cyclone boilers and NO_X, where industry launched a research effort when it learned of the EPA's initiative to regulate cyclones in Phase II, discovered an inexpensive technology that would lower NO_X to the proposed rate level, and then scaled down the research effort. This aspect of rate standards is explored in major studies such as Nicholas Ashford et al., *Using Regulation to Change the Market for Innovation*, 9 HARV. ENVTL. L. REV. 419 (1985); Kurt Strasser, *Cleaner Technology, Pollution Prevention and Environmental Regulation*, 9 FORDHAM ENVTL. L.J. 1 (1997).

fired boilers, where the cost of compliance exceeded estimates.[393] Therefore, rate standards that establish specific limits for an individual base technology such as a boiler type must be set conservatively, as that technology might not experience innovation. This limits the potential benefits from unexpected innovation when using technology-specific standards.

4. Traditional Regulatory Approaches Have Discouraged and Distorted Private Investment in Research and Development, and Capital Markets for Innovation

A significant negative effect of the current rate-based regulatory system is its role in lowering and limiting industry commitment to research and development. Since the rate standards create no continuous driver to lower emissions, firms do not invest continuously in research and development to enhance environmental quality, because there is no compliance benefit in doing so. Instead, the periodic effort to lower the rate standards becomes a political issue, with industry battling through its lawyers to make sure the rate standard is as lenient as possible and to use existing technologies for compliance. As demonstrated by the cyclone boiler situation, when a rate standard is announced, there is then a flurry of research activity on how to reach the standard at least cost, after which the research effort subsides again.[394]

This has virtually eliminated private venture capital in the environmental field, which has shrunk from a meager $200 million in 1990 to only $60 million in 1999, during a decade in which funding for technology skyrocketed to a record $35 billion.[395] Environmental financiers interviewed gave two reasons for this: innovative environmental technologies could not survive the length, transaction costs, and delay of the government regulatory approval process under technology-based rate systems; and the permitting process for the rate-based system fractures the national market into the hundreds of permitting districts, vastly reducing potential markets.[396] The consequence of this is that there is virtually no venture capital for environmental technology, when it could be one of the strongest drivers of innovation and progress.

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[393] *See supra* Part III.D.5.

[394] *See supra* Part III.D.5.c.

[395] *See* ELI INNOVATION, *supra* note 351, at 9, 25; *see also* PricewaterhouseCoopers, 1999 Money Tree Survey, *at* http://www.pwcmoneytree.com.

[396] *See* Interviews with environmental financiers; *see also* ELI INNOVATION, *supra* note 351.

In addition to the problems caused by rate-based standards, the new source/old source distinction in the CAA also distorts industry investments in research and development. The power industry research coalition, EPRI (formerly the Electric Power Research Institute), had a 1999 budget of $364 million, of which over 90% was devoted to improving existing plants, not developing new technologies.[397] On the other hand, government spending is about evenly split, with half of the DOE's energy research budget devoted to developing new electricity-generating technologies.[398] We see, therefore, that our regulatory system, which imposes stringent environmental requirements on new plants but not old plants, creates major economic pressure on business to extend the life of old plants, causing the industry to mis-allocate hundreds of millions of research dollars.

H. Imposing Stricter Standards on New Sources Has Proven Ineffective in the Power Sector, and Has Led to Neither Cheaper Compliance Nor Better Environmental Results

One of the fundamental elements of our clean air legislation has been to impose stricter standards on new sources than on existing sources, in order to attain ambient pollution levels, help prevent the degradation of airsheds, and to spur innovation.[399] Originally, federal standards applied only to new sources, on the theory that it would be cheaper to attain ambient standards by requiring new sources to install modern technologies or controls, and that retirement would ultimately lead to all sources being covered under new source standards.[400] Today the distinction is carried forward in the relatively lenient standards applied to existing sources under Title IV, compared to the stringent standards applied to new sources.

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[397]. EPRI's 1999 Annual Report shows a research program of $364,856,000, including $102,600,000 in supplemental project funding by its members. Almost all projects are applied and oriented towards improving existing plants and technologies. ELEC. POWER RESEARCH INST., ANNUAL REPORT (1999), *available at* www.epri.com.

[398]. Roughly half of the DOE's $2.1 billion fiscal year 2000 appropriation for "Energy Resources" is oriented towards new power technologies and energy conservation. U.S. DEPT. OF ENERGY, FY 2001 BUDGET REQUEST TO CONGRESS (2000); *see also* EIA, PUB. NO. SR/OIAF/1999-03, FEDERAL FINANCIAL INTERVENTIONS AND SUBSIDIES IN ENERGY MARKETS 1999: PRIMARY ENERGY, *available at* http://www.eia.doe.gov/oiaf/servicerep/subsidy/index.html (last modified July 10, 2000) (noting that overall, "nearly two-thirds of Federal energy R&D ($2.8 billion) is allocated to basic research") An additional $1.6 billion in applied research is divided between research to develop new technologies and research to improve existing technologies. *Id.* at 25.

[399]. FRANK P. GRAD, TREATISE ON ENVIRONMENTAL LAW § 2.03[14] (1995); Clean Air Act Amendment of 1977, S. Rep. No. 95-127 (1977); H. Rep. No. 95-294, at 11-14 (1977).

[400]. *See supra* note 399.

1. New Source Standards Have Not Effectively Reduced Ambient Pollution Levels

Contrary to the initial supposition that it would be cheaper to achieve significant reductions at new plants rather than older plants, it has not in fact been cheaper for new sources to reduce pollution. A review of the costs of NO_X reduction in Figure 3-7 shows that it is far cheaper today for older sources to reduce NO_X than for cleaner modern technologies. Because fundamental technology change in the power sector has produced far cleaner natural gas generation technologies,[401] significant reductions are available principally at old plants, where they are also far cheaper. Yet the new source standards impose very high costs on the new gas-fired facilities to reduce small amounts of NO_X, while many older and dirtier sources must make only modest or even no reductions.[402]

The law's emphasis on reductions from new sources may derive from an older, static view of technology in which the base technology is assumed to not change much. However, a modern view is that fundamental technology change may be expected in most industries, and new sources are likely to be more efficient and less polluting than old sources. A strategy focused on new sources will not work well when technology change is rapid, plants are long-lived, or when fundamentally different technologies are used for new sources than old sources. In these cases, New Source Review can become an obstructionist policy that achieves little pollution reduction, but imposes high transaction and compliance costs only on the new clean technologies. These findings stress the importance of adopting regulatory systems that create equal pressure on both old and new sources to reduce emissions.

2. New Source Standards Force Only Limited Kinds of Innovation

New source standards were also adopted in part for their role in prompting innovation, and here their role is more complex. New source

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[401]. Even without controls, modern gas combined-cycle plants emit virtually no SO_2, particulates, or air toxics. Their NO_X levels are around 0.05 lb/mmBtu, which is well below the NSPS and ten to forty times lower than that of coal units. Because they are more efficient than coal plants, they also emit roughly half the CO_2. *See* STATE AND TERRITORIAL AIR POLLUTION PROGRAM ADMINISTRATORS & ASSOCIATION OF LOCAL AIR POLLUTION OFFICIALS (STAPPA/ALAPCO), REDUCING GREENHOUSE GASES AND AIR POLLUTION: A MENU OF HARMONIZED OPTIONS 49 (1999).

[402]. *See* Figure 3-7. Modern gas plants are cheaper to build than coal plants, and achieve 55% efficiency instead of the 34% average for coal plants. This offsets the relatively more expensive fuel cost for natural gas, and the DOE estimates that 90% of new generation between the years 2000 and 2020 will be gas-fired. *See* DOE ANNUAL ENERGY OUTLOOK 2001, *supra* note 1, at 65, 78.

standards have led to development of new technologies, including innovative control technologies such as SCONOX and XONON.[403] They have also contributed to a collaborative federal-industry effort to develop cleaner and more efficient gas turbines, in which federal research funds have also played a large role.[404]

However, new source standards have also suppressed innovation and improvement. By definition, new source standards fail to prompt innovation in existing plants, and because they apply only at one time they did not encourage innovation and improvement in ongoing management and operational practices. As shown in Figures 4-2 and 4-3, new sources standards have created only limited innovation, focused on expensive, end-of-pipe controls. New source standards also discouraged improvement at old plants, as firms have limited upgrades or efficiency investments that might trigger New Source Review, which would impose major transaction and compliance costs on the firm.[405] Finally, new source standards have significantly distorted the focus of industry research efforts towards extending the life of older plants, and not developing new technologies.[406]

3. NSR Rate Standards Create Few Net Benefits When Combined with Offsets or in Conjunction with an Emissions Cap

New source standards also help to prevent the deterioration of airsheds, but this goal is addressed more effectively by establishing an emissions cap, especially if the cap level implements significant reductions. The irony is that once an emissions cap is established for a pollutant, there are no net environmental benefits from the stringent emissions rate limits imposed by New Source Review.[407] Despite imposing high costs on cleaner new technologies, they create no net reduction in emissions, which are now controlled by the cap. The same result applies today in nonattainment areas, where the CAA requires any new source to fully offset its emissions with matching reductions from existing sources.[408] In both of these circumstances, a better policy would

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[403]. XONON is a flameless catalyst module developed by Catalytica Combustion Systems. *Nutech, Ultra Low NOx Combustor*, *at* http://www.nutech.org/stationary/fuel_burn/boilers/other/xonon.html (n.d.).

[404]. Federal funding of the Advanced Turbine Systems program has risen from $5 million in Fiscal Year (FY) 1992 to $33 million in FY 1999. EIA, *supra* note 398, at 33.

[405]. *See supra* Parts II(A), III(E)(2).

[406]. *See supra* note 397 (noting that 90% of industry research efforts focused on existing plant and equipment).

[407]. *See supra* Part III.E.2.

[408]. *See* 42 U.S.C. § 7502 (1994).

be to not apply NSR, as it creates few net environmental benefits and may hinder the multi-pollutant benefits that come from the transition to cleaner new technologies.[409]

I. Transaction Costs in Cap-and-Trade and Rate-Based Programs

The NO_X and SO_2 cap-and-trade and rate-based programs differ greatly in transaction costs.[410] These include both the effort required to establish the programs and the ongoing transaction costs in applying the regulatory programs to new and old sources. In general, although the creation of cap-and-trade programs may involve extensive efforts and lobbying activity, once created they perform with very low transaction costs.[411] Rate-based regulations on the other hand may also be difficult to create if they are set at stringent levels, but importantly create high transaction costs and a culture of conflict in their implementation phase. In doing so they may exact a heavy toll on economic development by lengthening and creating uncertainty in the process of siting new plants, despite creating no net environmental benefits in comparison to a cap-and-trade approach.[412]

1. Transaction Costs in Establishing Legislation

Creating legislation for either a rate-based or cap-and-trade program involves extensive efforts and lobbying activity, which depend primarily on the stringency of the standard. There were considerable transaction costs in establishing the Acid Rain Program in Congress, especially with regard to the SO_2 standard.[413] There was significant lobbying activity as to the overall level of SO_2 reductions, and an even greater amount on specific provisions as firms jockeyed to have Congress include special allowance allocations that benefited their particular firm or region.[414]

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[409]. This is particularly true for carbon dioxide, the principal greenhouse gas. Since CO_2 is a long-lived gas that lasts for centuries once emitted, it is critical to achieve major carbon reductions in the next decade or two. The most feasible way to do so is to invest heavily in new gas-fired plants that are more efficient and far cleaner than the older coal-fired power plants. Yet our NO_X policies make such new investment considerably more difficult, leading to continued emissions from older plants. The cost burden of NSR is especially severe for smaller gas-turbine units that are precisely those used for co-generation at industrial sites, and could achieve the greatest efficiency gains and greenhouse gas reductions.

[410]. *See supra* Part IV.B.

[411]. *See supra* Part III.E.1.

[412]. *See supra* Part IV.G.4.

[413]. *See* COHEN, *supra* note 4, at 25-44.

[414]. This resulted in twenty-nine separate formulas for allowance allocation that have little to do with achieving program goals, but have a great deal of economic impact in redistributing allowances between firms. *See* ELLERMAN ET AL., *supra* note 10, at 16; MCLEAN, *supra* note 191, at 8.

Although the ten years it took to enact acid rain legislation might be interpreted to indicate the difficulty of establishing a cap-and-trade program, this delay had more to do with the stringency of the program itself rather than the cap-and-trade mechanism finally adopted in 1990.[415] The emissions cap and allowance-trading approach was only initiated under President Bush at the end of this period, and is generally thought to have facilitated enactment of the legislation by satisfying environmental concerns for a 10 million ton reduction while allowing business greater flexibility to reduce costs.[416]

The Title IV NO_X program occasioned far less discussion or lobbying activity in the legislative proceedings, in part because the 2 million ton NO_X reduction was less than the 10 million ton SO_2 reduction. In addition, the expected compliance cost was considerably less, even though the NO_X standard also represented a roughly 50% reduction from prior emissions levels. The expected capital cost of a low-NO_X burner was $20/kW,[417] far less than the $249/kW capital cost of scrubbing expected to meet the SO_2 standard. This suggests that there may be fewer transaction costs in enacting less costly standards. Indeed, establishing other more stringent NO_X rate standards for power plants such as the OTC NO_X reductions program,[418] the new NO_X NSPS,[419] and the new ambient limits for ozone have all involved major transaction costs.[420]

2. Transaction Costs in Establishing Regulations

Transaction costs were far lower for the Title IV SO_2 program than the NO_X program in the next phase, that of establishing regulations to

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[415]. *See* COHEN, *supra* note 4, at 152-66.

[416]. *See generally* ELLERMAN ET AL., *supra* note 10, at 31-35; COHEN, *supra* note 4, at 152-66 (discussing the legislative history of the Clean Air Act).

[417]. *See* Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase II Final Rule, 61 Fed. Reg. 67,112, 67,113 (Dec. 19, 1996).

[418]. The OTC NO_X reduction program, which included both rate-based standards in its first phase and an emissions cap and allowance-trading standard starting in 1999, took extensive discussions between states to establish the overall regulatory framework, baselines, and allocations. See the series of multistate memoranda and resolutions starting in 1991 that are listed at the Ozone Transport Commission homepage, *at* http://www.sso.org/otc/.

[419]. *See* Clean Air Act, 40 C.F.R. § 60.44a (2000); Revision of Standards of Performance for Nitrogen Oxide Emissions from New Fossil-Fuel Fired Steam Generating Units, 63 Fed. Reg. 49,442, 49,444 (Sept. 16., 1998) (setting NO_X New Source Performance Standard of 1.6 lb/MWh).

[420]. Industry sued the EPA over its new NAAQS for ozone and fine particulate matter smaller than 2.5 microns. National Ambient Air Quality Standards for Ozone, 62 Fed. Reg. 38,856, 38,856 (July 18, 1997), *struck down in part by* Am. Trucking Ass'n v. EPA, 175 F.3d 1027, 1037 (D.C. Cir. 1999), *modified on reh'g by* 195 F.3d 4 (D.C. Cir. 1999), *aff'd in part, rev'd in part sub nom.* Whitman v. Am. Trucking Ass'n, 121 S. Ct. 903 (2001).

implement the program. One reason was that key sections of the SO_2 provisions were self-executing.[421] Another was that there was less area for dispute in cap-and-trade programs, since the law established both the basic standard and the allocations. Except for a lawsuit concerning the rules for substitution units, which was settled,[422] the only lawsuits filed under the SO_2 program were relatively minor ones dealing with specific allocation disputes.[423] In contrast, the Title IV NO_X standards were the subject of an intensive government-industry negotiation process over the meaning of "low-NO_X technology" that significantly delayed the proposal of regulations.[424] An industry lawsuit then successfully contested the EPA's interpretation, delaying implementation of the program by a full year.[425]

The implementation of Phase II standards have been similar. There was relatively little conflict in implementing the Phase II SO_2 standard, which simply reduced allowance amounts. In contrast the NO_X

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[421] *See* Brian Mclean, *Evolution of Marketable Permits: The U.S. Experience with Sulfur Dioxide Allowance Trading*, 8 INT'L J. ENVTL. & POLLUTION 19 (1997). "If EPA failed to put implementing regulations in place, emission limitations stated in the law would apply to every source . . . . Coupled with the automatic noncompliance penalties, this provision encouraged the industry to support the timely promulgation of regulations to avoid the more costly statutory fallback." *Id.*

[422] Several major environmental groups and fifty utilities sued the EPA over its initial final rule for substitution units that would have allowed firms to count the reductions achieved by building a scrubber on a unit after 1985 but before 1990. *See* Proposed Settlement; Acid Rain Core Rules Litigation, 59 Fed. Reg. 42,227 (Aug. 17, 1994); Proposed Settlement; Acid Rain Core Rules Litigation, 59 Fed. Reg. 28,522 (June 2, 1994). The EPA agreed to change its rule to not allow this result. *See* Clean Air Act, 40 C.F.R. § 72.41 (2000); Acid Rain Program: Permits, 59 Fed. Reg. 60,218, 60,220 (Nov. 22, 1994).

[423] Only two other judicial challenges were brought, which focused only on a specific provision that outlined the extension allowances available to utilities that installed scrubbers. In one challenge, three utilities unsuccessfully sought to require the EPA to process extension allowance applications in order of receipt before issuing its final regulations for the acid rain program. Monongahela Power Co. v. Reilly, 980 F.2d 272, 278 (4th Cir. 1992). A second unsuccessful challenge was brought by an individual utility, Indianapolis Power and Light Company, challenging the EPA's failure to adjust its emissions data to account for an extended period of time a unit was out of operation due to unexpected major repairs. Indianapolis Power & Light Co. v. EPA, 58 F.3d 643, 643 (D.C. Cir. 1995).

[424] The EPA promulgated NO_X regulations in March 1994 (almost two years after the May 15, 1992, deadline set by statute), following lengthy but unsuccessful efforts to achieve a negotiated rulemaking that covered, among other things, low-NO_X burner technology issues. Acid Rain Program; Nitrogen Oxides Emission Reduction Program—Phase I, Final Rule, 59 Fed. Reg. 13,538 (Mar. 22, 1994).

[425] Following issuance of the regulations, the industry successfully challenged the EPA's decision that "low NO_X burner technology" included overfire air. *See* Al. Power Co. v. EPA, 40 F.3d 450 (D.C. Cir. 1994) (vacating the rule). As a result, utilities were not required to comply until January 1, 1996, after the EPA had re-issued the rule in April 1995, a full year after the statutory compliance deadline for Phase I NO_X emissions limitations. *See* Acid Rain Program: Nitrogen Oxides Emission Reduction Program: Direct Final Rule, 60 Fed. Reg. 18,751 (Apr. 13, 1995).

Deleted: NO_x

standards led to considerable efforts to determine the appropriate rate standards that fit with the statutory language, and the industry again filed lawsuits over the proposed Phase II NO_X regulations.[426] Again, the NO_X standards created greater transaction costs in establishing the regulations.

3. Transaction Costs in Implementing the Programs

The ongoing transaction costs under the NO_X and SO_2 programs are very different, especially for new sources. Phase I SO_2 permits consist simply of a sheet of paper that states the correct allowance allocation and monitoring protocols.[427] The principal government roles are to operate the allowance-trading systems, monitor emissions, and perform end-of-year reconciliations.[428] This creates extremely low transaction costs: the government role in recording allowance transactions typically takes place in less than twenty-four hours.[429] The Phase I NO_X program also faced relatively few transaction costs in requiring a one-time retrofit of a defined technology, although some firms had to apply for an alternative emissions limit.[430]

However, for new sources, the SO_2 cap-and-trade program creates far lower transaction costs than NO_X-based regulation, even though it implements a zero new source standard in which emissions cannot grow. New sources are simply subject to the same allowance system as other plants, which imposes low transaction costs and no permitting delays for new plants. In contrast, the ongoing transaction costs for new sources to comply with NO_X regulation are extremely contentious and time-intensive, with New Source Review a major cause of conflict between the industry and government over the past decade. The NSR process typically takes months or even years to permit a new plant, creating

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[426]. Challenges to SO_2 program implementation were primarily based on individual EPA allocation decisions. *See* Tex. Mun. Power Agency v. EPA, 89 F.3d. 858, 858 (D.C. Cir. 1996) (upholding EPA utility-specific allocation decisions); Madison Gas & Elec. Co. v. EPA, 25 F.3d 526 (7th Cir. 1994) (challenging successfully the EPA's failure to award bonus allowances).

The NO_X Phase II challenges were broad challenges that could have potentially delayed implementation of NO_X emissions limitations for Group 1, Phase II and Group 2 boilers. *See* Appalachian Power Co. v. EPA, 135 F.3d 791, 822 (D.C. Cir. 1998). The petitioners failed in several broad challenges to Phase II, Group 1 regulations and succeeded in part with their challenges to Group 2 regulations. *Id.*

[427]. Clean Air Act, 40 C.F.R § 72.31 (2000); EPA, PUB. NO. OMB-2060-0258, ACID RAIN PROGRAM: PHASE II PERMIT APPLICATION (1998), *available at* http://www.epa.gov/airmarkets/forms (last updated Jan. 19, 2001).

[428]. *See supra* Part II.C.11.

[429]. About 90% of SO_2 trades under the Acid Rain Program are recorded under the EPA Allowance Tracking System in less than twenty-four hours. Kruger et al., *supra* note 158, at 121. *See* EPA 1999 COMPLIANCE REPORT, *supra* note 1.

[430]. *See* EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 12-13.

administrative costs to governments and major opportunity costs for firms.[431] Under this process, the law requires government regulators to make a specific determination of what precise technology is the "best available" or "lowest achievable."[432] These standards pit regulators against the applicant in a series of factual issues, and create high transaction costs.[433] However there may be no gain to the environment if the plant is a modern gas plant, as NO_X emissions are minimal and the plant would be expected to create multi-pollutant benefits by displacing power from dirtier sources.

4. Transaction Costs in Incrementally Lowering Standards

An interesting benefit of the cap-and-trade approach was evident in the transition from Phase I to Phase II of Title IV. Under the rate-based approach for the NO_X standards, it would have been unfair to again require Phase I units to retrofit their boilers a few years after the beginning of Phase I in order to meet the slightly lower Phase II standard in 2000. Therefore all Phase I units were exempted from meeting the more stringent Phase II limits and were grandfathered at the lower Phase I limits.[434] In contrast, Phase II of the SO_2 program was able to require added reductions from all the Phase I units simply by reducing their allowance allocations, while including all other sources equally.[435] This was implemented without any grandfathering problem, transaction costs, or major lawsuits. The cap-and-trade approach therefore allows a simple, effective, and equitable way to require firms to reduce emissions if needed in the future.

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[431]. *See* Anthony Arcone & Josh Margolis, *New Source Review ERC Trading—The Good, The Bad and The Difficult*, ENVTL. FIN. 21 (Oct. 2000).

[432]. 42 U.S.C. § 7479(3), 7501(3) (1994). The procedure is detailed in EPA, DRAFT NEW SOURCE REVIEW WORKSHOP MANUAL; PREVENTION OF SIGNIFICANT DETERIORATION AND NONATTAINMENT AREA PERMITTING (1990). The results of individual determinations are collected in EPA, PUB. NO. EPA-456/R-99-004, RACT/BACT/LAER CLEARINGHOUSE CLEAN AIR TECHNOLOGY CENTER ANNUAL REPORT FOR 1999: A COMPILATION OF CONTROL TECHNOLOGY DETERMINATIONS (1990 ed., 9th Supp. 1999), *available at* http://www.epa.gov/ttn/cact/dir1/rblc99.pdf.

[433]. For BACT, the law requires these be made "on a case-by-case basis, taking into account energy, environmental, and economic impacts." 42 U.S.C. § 7479(3). Contested cases are frequent, and results of litigation are reported by state, or in cases of federal direct jurisdiction, in cases before the EPA Environmental Appeals Board, *at* http://www.epa.gov/eab/eabpsd.htm.

[434]. 42 U.S.C. § 7651a.

[435]. *See id.* § 7651d.

J. Monitoring and Compliance

Both Title IV NO_X and SO_2 programs have achieved 100% compliance with emission limitations in all years of Phase I.[436] The factors of regulatory design that contributed to this excellent result are described below.

1. Strict Monitoring and High Penalties

Key factors in the 100% compliance rate are the strict monitoring protocols that require continuous emissions monitors,[437] and the high penalties. Title IV imposes a penalty of $2000 for each ton of NO_X or SO_2 emitted in excess of emissions limitations requirements,[438] forfeiture of allowances under the SO_2 program, as well as regular civil and criminal penalties.[439] Since the monitoring ensures that violators will be caught, and the high penalties are many times the cost of compliance, both programs work well to assure compliance.

2. Design of Cap-and-Trade Programs

Another factor in the very high compliance levels is the design of cap-and-trade programs.[440] The Title IV SO_2 program achieved 100% compliance in emissions reductions, and there was only one violation of one ton in the OTC NO_X program in 1999, which led to a swift and automatic penalty.[441] These compliance rates are significantly better than the 80% compliance typical under other federal air programs.[442] Several factors contribute, including the factual simplicity of the standard, which lacks any limitations or special conditions. Also, the availability of

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[436]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 2; EPA 1999 OTC NO_X COMPLIANCE REPORT, *supra* note 204, at 2.

[437]. Title IV requires "CEMS, [or] any alternative monitoring system that is demonstrated as providing information with the same precision, reliability, accessibility and timeliness as that provided by CEMS." 42 U.S.C. § 7651k(a).

[438]. *Id.* § 7651j(a).

[439]. *Id.* § 7413.

[440]. *See* EPA, RULE EFFECTIVENESS STUDY (1993) (noting a compliance rate of 80% for traditional air programs). In the five years of Phase I, there were only thirty-eight actions against forty-five plants (ninety units) for more minor infractions such as violations of monitoring, record keeping, and reporting rules. This number of violations in comparison to the 2500 units covered by the Acid Rain Program monitoring requirements results in a 96% compliance result for the program over five years, again much better than typical compliance rates under the EPA's air programs. Zofia Kosim, *Acid Rain Program: Compliance and Enforcement*, Presentation at Elec. Utilities Envtl. Conference, Tucson, Ariz. (Jan. 9, 2001) (notes on file with author).

[441]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, at 2; EPA 1999 OTC NO_X COMPLIANCE REPORT, *supra* note 204, at 2.

[442]. EPA 1993 RULE EFFECTIVENESS STUDY, *supra* note 440.

trading coupled with the annual reconciliation period after the end of the year, creates a "no-fault" aspect to compliance under cap-and-trade helps firms achieve 100% compliance without compromising environmental integrity.[443] Finally, as demonstrated by the one OTC violation, enforcement is also very simple under cap-and-trade programs, with penalties immediately and automatically assessed.

3. Inclusiveness of Cap-and-Trade Programs

A final benefit of cap-and-trade programs is their lack of exceptions, which allows more sources to be included in the compliance system. Cap-and-trade programs typically include all relevant sources, and provide for no exceptions. In contrast, entire classes of boilers (i.e., the Group 2 boilers) were not placed in the Phase I NO_X program because of the perceived lack of available technology.[444] Second, special alternative emissions limits were provided to ten units that installed low-NO_X burners but could still not meet the rate standards.[445] Therefore, although the NO_X rate program achieved 100% compliance,[446] there was limited participation and the need to authorize exceptions for some units through the granting of alternate emissions limit (AEL) permits.

K. Over-Compliance and Other Conservative Compliance Strategies by Firms

Both Title IV programs led to conservative strategies by firms, leading to self-reliance and over-compliance. Under the Title IV NO_X program, Table A firms reduced emissions 11% below established rate limits to assure a margin of safety, resulting in additional pollutant reductions.[447] Emissions were 30% below authorized levels in Phase I of the Title IV SO_2 program, but the ability of firms to bank allowances means that these early reductions are not permanent, and the tons are likely to be emitted in the future. The OTC NO_X cap-and-trade program also surprised analysts when firms over-complied by 20% in the first year. The banking rules for the OTC NO_X program may result in future reductions of banked allowances,[448] creating additional environmental

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[443]. Sources that find themselves out of compliance at year end can purchase allowances to achieve compliance within sixty days of the end of the year. Clean Air Act, 40 C.F.R. § 77.3 (2000).

[444]. *See supra* Part III.D.5.

[445]. EPA 1999 COMPLIANCE REPORT, *supra* note 1, exh. 8, at 13.

[446]. *Id.* at 2, 13.

[447]. *Id.* exh. 9, at 14; *see also supra* Part III.D.4.

[448]. 1999 emissions were 174,843 tons compared to allowance allocations of 218,738 tons. Banked allowances may only be used up to 10% of authorized allowances in each year.

benefits. Thus, although both cap-and-trade programs led to over-compliance, future environmental benefits are diluted by the ability to bank reductions.

L. Flexibility Mechanisms with Low Transaction Costs Were Widely Used

Firms made extensive use of all flexibility mechanisms that provided economic benefits with low transaction costs. Under the NO_X program, 80% of units were included in averaging plans, and almost half of potential units used the early election option.[449] Under the Title IV SO_2 program, 30% of potential substitution units entered the program, and most firms used both the banking and trading mechanisms.[450] In contrast, flexibility mechanisms with high transaction costs, such as the AEL program, were infrequently used.

The effect of the flexibility mechanisms on firms' behavior can be seen in Figures 4-4 and 4-5 that compare compliance results achieved under both Title IV programs. The emissions figures for NO_X show most firms emitted at or around the rate standard level, with averaging provisions allowing some units to exceed the rate standard by a small amount. The data for SO_2 shows a different behavior, with unit emissions uniformly spread over a wide range from very low levels to 140% of the standard, indicating the importance of the flexibility provided by market mechanisms.

See Figure 4-4.[451] Emissions Results (by quintiles) for Unit Emissions of SO_2 in Phase I (1995-1999)

See Figure 4-5[452]: Emissions Results (by quintiles) for Unit Emissions of NO_X in Phase I (1996-1999)

The economic effect of the flexibility mechanisms was clearly positive, as it allowed firms greater flexibility in their compliance planning, leading to lower costs. However, they gave some slight economic advantage to larger firms, as larger firms may make the greatest use of

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Banked allowances are reduced by a variable ratio (2:1 in 2000) for use over that 10% threshold. The differences in banking rules for SO_2 and NO_X are motivated in part by the greater sensitivity of health benefits to short-term fluctuations in NO_X. *See* EPA 1999 OTC NO_X COMPLIANCE REPORT, *supra* note 204, at 2-3.

[449]. *See supra* Part III.D.3.

[450]. *See supra* Part II.C.9.

[451]. Data derived from analysis of EPA COMPLIANCE REPORTS 1995-1999.

[452]. *Id.*

provisions like averaging and internal trading, due to the greater number of units they have to include in the programs.

The environmental effect of the flexibility mechanisms was minimal or nonexistent. The tendency of most firms to comply autarkicly meant that most flexibility mechanisms were used locally. Eighty percent of SO_2 allowances used for compliance come from within the same state, and 80% of NO_X averaging plans are also confined to one state.[453] The concern that trading could shift emissions to cause hot spots also proved unfounded, as an analysis of the first four years of the SO_2 cap-and-trade program showed that regional movements of allowances were minimal (i.e., 3% of all allowances used), and that trading may even have helped cool hot spots by encouraging emissions reductions at the largest plants.[454]

M. Retirement and/or Switching to Cleaner Power Sources

Neither standard resulted in significant switching to cleaner power sources such as natural gas or renewable sources, or the retirement of older coal-fired facilities. In retrospect, it can be seen that neither standard was sufficiently stringent to create an economic rationale that would lead firms to switch from existing coal-fired plants. Since existing coal power plants have paid off their capital costs, they generate electricity at low cost—around 2¢ per kWh.[455] This is sufficiently below the cost of alternative sources of power, including new gas generation at 3¢ to 4¢ per kWh,[456] to lead firms to invest heavily in these older plants before it makes economic sense to retire them in favor of new generation. Economic analyses have shown that even imposing New Source Performance Standards on old plants, thereby requiring a 90% reduction in SO_2 and attainment of a 0.15 lb/mmBtu NO_X standard, would force only limited retirement.[457] Therefore, Title IV standards, which are far less stringent than new source standards, would evidently not lead to significant retirement.

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[453] SO_2 information from EPA Allowance Tracking System; NO_X averaging plans in EPA 1999 COMPLIANCE REPORT, *supra* note 1, app. C-1.

[454] *See generally* GAO 2000 EFFECTS, *supra* note 202, at 7 (discussing the movement of allowance trading); Swift, *supra* note 196 (showing major reductions in largest plants, several of which were scrubbed). For acid rain trading program information, see http://www.epa.gov/airmarkets/trading.html (last updated Dec. 11, 2000).

[455] DOE ANNUAL ENERGY OUTLOOK 2001, *supra* note 1, fig. 73, at 67.

[456] *Id.*

[457] Bruce Biewald et al., *Grandfathering and Environmental Comparability: An Economic Analysis of Air Emission Regulations and Electricity Market Distortions, at* http://www.synapse-energy.com/publications.htm (Jan. 26, 1998).

V. CONCLUSION

A. *Stringency*

A central conclusion of this study is that both the Title IV NO_X and SO_2 standards were too lenient, and failed to align the private costs faced by firms in reducing pollution with the society-wide benefits from pollutant reductions. In both cases, the private cost to businesses of reducing an additional ton of pollution was far below the social health and welfare benefits of additional reductions.[458] In the case of SO_2, these costs were possibly an order of magnitude lower, indicating major net benefits of further SO_2 reductions. This calls for additional action by legislation or regulation to further reduce SO_2 and NO_X emissions levels.[459]

B. *Regulatory Design*

Other major findings of the study relate to regulatory design, where dramatic differences were found in the efficiency and effectiveness of the various regulatory programs for NO_X and SO_2. Overall, the two Title IV standards embody fundamentally different methods of establishing objective and fair regulatory regimes, reflecting fundamental choices in environmental law. The NO_X regulatory program, like most environmental regulation today, is rate-based and embodies an "equal effort" philosophy that accepts any base technology, but requires firms to achieve reasonable or best controls for that given technology. Title IV's SO_2 and the OTC NO_X cap-and-trade programs are two of the first major pieces of environmental regulation to impose an "equal cost per ton" approach to pollution, in which all firms face a similar cost for an additional ton of pollution.[460]

These different approaches were found to have very different effects on firm behavior and the functioning of the regulatory systems, as summarized in Figure 5-1.

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[458]. *See supra* Part IV.B.

[459]. *See* Northeastern States Petition, *supra* note 343. Also, legislation has been introduced in both House and Senate to significantly reduce emissions of four pollutants emitted by power generating plants (SO_2, NO_X, CO_2 and mercury). *See* Clean Power Act of 2001, S. 556, 107th Cong. (2001); H.R. 1256, 107th Cong. (2001).

[460]. This is the other fundamental alternative for objectively neutral regulation, and is implemented through market-based regulations such as pollutant charges set at a uniform price, or emissions cap and allowance trading systems. Under these approaches, all firms face an equal cost per ton of pollution, which is indicated by the allowance price in cap-and-trade systems, or the level of a pollutant charge or fee.

Figure 5-1. Comparison of Performance of Rate-Based and Cap-and-Trade Systems for NO_X and SO_2*

	Cap & Trade	CAA Rate
1. Allows business flexibility to choose different compliance approaches	+	-
2. Applies uniform standards, creating benefits for firms that choose cleaner technologies	+	-
3. Lowers cost of compliance	+	-
4. Creates continuous drivers for improvement and innovation	o	-
5. Ensures effective monitoring of emissions	+	+
6. Achieves high levels or 100% compliance	+	o
7. Minimizes transaction costs and conflict.	+	-

*Note: + is positive, o neutral, and – negative

Overall, the rate-based or equal effort approach is shown to have a number of key problems that distort the economic context faced by firms in ways that prevent them from achieving lower costs or greater environmental quality. It creates few incentives for firms to choose cleaner base technologies, eliminating what is possibly the principal driver towards environmental quality. Second, it creates incentives for the business to achieve emissions reductions at only one point in time, and not continuously. Third, rate standards are inflexible, driving up costs and limiting compliance technologies and potential innovation. These problems are both magnified and added to by the new source/old source distinction in current air pollution laws. These characteristics create conflict rather than alignment between environmental and economic drivers that cannot be resolved without moving away from the rate standard approach.

The cap-and-trade programs performed far better, creating significant environmental and economic benefits by imposing a mandatory environmental standard while allowing firms to minimize their compliance costs. Important features of these programs were the elimination of the distinction between new and old firms and between different technologies, allowing greater efficiency in creating pollutant reductions. Overall, this approach was considerably less intrusive to businesses and dramatically lowered compliance costs, without compromising environmental integrity.

Several overarching issues are worth mentioning. One is the difference in the industry/government relationship under the two approaches. The rate-based standards in place for NO_X and new SO_2 sources require government regulators to review and permit every firm action to control pollution, imposing high transaction costs and inflexibility. Under the cap-and-trade programs, the government role is transformed to one of assuring high quality monitoring and compliance, and leaving the choice of compliance technology to firm decision-making. This vastly reduces transaction costs and delay, and also creates less friction and conflict between regulators and the regulated, possibly making future regulatory needs less contentious.

The second concerns innovation. In order to broadly support incentives for efficiency, innovation, and pollution prevention, environmental regulations must create a continuous driver for pollution reduction. Rate standards cannot do so, as they apply only at one time and create incentives only to attain a precise level, providing no incentives to go beyond the limit. The cap-and-trade approach creates such continuous incentives, both through the lack of growth in the cap and the opportunity for trading.

Thirdly, the two approaches differ in their ability to align economic and regulatory drivers toward cleaner production. For both NO_X and SO_2, economic forces could lead firms to make pollutant reductions, including drivers for greater efficiency, the use of low-sulfur western coal, and cheaper and cleaner gas turbines for new generation sources. However, traditional regulations for NO_X and SO_2 were found to actively interfere with these economic drivers, primarily due to the inflexibility of rate standards and the distinction between new and old sources. The record of traditional environmental regulations in actually frustrating environmentally positive economic forces is one of the most troublesome aspects of current regulation. As with many problems, this was able to be resolved in the period studied by moving towards a performance-based approach using cap-and-trade systems to control NO_X and SO_2 pollution.

Fig. 2-2 SO2 Emissions and Allowance Cap, 1990-1999

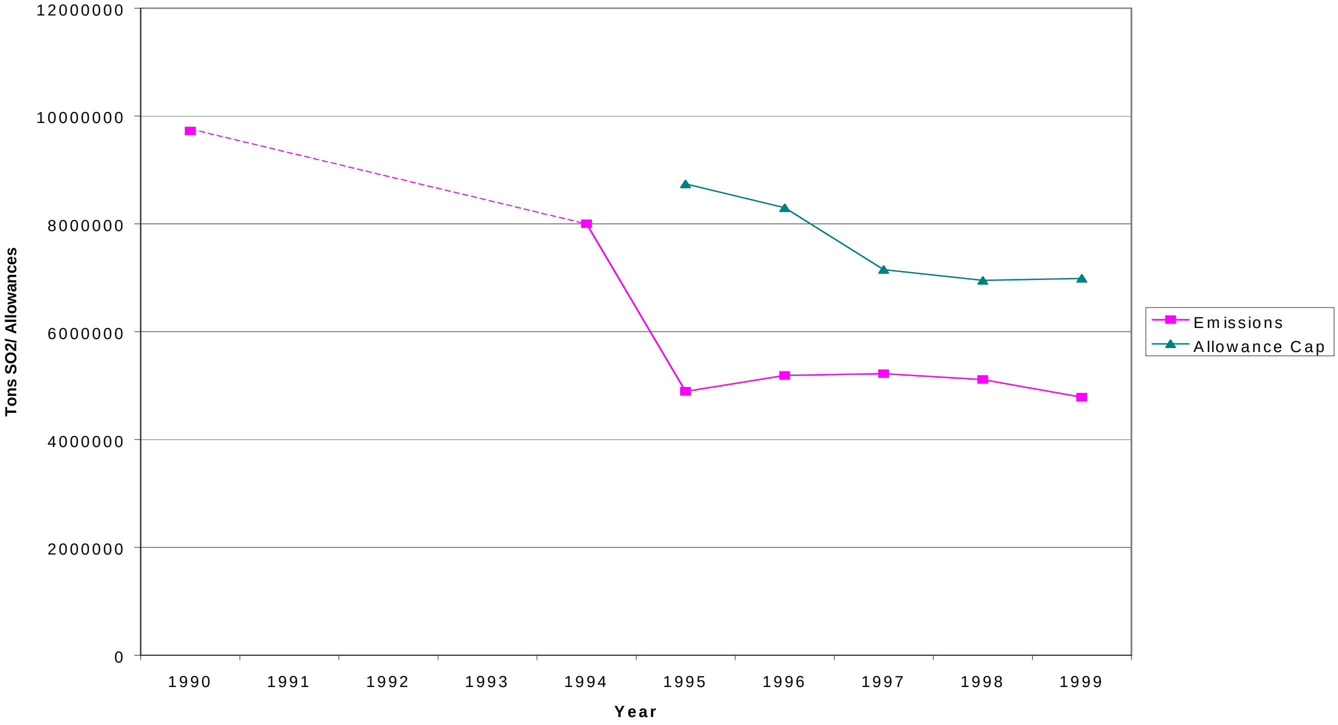

Fig. 2-3A SO_2 Allowances and Emissions of Top 10 Phase I Utilities by Allowances Allocated, 1995-1999

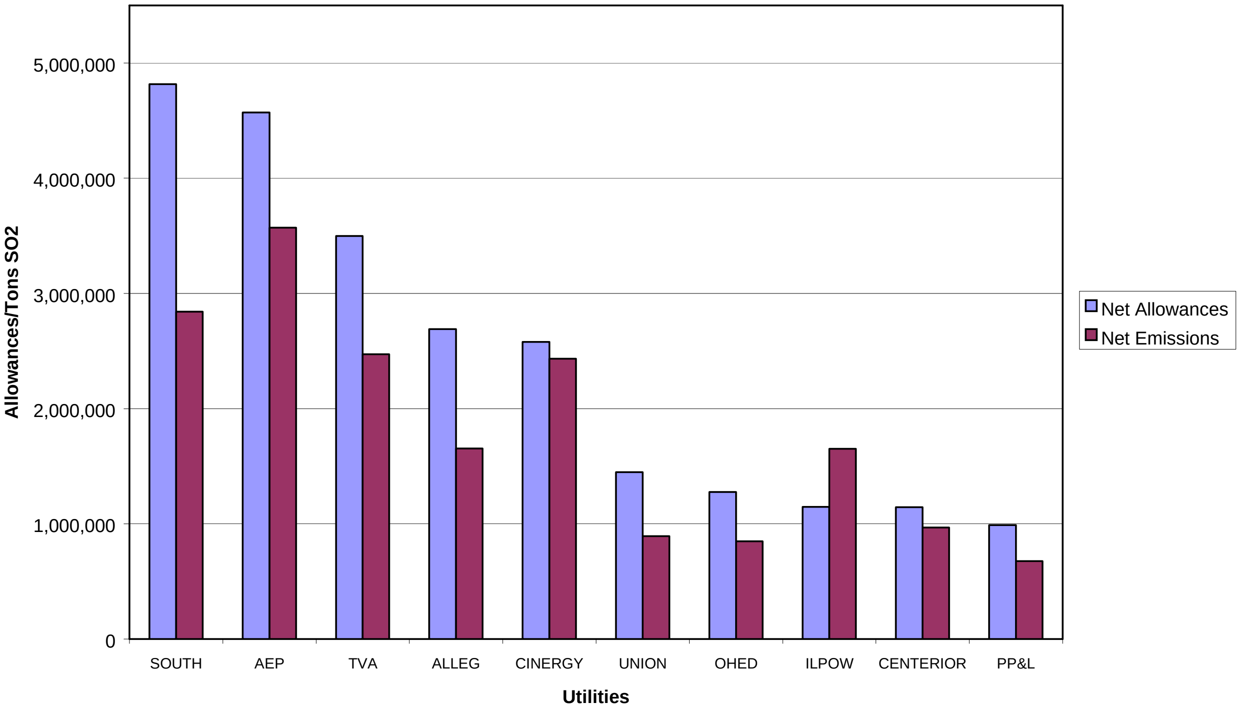

Fig. 2-3B SO_2 Allowances and Emissions, Phase I Utilities (except 10 largest), 1995-98

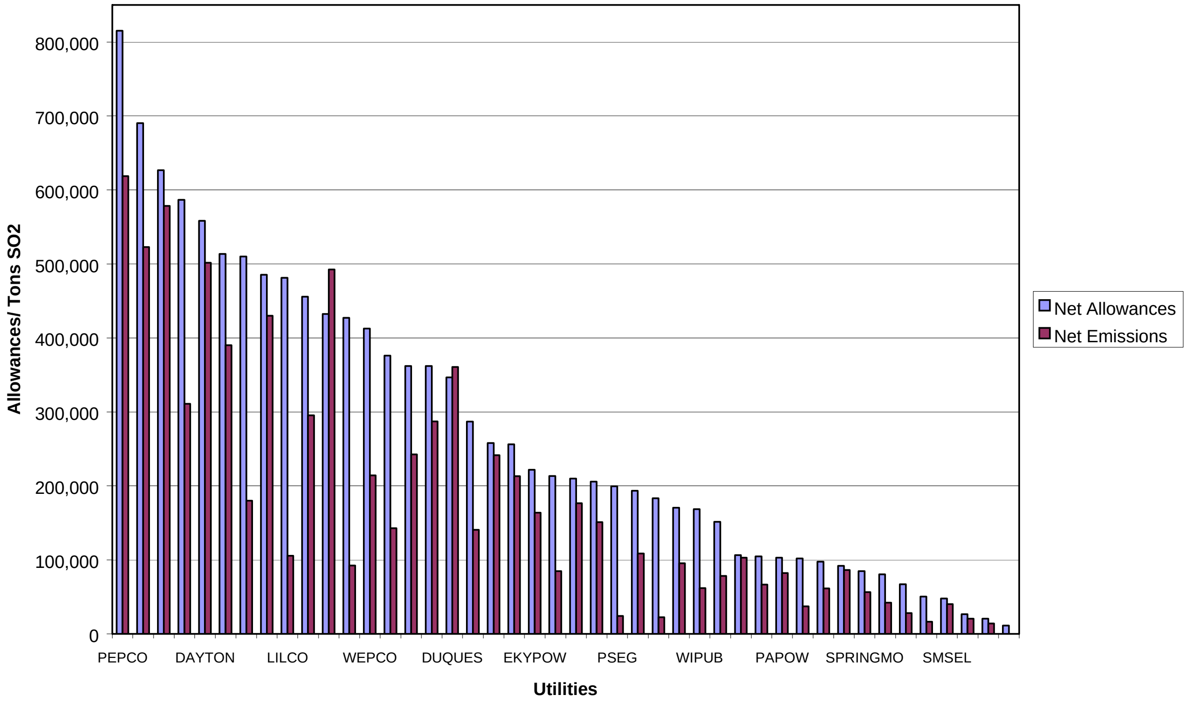

Fig. 2- 5 Compliance Methods of 51 Companies in Phase I (1995-1999)

Allowances gained

Total	Parent Company	Net Allowance Savings	Table 1 Under-emitters	Table 1 Over-emitters	Table 1 Scrubbed units	Table 1 Retired units	Substitution Units*	Bonus Allowances	Compliance Mechanism
0.70	Central Hudson	33,923	0	0	0		33,923	0	N/A
1.00	Cardinal	33,489	33,489	0	0		0	0	LSC
1.00	Iowa Power	11,295	0	0	0	11,295	0	0	Retire
1.00	Interstate Power	39,188	39,188	0	0		0	0	LSC
1.00	Kansas City	6,489	6,489	0	0		0	0	LSC
1.72	Midamerican	6,074	9,454	-3,380	0		0	0	LSC
2.00	Empire District	38,298	38,875	0	0		-577	0	LSC
2.00	Hoosier Energy	5,779	6,395	-616	0		0	0	LSC
2.00	S. Mississippi	7,546	0	0	0		7,546	0	N/A
2.00	City of Owensboro	64,659	0	0	64,659		0	0	Scrub
2.05	Duquesne Light	-14,237	20,807	-42,017	0		6,973	3,211	LSC/Trade
2.08	Atlantic City	71,879	0	-26,975	98,854		0	46,114	Scrub
2.28	IES Utilities	36,326	39,119	-2,793	0		0	0	LSC
2.96	Dayton	56,836	20,177	-62,166	0		98,826	0	Sub
3.00	East Kentucky Power	57,721	57,721	0	0		0	0	LSC
3.00	NIPSCO	334,559	105,037	0	229,522		0	152,355	Scrub
3.00	NYSEG	72,956	0	-6,276	79,232		0	0	Scrub
3.00	Utilicorp United	3,393	0	-1,367	0		4,760	0	Sub
3.00	VEPCO	167,688	0	-82,044	249,732		0	97,855	Scrub
4.00	Public Service of NH	16,517	0	-23,428	0		39,945	0	Sub
4.00	City of Springfield	28,542	4,012	0	0		24,530	0	Sub
4.00	Tampa Electric	-60,138	62,917	-131,769	0		8,714	0	LSC/Trade
4.17	S. Indiana Gas Co	74,560	2,309	-30,757	87,708		15,300	0	Scrub
4.21	BGE	46,445	0	-30,526	74,493		2,478	34,337	Scrub
5.00	Associated	329,950	314,005	0	0		15,945	0	LSC
5.68	Wisconsin Power & Light	128,668	80,600	0	0		48,068	0	LSC
6.00	LILCO	375,566	353,178	0	0		22,388	0	LSC
6.00	Commonwealth Edison	233,309	219,534	0	0		13,775	0	LSC
6.00	Northern States	38,112	10,862	0	0		27,250	0	Sub
6.19	PEPCO	142,389	24,997	-8,754	68,172		30,660	62,245	Scrub
6.20	Kentucky Utilities	275,801	89,417	-4,573	190,957		0	128,493	Scrub
6.33	GPU	42,789	0	-73,173	115,962		0	67,418	Scrub
7.00	Big Rivers	160,427	147	-16,414	139,665		37,029	98,890	Scrub
7.00	Dairyland	84,802	49,497	0	0		35,305	0	LSC/Sub
7.00	Kansas City Power and Light	146,332	76,746	0	0		69,586	0	LSC/Sub
7.32	Wisconsin Public Service	106,595	51,921	0	0		54,674	0	LSC/Sub
9.00	Consumers Power	119,406	102,187	0	0		17,219	0	LSC
9.23	Pennsylvania Power and Light	304,121	154,939	-3,251	80,154		72,279	50,921	All
10.26	Niagara Mohawk	43,121	0	-44,711	0		87,832	0	Sub
11.00	Indianapolis Power and Light	123,378	3,261	-21,570	157,814		-16,127	0	Scrub
11.30	Other Utility Companies	637,369	215,742	-38,357	338,072		121,911	177,860	N/A
14.40	Union Electric	554,952	448,480	-19,864	0		126,336	0	LSC
15.20	CIPSCO	48,196	90,022	-28,469	0		-13,357	0	LSC
17.00	WEPCO	198,480	82,825	0	0	107,355	8,300	0	LSC/Retire
22.20	Illinois Power	-503,208	70,258	-707,217	0		133,751	0	Trade
22.38	Allegheny Power	1,036,131	47,598	-98,589	1,053,448		33,674	569,609	Scrub
23.97	Cinergy	145,055	74,342	-262,427	202,428		130,711	120,470	Scrub/Sub
25.25	Ohio Edison	426,446	243,291	-87,574	20,596		250,133	75,520	LSC/Sub
26.00	TVA	1,025,569	292,345	-556,918	1,290,142		0	807,217	Scrub
29.68	Centerior	177,301	36,533	-203,713	0	63,855	280,625	7,081	Sub
36.46	AEP	1,001,083	344,991	-921,358	1,271,101	101,400	204,949	863,790	Scrub
49.07	Southern Company	1,976,284	1,602,950	0	43,664		329,670	141,972	LSC
467.28		10,518,211	5,526,657	-3,541,045	5,856,376	283,905	2,365,005	3,505,357	

* Includes 10 Opt-in Units

Fig. 2-6 Scrubber Installations by Year and Type

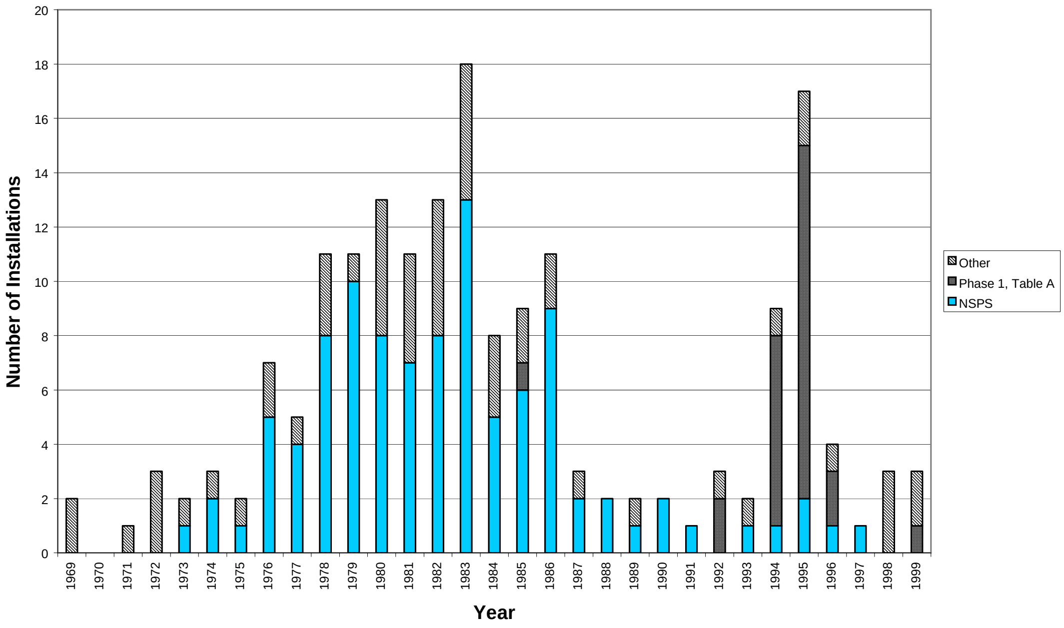

Fig. 2-9 Difference Between SO2 Emissions and Allowances, Phase I Units, 1995-1999

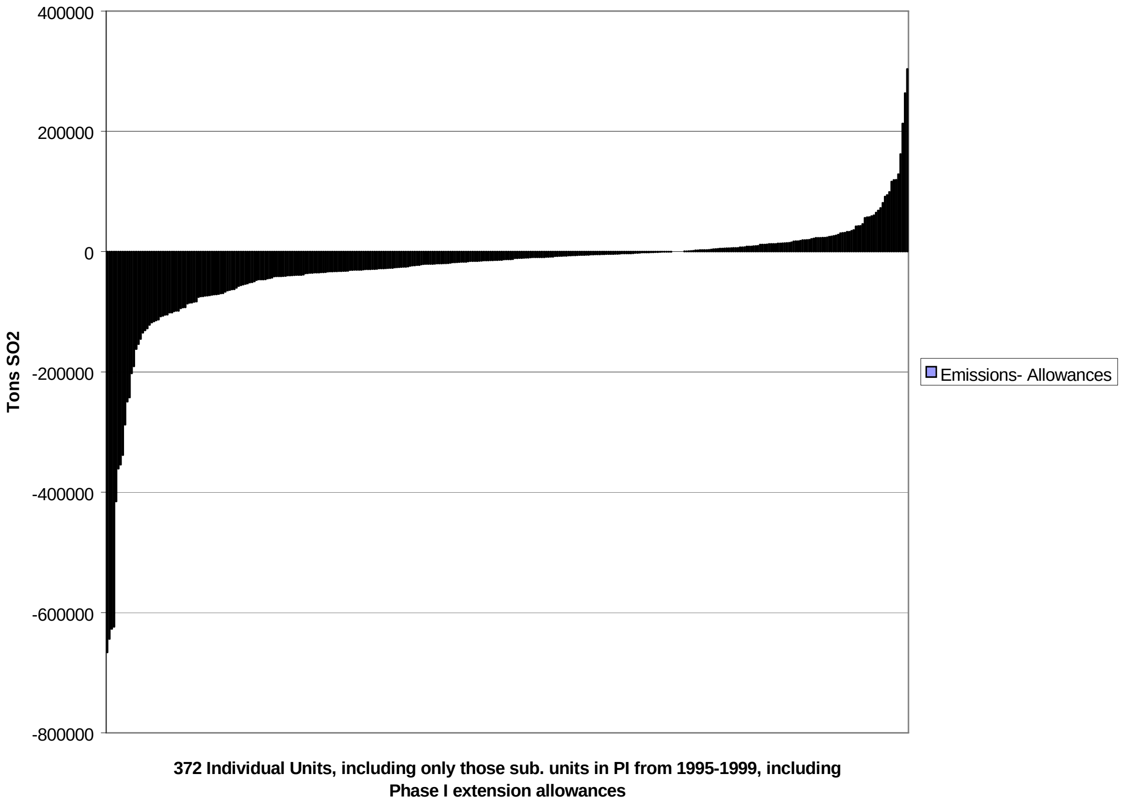

Fig. 2- 10 SO_2 Allowances Allocated and Emissions by State, 1995-1999

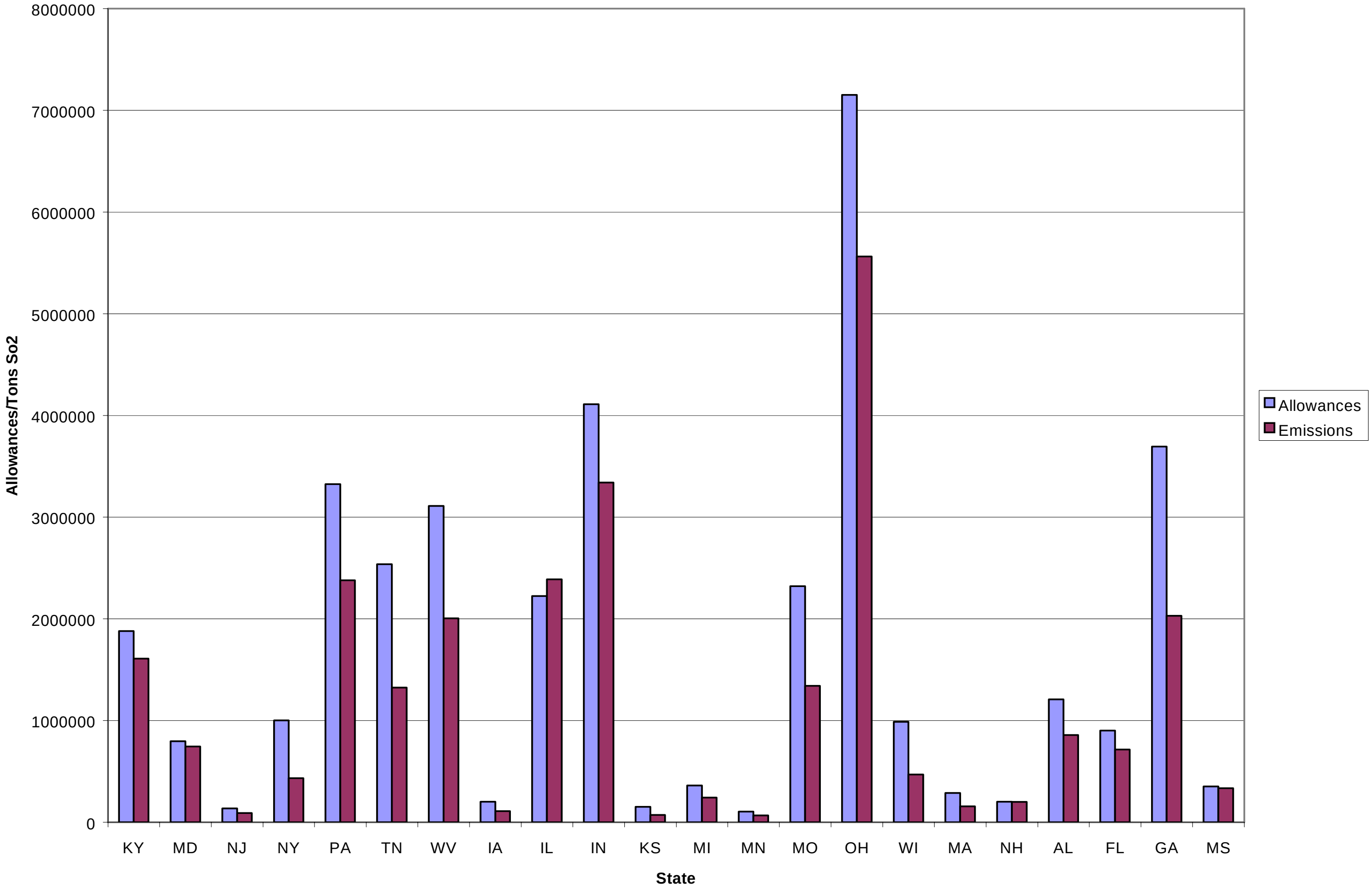

Fig. 2-11 Top 20 Phase I Plants by 1985 SO_2 Emissions: 1985 Emissions, 1999 Allowances, and 1999 Emissions

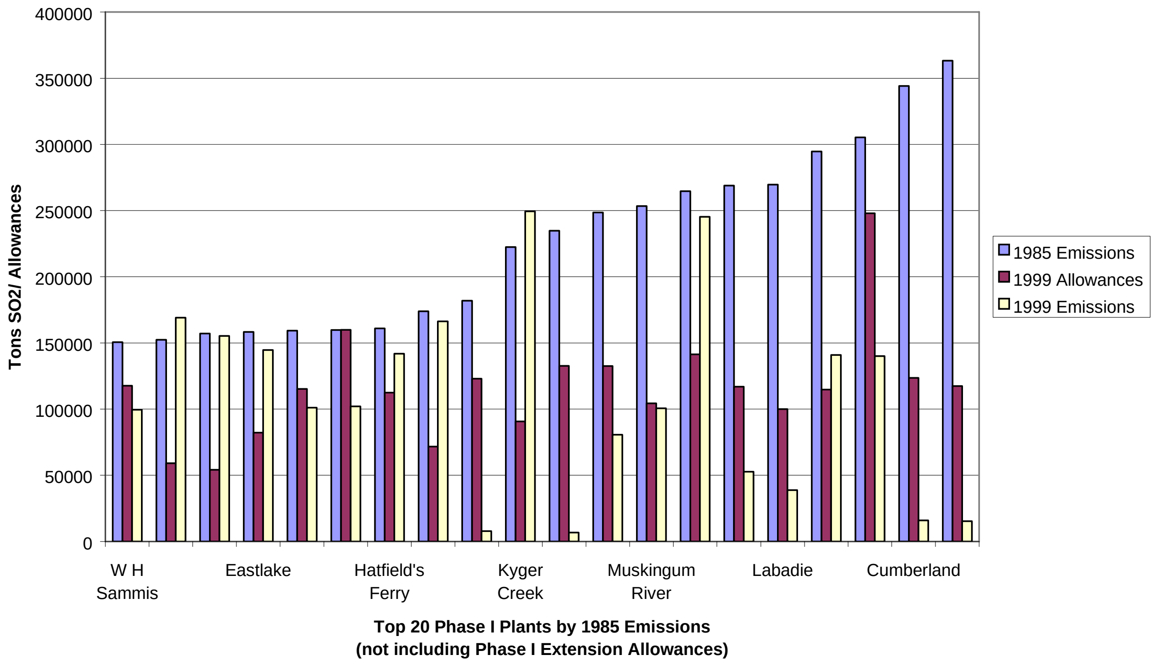

Fig. 3-2 NO_x Rate Reductions During Phase I

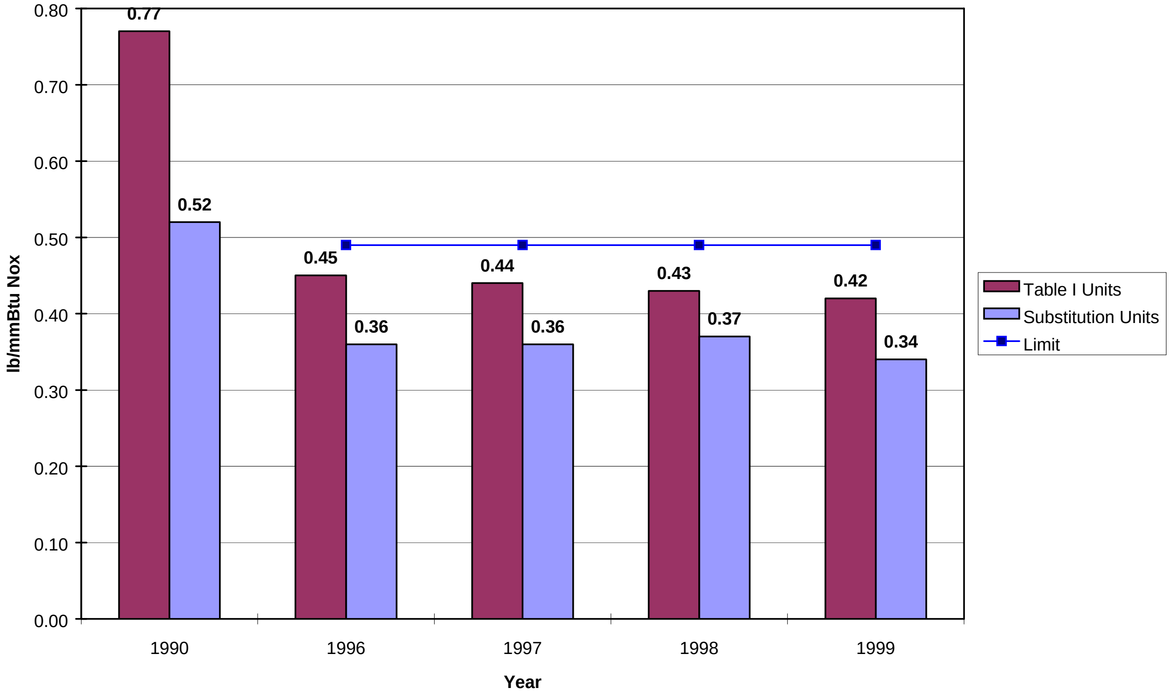

Fig. 3-3 NO$_x$ Tonnage Reductions During Phase I

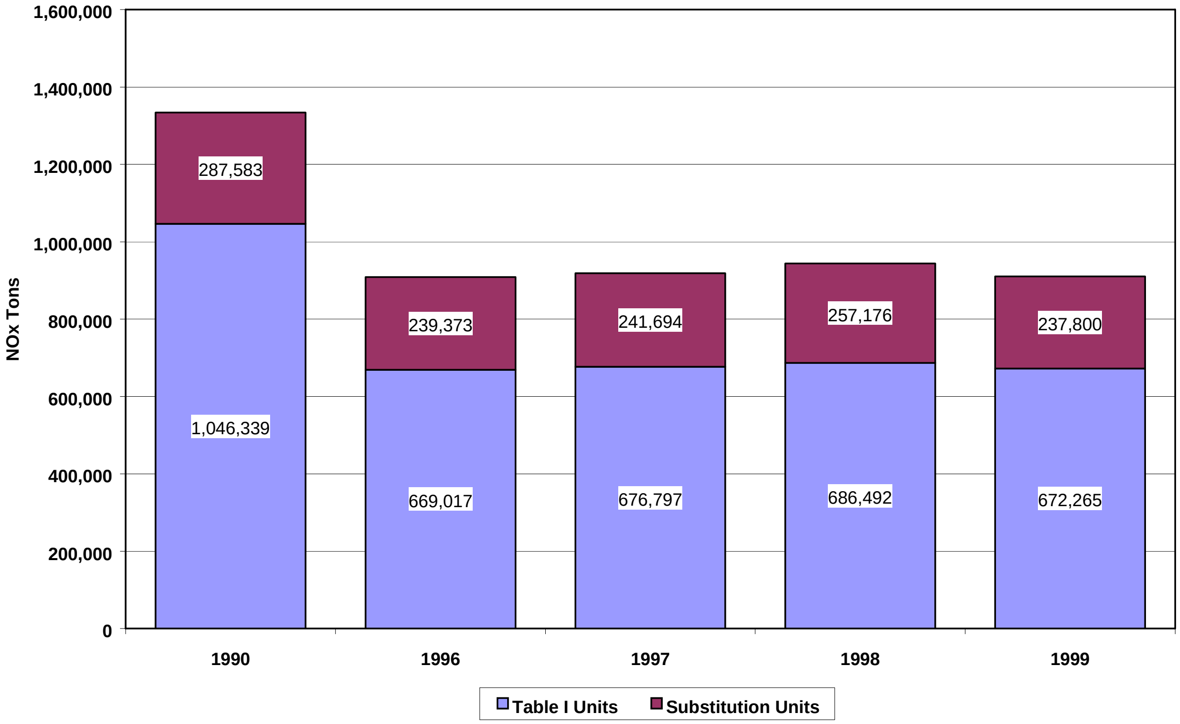

Fig 3-4 NO_x Controls on Phase I NO_x Plants, by Age of Plant

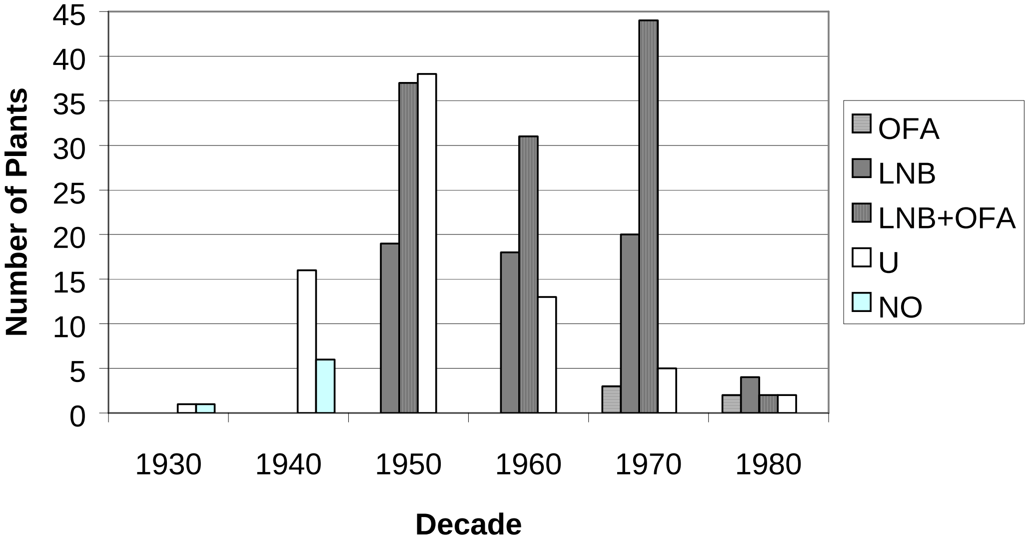

Fig. 4-4 Emissions Profile SO_2

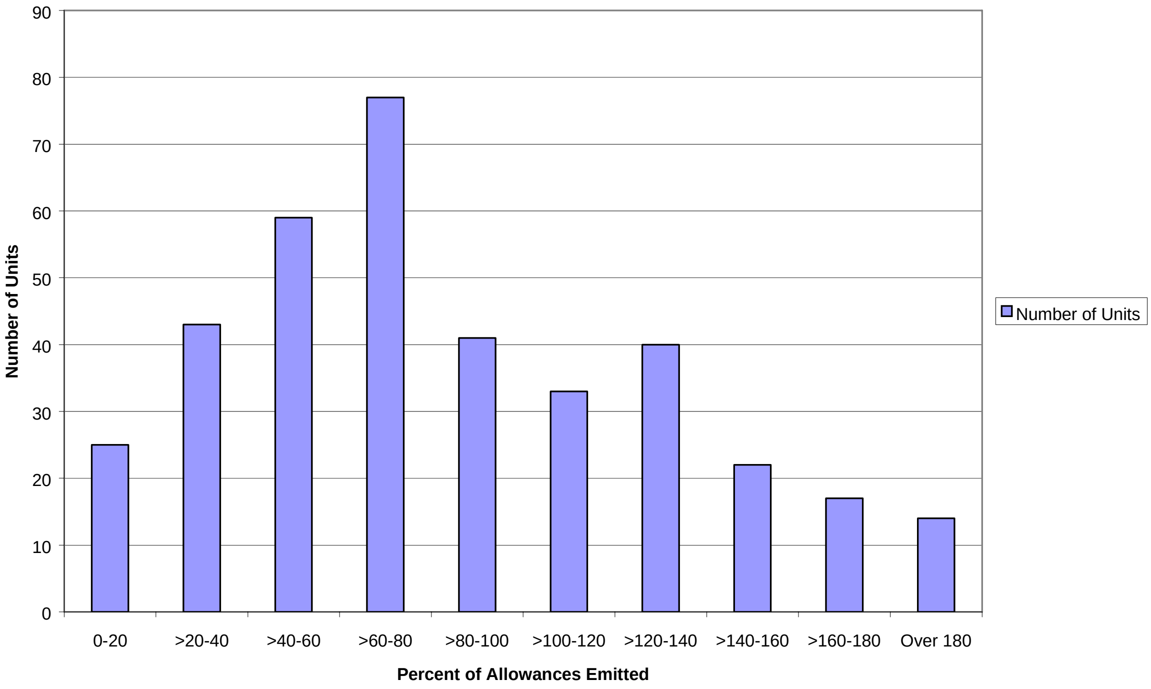

Fig. 4-5 Number of Units Emitting at Percent of NO_x Emissions Rate Limit