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Grandfathering and coal plant emissions: the cost of cleaning up the Clean Air Act

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Abstract

The Clean Air Act imposes much stricter emission limits on new coal-burning power plants than on older ones — a practice that has no obvious theoretical justification. Elimination of "grandfather rules", i.e., applying new plant standards to the US electric industry as a whole, would eliminate 40% of nationwide SO_2 emissions and 15% of NO_X emissions, while raising average retail electricity rates by only 4%. Under this scenario, 94% or more of existing coal plants would remain economically competitive with new gas-fired power plants. Policy options for elimination of grandfathering include: an explicit requirement that each existing plant meet new-plant standards; a "cap and trade" system of emission allowances similar to the current SO_2 trading system; and a generation performance standard, an interesting new variant on emissions trading which incorporates a more equitable and flexible allocation of allowances. © 2000 Elsevier Science Ltd. All rights reserved.

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1. Introduction

The Clean Air Act is widely recognized as an environmental success story. Compliance with the Act has, indeed, cleaned up America's air. Under its influence, there have been noticeable declines in the emissions of key pollutants such as sulfur dioxide (SO_2) and nitrogen oxides (NO_X), both precursors of acid rain.

Yet there is a less widely recognized feature of the Clean Air Act that limits its success and biases its benefits. Older facilities, those that were in existence when emission limits were adopted, are held to much less stringent standards than newer ones. This practice, known as "grandfathering" of the older facilities, has a substantial effect on overall emissions. As we will show, most of the SO_2 and NO_X emissions from coal-fired power plants – and almost half of all SO_2 emissions nationwide – would be eliminated if all power plants were held to the new-plant standards.

There are three principal sections to this article. Section 2 reviews the economic theory of grandfathering, arguing that there is little or no theoretical justification for differential treatment of old and new emission sources in environmental regulations, at least beyond a phase-in period.

Section 3 analyzes the data on plant emissions and costs, finding substantially lower average emissions from plants that began operation after 1975. Our simulations show that bringing industrywide average SO_2 and NO_X emissions down to new plant standards would impose noticeable costs and create a modest increase in the price of electricity. However, at least 94% of existing coal-fired capacity would remain economically competitive relative to new gas-fired power plants, even at today's low costs for gas plants. The competitive position of coal plants worsens if SO_2 and NO_X reduction policies are combined with other environmental regulations such as a CO_2 tax. To deal with such interactions, environmental policies should be coordinated across different pollutants.

Finally, Section 4 turns to policy options. A requirement that each existing plant must meet new-source standards would have advantages of logical transparency and impartiality; however, it is neither the lowest cost nor the most popular option today. A cap and trade system of allowances, like the existing one for SO_2 emissions,

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has many advantages, but also some important drawbacks. In particular, the initial process of allocation of allowances can lead to a new form of grandfathering. A variant on the cap and trade system, a generation performance standard (GPS), may do even better than existing trading arrangements – because GPS applies equitably across the entire industry, to old and new plants alike.

2. Grandfathering and economic theory

Economic theory offers little support for the inclusion of grandfather clauses in environmental regulations. The classic economic policy recommendation for environmental problems, the use of Pigouvian taxes to internalize externalities and reduce the incentives for pollution, makes no distinction between new and old sources of emissions. Newer policies favored by many economists today, such as tradable allowances, are compatible with many different initial distributions of pollution rights. There is, for example, no obvious basis in economic theory for the intricate allocation of SO_2 allowances under the 1990 Clean Air Act Amendments, as opposed to alternatives such as an annual government auction of all allowances (Ackerman and Moomaw, 1997).

The question of grandfathering has received little attention in the recent environmental economics literature. Economists in the "law and economics" school, who are often critical of environmental regulation, have argued that command and control regulation, combined with grandfathering of existing sources, gives a competitive advantage to the industries, firms, and regions where the existing sources are located. This creates a powerful, hidden self-interest in support of such regulation (Maloney and McCormick, 1982; Pashigian, 1985; Bartel and Thomas, 1987).

One perverse effect of grandfathering is the incentive it creates to prolong the life of old equipment. The initial imposition of auto emission standards, making new cars more expensive, led many people to hold onto their older, more polluting cars for longer. Similarly, two studies have estimated the effect of environmental regulation on the rate of capital turnover in the electric utility industry (Nelson *et al*., 1993; Maloney and Brady, 1988). Despite many differences in detail and outlook, the two studies' conclusions are quite similar: the regulations in place as of 1980 increased the average age of fossil fuel generating plants by 3–4 years.

What, then, is the rationale for grandfathering? The cost of installing pollution controls is lower when constructing a facility than when retrofitting an existing one. So it is possible that immediate application of new regulations could make it unprofitable to continue operating many existing facilities. However, the analysis in Section 3 shows that this problem does not apply to coal-fired electricity generation today, since virtually all existing coal plants would remain economically competitive under new-plant standards.

Perhaps the strongest argument for grandfathering is that imposing new rules on an existing facility seems unfair, as if the government is changing the rules during the game. This is an important but vague argument, which has been proposed in several different forms.

The most extreme claims about fairness compare the imposition of new regulations on existing facilities to seizure of property without compensation. Yet environmental regulation is only one of many government actions that can cause changes in the value of private properties. If all policy changes that reduce the value of existing property were classified as "takings" that entitled the property owner to compensation, the result would be to offer property owners a guarantee that the effects of laws and regulations will never change — an undemocratic and impractical outcome. The symmetrical policy of imposing windfall profits taxes to capture all increases in property values caused by government action is even less popular, but is no more or less defensible than the strongest forms of the "takings" argument (Kaplow, 1986).

A more moderate version of the fairness argument might rest on John Rawls' concept of "formal justice", which requires security for legitimate expectations arising from existing legal institutions, regardless of the content of those expectations. However, if this were made an absolute standard, it would suffer the same shortcomings as the "takings" argument. In practice, formal justice is one of several potentially contradictory principles, which often must be weighed against each other (see the discussion in Goode, 1987).

2.1. Perspectives from tax policy

Grandfathering has received more extensive treatment in analyses of tax policy; the 1986 tax reform included special provisions and transitional assistance worth $10 billion to owners of assets whose taxes were raised by the act. The economic critique can be heard here as well: Kaplow (1986,1992) has argued at length that compensation should almost never be paid for the effects of government policy changes. In his view, the risks of future government action are no different from any other risks facing an investor. Sheltering investors from risks is directly at odds with the incentive effects that lead to efficient resource allocation. The preferable response, according to Kaplow, is for an investor or business to buy private insurance against risk; the insurance premium will correctly internalize the risk, preserving the market incentive for risk reduction.

Other analysts have offered more mixed evaluations. Zodrow (1992) argues that grandfather rules can be politically desirable, converting potential losers from reform proposals into winners and building broader support for change. However, he suggests that grandfather rules should be used with caution; in particular, the length of time they are in effect should be carefully limited. If a grandfathering provision remains on the books much longer than is needed to offset the affected property owners' potential losses, then the excessive exemption constitutes a loss to the rest of society, making the policy undesirable.

In a similar middle-of-the-road position, Goode (1987) suggests 10 criteria for judging when investors deserve grandfathering or other compensation for tax law changes. While some of his criteria are specific to tax policy, others are relevant to environmental issues, including the following (where the "benefit" can be interpreted as the right to continue past levels of emissions):

- How specific are the expectations that an existing benefit will continue?
- Did the benefit originate as an intentional or accidental result of past policy?
- How controversial is the benefit? How much public discussion of change has occurred?
- How long ago did the investment occur? Was a change in policy under discussion at that time?
- How much has been invested, and how large would the losses on the investment be (both absolutely and relative to the investor's resources) if the policy change takes effect?
- How is ownership of the investments distributed by income and wealth? (That is, how rich are the people who will be paying the tax?)

In summary, the spectrum of opinion among economists, legal scholars, and tax analysts ranges from those who would always oppose grandfathering as a needless distortion of market incentives, to those who see it as a politically necessary expedient that should be used selectively in a time-limited and cautious manner. Only the most extreme advocates of the "takings" argument see grandfathering as a generally attractive, long-term policy.

However, the argument based on political expediency will remain important for the foreseeable future. Thus, the criteria for appropriate use of grandfathering should reflect the fact that it may be a necessary compromise rather than a desirable policy on its own merits. Particularly relevant to the electric power industry is Zodrow's concern about limiting the time period for which grandfathering applies, and ending it as soon as possible after the affected investors have been compensated for the change in policy. For regulated utilities, this implies that grandfather clauses in environmental rules should not last beyond the period required for full recovery of the capital that was in the rate base when the rule was adopted. Any use of the facility beyond that time, or investment in plant life extension, should be viewed as a decision made after the new rule was in effect, and hence subject to that rule on the same basis as new facilities.

The database used in Section 3 shows that almost one-fourth of all coal plant capacity operating in 1996 was built before 1965, and more than half was built before 1975. This suggests that many plants have had ample time for recovery of the capital investment that was in use when the regulations changed. Indeed, many of these older facilities have had substantial additional investment in plant life extension, while continuing to enjoy old-plant emission standards. When the Clean Air Act was adopted, policy makers did not anticipate that the regulation-induced cost differential would be great enough to stimulate widespread efforts to extend the useful life of older facilities (see Hahn and Hester, 1989). Yet today, power plants are operating for longer than originally expected, a trend which is likely to increase with the deregulation of the electric industry.

3. Power plants and the Clean Air Act

How does the Clean Air Act treat old and new power plants differently? To make a very long story short (see Biewald *et al.* (1998) for a much more detailed version), there are three principal forms of grandfathering under the Act. First, in attainment areas, i.e. regions that generally meet the Act's ambient air quality standards, new sources must meet both New Source Performance Standards (NSPS) and Prevention of Significant Deterioration requirements, while existing sources face no comparable requirements. Second, in non-attainment areas, new sources must meet both NSPS and New Source Review emission standards, while existing sources face some, but much weaker, standards. Finally, under the SO_2 allowance trading system adopted in 1990, existing sources receive free allowances roughly in proportion to their fuel consumption in the mid-1980s, while new sources must buy allowances to match their emissions. The analysis in this section focuses on the first two of these differences, while allowance trading is discussed in Section 4.

To analyze the effects of the Clean Air Act on SO_2 and NO_X emissions, we have assembled a database combining generation, cost, and emissions data for individual coal-burning power plants in 1996. The database combines data from the Energy Information Administration on unit capacity ratings and vintages, EPA data on emissions by stack, and Utility Data Institute figures on fuel costs, operating costs, and electricity generation by plant. The 886 units in the database generated 1552 million MWh in 1996 – 89 percent of the coal-fired generation, and 50 percent of all electricity generation by utilities in the US that year. Thus, our calculations rest

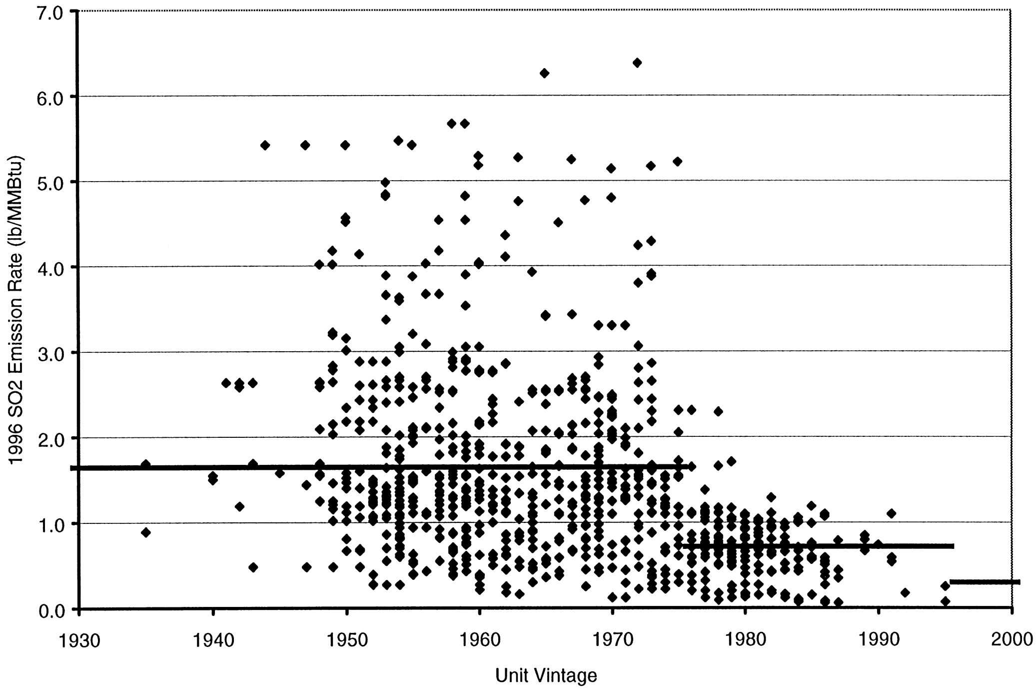

Fig. 1. 1996 SO_2 emissions by vintage.

on a plant-by-plant examination of virtually the entire fleet of coal-burning facilities.

3.1. Emissions and costs under current conditions

The change in emission rates caused by the Clean Air Act can be seen in Figs. 1 and 2, showing SO_2 and NO_X emissions, respectively. Each point represents a coal-burning unit; the horizontal coordinate is the unit's vintage (first year of operation), and the vertical coordinate is the unit's emission rate in lb/MMBtu. In both cases, there is an extremely wide range of emission rates among the older plants. Interestingly, while the patterns of pollution by age appear similar for SO_2 and NO_X, it is not the same units that are high emitters for both pollutants. Some of the high SO_2 emitting units are low NO_X emitters, and vice versa.

In both graphs, a sharp drop occurs in maximum, and average, emission rates in the mid-1970s, as the regulations adopted in 1970 took effect. The first NSPS applied to plants that began construction after August 1971; with typical construction and permitting schedules, this corresponds to plants that came on-line in the mid-1970s.

Three different eras are indicated by three horizontal lines on each graph. The first line is the average emission rate for units that began operation in 1975 or earlier; for SO_2, in Fig. 1, it is 1.7 lb/MMBtu. The second is the average emission rate for units that began operation in 1976 or later – 0.7 lb/MMBtu for SO_2. The third is the emission rate now required by New Source Review (NSR) for new plants in non-attainment areas – 0.3 lb/MMBtu for SO_2. The corresponding levels for NO_X in Fig. 2 are 0.7, 0.4, and 0.15 lb/MMBtu.

Note that the third line, representing current NSR standards, is below the level of most (Fig. 1) or all (Fig. 2) of the post-1975 plants. NSR requires that new plants meet the lowest achievable emission rate (LAER), a standard that has declined over time as control technologies have improved. LAER for the late 1990s is a lower emission standard than was required of plants that began operation 10 or 20 years earlier. That is, the third line on the graphs represents the emission standards that would apply to a new coal plant built today, which are lower than the standards for existing post-1975 plants – which in turn are lower than the standards for pre-1975 plants.

Few, if any, coal plants are likely to be built in the near future. Almost all new electricity-generating capacity built in the next 20 years is expected to be natural gas-fired combustion turbine and combined cycle plants (EIA, 1997a). The combination of improvements in gas turbine technology and remarkably low natural gas prices has made new gas-fired capacity a bargain, with estimated total costs of construction and operation as low as \$30/MWh for plants running at a high capacity factor. Gas-fired power plants emit no SO_2 and insignificant quantities of NO_X, making them desirable in terms of emission reduction as well.

However, while it appears uneconomic to build a new coal plant, it is quite economically attractive to keep existing coal plants running. Since the capital costs of

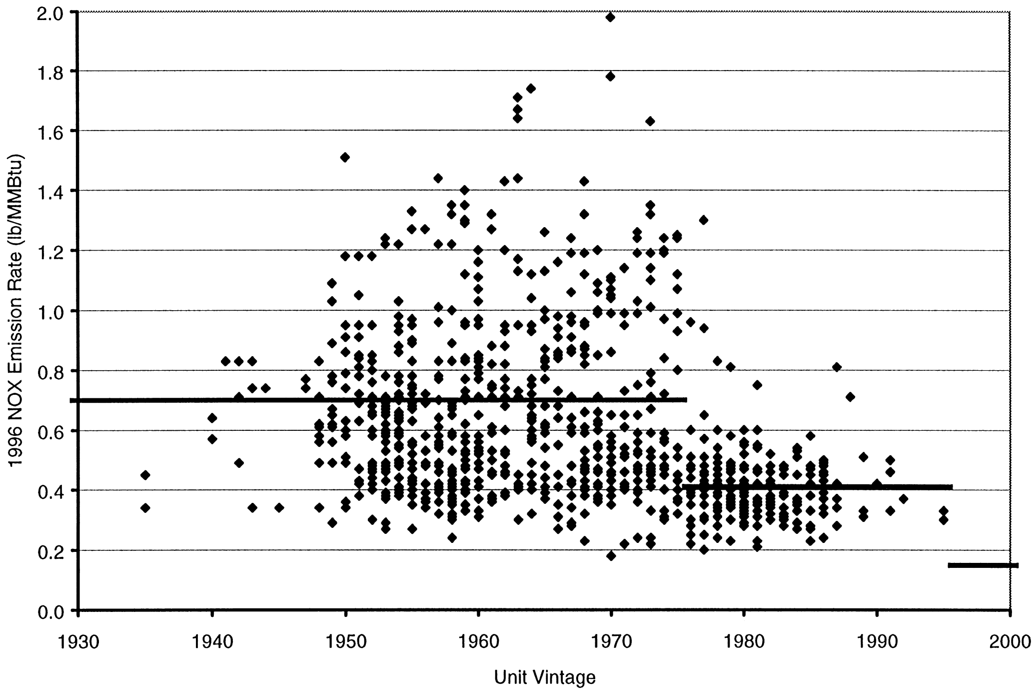

Fig. 2. 1996 NO_X emissions by vintage.

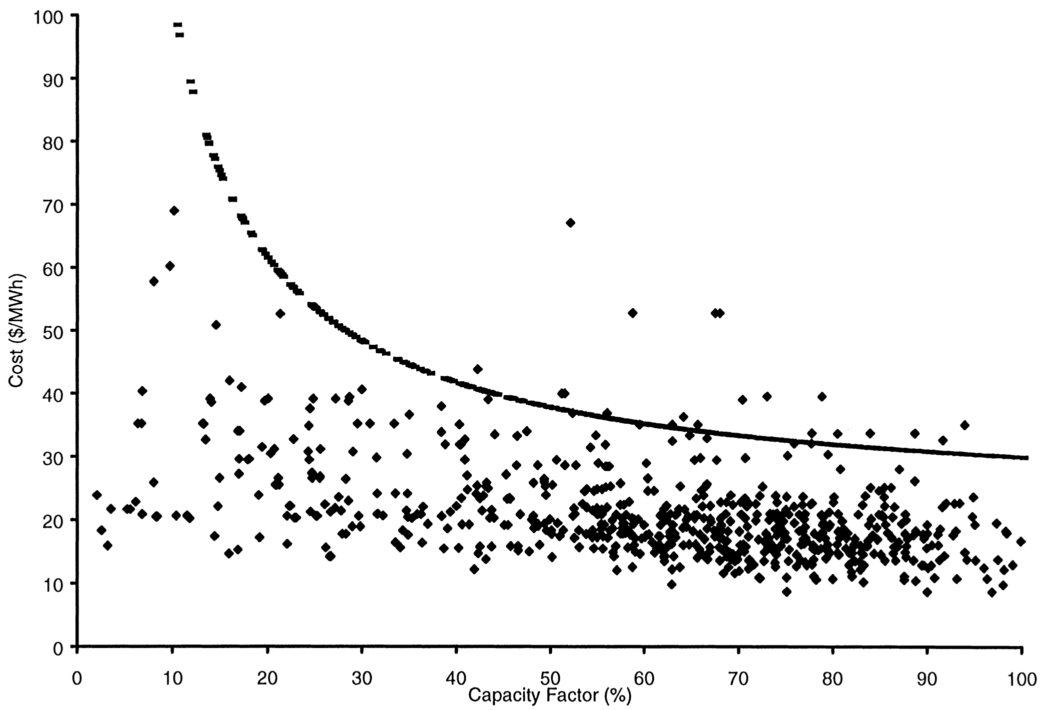

Fig. 3. Existing coal versus new gas CC; current conditions.

existing plants are sunk costs, all that can be saved by shutting them down are the operating costs. So the appropriate comparison is between the operating costs of existing plants, and the full operating plus capital costs of new gas-fired plants that could replace them. Running the coal plant is cheaper than building and operating a replacement in almost every case, as shown by Fig. 3. Each dot is an existing coal unit; the horizontal

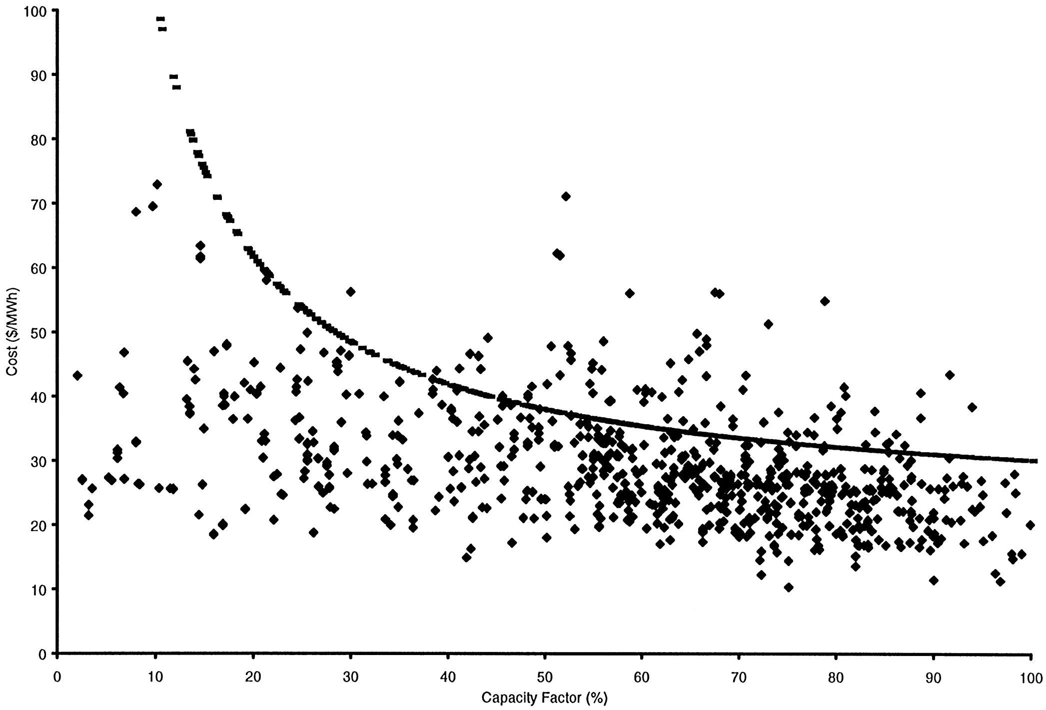

Fig. 4. Existing coal versus new gas CC; comparable SO_2 and NO_X emissions.

coordinate is the capacity factor (the ratio of actual 1996 output to maximum possible annual output), and the vertical coordinate is the operating cost of electricity generated by the unit. The curved line on the graph represents the average capital plus operating cost of electricity generated by a new gas combined cycle unit; the average cost is lower at high capacity factors since the fixed capital costs can be spread over more electricity generation.

Points above the line in Fig. 3 represent coal units for which the 1996 operating costs exceeded the costs of building and operating a gas-fired unit at the same capacity factor. Only 20 of the 886 coal units are above the line. These 20 units are potentially at risk of being shut down as a result of market forces. It is also possible, though, that they could renegotiate their coal contracts, cut other operating expenses, or operate at a lower capacity factor, any of which could make them competitive. In any case, these 20 units are smaller than average, representing only 1% of the industry's total capacity. The more important economic conclusion is that while building and operating new gas plants is cheap, continuing to run existing coal plants is almost always cheaper (for another recent study reaching similar conclusions, see Biewald, 1997).

3.2. *The environmental comparability scenario*

We can now pose the central question about the economics of grandfathering under the Clean Air Act. Is the continued profitability of existing coal plants dependent on their exemption from new-plant emission standards? If existing plants had to meet NSPS and NSR standards, would the added cost of emission controls drive them above the line in Fig. 3 – meaning that it would be cheaper to replace them with new gas plants? To anticipate a conclusion that requires a little explanation, the answer will be seen in Fig. 4: if the industry as a whole had to meet current new-plant standards, only a small number of additional units would become uneconomic.

To model the impact of new-plant emission standards on existing plants, we did not assume that every unit would individually comply with NSPS and NSR. Rather, we assumed that the industry as a whole had to meet these standards. That is, average emissions for all 886 coal units had to be reduced to 0.3 lb/MMBtu of SO_2 and 0.15 lb/MMBtu of NO_X, the levels of the lowest, rightmost horizontal lines in Figs. 1 and 2. We then constructed an "environmental comparability" scenario, based on the assumption that the industry would utilize a market-based system to trade emission rights in order to achieve the aggregate reduction, while keeping generation from each unit unchanged.

Under these assumptions, what strategy would be adopted for emission reduction? We used EPA data on control costs and removal rates of available technologies (from EPA, 1996, Appendix 5), and applied them to units in our database, in order of increasing cost per ton of emission reduction, until we reached the target emission levels. More specifically, for SO_2 we first assumed that a limited quantity of additional low-sulfur coal was available, and then added scrubbers to achieve the balance of the required reduction. For NO_X we examined both combustion controls (e.g., low-NO_X burners) and post-combustion controls (e.g., selective catalytic reduction), which can be applied jointly or separately at an individual unit. Combustion controls are always cheaper, so they were considered first. Nine types of combustion controls, differentiated by boiler type and other plant characteristics, were applied as appropriate.

The resulting scenario has total annual SO_2 emissions reduced by 7.3 million tons, and total annual NO_X emissions reduced by 3.3 million tons. For SO_2, the reduction represents 75 percent of the 1996 emissions from this group of coal plants, and roughly 40 percent of total US emissions from all sources. For NO_X, the reductions represent 75 percent of the 1996 emissions from this group of coal plants, and roughly 15 percent of the US total.

The added cost of emission controls amounts to $9.6 billion on an annualized basis. Of this, $0.4 billion is for controls at units that might economically be retired and replaced with new capacity. Thus, the net anticipated cost of emission controls for the scenario amounts to $9.2 billion per year, of which about two-thirds is for SO_2 controls and one-third is for NO_X controls. If passed on to consumers, this $9.2 billion would be a 4.3% increase in the retail cost of electricity, which totaled $212 billion nationwide in 1996.

Even with the large added cost, almost all existing coal plants remain competitive under the environmental comparability scenario, as shown in Fig. 4. This figure portrays the same group of coal units, plotted in much the same way as in Fig. 3, with the same line indicating the cost of new gas-fired replacement plants. Here, however, the points for the coal units have been moved up to include the cost of SO_2 and NO_X emissions reduction. In this scenario 98 existing coal units are rendered uneconomic, or at risk of being so (i.e., they are above the line in Fig. 4), including the 20 that were already at risk under current conditions. These 98 units produce only about 6 percent of total coal-fired generation. They are about one-half the size, on average, of the units in our database.

At the same time, the 788 other units, accounting for 94% of total capacity, would continue to operate economically. That is, for the vast majority of existing coal units, operating costs are low enough, even when the costs of emissions controls are added, to remain below the cost of replacement with a new gas combined cycle unit.

This analysis probably overstates the costs of achieving the environmental comparability scenario for a variety of reasons. Market responses such as improved energy efficiency, fuel switching, changes in capacity factors, and improvements in the cost and performance of retrofit controls – none of which are included in our analysis – would likely contribute to lowering the costs of achieving emissions reductions.

In general, the outlook is bright for the economics of existing coal plants. The real price of coal has been dropping, and is projected to decline at more than one percent per year through 2015 (EIA, 1997a). Other operating costs of existing coal plants are declining in real terms as well (Utility Data Institute, 1997). And even the most expensive of the older coal plants can be competitive at lower capacity factors, where the cost of a replacement plant is higher (represented by the rising left-hand portion of the gas-plant cost curve in Figs. 3 and 4). For reasons like these, some of the 98 at-risk units would undoubtedly remain competitive even under the environmental comparability scenario.

3.3. *Effects of a carbon tax*

The Clean Air Act also regulates other criteria air pollutants, namely particulate matter, volatile organic compounds, carbon monoxide, and lead. There are grandfather provisions for these emissions as well, but meeting new-plant standards in these cases would impose only modest costs on existing coal plants, several orders of magnitude smaller than the costs of SO_2 and NO_X emissions reduction. With few exceptions, public policy toward other pollutants is far less important to the economic prospects for the coal industry.

The leading exception is carbon dioxide (CO_2), a ubiquitous result of fossil fuel combustion and a potent contributor to global climate change. Policy initiatives that address the threat of global climate change, such as the Kyoto protocol, are all but certain to call for reductions in US emissions of CO_2 – roughly one-third of which come from electricity generation. Unfortunately, our environmental comparability scenario which abates SO_2 and NO_X emissions does almost nothing to reduce CO_2 emissions. New gas plants emit less than half the CO_2 per MWh of coal plants, so any CO_2 reduction strategy will strongly favor a switch to gas.

To analyze a hypothetical policy, we return to our environmental comparability scenario, adding to that scenario a $10/t tax on CO_2 emissions (equivalent to $40 per metric tonne of carbon). This is a typical tax assumption in recent policy discussions of electric utilities, though lower than many proposals that have been introduced in discussions of global climate change. Fig. 5 presents the revised results, in the same format as Figs. 3 and 4.

The CO_2 tax raises the cost of electricity from gas plants by $3.60/MWh; the gas cost curve in Fig. 5 has moved up by that amount, relative to its position in Fig. 4. However, the tax raises the cost of coal-fired electricity by an average of $10.30/MWh. As a result, the coal units have moved up, on average, by $6.70/MWh

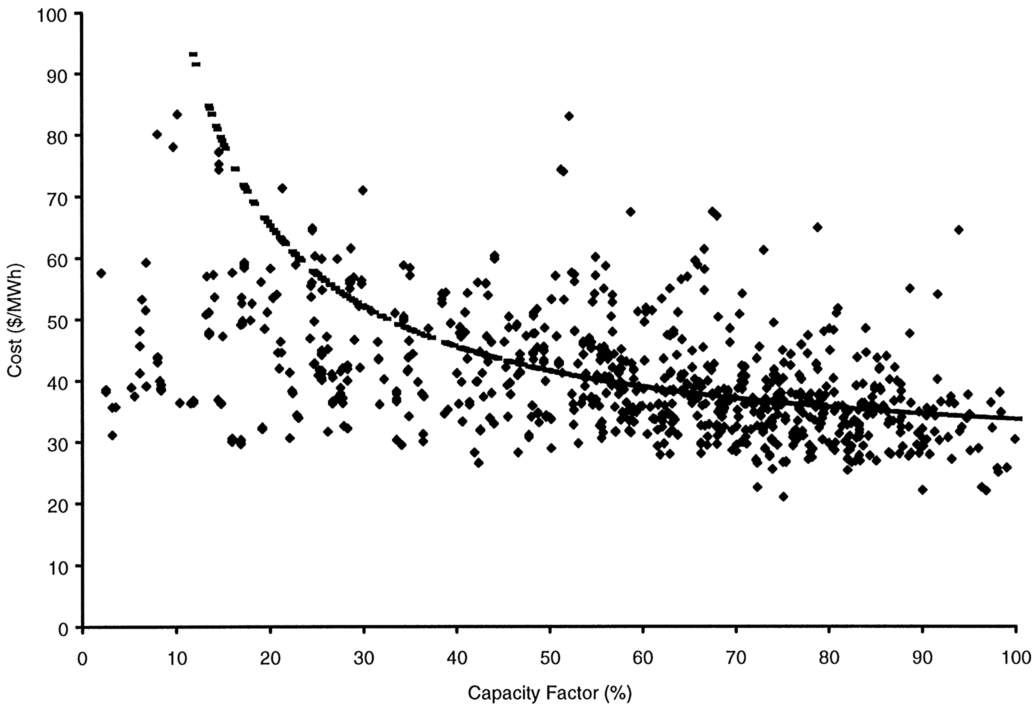

Fig. 5. Existing coal versus new gas CC; comparable SO_2 and NO_X emissions, and CO_2 at $10/t.

relative to the gas cost curve. The total impact of the CO_2 tax on the competitive margin of the coal plants is $10.4 billion ($6.70/MWh multiplied by total coal-fired generation of 1552 GWh), similar to the total cost of the environmental comparability scenario. While either the CO_2 tax or the SO_2 and NO_X standards alone would allow almost all coal plants to remain competitive, the picture is quite different when we combine the two policies, as in Fig. 5. With both policies in place, 379 existing coal units, representing 36% of total capacity, become at risk.

A shutdown of one-third of total coal capacity is hard to imagine, and the options for at-risk units, as discussed above, would apply here as well, mitigating the economic impact of the combined environmental policies. Nonetheless, an active CO_2 abatement policy, together with the elimination of grandfathering for SO_2 and NO_X, could lead to significant coal plant retirements.

The possibility of plant shutdowns due to a carbon tax or other climate change policies affects our analysis of SO_2 and NO_X emissions. In the environmental comparability scenario, we projected the need for substantial investments to reduce SO_2 and NO_X emissions from existing coal plants. It would be wasteful to make such investments in plants that might have to be shut down to meet carbon reduction goals. (Similar interactions could arise if controls are introduced on mercury emissions from coal-burning plants, a possibility that we did not examine in this analysis.) Only through coordinated abatement strategies across different pollutants is it possible to achieve a cost-effective plan for environmental protection.

The economic analysis shown in Figs. 3–5 is summarized in a different format in Fig. 6. Here the vertical coordinate measures the operating cost margin, i.e. the difference between the operating cost for existing coal units and the cost of replacement gas plants. In graphical terms, it is the vertical distance between the points for coal units and the gas-plant cost curve in the earlier figures. A positive margin in Fig. 6 corresponds to a plant that lies below the gas-plant cost curve in the earlier figures; a negative margin corresponds to a plant that was identified as uneconomic or at risk in our earlier discussion. To construct Fig. 6, the coal units were arranged from left to right in decreasing order of operating cost margin. The horizontal axis depicts the total amount of 1996 generation from the coal units.

The top line in Fig. 6 represents the results shown in Fig. 3. Under current conditions, most coal units have clearly positive margins, and only the last 1% are more expensive than replacement plants. The second line represents the environmental comparability scenario, and the results shown in Fig. 4. While the costs of reducing SO_2 and NO_X emissions have lowered margins for all coal units, only the last 6% have negative margins. The lowest line in Fig. 6 represents the environmental comparability scenario with the addition of a $10/t tax on CO_2 emissions, as shown in Fig. 5. Now, more than

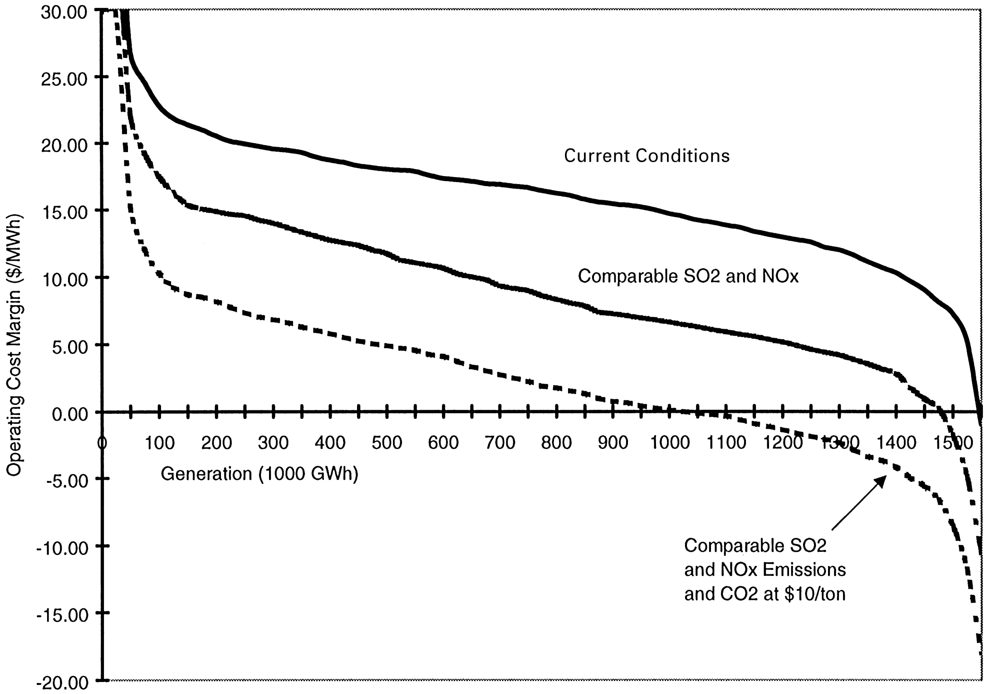

Fig. 6. Operating margins for existing coal generation: Three environmental regulation scenarios.

one-third of total generation comes from plants with negative margins; i.e., the last third of the curve lies below zero.

The fact that a combination of possible policies would make many coal plants uncompetitive qualifies, but does not negate, our earlier finding. Elimination of grandfathering under the Clean Air Act, by itself, would allow almost all coal plants to remain competitive.

4. Policies to promote environmental comparability

We have shown that virtually all existing coal-fired power plants could meet the stringent SO_2 and NO_X standards for new sources and still remain competitive with replacement plants. At today's abatement and control costs, grandfathering of existing coal plants is not an economic necessity for the electric power industry. If new-source standards were applied to all power plants, the result would be massive reductions in industry total – and even national total – SO_2 and NO_X emissions, in exchange for a modest percentage increase in electricity bills.

Grandfathering of existing facilities was politically helpful in winning passage of the Clean Air Act and its amendments. At the time, it may have seemed that fairness to established plants required that they initially face more lenient standards. Yet today, the grandfather clauses and the facilities they favor are no longer young. The criterion of fairness now points in the opposite direction: it is unreasonable for the oldest plants to enjoy an unending windfall, at the expense of both their newer competitors and the quality of our air.

The issue of fairness between old and new facilities is of increasing importance in an era of deregulation and retail competition among electric utilities. Utilities with older power plants will be competing head-to-head with developers of new plants. Grandfathering will give the owners of the older plants a competitive advantage over newer facilities, creating a market distortion.

How could environmental comparability between old and new plants be achieved? We will examine three policy options: application of new source requirements to all plants; emission cap and trade systems; and finally, generation performance standards, a trading system that offers some improvements over existing cap and trade approaches.

4.1. *Extension of new source requirements to all plants*

The most direct approach to environmental comparability would be to require each existing plant to meet the standards imposed upon new power plants. This approach has the advantages of logical transparency and simplicity: it operates in an obvious manner, and reduces the number of different regulatory categories and standards. Its impartiality between old and new plants, or any other categories, is obvious as well. These strengths should not be dismissed lightly – although, as we will see in a moment, there are also substantial drawbacks to the direct regulatory approach.

Extension of new source requirements to all plants would likely be done somewhat differently for NO_X than for SO_2, due to differences in current regulations. For NO_X, existing plants would be required to emit at the lowest achievable emission rate or install the best available NO_X control technology. This approach would essentially require all existing plants that do not already have control measures to install low-NO_X burners and selective catalytic reduction.

One modification of this approach would be to establish "sunset" provisions, which would limit the exemption from New Source Review that existing plants currently enjoy. The exemption might expire after a fixed plant lifetime (e.g., 40 or 50 years), or after a certain level of spending on upgrades and technology replacement has been reached (since at that point, the plant effectively becomes a new facility).

Since a trading system for SO_2 allowances already exists, comparability for SO_2 could be achieved by allocating allowances equitably among all generation companies. Allowances could be allocated to all generation companies on the basis of the emissions they would have, based on their annual generation, if they reached the lowest achievable emission rate or installed the best available control technology. Some remaining allowances could be placed in a "new source reserve", so that new plants could be allocated allowances on the same basis as all other plants.

While this approach would be very effective at ensuring comparable environmental standards, it would be far from the most economically attractive option. Requiring all plants to install control technologies is less efficient than a trading system, because it does not provide companies with the flexibility to reduce emissions through less expensive alternatives, such as emissions averaging, alternative dispatching, energy efficiency, renewable resources or plant retirement. Nor does it allow those with high abatement costs to purchase allowances from those with lower costs, a key feature of trading options.

In our environmental comparability scenario, in which allowance trading was assumed to take place, only 259, or less than 30%, of the 886 coal units ended up in compliance with both the SO_2 and the NO_X standards for new sources. These 259 units were bigger than average, but still accounted for only 38% of capacity and 42% of electricity generation for the plants in our database. Roughly three-fifths of both capacity and generation came from plants where it was more economical to buy allowances for one or both pollutants than to meet the standards on their own.

Requiring each plant to meet new source standards, therefore, would have added significantly to the costs of compliance that we estimated in Section 3. In comparison to direct regulatory approaches, trading systems hold out the promise of substantial cost reduction, which is a principal reason for their current popularity.

4.2. Emission cap and trade systems

Emission trading has received increased attention and support since the 1990 Clean Air Act Amendments established the SO_2 allowance cap and trade system. Such systems establish an overall emission cap, in tons, and require companies to hold one emission allowance for every ton emitted each year. Allowances are allocated — given or sold — to the companies generating the emissions; the companies are then free to buy and sell allowances in an open market.

To achieve environmental comparability, an emission cap and trade system would have to be explicitly designed to eliminate the differing standards applied to new versus existing plants. At present, grandfathering is intentionally built into the distribution of allowances. Generation sources that existed in the mid-1980s are given free SO_2 allowances based on historical generation and fuel use, but newer sources must buy all their allowances.

It is not hard to imagine more equitable allocation schemes. For example, all allowances could be auctioned by the government, giving equal access to all generation companies — those owning existing plants, those owning new plants, and even those planning to operate new plants in the future. Another option is to set aside a reserve of allowances, to be made available to new sources when they come on line, without exceeding the total emission cap. The formula for calculating allowance allocations to new units should be the same as the formula used for old units. The same principles should of course apply to a new trading system for NO_X, as well as to the existing system for SO_2.

Cap and trade systems can be efficient mechanisms to achieve a particular environmental objective, because they provide a great deal of flexibility to individual firms. Under such systems, generation companies have an incentive to select the lowest cost options for reducing emissions, including increases in dispatch of less-polluting resources, installation of more efficient or cleaner generation facilities, installation of control technologies, or retirement of plants with high emissions. Several cap and trade systems have been implemented or proposed: in addition to the SO_2 trading scheme, a number of states have established cap and trade systems for NO_X or volatile organic compounds (VOC) allowances; EPA has proposed a regional NO_X cap and trade system to assist in compliance with ground-level ozone standards; and the US government, along with other parties, has proposed cap and trade systems as a means of reducing CO_2 emissions worldwide.

Despite their popularity, cap and trade systems present two important potential problems. Neither problem is inherent in the process of trading itself; rather, both problems stem from the allocation of allowances under a cap and trade regime. First, there is a danger of grandfathering of existing sources in general, or favoritism to particular, politically connected private interests, in the initial allocation. In the drafting of the 1990 Clean Air Act Amendments, a lengthy, little-noticed process of negotiations established an intricate pattern of 29 different rules governing the allocations for SO_2 allowances. Second, once allowances are allocated it can be politically difficult, if not impossible, to reduce or reallocate them. Firms will tend to view their allowances as a permanent entitlement or property right, and naturally will fight to keep them. In exchange for the initial reduction in pollution, the cap and trade system creates a new barrier to further reduction, or to equitable treatment of new firms.

Moreover, while cap and trade systems do have real advantages, it is possible to overstate their impact. The pleasant surprise of rapid, low-cost reduction in SO_2 emissions in the 1990s, often attributed to the new trading system, actually has more to do with the increased availability and decreased cost of low-sulfur coal – a development that would have proved beneficial under many different regulatory regimes (Ackerman and Moomaw, 1997, EIA, 1997b).

4.3. *Generation performance standards*

A third policy option, generation performance standards (GPS), involves a trading system that differs from the cap and trade approach in a few key features. Rather than a permanent cap on total emissions in tons, the GPS sets an annual performance standard of allowable emissions per unit of output, for example in lb/MWh. Each year, firms with emissions below the standard generate credits that can be sold to firms with emissions above the standard. Every producer must meet the standard, or buy credits to offset any emissions above the standard.

The GPS preserves the market-based flexibility of the cap and trade system; companies are free to pursue any strategy that reduces emissions per MWh, or to buy credits from firms that can reduce emissions at a lower cost. However, it has several advantages over cap and trade systems. The GPS is targeted more accurately toward society's objectives, rewarding all firms for achieving a maximum of useful production with a minimum of accompanying pollution; in contrast, the SO_2 cap and trade system simply rewards past polluters (those who receive the allowances) for pollution reduction. Under GPS there is no permanent allocation of allowances, and hence no tendency toward favoritism or grandfathering of established producers. Each year's credits belong to that year's low-emission producers, whether they are old or new firms. And there is no inherent obstacle to subsequent policy changes in the standard, since the system of credits must be recalculated each year in any case.

The annual recalculation provides a unique opportunity for fine-tuning of emission standards. One simple approach would be to set the standard relative to the previous year's performance. For example, if generation is growing at 2% annually, a standard of 98% of the previous year's average lbs/MWh will lead to roughly constant total emissions, comparable to a cap and trade system. A tighter standard, such as 95% of the previous year's average, would then require 3% annual reduction in emission rates. Even a more relaxed standard of 100% of the previous year's average would still provide some ongoing incentives for reduction in emission rates, since those who do worse than average must buy credits from those who do better than average. Over time, as producers responded to this incentive, the average emission rate would likely decline.

Although GPS is simpler than a cap and trade system in many respects, it still involves complex questions of measurement and definition. One such question with policy significance is the definition of the company's output that is used in measuring its emissions per MWh. If only coal-fired generation is counted, there is a transparent standard of equity among coal plants. If all fossil-fuel generation is counted, there is an added incentive to switch to natural gas with its lower emission rates. If renewable energy sources and demand-side efficiency programs are counted, there is an incentive to diversify into these options as a means of achieving the standard. Increasing the number of options available to meet the standard will in general lower the cost of complying with the standard.

As a market-based policy instrument that resembles but improves upon the better-known cap and trade approach, GPS has gained increasing support in recent years. GPS policies have been established as part of the electricity restructuring processes in Massachusetts, Connecticut, and New Jersey, and are being proposed nationally in bills before the US House of Representatives and the US Senate.

We expect that GPS will become an increasingly important part of the discussion of market-based policies for environmental protection. Among its other advantages, we would emphasize in closing that it provides a promising instrument for eliminating the market distortions caused by grandfathering of older plants under the Clean Air Act.

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