Compliance Costs and Markets

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Abstract

The Title IV acid rain program is a well-recognized success leading to significant savings, esp. in company flexibility, choices available for compliance, and competition between them that helped drive down prices. Touted for its flexibility, low administrative costs, invitation to innovation, and tangible cost savings, perhaps the most notable feature of the Title IV program to date has been the moderate stringency of required SO_2 reductions during Phase I, providing supplies for trade and immediate use as well as for future use. This permitted non-technological options to play a role, fostering competition among lower-sulfur coals. The trading and banking provisions led to substantial overcompliance, with over half of such supplies derived from fuel switching according to MIT's definitive analysis of the first three years of Phase 1. Important too has been the coincident element of surprise, with changes in the energy infrastructure – notably expansion of Powder River Basin coal – favoring lower, not higher, compliance costs. Looking ahead, there is considerable uncertainty in stringency, costs of compliance and the pattern of SO_2 allowance market prices due to political, legal and regulatory factors. Scrubbing and switching costs both declined beyond expectations, but one should be cautious about the repeatability of this trend. One area of continuing technological change is that of scrubbing systems geared to somewhat lower-sulfur coals or to better byproducts. A review of past compliance cost forecasts indicates they were not wildly off the mark, but the world they envisioned is being rewritten and will never be tested by future events. A second wave of 14,000 MW scrubbers is already under way for various reasons (5,600 MW built within the past two and one-half years), an amount as large as the Phase 1 fleet. One way the next decade will likely depart from prior expectations is that stringent measures requiring technology controls could lead to another disconnect between compliance costs and emission allowance prices, a disconnect beginning today. The retirement or sterilization of allowances under measures that could force technology controls is a key issue. A company example illustrates the magnitude of possible future compliance costs.

Background

The Clean Air Act Amendments of 1990 established an innovative, large-scale and successful framework for achieving environmental goals with market-based incentives. This paper reviews the basic performance of that framework, comments on the energy market conditions that influenced the compliance history during the 1990s, and provides some partial estimates of future conditions affecting compliance planning and costs.. While costs of technology controls and low sulfur coal are lower than levels anticipated in the debates leading up to 1990, and while emissions trading and banking have afforded flexibility, efficiencies and real savings in costs of compliance, an important observation is that the relatively modest stringency of required emissions reductions during the 1990s was very important to the widely recognized success of the program during that period. Understanding the role played by this level of stringency, and not simply environmental market design, is important to gauging savings from continued implementation of flexible, market-based programs under far more stringent circumstances, e.g., in the event emissions caps are reduced by 50% or more from prior anticipated levels.

The paper draws on little original EPRI research, as EPRI's programs in clean air compliance market analysis were most active in the years leading up to Phase 1 of the CAAA and during the first few years thereafter. The leading analysis of the Phase 1 compliance experiences is: *Markets for Clean Air – The U.S. Acid Rain Program*, Cambridge University Press, 2000, by A. Denny Ellerman, Paul L. Joskow, Richard Schmalensee, Juan-Pablo Montero and Elizabeth M. Bailey (referred to as "MIT 2000" in this paper).

Readers are strongly encouraged to review this comprehensive and balanced assessment of the first three years of this very innovative program. The author acknowledges discussions with Denny Ellerman of MIT for some of the data presented here, John Dean of JD Markets for information on coal markets and FGD technology, and Tom Hewson of Energy Ventures Analysis for information on the status of recent FGD projects (as of March 2001). Anne E. Smith of Charles River Associates provided a concise summary comparing forecasts and actual compliance costs in the paper, "The Costs of Reducing Utility SO_2 Emissions -- Not as Low as You Might Think", 1998, MIT-CEEPR 98-010 WP, co-authored with J. Platt and D. Ellerman.

Overview of the Market

The first three slides summarize provide a high-level view of developments. Figure 1 is a tally of actual emission levels, formerly anticipated emission levels, emission levels adjusted for the popularity of switching to lower cost, low-sulfur Powder River Basin coal (capturing the fact that emissions would have come down somewhat even in the absence of the CAAA due to "economic switching" of coal supplies), and the caps imposed for Phase 1 (1995-1999) and Phase 2 (2000 ff.). The information here is for Phase 1-affected units, not the US as a whole. It is easy to see the degree of "overcompliance" during Phase 1, as industry reduced emissions some 1.5-3.0 million tons SO_2 per year below the nominal Phase1 cap. Also shown is EPA's preliminary estimate of 2000 emissions which is above the 2000 cap, thus requiring a withdrawal from banked emissions. An interesting question is whether the coal shortages that caused an unprecedented fly-up in coal prices during 2001 would lead to a higher level of emissions and matching withdrawals from the bank.

Recent coal price movements are summarized in Figure 2. During late 2000 and throughout much of 2001, coal prices escalated to unprecedented levels, the highest in about 20 years, in nearly every district. Reasons for this phenomenon include the booming economy with high levels of demand, low nuclear availability, reductions in hydroelectric output, stratospheric natural gas prices, difficulties with maintaining production levels at specific mines, and progressive structural change in the industry, including fewer small mines and ever-larger, more concentrated major companies.[1] Companies had difficulty obtaining coal of any kind, not just coal conforming to

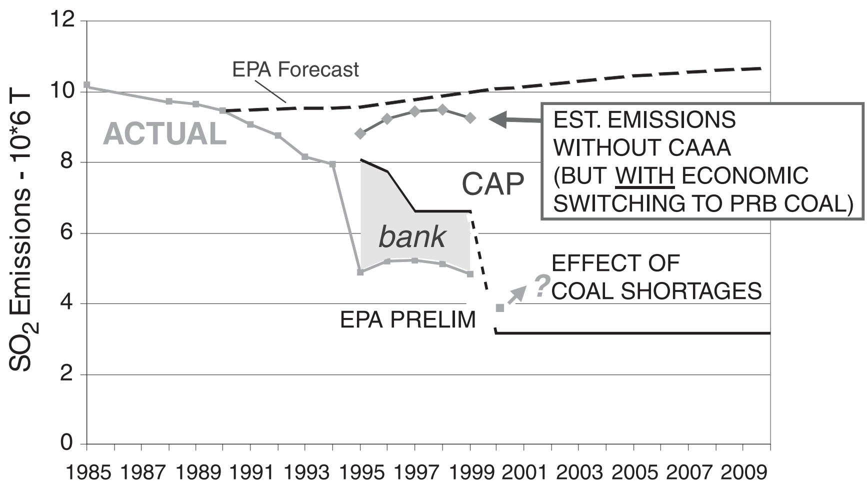

Figure 1. Actual and Projected Annual Emissions, Caps and Banked Allowances -- Phase 1 Affected Units Only. Source: MIT 2000, updated 4-00; 2000 actual: illustrative, est. based on prelim EPA data.

[1] EPRI, The Tight Coal Market: Volatility Spike or Trend? Palo Alto, Calif.: 2001. 1004589. Issued six months after the conference, this report discusses the reasons for the run-up in coal prices, and it concludes that coal prices are likely to continue to be more volatile in the future than in the past.

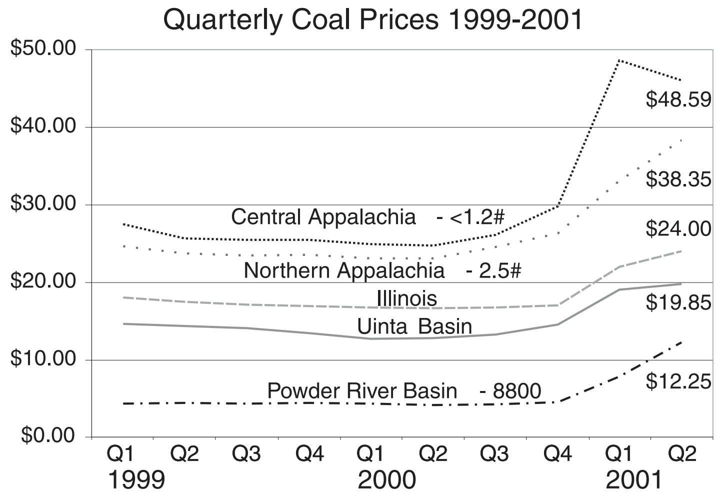

Figure 2. Coal Prices – Quarterly, 1999-2001. Source: JD Energy

desired specifications. The reason to highlight these very unusual circumstances in this overview is because unanticipated events can always be expected to happen. In this case, the ability to use coal of different qualities and simply adjust for SO_2 through emission allowance accounting is a great benefit and a great example of the flexibility afforded market participants by emissions trading and banking.

The history of SO_2 emission allowance prices is shown in Figure 3. There is neither just one price, nor a random pattern of prices. The SO_2 market has become a very real market, responding to many forces and perceptions like any other market. The lowest prices in 1996 correspond to the variable cost (short run marginal cost) of operating scrubbers, without allowing a return on the capital investment. The higher prices, e.g. $200 in 1998-99, indicate a shift in market power between buyers and sellers of allowances. $200 (or more) is MIT's estimate of average Phase 1 costs of scrubbing. $200 is also much closer to the long-

Figure 3. SO_2 EA Market Price Index. Source: TradeSpark (now CantorFitzgerald Environmental Brokerage Services MPI

run marginal cost of controlling SO_2 (and discounted back to the present), yet one cannot trace any specific cause and effect to these benchmarks. In between, prices of $150/ton match MIT's estimate of average Phase 1 costs of switching to low-sulfur coal.

The price collapse in November 1999 was influenced by the initiation of New Source Review litigation by EPA and the Department of Justice against the compliance measures adopted at a number of major power plants. It reflected the view that one outcome might be widespread adoption of technology controls. Resulting steep reductions would add to the potential supply of allowances for sale, while removing the plants from the population of potential users of allowances, driving the price down. With the announcement of the Administration's Clear Skies Initiative (February 2002), seeking even more stringent overall reductions in SO_2 far into the future by following market-based mechanisms rather than forced scrubbing, the recurrence of such a price collapse is increasingly unlikely.

Details of Emissions Reductions and Emissions Trading During Phase 1

Figures 4 through 7 provide a more detailed look at emissions reductions, allocations and the use of allowances on a state by state basis and by company, ending with an indication of how much companies are participating in trading activity with one another. While it is inconceivable now, many suspicions surrounded the launching of SO_2 emissions trading. The existence of the annual EPA auction was designed to kick start a market. The government's offer to supply allowances at $1,500/ton was designed to serve as a back stop to the market. Both were mechanisms to counter inhibitions and market abuse, especially hoarding of allowances by incumbents. The message from this sequence of figures is the evidence of widespread participation in allowance trading.

Figure 4 plots state reductions for 1997. Physical reductions in emissions were achieved across a broad area, with nine states in the northeast, midwest and southeast responsible for reductions of over 200,000 tons per year. By 1997, the total amount of reductions was 4.1 million tons per year, with nearly half (1.92 million tons) achieved by scrubbing (flue gas desulfurization, FGD). As intended, these reductions took place in the "upwind" states, namely upwind of regions experiencing acidic deposition. Scrubbers were responsible for nearly half or more of state reductions in Pennsylvania, West Virginia, Ohio, Kentucky, Tennessee and Indiana. Farther west (Missouri, Illinois), switching to low sulfur coal was the preferred approach, aided by shorter rail distances to the Powder River Basin of Wyoming.

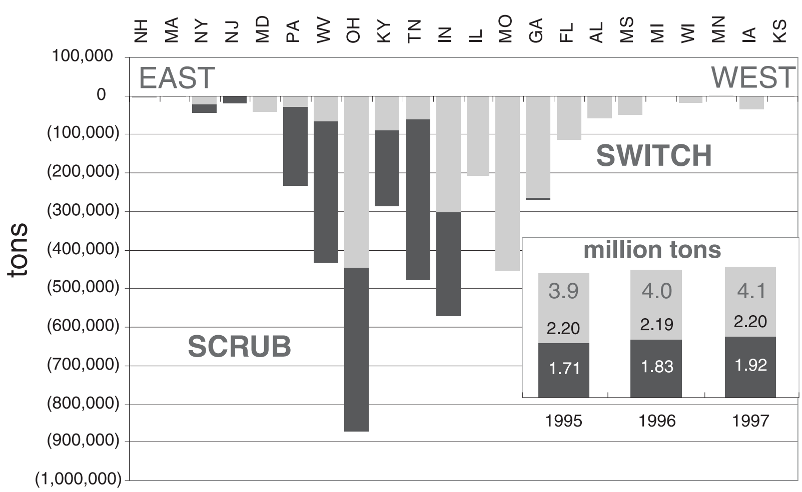

Figure 4. Emissions Reductions and Scrubbing-Switching Choices by State (1997). MIT 2000, updated MIT Center for Energy & Environmental Policy 4-00

While it is self-evident from the figure, physical reductions took place all across the region.

Emissions trading did not create pockets where reductions were achieved primarily by financial rather than physical means (i.e., with no significant real decline in emissions). This is the reason that analysts have concluded that trading did not have deleterious environmental effects. This is underscored in Figure 5, which compares state actual reductions to state allocations, i.e., to allowed levels of emissions based on allowances allocated to companies in each state. Illinois is the only state where a significant share of the requirement was met by purchasing a significant amount of allowances. In Illinois, the Baldwin power plant used a combination of local coal and allowances to come into compliance, prior to implementing a strategy of switching to low-sulfur Powder River Basin coal for Phase 2 compliance.

A more complete view of actions during Phase 1 is summarized in Figure 6. This figure indicates the degree to which individual companies relied on tangible measures to reduce emissions through 1999 (yearend 1999 is the "end of period" date, referring to the end of Phase 1). It is based on information reported to EPA and acquired and analyzed by MIT in its ongoing studies of Phase 1 compliance, without checking for any possible discrepancies with any of the individual companies listed. In some cases, companies may hold more allowances or have sold more allowances than indicated, through private transactions. More important than each company's detail is the pattern of cumulative compliance actions summarized here. For each Phase 1-affected company, the sum of its cumulative Phase 1 emissions and banked allowances is divided by its cumulative allocated allowances, to form a ratio.

All companies with a ratio greater than 1.0 are net purchasers of allowances through 1999. Illinova (now Dynegy Midwest Generation), owners of the Baldwin plant, stands out as the single, large company whose emissions exceeded the allocation, achieved by pursuing a strategy of buying and consuming allowances over this period. In nearly all other cases, the combination of switching to lower sulfur coal and scrubbing led to emission levels that were actually lower than allocations. Through reducing emissions and purchasing of allowances, nearly all companies carried a cushion of allowances into Phase 2, typically 20-40% of the amount of Phase 1 allowances allocated to each company. All companies with a ratio less than 1.0 are net sellers of

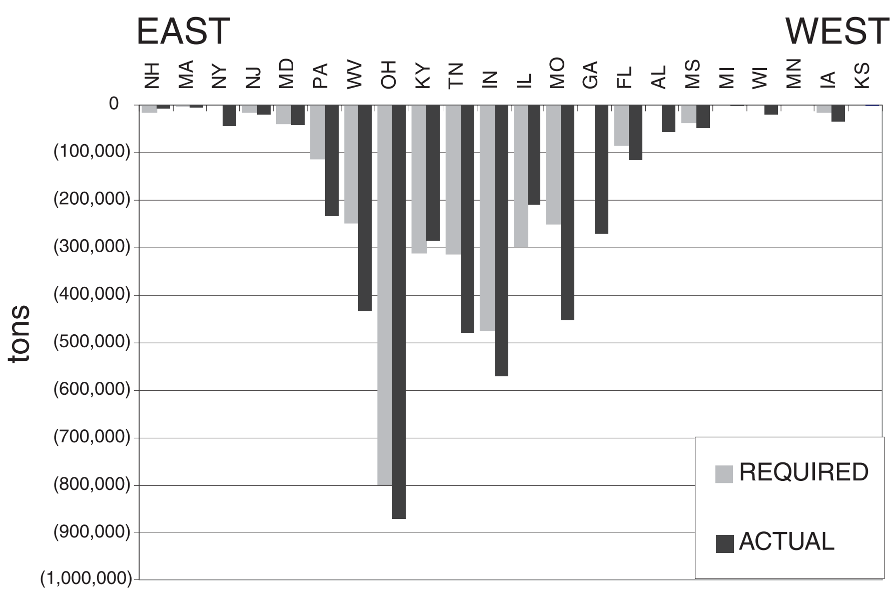

Figure 5. Emissions Reductions vs Allocations by State (1997. MIT 2000, updated MIT Center for Energy & Environmental Policy 4-00

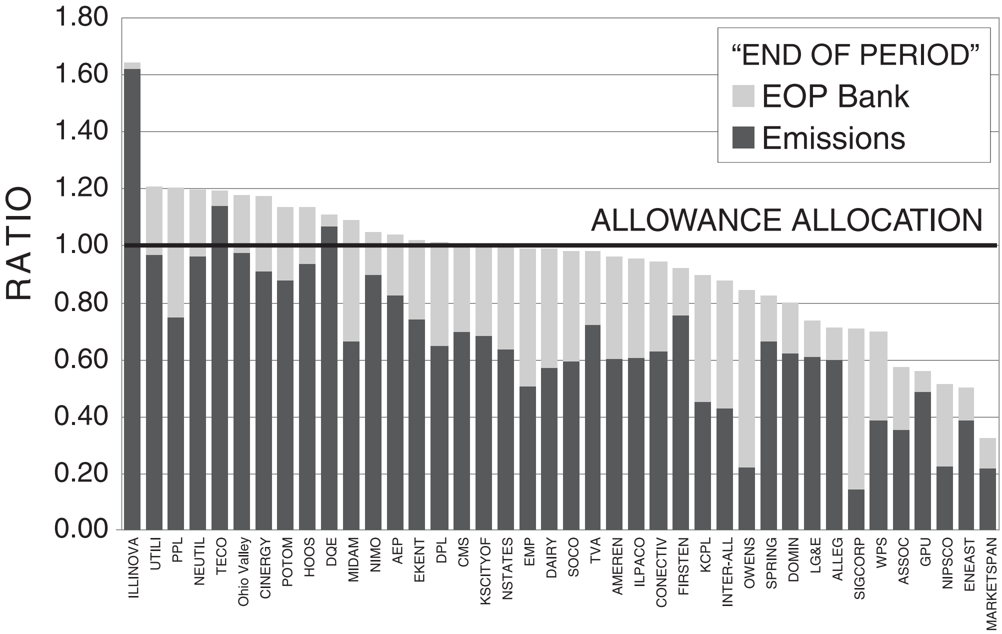

Figure 6. Phase 1 Company Detail: Ratios of Cumulative Emissions and Banked Allowances to Allowance Allocations. Source: MIT Center for Energy & Environmental Policy 4-00

allowances, whose actions added to the liquidity of trading.

Figure 7 provides an up-to-date (through 2000) synopsis of trading activity, as recorded by EPA's allowance tracking system. Trading activity is divided into two parts, internal (using allowances for a company's own account) and external (engaging in transactions with other companies (with and between brokers, other utilities, coal producers and others). The amount of external transactions recorded, which understates the level of actual transactions since not all are private transactions are recorded with EPA until final disposition, climbed each year through 2000 (except for 1999). EPA's data illustrate how trading activity has been increasing, which is a good non-anecdotal evidence that the product (EAs) is a useful commodity to market participants. Data revisions subsequent to the conference indicate the 2000 activity level was split evenly between internal and external transactions (15 million tons in each category).

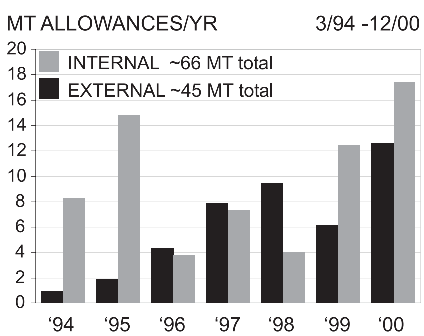

Figure 7. Allowance Trading Activity Recorded by EPA's Allowance Tracking System. Source: EPA website - http://www.epa.gov/airmarkets/trading/so2market/cumchart.html

A Successful Framework with Tangible Cost Reductions in Phase 1

The foregoing summarizes many aspects of Phase 1 compliance. Although physical measures dominated compliance, companies widely embraced and participated in emissions banking and trading. Most of trading was aimed at procuring internal efficiencies that proved to be very significant. One example is the ability to respond to changes in coal quality. More significant from a capital cost point of view was the design efficiency afforded scrubbers, where spare vessels required to assure compliance under command and control were no longer necessary. Companies could rely on banked allowances to obtain the necessary flexibility in the event of equipment failure.

Costs of compliance fell during Phase 1 and matched the low end of earlier forecasts. Industry costs had been estimated at $0.5-1.3 billion/year, and came to about $0.73 billion/yr. In dollars per ton, estimates ranged from $150 to 300 average cost, and came to about $200/ton (1995$; Smith and others citing MIT studies). Gains in scrubber performance were significant, both in O&M and in greater removals than first anticipated (exceeding 95%). Contributing to the decline in costs was the expansion of Powder River Basin (PRB) coal use, due to unforeseen reduction in rail rates, heightened mining productivity, and advances in knowledge about how to use subbituminous coal in boilers designed for midwest and eastern bituminous coals.[2] Too, lower sulfur coals from the midwest were found and exploited, along with other western coals. Altogether, less higher-cost Central Appalachian low-sulfur coal was required. The power industry benefited from the competition among coal sources.[3] Importantly, the fact that the overall stringency of emission reduction requirements during Phase 1 was quite modest, approx. 2.5 lbs SO_2/mmBtu, opened up opportunities to comply or to overcomply by switching to different coals rather than on technology controls. The modest cap also enabled companies to readily generate allowances for internal use and external trading through scrubbing.

Phase 2 Look Ahead

Uncertainties cloud Phase 2. Most significant are changes in the legislative/regulatory regime which make moot any comparisons between past estimates of Phase 2 compliance costs and whatever actually transpires. Nevertheless, earlier estimates of Phase 2 compliance costs ranged from $1.5 to 6.5 billion per year. Average costs per ton ranged from $225 to 500. By 1998, estimates of average costs for Phase 2 compliance (once the bank had been consumed) were about $200/ton, i.e., at the low end of the range. Projected prices are expected to correspond to higher marginal costs, rather than average costs, and by 1998 different scenarios were contemplated leading to a wide range of possible marginal costs (from $350 to 600/ton).

One uncertainty is the effect of how the New Source Review litigation is disposed. One year after the conference, it appears the resolution of these cases may be integrated into measures to advance the Administration's Clear Skies Initiative, a multi-pollutant environmental program. The plants targeted under NSR correspond to about 20% of unscrubbed coal capacity. Should scrubbers be required, the impact on the allowance market has been estimated to add as much as 0.5 million tons per year of emission allowances (thus the price-depressing effect mentioned previously). Other major uncertainties, made concrete by the Clear Skies Initiative, include further reductions in SO_2 caps, motivated by acid rain or fine particulate concerns. Scrubbers have also been required, at least in the West, to mitigate regional haze. Measures to reduce mercury emissions may also affect technology choices and economics of SO_2 control.

Referring again to 1998 analyses, preliminary estimates of a "half cap" scenario for SO_2 (a 50% reduction in the Phase 2 cap) were additional costs of $2-4 billion/year, construction of an additional 60-100 GW of scrubbers, a doubling of average compliance costs (to $350-500/ton) and possible marginal costs in excess of $800/ton. Obviously the time is right to reexamine all such cost estimates, incorporating advances in wet and dry FGD technologies and in still-developing "integrated environmental controls" aimed at capturing synergies in controlling multiple pollutants. While advances in technology will reduce average costs, many larger, newer stations in the Midwest and East may miss the prospective efficiencies of

[2] EPRI, Impact of Powder River Basin Coal on Power and Fuel Markets, Palo Alto, CA: 1998. TR-109000.
[3] EPRI, Coal Supply and Transportation Markets During Phase One: Change, Risk and Opportunity, Palo Alto, CA: 1996. TR-105916.

integrated solutions because they will have had to install single-pollutant controls earlier (e.g., 2004 NO_X SIP Call). In any case, costs of control at the most difficult affected units will have the greatest impact on market prices.

Given all the uncertainties in the stringency of environmental requirements within the decade, it is not surprising that companies are discounting future developments in a financial sense. That this has occurred is apparent from viewing the price history of EPA's annual auctions for SO_2 allowances, one of which is for allowances for immediate use and one of which is for allowances that can be used in 7 years (the "7 yr advanced auction"). The history of prices is plotted in Figure 8, as well as calculations of the implied discount rate applied to the advanced auction. In a departure from the past where implied discount rates were negligible, less than or equal to inflation, during 2000 and 2001 they had jumped to 11% and 7%. By March 2002, auction results ($168.50 and $68.00) again indicated very high discounting (11.5%)

There is no cookbook to deciphering all that defines allowance prices at any point in time. Still, it is interesting to reverse-calculate how possible 7% or 11% discount rates might link today's prices to future prices. At the time of the conference (April 2001), prices were about $200/ton. These corresponded to 2010 prices (or long run marginal costs) of $375/ton (at 7%) or $500/ton (at 11%).[4]

The next wave of building scrubbers has started. There were 13,000 MW of retrofit FGD units added for Phase 1 compliance. 14,000 GW have since been added or announced. The breakdown is 5,600 MW completed already, 4,200 MW scheduled for early Phase 2 operation, and 4,400 MW under development for other reasons (regional haze or NSR settlements). The size and cost distribution of these units is summarized in Figure 9. As expected, the newer units fall in a lower cost range than achieved for the Phase 1 units, ranging from ~$100 to 230/kW. These data should be interpreted with caution, especially since some of the projects represent "low hanging fruit"

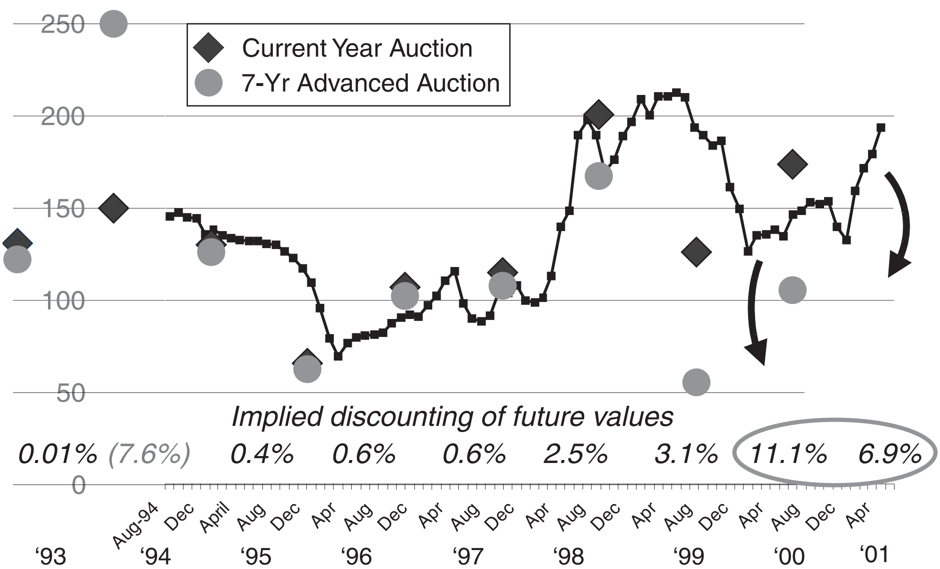

Figure 8. Discounting of Out Year Allowance Values, Based on EPA Annual Auctions. Source: EPA Auction Results; TradeSpark MPI; and J. Platt, discount rates.

[4] Subsequent analysis by PA Consulting reached prices of only $270-320 in 2010, depending on natural gas price assumptions. However, SO_2 emission allowance prices under a multi-pollutant scenario (with 50-60% reduction in SO_2 emissions) were projected to exceed $500 (approx. $530-550) by 2010 and escalate thereafter. "Rethinking Coal Development – Environmental Hurdles", by J. Eyster and S. Kaplan, presented to EPRI Annual Seminar on Energy Markets and Generation Response, Dec. 6-7, 2002.

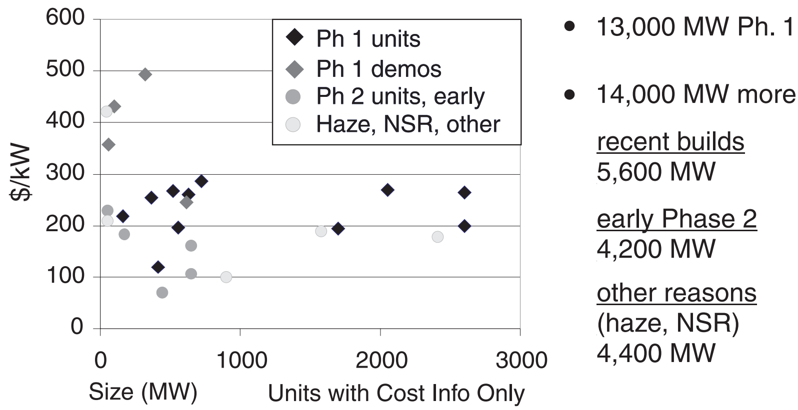

Figure 9. Capital Cost of FGD Units. Source: J. Platt interpretation of data from Energy Ventures Analysis, Inc.

where the economics of scrubbing are most attractive.

Current estimates of capital costs for scrubbing (FGD), NO_X control (selective catalytic reduction) and mercury controls (baghouses) are as follows:

- FGD: $170-190 /kW
- SCR: $100 /kW
- Hg: $35-45 /kW

SO_2 control costs will be a substantial part of multi-pollutant compliance control costs. One company with a diversified fleet of fossil generation units estimates that about 40% of coal plant environmental control costs through 2012-2015 would be associated with capital costs of scrubbing (Figure 10). The share would be larger but for offsetting savings from using higher sulfur coals.

Conclusions

This paper concentrates on SO_2 control costs and draws primarily on the Phase 1 experience. Without a doubt, compliance costs have come down compared to what was anticipated in the early and even mid-1990s. Still, SO_2 control is capital intensive and may account for the lion's share of control costs even under multi-pollutant legislation. An underappreciated implication of the Phase 1 experience is that real physical conditions – productivity gains in coal mining and transportation, FGD technology operating costs and

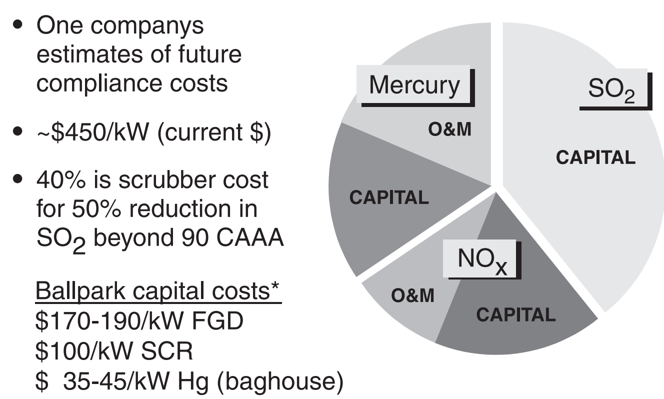

Figure 10. One Company's Breakdown of Potential Future Compliance Costs

performance – accounted for the bulk of costs reductions. The framework of emissions trading and banking was widely endorsed and is widely applauded for the efficiencies it afforded, but the degree of overcompliance and the degree of competition between coal suppliers that created savings and drove down compliance costs owes much to the very modest level of stringency that characterized Phase 1. The outlook for compliance costs over the remainder of Phase 2 is very uncertain, with many issues yet to be resolved in the political realm. Any extrapolatoin of the Phase 1 experience should be done with caution, recognizing the specific features of Phase 1 that are unlikely to repeat. Very likely, it will be the stringency of reductions and not the capturing of market mechanisms that will drive compliance costs in the future.

Questions

MR. MC CORMICK: I am John McCormick. I am with the Citizens Coal Council in Washington. I wanted to dispute some of your inferences that the field switch did not include as much central Appalachia as it did the northern plains.

I am looking at form 423 data. In 1985, in central Appalachia, compliance coal was about 33 million tons production. In 1999, it is 54 million tons. The non-compliance, or the 1.2 to 2, is mountain top mining.

I want to say that the Citizens Coal Council is 54 organizations in the coal-producing states. They are with you on the issue of reducing aerosols, but they realize that the central Appalachian Mountains have been sacrificed in large part to meet the goals of Phase I of the Clean Air Act.

They are not going to allow this to happen again. Further reductions of SO_2 emissions that are met by trading – i.e., fuel switching – that puts more pressure on the bituminous low sulfur coal deposits in central Appalachia. This will not be tolerated by the 54 organizations I speak for.

We need to come together because technology is part of the solution and not so much fuel switching, because this is the cost of fuel switching. If anyone would like to talk further about it, I would be more than happy to. Thank you.

MR. PLATT: One of my points was that the reliances on Appalachian coal turned out to be somewhat less than it was anticipated to be, but it has been very important.

I would say probably a lot of that strip mining in central Appalachia is because that is the economic way to produce coal for whatever reason, regardless of whether there had been a Clean Air Act. There would have been equal pressure to produce coal in that manner in that region.

MR. LEWIS: Preston Lewis, New York State Department of Environmental Conservation.

I know that EPRI has, for a long time, been the research arm for the utility industry. I am curious to know what kind of research is being done in reducing the sulfur dioxide emissions, particularly from existing units, perhaps competing with the scrubbers. Are there improvements in the scrubbers?

MR. PLATT: I don’t think we have a very active program on scrubbing right now. I think we have cut back the intensity of that. Dick Rudy is the guy at EPRI who manages that program.

I know there are some advances being made, for example, whether it is by us or others. I hear about fertilizer by-products using an ammonia-based system rather than a limestone-based system that maybe produces a product that would have high value in the fertilizer industry. The problem is in permitting large tanks of ammonia on site.

I have heard about it for smaller plants. Maybe a circulating fluid bed might be one of the methods that might come into its own. This has just been demonstrated in Austria, I believe.

I say the commercialization and advance of technology is continuing progressively and incrementally on SO_2, aiming for higher removals, lower operating costs, better by-product utilization, that kind of thing.

In the old days we thought just about the biggest dirtiest units, wet limestone scrubbing or maybe magnesium enhanced limestone scrubbing, which turns out to have some real advantages.