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THE RUSH TO COAL: IS THE ANALYSIS COMPLETE?[1]

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"Truth is confirmed by inspection and delay; falsehood by haste and uncertainty."
Publius Cornelius Tacitus

Overview

After a period of very low activity, a large number of new coal power plants are under development in the US – nearly 100 GW. At the same time, the costs of construction materials and services have seen increases unprecedented in 20 years. Perhaps of the most significance for coal plant development, legislation limiting greenhouse gas (GHG) emissions has been adopted in several states and has been proposed in many other states and at the Federal level. GHG regulation can impact coal plants particularly because of their high emissions of CO_2. In addition, anticipation of GHG regulation has led to a rush to develop renewable power technologies, nuclear power, and new cleaner coal power technologies.

History, economic theory, and experience all suggest that, in times of high uncertainty, learning has high value and investments should face a higher hurdle. The question arises, "Are coal plant developers adequately considering the potential for learning about GHG regulation, construction cost trends, new technologies, and the consequent impacts on coal plant economics when making decisions about building new coal plants?"

We begin with a discussion of the fundamental principle that the hurdle for investment should rise in times of high uncertainty. We then present some empirical evidence regarding the value of waiting and learning. The empirical evidence comes from outside and within the electric power industry. We present both statistical and, for illustration, anecdotal evidence. Finally, we argue that this is a period of especially high uncertainty for coal based power and that alternatives exist to rapid expansion of traditional coal capacity.

The Value of Learning: Fundamental Principles

What is the appropriate response when considering an investment in the face of uncertainty? Consider your last investment in a cell phone, computer, or other high tech device. If a highly anticipated new device was soon to be released, did you delay your purchase? If a "bubble" of demand seemed to be pushing prices up, did you consider postponing your purchase? Did you wait to learn what the new value-to-price tradeoff would be – many people do. The high tech industry anticipates a slowdown in sales just prior to the release of blockbuster products such as the IPhone, major new processor releases from Intel, or a new operating system from Microsoft or Apple. Frequently, prices are slashed prior to the new product's release to try and keep buyers buying, but still many of us delay to learn.

A fundamental result of real options theory is that a tradeoff must be made between the cost of delay and the value of learning. The greater the uncertainty, the higher are the rewards to learning. This includes uncertainty with respect to input costs, output prices, and regulatory actions. We illustrate this with a simple example, similar to that used by Dixit and Pyndyck in their classic text on real options.[2]

Consider a potential investment of $1000 Million in a coal fired power plant. The investment is made at the start of Period 1, and we are confident of receiving $200 Million in net revenue at the end of Period 1. Returns following Period 1 are uncertain; however, we believe that by the end of Period 1 we will learn that the NPV of future net revenues is $1300 Million or $800 Million. Finally, we assume that the probability p of the high value is 50% and the returns are uncorrelated with markets[3]. The payoffs from investment are illustrated in Figure 1. If we don't invest, the cost and payoff are $0.

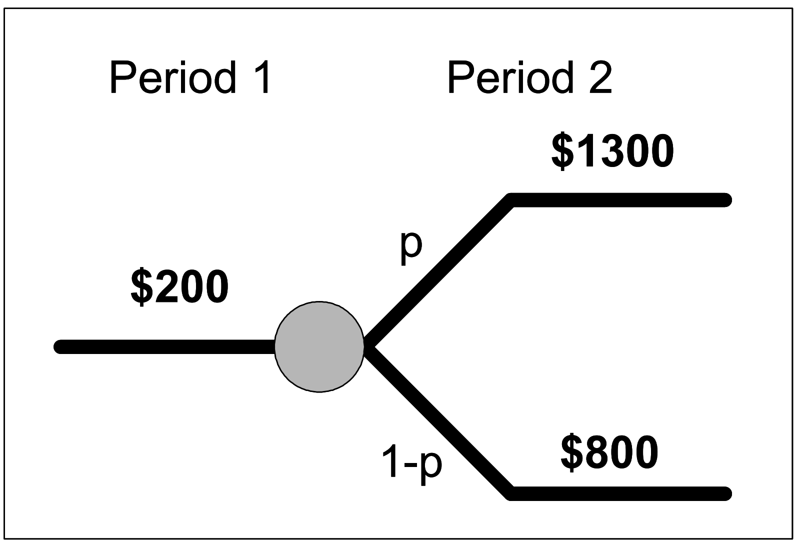

Figure 1. Payoffs from Investment

Should we invest or not? The traditional rule is that if the discounted expected net present value (NPV) is positive, we should invest. Assuming a 10% discount rate, the calculations of expected NPV including investment are:

$$-\text{Investment} + \frac{\text{Period 1 Return}}{\text{Period 1 Discount}} + \frac{\text{Period 2 Return}}{\text{Period 2 Discount}} = \text{NPV}$$

or

$$-\$1000 + \frac{\$200}{1.1} + \frac{0.5 \times \$1300 + 0.5 \times \$800}{1.1^2} = \$49.60$$

NPV is positive; the traditional rule says invest.

Now assume that we have the option to invest at the end of Period 1, after we learn about the long-run returns. If we delay, we will forego the revenue of $200 Million in the first period. If we learn that future net revenues will be $1300 Million; we will invest. If we learn that future net revenues will be $800 Million; we will not invest. If we delay one period, the calculations of expected NPV including investment are:

$$0.5 \times \left(\frac{-\$1000}{1.1} + \frac{\$1300}{1.1^2} \right) + 0.5 \times 0 = \$82.64$$

Delay and learning increase our returns dramatically.

Figure 2 illustrates the NPV and strategy in our example as the probability of the high payoff changes.

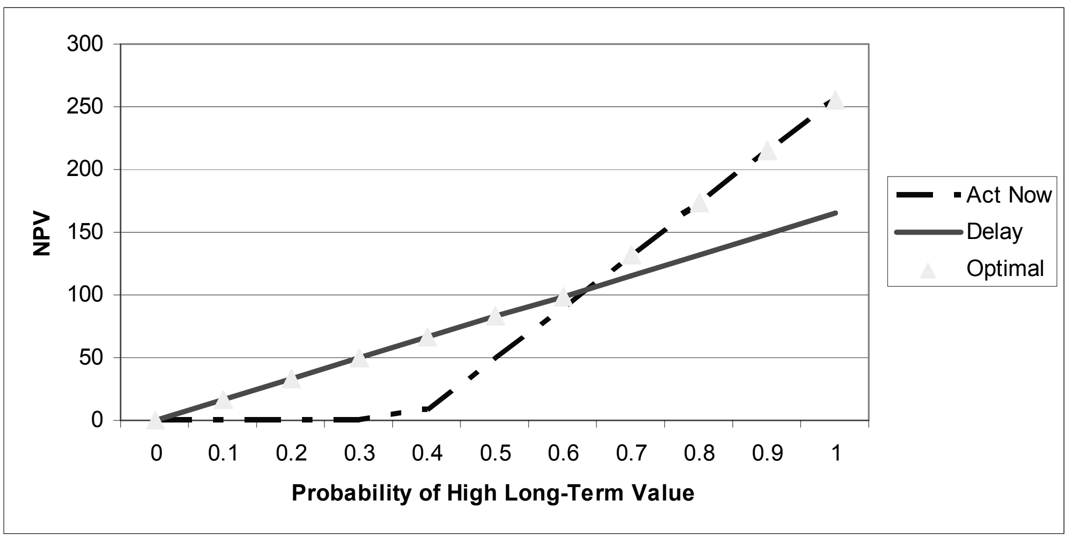

Figure 2. NPV and Optimal Policy as Probability Varies

If "Act Now" was our only alternative, we would not invest unless the probability of the high payoff was greater than 30%. This means that we actually lose money more than 50% of the time, but the chance at high returns makes it a good investment. In the range of approximately 30% to 60%, we delay our investment when the option to invest later is available. Over 60% probability of the high outcome, we invest now even with the delay option.

Our model is extremely simple but it illustrates that in the face of uncertainty with the option of delayed investment, it is often optimal to wait. Dixit and Pyndyck develop and test a number of more realistic models where learning is incomplete and investment can occur at anytime. Their conclusion, "Hence the simple NPV rule is not just wrong; it is often very wrong."[4]

This principal of the value of delay and learning has also been studied in the realm of regulated utilities. This analysis has shown that if regulation reduces the uncertainty in future returns, it may modify but it does not eliminate the value of learning.[5]

The Value of Learning: Experience

The prior section illustrated the logic of balancing act-now versus delay-and-learn. For individual companies, we see many cases where the most aggressive "first-to-market" firms lose out to firms that learn from the experience of these leaders. Also, we see examples where entire industries seem to get caught up in investment rushes that end in disaster. In this section, we look at examples outside and within the electric power industry. We first review a few limited cases where statistical analysis has been possible and then review some of the more anecdotal evidence for the value of learning.

Experience Outside the Electric Power Industry

Some statistical analysis:

- Bulan conducted two studies of the impact of uncertainty on investment. The first study was of 1200 real estate developments in Vancouver, BC. The second study was of 2300 publicly traded firms with a total of 17,000 observations. The major finding was that greater uncertainty in prices significantly reduces the pace of investment.[6]
- In a study of 80 Internet companies, McKinsey found that speed at the expense of developing a solid business plan and gathering the right resources rarely paid off.[7]
- Cotrell and Sick examined individual competitive situations. They found that delay to learn about market development, technology change, or input or output prices provided significant advantages in nine different industries. They site similar results for 28 other consumer products.[8]

Perhaps the best recent example of an industry-wide rush to invest in the face of very high uncertainty was the 1996 to 2001 telecom investment spree followed by the 2001 – 2002 worldwide telecom meltdown. The telecom industry raised $650 billion in debt and equity 1996 to 2001.[9] The uncertainties in this period included whether an extremely sudden and rapid growth in bandwidth demand would continue, how fast and which new telecom technologies would develop, and how much demand there would be for personal communication and data services.

In the US beginning about 1996, deregulation and demand for internet services created a frenzy to acquire network resources. Established companies began spending wildly on network installation, many new network companies started up, and companies with high speed lines were purchased at 10X the value of their assets.[10] Demand failed to materialize. By 2001, seven new American telecom companies had filed for bankruptcy and more than $100 billion in junk bonds were rated at high risk.[11] By 2002, half a million jobs in telecom were lost and the market value of sector had dropped $2 trillion.[12]

In Europe, the focus was on Third Generation (3G) mobile networks and the licenses to operate these networks. The investment and collapse happened more quickly than in the US. In 2000 Martin Bouygues, who ran France's No. 3 cell-phone network, wrote an open letter saying that it was crazy to bid billions of dollars to buy licenses and build networks, when technologies to use the networks were still under development and the services to be sold were undefined. No one paid attention, but Bouygues was right. In just two years, "Europe's phone giants -- after spending half a trillion dollars on licenses, acquisitions, and networks--are treading madly to stay afloat in a sea of debt. But 3G phones may well cost $800--and devour batteries. Worse yet is bandwidth's dirty secret: Without compelling content and services to sell, high-speed networks are a waste of money. The [phone companies] are paying through the nose for something that's not very valuable."[13] The biggest spenders had to sell off prime assets to cover debt or make share offerings. On average, European telecom stocks fell nearly 60% from May 2000 to June 2001.[14]

Experience Inside the US Power Industry

The 1990 Clean Air Act Amendments were a revolution in US environmental regulation. The Act was performance based providing great flexibility in meeting the requirements. The Act introduced trading of pollution allowances creating the opportunity for the market to efficiently distribute the emissions reductions. Here we consider the sulfur dioxide controls in the Act.

The major choices for compliance were installing scrubbers, switching to low sulfur coal, and buying allowances. The early estimates of the costs of these approaches were extremely inaccurate. Table 1[15] shows a pre-1989 industry estimate of allowance prices, an EPA 1990 estimate of allowance prices and actual trade prices from 1993 to 1995. The actual prices were one fifth to one tenth of the estimated prices.

Table 1. Predicted and Actual Allowance Prices

Industry Estimates Pre-1989	EPA 1990 Estimate	Early Allowance Trades	Early 1995 Allowance Trades	1993 CBOT Allowance Auction	1994 CBOT Allowance Auction	1995 CBOT Allowance Auction
$1500	$750	$250	$170	$122	$140	$126

In 1990, many analysts projected that the average price for low-sulfur Central Appalachian coal would reach $40 per ton by 1995, but the actual price was less than $25 per ton. Scrubber prices fell through out the early years of the regulation while at the same time increasing in efficiency.[16] At least in retrospect, it is obvious that there was great uncertainty about the costs of compliance.

Logic would suggest that utilities would avoid investment and choose flexible approaches for compliance until the cost of different approaches became more clear. Table 2[17] shows early compliance strategies.

Table 2. Choice of Compliance Strategies

Compliance Approach	% of Utilities Using Approach
Switch and/or Blend Coals	55% to 63%
Pre-Phase I Compliance	10% to 18%

Install Scrubbers	10% to 16%
Purchase Allowances	3% to 15%

"Install Scrubbers" the most capital intensive approach was used by a limited number of utilities, even though utilities that scrubbed were eligible for an "extra" 3.5 million allowances – a political concession to reduce the Acts impact on states producing high sulfur coal.

Coal switching was by far the most popular strategy. This is a fairly flexible strategy with relatively low upfront costs.

But why did the most flexible strategy "Purchase Allowances" have so little use? There have been a number of reasons advanced: transaction costs, cost savings not shared with utilities, asymmetry of regulatory risk, legislative trading prohibitions, negative public reaction to buying the right to pollute. We feel another reason was a lack of recognition of the uncertainty of allowance prices and the value of waiting and learning.

One major utility, Illinois Power, did pick a Purchase Allowances approach.[18] Illinois Power used a simple real options analysis of the regulations and considered their maverick approach highly successful.[19]

Uncertainty and Alternatives

Uncertainty

Both capital and operating costs for coal power plants are highly uncertain at this time.

Recently, utilities have seen rapid changes in capital costs. For example, Duke Energy has seen the total price of two new 800 MW coal units escalate from $2 billion to $3 billion[20] Figure 3 illustrates that the recent escalation of key components of generating facility construction costs is unprecedented over the last 20 years. The Producer Price Indices for New Construction, Steel Mill Products, and Concrete are shown.[21] All three graphs show a significant acceleration in costs beginning in 2004 and continuing to the present.

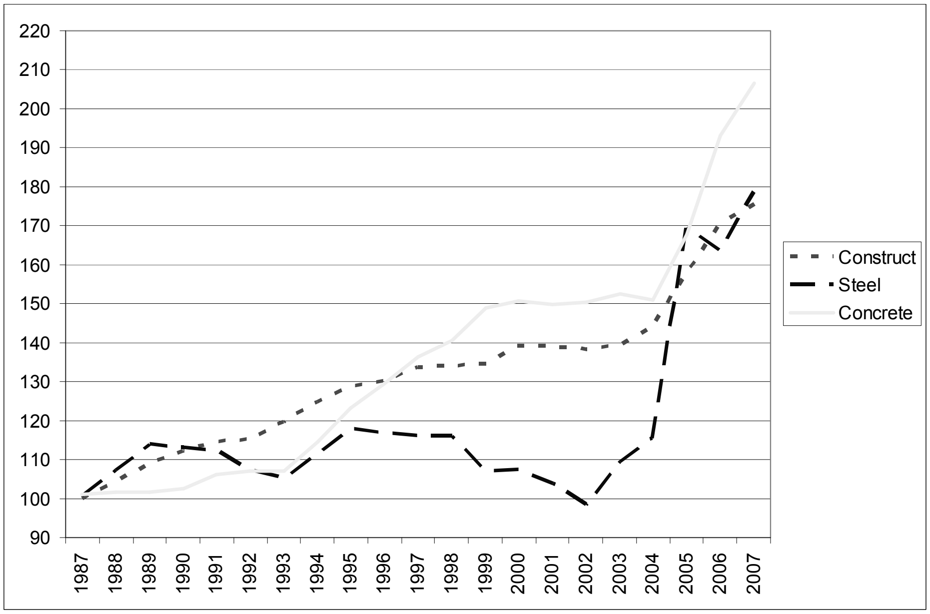

Figure 3. Construction Cost Increases

Is this a short term run up due to supply-demand imbalances that will go away as supply increases, or does it mark a more permanent move of these commodities to higher prices? No one knows the answer to that question. Because the run up has been both sudden and unique, we believe it indicates a period of high price uncertainty.

Operating costs for coal are highly dependent on environmental regulation, and it is likely that the most important environmental regulation ever for fossil fuel power will be enacted in the next few years. Currently, there are ten Greenhouse Gas (GHG) Emission bills in Congress. One bill would cap the cost of CO_2 emissions at $7/ton of CO_2 released. Some advocates of strict limits suggest that $30/ton is needed to significantly affect the production of CO_2 from coal. These represent an increase of 25% to over 100% in the operating costs of coal plants. Some utilities see the passage of GHG legislation with some type of an allowance trading provision as a virtual certainty, but there is still much to be learned. The bills differ significantly in the following dimensions:

- Severity of limits;
- Existence of a safety-valve (maximum) allowance price;
- Economy wide versus electric utility only trading;
- Ability to use international credits, forestation, and sequestration;
- Allowance distribution rules; and
- % of free versus auctioned allowances.

This regulation and the way the Federal law and State regulators distribute costs between companies and consumers pose huge risks for utilities now developing coal.

Alternatives

Capacity margin levels are projected to drop below minimum target levels in Texas, New England, the Mid-Atlantic, the Midwest, and the Rocky Mountain area in the next two to three years.[22] NERC expects 141 GW of demand growth by 2015.[23] NERC estimates 16% growth in energy needs and 17% growth in peak demand, 2006 to 2014. The EIA estimates 14.5% (reference case) and 17% (high case) electric energy demand growth over the same period.

The industry is rushing to build new capacity and new coal capacity in particular to meet this need. 246 coal-fired units totaling over 85 GW are in various stages of development in North America. 233 of the new units are proposed for the U.S., 11 for Canada, and two for Mexico. Combined, these projects represent an investment of more than $127 Billion. Of the 246 coal-fired units that have been proposed, 72 (representing 27 GW) plan to break ground in 2007, and another 95 units totaling 31 GW may get under way in 2008. (In addition, 82 GW of gas, 51 GW of renewable, and 40 GW of new nuclear are under development or have been proposed.) [24]

If new capacity is the only way to bring supply and demand into balance, perhaps building coal now is the only alternative. But, utilities have a number of alternatives to deal with this growth. In order of increasing flexibility, alternatives include: invest in large plants, invest in transmission, invest in smaller plants, invest in demand side management, delay planned retirements, and let prices rise. Consider the two most flexible: delay planned retirements and let prices rise.

- Between now and 2010, it is assumed that 20GW are likely to be decommissioned. Delays in these retirements would significantly reduce the short-run need for new capacity.
- The current EIA estimate assumes that approximately 10% of recent price increases will disappear moving into the future. If prices held constant -- a 10% rise over the current EIA reference case through 2014 -- it is estimated that demand growth in the 2006-2014 period would be reduced from 14.5 percent to 10.6 percent. This is approximately a 25 GW reduction in needed plants between 2006 and 2014.[25]

These alternatives would allow time to learn more about carbon regulation, costs, and new technologies.

Summary and Recommendations

Coal plants in particular face an extremely uncertain future. The cost of constructing plants has experienced a rapid increase over a short period. It is uncertain if a new plateau has been established or if prices may revert to lower levels. The most dramatic environmental legislation in the history of the industry is on the horizon. But the nature of this legislation and its implementation is uncertain.

Real options theory is clear that as volatility increases there is an increasing value to delay and learning. Investments should only be undertaken when the returns cover both the investment costs and this shadow cost of lost learning.

Historical patterns show that companies vaguely recognize this principal; however, it does not seem to be systematically applied and followed.

Given current conditions in the utility industry, it seems a critical time for the industry to recognize the value of caution and learning, particularly with respect to the construction of new coal plants. Utilities do have options such as delaying retirements and/or allowing prices to rise. Further, utilities have the capability of analyzing their alternatives with consideration of the value of learning. Real options analysis is a practical tool for the examination of risky and flexible investments.

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[1] This article was developed with the support of EPRI and under the direction of Mr. Victor Niemeyer. However, opinions are those of the authors alone.

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