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RESEARCH review
UNIVERSITY OF CALIFORNIA ENERGY INSTITUTE • EDITOR: KAREN NOTSUND

Have New Source Review Environmental Regulations Been Counter-Productive?

One of the long-standing disputes between environmentalists and parts of the electricity industry concerns the regulation of emissions at power plants, particularly coal-fired power plants. When the Clean Air Act was passed over thirty years ago, new criteria were established for the emissions of power plants. These criteria have been tightened several times in the ensuing decades. However, while emissions regulations were applied to new power plants, plants already in operation at the time the regulation was developed were grandfathered, or exempted from many specific requirements. It was expected at the time that these plants would retire in the following decades and be replaced by newer, cleaner plants.

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Economists have long recognized that grandfathering regulations is a double-edged sword. On the one hand, the costs of retrofitting existing plants with new mitigation technologies may be much more expensive than an installation at a new facility. It could be more cost effective to let the existing facilities run out their useful lives and gradually be replaced by new facilities over time. However, by imposing a potentially costly regulation that applies only to new plants, the regulation itself can create an incentive to extend the lifetimes of existing dirty facilities.

Recognizing the potential incentive to extend the lifetimes of plants, the Environmental Protection Agency (EPA) created the New Source Review (NSR) program. Under NSR, a power plant is required to submit to an approval process for major maintenance projects to determine whether such activities extend the lifetime of the plant to such an extent that the plant should be considered a new source. However, determining exactly what constitutes "lifetime extending" maintenance has always been a difficult and controversial task.

In 1999, the EPA took a more aggressive stance and sued several companies for violating the NSR program at dozens of generation units around the country. The move signaled a much stricter interpretation of the definition of lifetime extending than what had traditionally been the case, according to industry representatives. Industry groups decried the move, claiming that such rigid interpretations would have a chilling effect on even routine maintenance. This would erode the efficiency of plants and even environmental quality. Under the Bush administration, the EPA has reversed course and significantly loosened the definition of lifetime extending maintenance. Various lawsuits have kept the issue in play, with environmental groups and regulators in several states fighting the new EPA rules.

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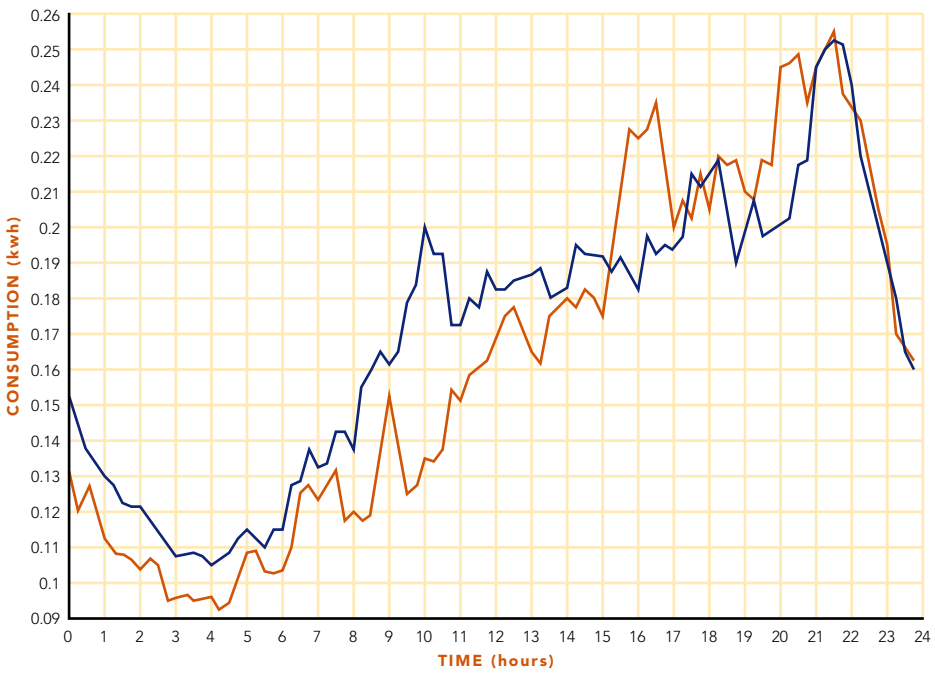
Evaluating the Anaheim Critical Peak Pricing Experiment

A headline in the San Francisco Chronicle on July 24, 2006 announced "Stage II emergency declared for Northern California... Power cut to businesses, but rolling blackouts avoided." Those responsible for managing California's electricity market are still looking for ways to handle hot summer days without declaring emergencies. One possibility is to offer residential consumers a financial incentive to reduce their electricity consumption on those critical afternoons. A California utility recently tested this option and found that customers did significantly reduce their electricity usage, when offered a rebate to do so, on those hot summer afternoons.

The City of Anaheim Public Utilities (APU) ran an experiment during the summer of 2005 to evaluate how responsive customers would be to a rebate that paid them to reduce their electricity consumption during critical peak periods. Critical peak periods ran from noon to 6:00pm on days the California Independent System Operator (ISO) expected the supply of electricity to be tight and wholesale prices of electricity to be unusually high. A random sample of APU customers were selected to participate in the experiment and had meters installed to record their hourly consumption. The experiment participants were then randomly assigned to a "treatment" and a control group. [Figure 1 shows the daily pattern consumption of both groups prior to the experiment. Although the two lines do not coincide, the difference between them is not statistically significant.] Both groups paid for electricity according to APU's conventional fixed two-tiered rates. However, customers in the treatment group were notified on a day-ahead basis of critical peak pricing (CPP) days and were eligible for a 35 cents/kwh refund for reductions in their consumption below their "reference" level during the CPP peak period.

FIGURE 1: PRE-TREATMENT PERIOD COMPARISON



Meters installed for all customers in experiment before June 1, 2005 start date of experiment. Consumption recorded at 15-min. intervals throughout the day for customers in both groups. Comparison of pre-treatment 15-min. means to assess randomness of selection of customers in experimentt and their assignment to treatment control groups.

A customer's reference level was set at the average of the customer's three highest non-CPP peak period consumption amounts over all non-CPP days during the experiment. At the end of the experiment, a reference level was calculated for each customer in the treatment group and compared to the individual's electricity consumption in the CPP periods. If a customer's average electricity consumption during the CPP periods were less than her reference level, she would receive a rebate of 35 cents/kwh for every kwh reduction below the reference level during the CPP period. If she hadn't reduced her usage below her reference level in the CPP period, then she wouldn't receive a rebate and would have paid the same amount for electricity as if she had not been in the experiment. Customers in the control group were not provided any financial incentive to alter their consumption in response to system conditions, nor were they notified of CPP days.

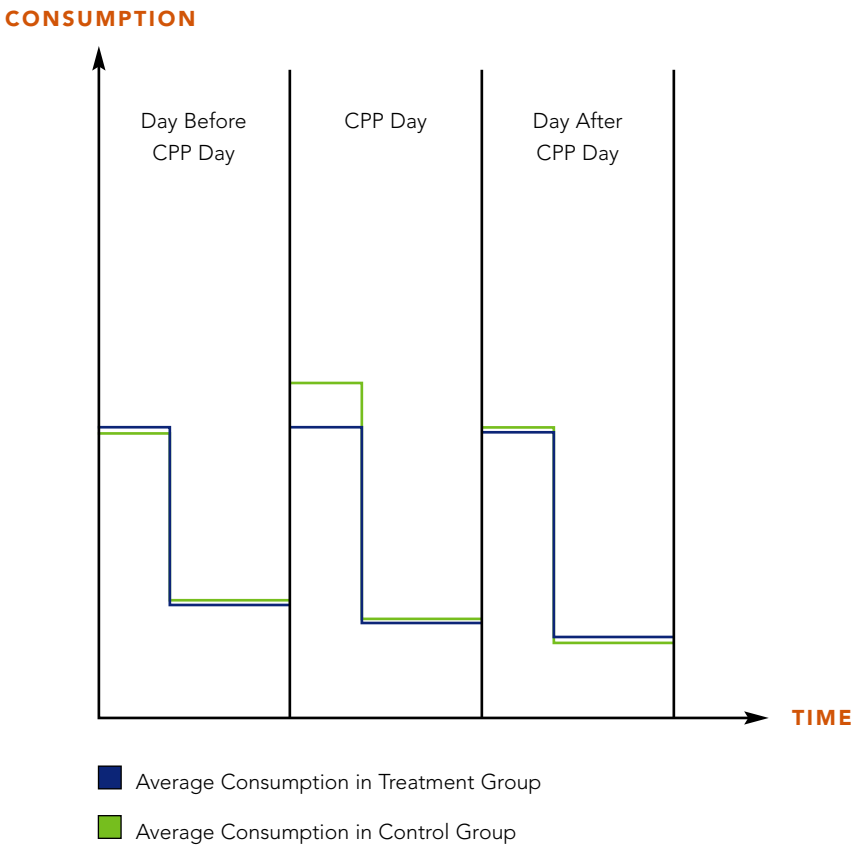
Frank Wolak, a professor of economics at Stanford University and currently a visiting researcher at the UC Energy Institute, analyzes this experiment in

his paper, "Residential Customer Response to Real-Time Pricing: The Anaheim Critical-Peak Pricing Experiment" (CSEM WP 151). Wolak's primary conclusion is that APU residential customers responded to the rebate offer by substantially reducing their peak period consumption on CPP days.

Wolak found that households in the treatment group consumed an average of 12 percent less electricity during the CPP periods than those in the control group. This reduction in consumption during CPP periods does not appear to show up as higher consumption in off-peak periods in the same day or the day following a CPP event. Figure 2 presents a simplified illustration of the estimated demand response to a CPP day. For each day, the shorter line is the average *peak* period consumption and the longer line is the average *off-peak* period consumption. The blue line plots the average consumption of households in the treatment group and the green line plots the average consumption of households in the control group during the peak and off-peak periods the day-before, day-of, and day-after CPP days. This result suggests that customers did not simply shift their electricity consumption to non-CPP periods but reduced their overall electricity consumption because of the incentives they faced during critical peak periods.

An important issue with the method used to calculate the rebates is it provides customers in the treatment group with an incentive to increase their consumption during peak periods of non-CPP days in order to increase their reference level and thereby earn larger rebates. Wolak found that the treatment group's average consumption during peak periods of non-CPP days was significantly higher than the control group's average consumption for the same time periods. This finding is consistent with the logic that the treatment group realized they could earn a higher rebate if their reference level were higher.

FIGURE 2: ESTIMATED DEMAND RESPONSE TO A CPP DAY



Wolak also explored the impact of using the average of the three highest non-CPP peak period consumption amounts to compute the reference level on the total rebates paid. To do this, he first computed a reference level for customers in the control group. He then compared the control household's reference level to its consumption during the peak periods of each CPP day. Although customers in the control group did not receive a rebate payment, Wolak found that these customers would have received substantial rebates simply as a result of the mechanism used to set the reference level. Tables 1 and 2 on Page 6 show the rebates actually paid to customers in the treatment group and rebates that would have been paid to the customers in the control group. From this analysis, Wolak concluded that the vast majority of the rebates paid to customers in the treatment group would have been paid without any demand reduction by customers in the treatment group. Even for customers in the control group, the average of their three highest non-CPP peak period consumption amounts was much larger than their typical consumption during peak periods of CPP days. These results underscore the importance of balancing a number of competing goals in setting the reference level for customers on a CPP rate.

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Are Competitive Wholesale Electricity Markets Feasible in Developing Countries?

Over the last few years many countries have been radically reforming their electricity sectors. Electricity sector reforms in developing countries commonly focus on privatizing publicly owned electric utilities and establishing electricity regulatory commissions. The stated rationale for reforms focused on privatization has been that public utilities are highly inefficient and that the public sector is not capable of making the necessary investments to meet the rapidly growing demand. In light of some negative outcomes for introducing competition in developed countries (e.g., California), there has been rethinking about the feasibility of wholesale competition in most developing countries.

Some argue that wholesale competition is even more difficult to establish in developing countries for a variety of reasons, such as the electricity sector is too small and has one dominant generator or there is a severe power shortage such that electricity companies can exercise market power. Although these concerns are valid for some developing countries, not all have characteristics that make competitive wholesale markets infeasible to establish. On the contrary, some developing countries may have characteristics, such as the availability of large quantities of back-up generation for industrial customers and the feasibility of interruptible tariffs, which could increase the potential for a competitive wholesale electricity market. Also a significant presence of public generation firms, which is commonly observed in developing countries, can increase the competitiveness of a market because public firms do not face a strong incentive to exercise market power and are likely to act as price taking firms. Amol Phadke — a former graduate researcher at the UC Energy Institute and as of October 1, 2006 a post doctoral fellow at the Lawrence Berkeley National Laboratory — analyzes these issues in his paper, "Feasibility of Wholesale Electricity Competition in a Developing Country: Insights from Simulating a Market in Maharashtra State, India" (CSEM WP-152). Phadke finds that competition is feasible if the appropriate policies are in place.

Phadke models a potential wholesale electricity market in Maharashtra (MH) State using data on generators, transmission constraints and electricity demand and then simulates the impact of different combinations of public policies – the divestiture of generation, implementation of demand response and requirement of long-term contracts – on the competitiveness of the wholesale electricity market. Phadke models the year 2007-2008 because he believes it will be representative of the supply and demand conditions that are likely to prevail in the next 10 – 15 years. Phadke calculates the market prices in December, June and April to include the impact of seasonality on prices.[1]

Phadke first models a perfectly competitive market as a reference point for electricity prices. He then models a base case scenario in which no policies for facilitating competition are implemented. The base case scenario assumes a single private firm that owns a large share of the thermal generation capacity, no long-term contracts and no demand response. Simulated prices from this scenario are substantially higher than the competitive price even when demand is low which means that the market will not be competitive for most of the time in the simulation year.

1 The majority of monthly variation in demand is driven by the variation in agricultural pumping demand. Agricultural activity and pumping demand is greatest in December.

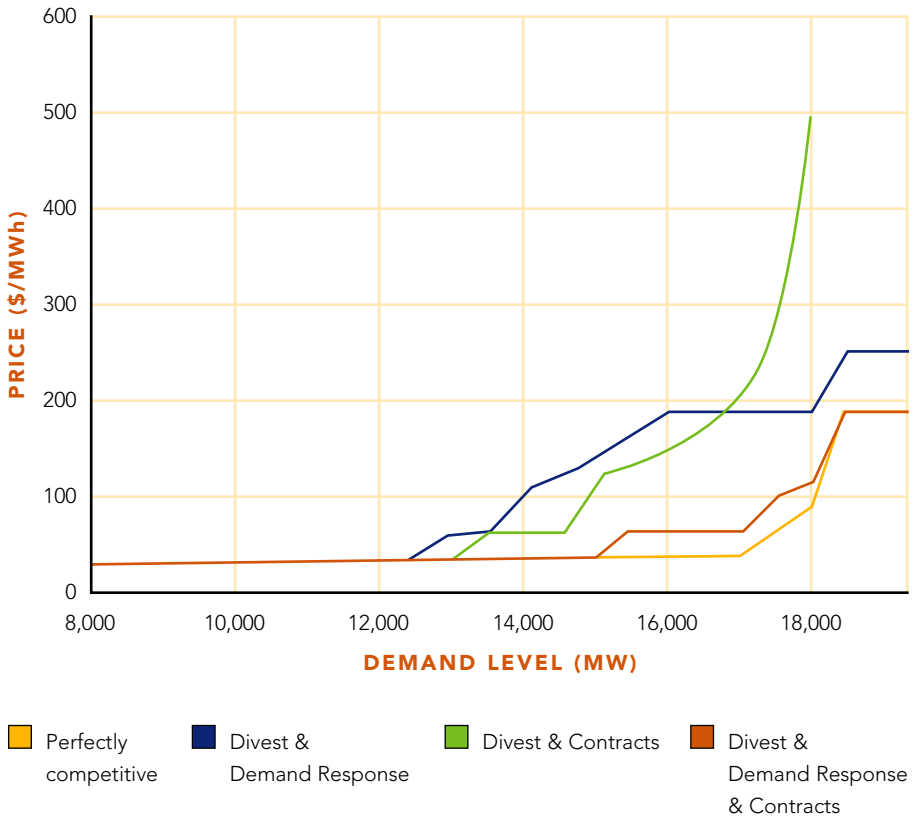
The next scenario assumes that the dominant thermal firm is divested to an extent that is reasonably plausible in the MH electricity sector. Although the divestiture itself leads to more competitive prices generally, the prices for some of the highest demand levels in the simulation year are still above the competitive benchmark prices. Phadke then incorporates demand response from industrial, agricultural, commercial and residential customers into the model. In response to growing power shortages over the past few years, many industrial customers have invested in back-up generation which they can turn to when electricity prices are high. This back-up generation capacity will be extra capacity available in the system once the power shortages are reduced, which is likely to be the case in the near future. Phadke assumes that approximately a third of industrial back-up generation will be available as demand response when the wholesale price of electricity exceeds the cost of the back-up generation. Agricultural customers use significant amounts of electricity for agricultural pumps. The state utility in MH state is making changes to their distribution network that allow them to selectively cut off the power to the agricultural pump sets. Phadke conservatively assumes that a third of agriculture's peak demand can be cut off and shifted to off-peak periods when electricity prices go above a certain level. For the residential and

commercial customers, Phadke assumes that only 6-7% of the residential consumers' demand will be on interruptible tariffs and power supply to these consumers can be cut off if the price goes above a certain level. In the divestiture and demand response scenario, electricity prices are identical to the competitive prices for most of the hours in the simulation years except for some high demand hours when the wholesale electricity prices depart from the competitive benchmark prices and increase significantly. At these demand levels, the available demand response is insufficient to mitigate the market power of the private generation firms, who are motivated to withhold capacity and raise prices.

An alternative scenario combines a policy of divesting the generation plant and requiring long-term contracts for a portion of the plants' capacity. Market prices under this scenario fall to competitive levels except for some of the highest demand levels in the simulation year. As the contract obligations of the firms increase, their net position in the spot market decreases which reduces their incentive to exercise market power in the spot market.

Phadke finds that any one of the policies of divestiture, demand response, and contract requirements if implemented to the maximum extent attainable could make the electricity market in Mahrashtra State almost perfectly competitive. However, to implement these policies to such an extent would be difficult and in some cases impractical. Instead, all of these policies could be implemented simultaneously at easily attainable levels. Phadke simulates such a scenario and finds that the electricity prices are identical to the competitive benchmark prices in all but 14 hours of the year. This scenario indicates that the appropriate policies can foster effective competition. This result is robust

FIGURE 1: COMBINED EFFECT OF POLICIES



when tested against alternative assumptions but does depend on two key components: supply shortages of less than 5% and the presence of public generation firms that act as price takers. As a corollary, Phadke finds that in the absence of these policies to increase the competitiveness of the market, the market exhibits substantial market power.

Figure 1 shows the market prices under a hypothetical perfectly competitive market and under each of the policy scenarios examined. The graph illustrates how close market prices under each of the policy scenarios are to the benchmark perfectly competitive prices. Peak demand in MH State for the simulated year 2007-08 is expected to be around 16,000MW.

Many of the characteristics of the MH state electricity sector that can increase market competitiveness are common to other states in India and other developing countries. If the effects of these characteristics are taken into account, a competitive wholesale electricity market will be more feasible in developing countries than is currently believed. In the context of limited regulatory capabilities in developing countries, rigorously assessing the option of introducing competition into the wholesale electricity market is all the more important.

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EVALUATING THE ANAHEIM CRITICAL PEAK PRICING EXPERIMENT

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TABLE 1

TOTAL REBATE

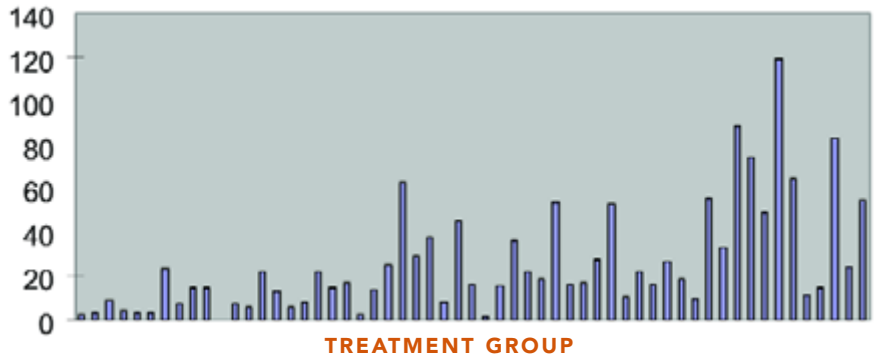
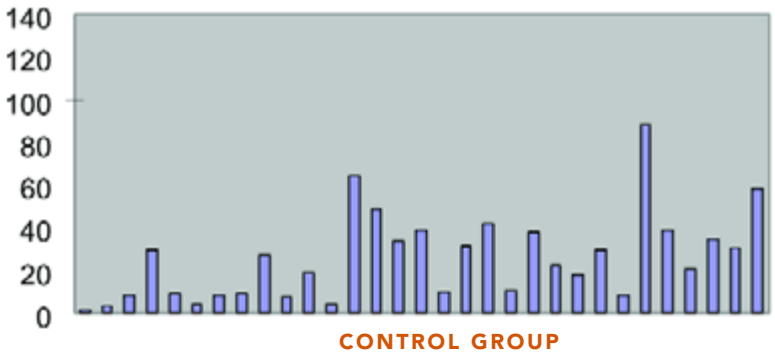


TABLE 2

TOTAL REBATE



Setting the reference level for a CPP rebate mechanism involves trade-offs between the generosity of the rebate and the responsiveness of customers to the program. In particular, if the reference level is set so low that the customer believes that his best effort to reduce consumption will not result in a rebate, then the customer may simply give up and not attempt to reduce consumption during the peak periods of CPP days. Wolak posits that from a system reliability and market efficiency perspective, the most valuable aspect of a CPP rebate program is its potential to reduce overall system demand significantly and reliably with very short notice. A higher reference level that encourages households to reduce their consumption during peak periods of CPP days may be more cost effective if it results in a larger and more predictable reduction in consumption, even if it gives very generous rebates.

Wolak also considered the benefits of different numbers of customers on CPP programs. Specifically, the more customers on the CPP program, the more likely their consumption reductions will produce lower wholesale electricity prices. The presence of a substantial amount of final demand on the CPP program can reduce both short-term energy prices and long-term contract prices that retailers pay to serve all of their customers. This logic strongly argues for making CPP programs mandatory for all customers who have the meters necessary to record their hourly consumption.

In today's political climate, offering rebates to motivate customers to consume less during critical peak periods is well received by customers and more palatable to regulators than charging higher prices on those days. Although the rebate program may not pay for itself in terms of the wholesale energy costs savings exceeding the rebates paid, if a substantial fraction of residential customers are given an incentive to cut back on their electricity usage during critical periods, the California ISO is much less likely to declare system emergencies during heat storms like the one experienced in July of 2006.

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HAVE NEW SOURCE REVIEW ENVIRONMENTAL REGULATIONS BEEN COUNTER-PRODUCTIVE?

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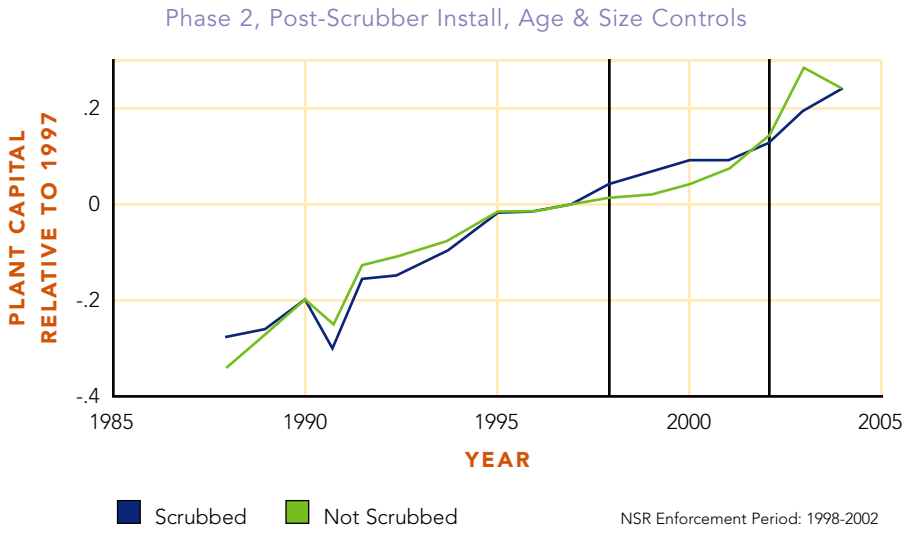
The question remains as to how much distortion the original regulations, and the NSR program itself, has introduced into the business of building and operating power plants. James Bushnell, research director at the UC Energy Institute, and Catherine Wolfram, an associate professor at the UC Berkeley Haas School of Business, probe the impact of the NSR regulation in their paper "The Economic Effects of Vintage Differentiated Regulations: The Case of New Source Review" (CSEM WP 157). In particular, Bushnell and Wolfram analyze whether the aggressive enforcement of maintenance activities in the late 1990s under the Clinton EPA had a chilling effect on operations and investment as predicted by industry groups at the time.

Bushnell and Wolfram examine the maintenance and operations activities of a broad cross-section of U.S. power plants. A key difference between plants is the presence of "scrubbers," an extremely expensive technology designed to remove sulfur from emissions after coal is combusted. Scrubbers are required for all new coal-fired power plants in the U.S., but existing plants were exempted from this requirement. The installation of scrubbers constitutes the bulk of the overall cost of bringing an existing plant up to "new source" standards. Bushnell and Wolfram argue that plants that have already installed scrubbers have had much less to fear from a negative NSR finding, and would therefore have responded differently to the increased oversight of the Clinton EPA. In fact, Bushnell and Wolfram find that power plants without scrubbers experienced a significant drop-off in plant investment during the late 1990s relative to plants with scrubbers, consistent with the idea that they reduced spending to avoid triggering NSR enforcement. *(See Figure 1.)* This reduction in plant investment does not appear to impact operations, however, as there is no comparable difference in the fuel efficiency and maintenance expenditures of the two groups of plants during that period. The study controls for other confounding factors such as plant age and size.

FIGURE 1: PLANT CAPITAL – TRENDS BY PLANT CATEGORY
Phase 2 Plants, Post-Installation of FGD, Controls for Age- & Size-Specific Trends



These results are consistent with a conclusion that the more aggressive enforcement did have a chilling effect on investment, but did not impact the operational efficiency of the plants. One possibility is that the policy did not last long enough for the effect to filter through to operations. Another is that the scope of the EPA's enforcement was in fact limited to the most egregious offenders, so that operations at more typical plants were not affected.

Bushnell and Wolfram also consider whether the pollution control requirements for new plants delayed retirements of the grandfathered plants. They find evidence that existing plants have been kept in service significantly longer than they would have been absent the grandfathering provision. This effect no doubt contributes to the contentiousness surrounding the enforcement of NSR, as environmentalist are frustrated that plants exempt from a regulation nearly thirty years ago are still in operation.

Grandfathering can certainly lead to distortions, and Bushnell and Wolfram find that NSR's differential treatment of old and new coal plants created counter-productive incentives. As more pollutants are regulated with cap and trade programs, the incentives to keep old dirty plants in service should be mitigated as even grandfathered plants are responsible for acquiring permits for their emissions. The issues related to grandfathering provide one more argument that, for many pollutants such as sulfur, more flexible forms of regulation, such as cap-and-trade, are preferable to source-specific rules.

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