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"Dirty, Old" Coal Plants: Silk Purse or Sow's Ear?

Adam Borison and Greg Hamm, Stratelytics

Introduction

There are more than 100 GW of "dirty, old" coal-fired power plants in the United States. By "dirty," we mean plants where SO2, NOx and other emissions are largely uncontrolled. By "old," we mean plants that are more than 35 years old. These plants constitute a significant fraction, roughly 10%, of the country's electricity generation capacity and an even higher fraction, roughly 15%, of the country's electricity generation. They represent an asset base worth hundreds of billions of dollars in market or replacement value.

These plants are both a challenge and opportunity to their owners, their customers and society. On the positive side, despite their age, they have low operating costs and good reliability. Instead of "dirty, old" plants, they can be thought of as "inexpensive, well-seasoned" plants. A typical plant produces power at a cost of perhaps half the average market price and well below the all-in cost of alternative power sources. As a result, it generates hundreds of millions of dollars in revenues each year. In addition, these plants are often located near major load centers and at critical points in the transmission system.

On the negative side, with emission controls largely absent, these plants produce substantial quantities of pollutants that can have both local and dispersed impacts. A typical plant can produce a hundred thousand tons of SO2 a year, tens of thousands of tons of NOx, and hundreds of pounds of mercury…not to mention millions of tons of CO2.

There is an ongoing nationwide debate about the strategy for managing these plants. The nature of the argument and the participants are similar across the nation. The debate is fundamentally between a "performance preservation" strategy advocated by utilities and an "emissions reduction" strategy advocated by environmentalists.

Most utilities, presumably with their customers and owners in mind, view the current status of these plants positively. They like their low operating costs, good reliability, and favorable location. These utilities propose to operate the plants fundamentally "as is" for the indefinite future, and they advocate substantial ongoing maintenance and upgrading of the existing equipment to make this possible.

Environmental groups, presumably with the public interest in mind, view the current status of these plants negatively. They dislike the high levels of emissions and resulting impacts. These groups propose to modify these plants significantly, and they advocate immediate installation of capital-intensive emission controls such as SO_2 scrubbers and NO_x SCR's.

This debate has been going on for many years. The outcome varies from plant to plant and region to region.

In some cases, plants continue to operate with considerable ongoing expenditures on efficiency and reliability improvements and without additional emission controls such as scrubbers and SCR's. There are many examples, with Alabama Power's EC Gaston plant as one. The plant was completed in the 1960's and early 1970's. It generates more than 13,000,000 MWh of electricity a year, valued at more than $500 million. In addition, it produces roughly 120,000 tons of SO_2, 30,000 tons of NO_x and 1,200 pounds of mercury a year, along with 13,000,000 tons of CO_2. Alabama Power spends tens of millions of dollars each year in ongoing capital and O&M consistent with the performance preservation strategy. For example, a new control system was recently installed at substantial cost.

In other cases, due to environmental concerns and pressure from environmental groups and government agencies, utilities have agreed to install capital-intensive emission controls. Again, there are several good examples. Dominion's Mt. Storm plant is one. Like EC Gaston, the plant was completed in the late 1960's and early 1970's. In 2000, Dominion agreed to install emission controls (SO_2 scrubbers and NO_x SCR's) at a cost of roughly $400 million. Mt. Storm generates more than 10,000,000 MWh of electricity a year, valued at more than $400 million. After installation of emission controls, it produces 25,000 tons of SO_2 each year (down by 100,000 tons due to scrubbers), 40,000 tons of NO_x (down by 20,000 tons due to SCR's) and 1,000 pounds of mercury. In addition, it produces more than 12,000,000 tons of CO_2.

The Role of Decision Frames

The ongoing, widespread debate between these two strategies is both unnecessary and unfortunate. It is unnecessary because there are other alternatives that should be considered for dealing with these plants. It is unfortunate because, in many cases, these alternatives will be better both on economic and environmental grounds.

How is it that the presumably complex issue of dealing with these plants has been reduced to a debate between two suboptimal extremes? The key reason is that the "decision frame" adopted by the parties involved is too narrow and too rigid. The concept of a decision frame was first popularized by decision theorists and economists in the 1970's.[1] This term refers to the fundamental manner in which an issue is presented – the potential choices, the potential consequences and the language used to describe them.

A “narrow” decision frame is one where the major uncertainties inherent in the problem are minimized or assumed away entirely. In this case, these uncertainties include the level of environmental regulation, the structure of energy markets, the development of generation technology and the like. Instead of acknowledging this uncertainty, these factors are assumed in a narrow frame to be known and stable within an unrealistically small range. This tendency towards overconfidence has been widely observed since the concept of a decision frame became popular.[2]

A “rigid” decision frame is one where the alternatives being considered are unchanging or fixed over time. This tendency towards inflexibility has also been widely observed in recent years.[3] The Electric Power Research Institute even developed a planning process called CATALYST to help utilities overcome this rigidity and uncover and evaluate flexible strategies.[4] Of course, in a world with minimal uncertainty, there is little need for flexibility. Consequently, an overly rigid frame is often a byproduct of an overly narrow one.

It is quite common to make decisions using a narrow and rigid “decision frame.” However, that does not make it good. Such a frame dramatically overstates what we know about the future, and dramatically understates our ability to adjust as that future unfolds. Consequently, it significantly misstates the pros and cons of the alternatives, and leads to decidedly inferior decisions.

There is a better way, and that is to frame the problem in a broad and flexible manner. A “broad” decision frame is one that acknowledges the wide range of future possibilities…some of which may depart radically from the past and present…and our uncertainty about these futures. A “flexible” decision frame is one where we consider adjusting or adapting our strategy appropriately as the future unfolds. If we take a broader and more flexible view, the debate over these plants as well as the result of that debate is entirely different.

The ABC Plant: Narrow & Rigid Frame, Standard Analysis

This choice of a decision frame is not an academic or theoretical issue. It can make a real economic and environmental difference, and it often does so in the case of these “dirty, old” power plants. This is best seen using a specific, but disguised, example drawn from work with major US utilities.

Consider ABC, a typical “dirty, old” coal plant. The plant was built during the 1960’s. It has multiple units with a total rated capacity of over 1000 MW. Last year, it produced more than 8,000,000 GWh of electricity from more than 3 million tons of low-sulfur coal. The plant currently has neither SO2 scrubbers or NOx SCR’s. It relies on low-sulfur coal for SO2 control and low-NOx burners for NOx control. It produces 50,000 tons of SO2 and 20,000 tons of NOx per year, along with 200 pounds of mercury. It produces roughly 9,000,000 tons of CO2 per year.

By and large, the strategy for ABC has been analyzed by its owners and the other stakeholders using the kind of narrow, rigid frame discussed above. The analysis assumes a world of volatile, but familiar, electricity and fuel prices, known environmental and market regulations, and stable generation technology. And it considers only two fixed alternatives: performance preservation vs. emissions reduction.

Figures 1a and 1b show the results of this analysis along economic and environmental lines. The performance preservation alternative requires an ongoing investment of $50M to $100M a year in capital and fixed O&M with a present value of roughly $500M. It produces a contribution or operating profit present value (PV) over a 30 year period of $1700M, including the cost of fuel and emission allowances. The overall NPV is $1200M. As noted above, this alternative is associated with an annual average of 50,000 tons of SO2 emissions, 20,000 tons of NOx emissions and 200 pounds of mercury emissions.

Figure 1a. Economic Scorecard with Original Frame

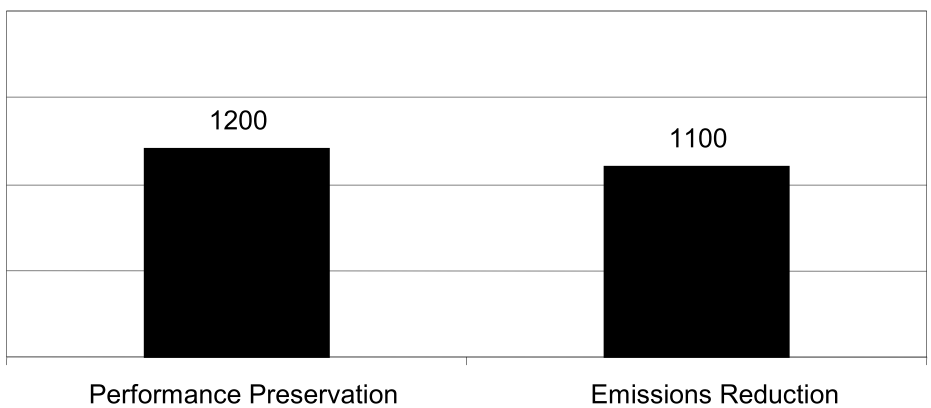
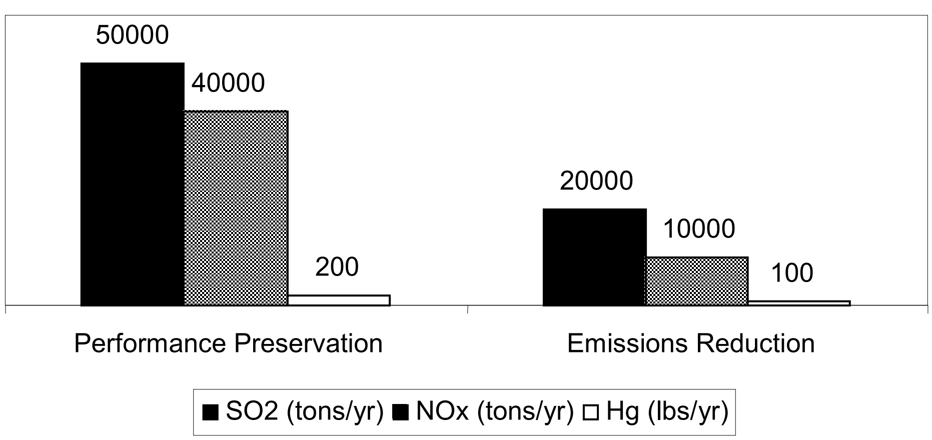


Figure 1b. Environmental Scorecard with Original Frame



The emissions reduction alternative requires an investment of an additional $400M in capital, as well as an ongoing investment of $60M to $120M a year in capital and fixed O&M. The combined present value of these investments is $1100M. It produces a contribution or operating profit present value (PV) of $2200M. The overall NPV is $1100M, somewhat lower than the performance preservation alternative. As expected, this alternative is associated with lower annual SO2 emissions of 10,000 tons, NOx emissions of 5,000 tons and mercury emissions of 100 pounds.

From an economic point of view, this analysis clearly supports a "performance preservation" strategy. This strategy is more profitable by $100M, and one could argue that environmental concerns are already factored in through emission allowances. From an environmental point of view, the analysis clearly supports an "emissions reduction" strategy. This strategy reduces emissions by 50 to 80% with an 8% drop in NPV.

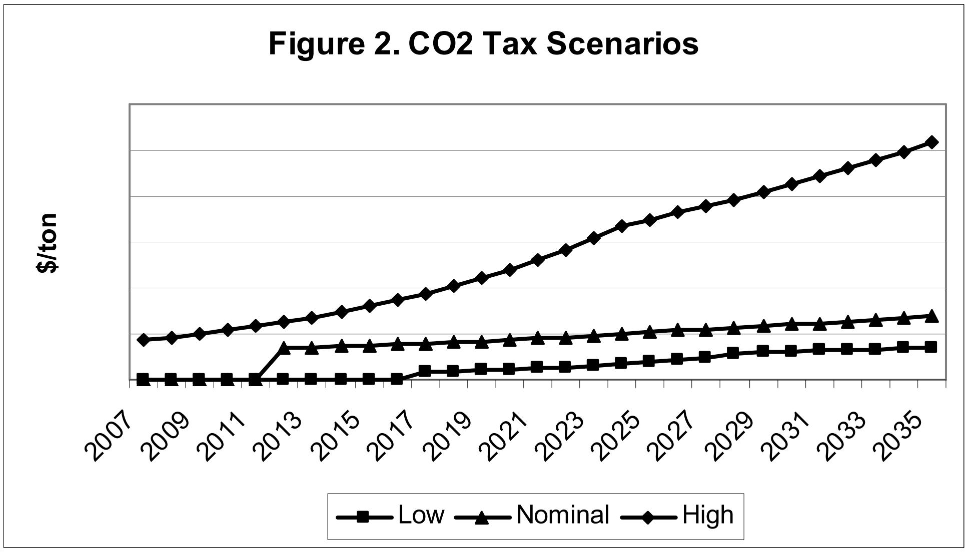
Historically, the strategy for ABC can be characterized as the typical debate between these two extremes. The economic argument has prevailed, although the environmental argument has been gaining ground. Until recently, little serious attention was paid to major uncertainties and flexible alternatives.

The ABC Plant: Broad & Flexible Frame, Improved Analysis

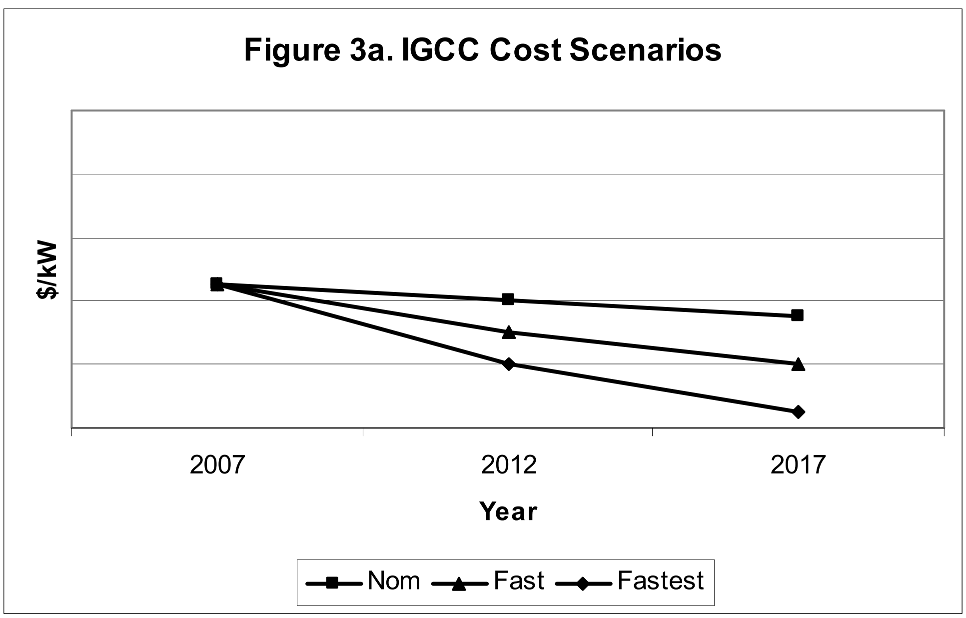
Consider first, a broader frame. There are two issues involving the future situation for ABC that are particularly unpredictable. The first is environmental policy/regulation. The range of potential futures in this area is quite broad, and there is a distinct possibility that substantial fees or limits will be placed on CO2 emissions. The second is coal-fired generation technology. The range of potential futures may not be quite as broad as with environmental policy/regulation. Nevertheless, there is a possibility that technology will develop substantially and lower-carbon alternatives (IGCC or IGCC/capture) will become more economic.

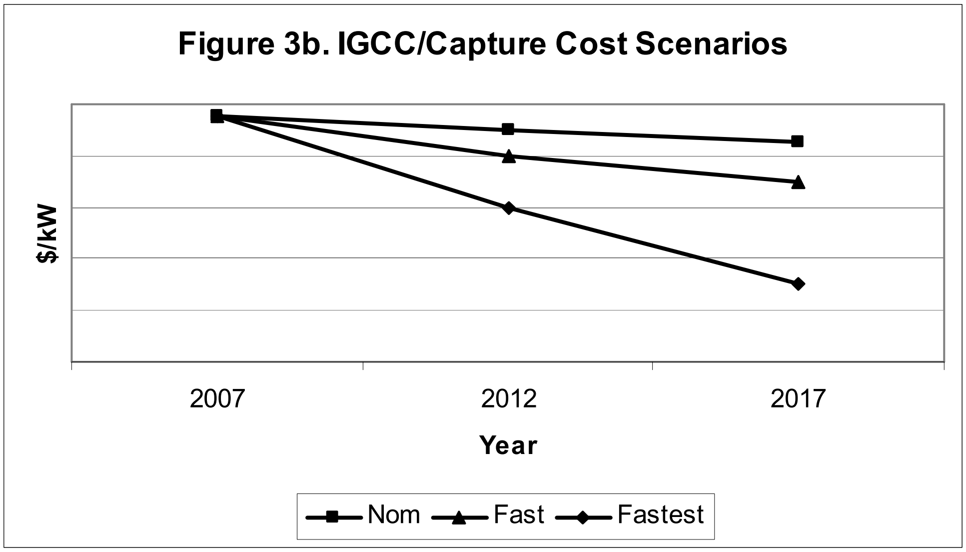
In the narrow view, these two factors are assumed to be known and not widely different from the current situation. A broader and more realistic view is shown in Figures 2 and 3.

In Figure 2, there are three potential scenarios for future environmental policy/regulation. The nominal scenario, the one underlying the narrow frame, shows a moderate increase in a CO2 tax starting in roughly five years. There is also a low scenario, where the CO2 tax does not become effective for ten years and then remains fairly low and constant. Finally, there is a high scenario, where the CO2 tax becomes effective almost immediately and rises quickly. The likelihood of these scenarios is a matter of individual judgment since there is no source of readily-available, objective data. In the analysis described here, probabilistic assessments were made by industry experts.



In Figures 3a and 3b, we see a broader and more realistic view of coal-fired generation technology. In the nominal scenario, IGCC remains expensive and IGCC/capture prohibitively so.





This nominal scenario is the one underlying the narrow frame. There is also a fast scenario where IGCC technology improves rapidly but IGCC/capture does not. Finally, there is a fastest scenario where the technology for both IGCC and IGCC/capture improves quickly. Again, the likelihood of these scenarios is a matter of judgment, and assessments were provided by industry experts.

Figures 4a and 4b shows how this broader frame affects the analysis of ABC strategy. Rather than just capturing the effect of a single scenario, these figures provide the mean and standard deviation across the entire range of scenarios.

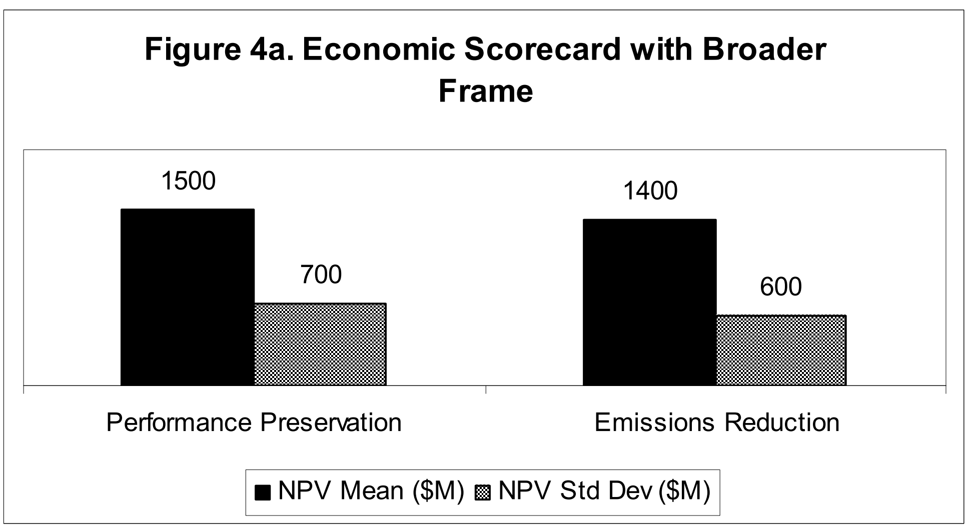
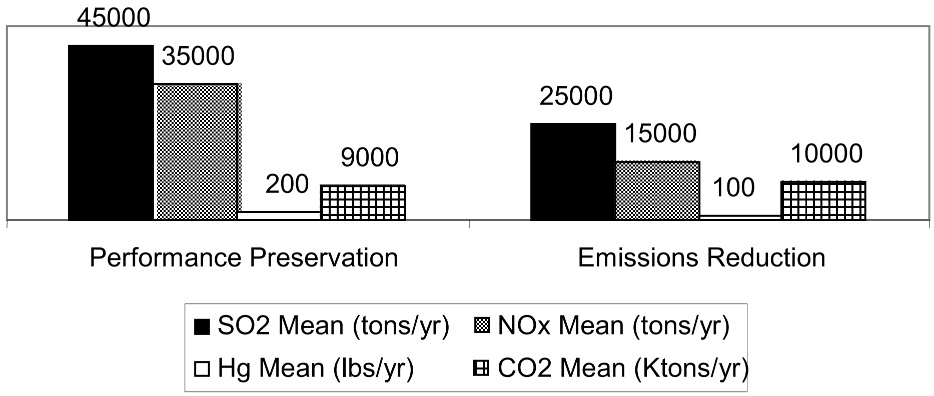


Figure 4b. Environmental Scorecard with Broader Frame



With uncertainty factored in, the "performance preservation" alternative looks less like an economic slam dunk. The mean NPV across the scenarios is a healthy \$1500M. However, because of the potential impact of CO_2 regulation and related factors, the NPV could easily be 50% lower or higher as shown by the sizable standard deviation of \$700M. The mean NPV of the "emissions reduction" alternative is somewhat lower at \$1400M, but the range (or risk) is also somewhat smaller as indicated by the standard deviation of \$600M. This makes the economic comparison between the two alternatives more difficult. When CO_2 scenarios are considered explicitly, the "emissions reduction" strategy does not look so environmentally sound either. Because controls lower the operating cost of the plant, the installation of emissions controls actually increases mean CO_2 production significantly. Standard deviations are not shown here because the variation is fairly small across scenarios.

This broader frame reveals that neither alternative may be particularly well-suited to the range of plausible future scenarios. The "performance preservation" strategy may be a bit like investing hundreds of millions of dollars in maintaining a leaded gasoline refinery just prior to regulation banning lead in gasoline, hardly a good economic (or environmental) decision. The "emissions reduction" strategy may be akin to investing hundreds of millions of dollars in modernizing and expanding a CO_2 factory, hardly a good environmental (or economic) decision.

Consider then, a flexible frame with more, and potentially better, alternatives. Figure 5 shows this wider set of alternatives, including some that involve adjusting over time. At the top left are the original two strategies, "performance preservation" and "emissions reduction." Further down, there is now a set of flexible alternatives – beginning with operation of the plant in "minimum investment" mode for five to ten years while tracking the state of CO_2 regulation and generation technology. Depending on how these uncertainties come out, the plant can be preserved in its present configuration, emission controls can be added or the site can be re-powered with a low carbon technology using some of the existing equipment. This is a more complicated strategy, but also one of potentially higher value.

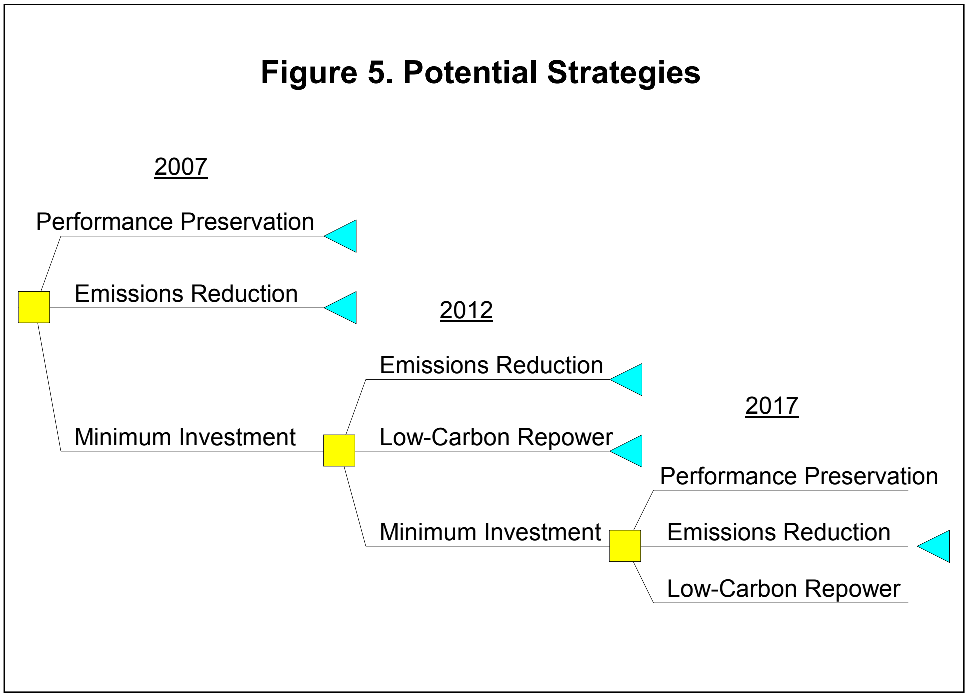
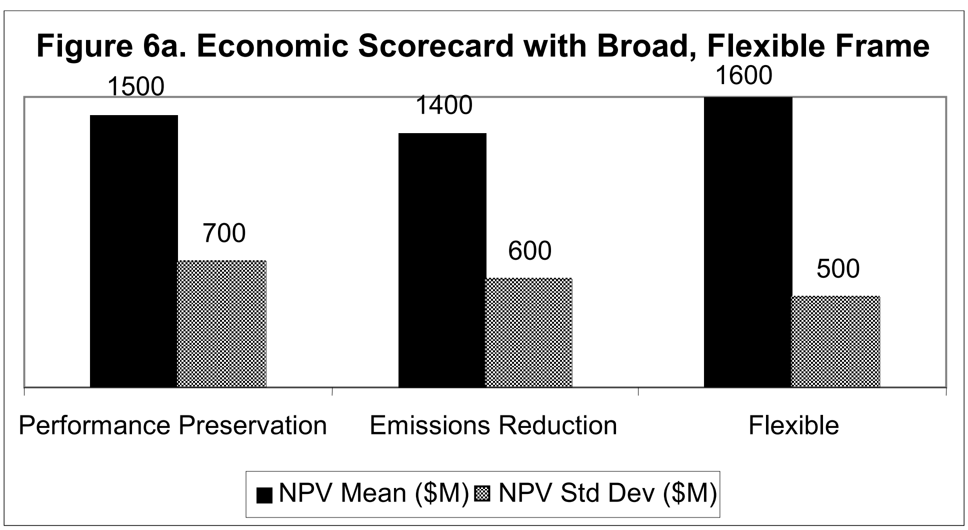
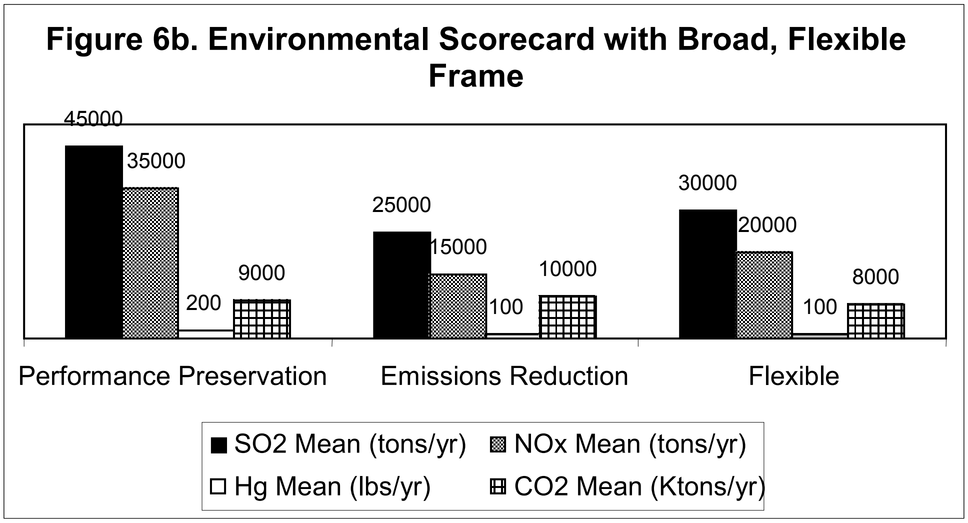


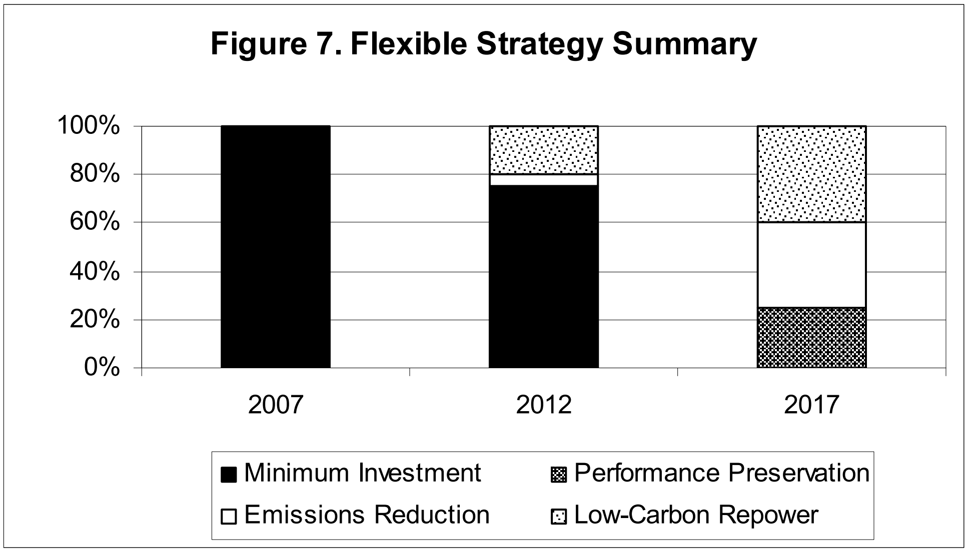
Figure 6a and 6b show the economic and environmental bottom line of the analysis with a broader, more flexible frame. Unlike the narrow and rigid analysis, these results include both the uncertainty in this problem and the flexibility to deal with it. As such, these results reflect a much more realistic view than the narrow, rigid view underlying Figure 2.





Figures 6a and 6b show that the flexible strategy is preferred over the two fixed strategies on both an economic and an environmental basis. On an economic basis, it has an NPV that is higher than the alternatives with lower risk. On an environmental basis, it produces substantially less CO2 and no more mercury than the two original strategies. It does have slightly higher SO2 and NOx emissions than the "emissions reduction" alternative, primarily because of the "minimum investment" period. However, the dramatically lower CO2 emissions make it superior environmentally as well. On an expected value basis, the flexible strategy at ABC has an increased NPV of at least $100M and decreased CO2 production of at least 1,000,000 tons per year.

What exactly is this flexible strategy? It is not as easy to specify or communicate as the fixed strategies of performance preservation or emissions reduction. The strategy begins with a "minimum investment" or "wait and see" phase of either 5 or 10 years, and then adapts differently depending on how the future unfolds. In some cases, emissions controls are installed. In other cases, a lower-carbon technology is installed. The flexible strategy is summarized in Figure 7. As this figure indicates, there is about a 25% chance that events will unfold so that the "minimum investment" decision shifts in five years to either to a low-carbon repower or an emissions reduction strategy. Within 10 years, low-carbon repowering becomes the most likely alternative, followed by emissions reduction and performance preservation.



Conclusion

The current debate over what to do with "dirty, old" power plants is severely hampered by a narrow and rigid decision frame. The ABC example shows how adopting a broader, more flexible decision frame, and using improved analytical tools suited for that frame, can make a real and important difference in the strategy for such plants, creating both economic and environmental benefits. Although ABC is only one plant, its characteristics and situation are fairly typical. Spread across the industry, this could mean a reduction in costs of billions of dollars and CO2 emissions of tens of millions of tons per year.

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