4 Real Options: What Telecommunications Can Learn from Electric Power

Todd Strauss
PHB Hagler Bailly, Inc.

Abstract - An example of an option associated with operating flexibility in electric power production and a real options approach to valuing the option are presented. This approach is contrasted with the standard discounted cash flow approach and a pure financial option valuation approach. Some connections between electric power and telecommunications are drawn, and lessons for the telecommunications industry are highlighted.

This paper describes a real options approach to assessing the value of a power plant. On face, it might seem odd to include a paper describing an electric power application in an edited volume on real options in the telecommunications industry. But the industries are not all that dissimilar. Both are capital-intensive, technologically-oriented industries with a long history of regulation. And both are undergoing rapid transformation in an age of globalization and deregulation.

Also, an understanding of the modeling process illustrated here will bear fruit for those interested in applying real options to the telecommunications industry. Much of the real options literature focuses on investment options – options to expand, delay, or abandon investments in capital assets. The application described here focuses on an option associated with operating flexibility in a network industry.

Last, much of the literature on the real options approach contrasts it with the standard discounted cash flow approach. This paper also illustrates the distinctions between a real options approach and a pure financial option valuation approach.

1. APPLICATION: ASSESSING THE VALUE OF A POWER PLANT

There is much regulatory interest in answering the question: What is the value of a power plant? There is also a substantial business need for answers to this question. The answers are used in formulating bids for plant auctions and in the syndication of debt financing of power plant acquisitions.

For this discussion, only the broadest outlines of electricity generation need be mentioned. For one, power plants are like refineries for electricity. A commodity fuel goes in, and out comes electricity. Also, there are constraints on production. Some constraints are associated with the physical characteristics of boilers, turbines and generators. Others are associated with regulatory requirements, such as environmental restrictions. That's all we really need to know about power plants for right now.

The usual approach to valuing a power plant is to perform a discounted cash flow analysis. The first step is to forecast each year's revenues and costs. Annual net revenues are then computed. Next, each year's net revenues are discounted using some risk-adjusted discount rate. Finally, the discounted annual net revenues are summed to yield a net present value. Market prices, gross revenues, and annual net cash flows are determined using production cost models.

Production cost models for electric power have features that are similar to those of the cost models used in telecommunications. The models are purported to focus on economic fundamentals. However, while the models have detailed engineering representations on the supply side, they have very poor representation on the demand side. Neither the uncertainty of demand nor the elasticity of demand is represented. It is assumed that price equals marginal cost. Modelers are clever, in electricity as in telecommunications, and so they try to jigger the inputs so that the prices output by the models represent market competition, perhaps even ability to exercise market power. The most striking similarity between the telecommunications and electric power cost models is that they are legacy models coming out of the regulatory contexts of the 1970s and 1980s.

In particular, both types of model exclude real options. For example, the electric power models do not include the value of possible site expansion. An old, inefficient power plant has infrastructure – electric transmission connections, gas pipeline connections, operating permits – making it easy to upgrade to a new, highly-efficient power plant in several years. This opportunity to upgrade may be worth a lot, particularly in areas where it is very difficult to obtain a new, "greenfield" site for a power plant. However, possible site expansion is not captured in the standard discounted cash flow analysis. This is broadly recognized. Many analysts attempt to include the value of possible site expansion by using a subjective probability of site expansion and a projected net cash flow for the site expansion, then computing an expected value for the site expansion possibility, and finally adding the expected value to the base case NPV. As discussed elsewhere in this book and in the literature, the real options approach is a superior way to value possible site expansion.

The most commonly cited examples for applications of the real options approach tend to be investment options – options to expand, delay, or abandon investments in capital assets. Included in this category is the above-mentioned option for site expansion. Investment options are rather generic in nature, with applicability across a broad spectrum of industries and organizations. A growing literature maps out how to identify and value investment options, and there is no special insight the telecommunications industry can glean from an application in electric power.

Examples of options associated with operating flexibility appear much less frequently in discussions of the real options approach. An example of such an option and an approach to valuing it is presented next. To tailor the lesson to the telecommunications industry, some connections are drawn between electric power and telecommunications, and the lessons that may be applied to the telecommunications industry are highlighted.

Now, more on electricity markets and power plants. Across the country and around the world, there are wholesale electricity markets for production, specified in intervals as short as one hour. Such markets are one of the hallmarks of the global trend toward electricity deregulation, or as insiders put it, "restructuring." Electric power is becoming a commodity. Because electric power is difficult or expensive to store, and because the regulatory transition leaves many retail customers insensitive to short-term swings in wholesale price, electric power prices are the most volatile of any commodity traded today.

In the face of this uncertainty, what's a power plant to do? A power plant does have some operational flexibility, and can use this in responding to prices. When it is profitable to produce electricity, the plant should produce. And when it is unprofitable, the plant should try to shut down temporarily. (If the power plant has some contractual obligation to provide electricity to some customers, it may be profitable – or more precisely, less unprofitable – to shut down temporarily, and fulfill its obligation by supplying less-costly power purchased in the market.) But market prices are uncertain, so it is not known in advance when the plant will be profitable or unprofitable; hence, it is not known in advance whether the plant should be operating or shut down.

However, the operating policy for the power plant can be specified in advance. As prices are revealed in the marketplace, the power plant's operators can adjust the operating level of the power plant in response to the market prices, and in accord with the operating policy for the power plant. Furthermore, the plant's operating policy can be changed as market conditions change, as regulatory requirements change, or as plant ownership, control, or governance changes.

There are two conditions leading to an option associated with operational flexibility. First, market prices for electricity output (and fuel input) are uncertain. Second, a power plant has some capability to adapt its operations when the uncertainty is revealed.

Surprisingly to some industry modelers, this option is poorly captured by the production cost models described earlier. In spite of all their engineering detail, these models include limited sources of uncertainty. The production cost models thereby miss almost all of the value in a power plant's ability to respond to fluctuating market prices. This ability to respond, often referred to as "dispatchability" in the electric power industry, may be a significant component of the total value of the power plant, but is absent from an NPV calculated using the discounted cash flow approach.

Recognizing this operating flexibility as an option is crucial for the accurate valuation of the power plant. But it is not sufficient.

An option-based approach to valuing a power plant is often used, typically by financially-oriented power traders who come from other commodity backgrounds, especially natural gas trading. These traders recognize that a power plant (at least, a "merchant" power plant not owned by a regulated utility) has a right, but not an obligation, to generate electricity in the marketplace. These traders model a power plant as a strip of European call options on the Btu (British thermal units) spread. That does not mean anything to power plant engineers, and may not mean anything to telecommunications people, but the Wall Street folks understand what that means. Let's dissect this beast.

The Btu spread is the differential between an electricity price and a fuel price. Because prices for electricity and fuel are expressed in different units, fuel prices are typically transformed to units of electricity price. The arithmetic calculation includes an adjustment for the thermal efficiency of the power plant (how much fuel input is required to produce one unit of electricity output). Thermal efficiency is commonly expressed as the Btu required as fuel input to yield one kilowatt-hour of electricity output. Hence, the Btu spread is a measure of the power plant's relative economic efficiency, given particular electricity and fuel prices.

A call option grants the holder the right, but not the obligation, to take delivery of the underlying instruments at the strike price. A call option pays off – is "in the money" – when the value of the underlying instrument is greater than the strike price. A call option on the Btu spread is the right to purchase fuel and sell electricity at the specified differential in electricity and fuel prices. In this light, a power plant has an opportunity to make money on the difference between electricity and fuel prices by burning fuel and producing electricity. In some sense, the plant is arbitraging the separate markets for electricity and fuel. A European option means that the option can be exercised only at maturity, not before. Because electricity is not readily storable, this is appropriate. A power plant has such an option for each hour of production. The strip is the collection of separate hourly options.

This option-based approach is inaccurate. It typically estimates the value of a power plant at an amount too high to be believed. The problem is that this pure financial approach ignores the operating characteristics of the power plant. It includes an assumption that the power plant can costlessly respond to market prices by turning up to maximum capacity when the Btu spread is positive and by turning off when the Btu spread is negative. Power plants have some freedom to respond to market prices, but this freedom is constrained by the operating characteristics of the power plant. Precisely because this assumption is not true, production cost models include engineering and regulatory detail on the power plant's operating characteristics.

So the approach we have taken at PHB Hagler Bailly is a real options approach. Figure 1 displays a schematic of this approach. Our proprietary market valuation process, MVP℠, starts with a characterization of market price volatility, as does the pure financial options approach described above. The model then values the ability of the power plant to respond to fluctuating market prices. Unlike the pure financial options approach, this model accounts for the decrease in value associated with the lost market opportunities caused by operating "frictions" such as physical and regulatory constraints on the power plant. These frictional losses are valued using standard optimization techniques such as dynamic programming and linear programming. The frictional losses are linked to the financial strip by constructing a new derivative (in the financial sense). This new derivative is a modification to the strip of call options on the Btu spread. The new derivative is then valued.

MVP℠ has been used to value power plants at auctions and in syndication of debt financing. Table 1 compares the values yielded by MVP℠ with those yielded by discounted cash flow methods based on production cost models, and with values from the pure financial approach. Values are stylized and have been scaled to make it easier to compare results across plants and valuation techniques.

As Table 1 shows, there is generally an option premium associated with operating flexibility. The magnitude of the option premium depends on the specific operating characteristics of the power plant. A nuclear power plant has little operational flexibility and does not readily respond to price signals, so the option premium is negligible. At the other end of the spectrum, oil plants used to meet peak conditions have high optionality. In most cases, the frictional losses due to operating constraints are substantial, so the pure financial option approach grossly overestimates the value of a power plant.

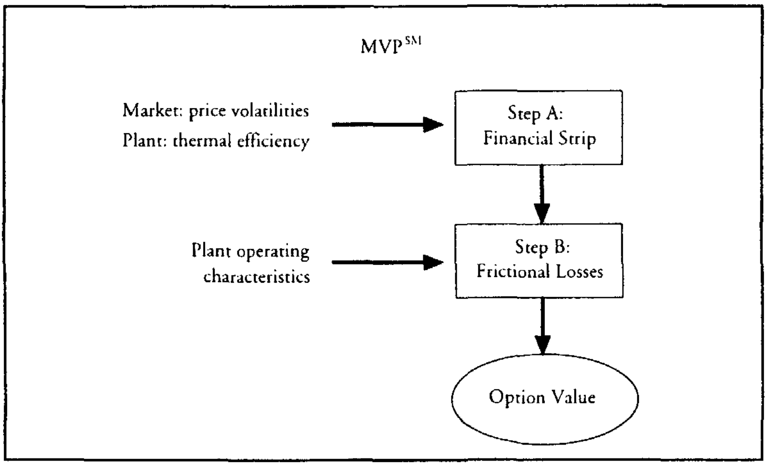

Figure 1: Real options approach to valuing a power plant

Table 1: Power Plant Values

Power Plant Type	DCF value	MVP℠ value	Financial Strip Value
nuclear plant A	100	100	110
coal plant B	100	134	> 300
natural gas plant C	100	200	250
coal plant D	100	229	> 500
oil plant E	7	100	300

2. LESSONS

Before gleaning some lessons for telecommunications from this electric power application, some salient features of electric power should be identified, with attendant comparisons for telecommunications. First, industry deregulation and restructuring are turning wholesale electric power into a commodity, with commodity markets. Second, there is no inventory because bulk electricity is difficult and costly to store. Third, electricity is transmitted over a network grid. The network is unswitched; electricity flows according to Kirchhoff's Law in physics. Fourth, electricity production has significant variable operating costs for most of the technologies in existence today. This is not true for solar power, but is true for fossil-fuel burning power plants.

Telecommunications has many similar features. The commodity seems to be bandwidth. There is no inventory: any bandwidth not used in one time period is forever unutilized. Telecommunications operates over a network grid. However, the network is switched, with much less network congestion. The greatest difference between telecommunications and electric power seems to be that telecommunications has negligible variable operating cost.

The electric power example above, of optionality in operating flexibility, hinges on variable operating cost. There appears to be no immediate analogous application of the model to telecommunications. This is fine. The most important lesson is to focus on the assets of interest, study the crucial characteristics associated with optionality, and build an appropriate model.

Focus on the assets of interest. In electric power, production cost models typically model wide swaths of regional electric power systems, in great detail. Much of this detail is extraneous. It does not materially affect the value of the assets of interest, and is not pertinent to the decisions of interest. Assembling the data inputs needed and debugging outputs for the wide swaths frequently divert time and money from the crucial modeling issues, such as validating important assumptions and assessing important sensitivities.

Study the characteristics of the assets of interest. This is accomplished by focusing on the crucial characteristics associated with optionality. PHB Hagler Bailly's first cut at an option valuation approach for power plants took us along the well-worn path of the pure financial option approach. But the operating characteristics of power plants yield constrained flexibility, and the standard option approach developed for pure financial options missed this. So we were confronted by the collision between the financial and engineering paradigms. The first step was to carefully identify the relevant details each paradigm framed best. The financial paradigm focused on price uncertainty – the strip of call options on the Btu spread. The engineering paradigm focused on operating constraints – the operating detail input to the production cost model.

Build an appropriate model. The MVP℠ model focuses on the key characteristic of market prices – volatility – to value operating flexibility. It distills from the host of power plant information input to production cost models the operating characteristics of the power plants of interest. For the power plants of interest, the model makes use of additional operating detail not typically part of the production cost model data set. The modular design of the MVP℠ process facilitates focusing on the assets of interest.

More generally, the way we integrate financial option models with engineering suggests a general modeling approach to value operating flexibility in network industries or services such as telecommunications and transportation. We link the engineering model with the financial model by creating a new financial derivative that synthesizes the operating characteristics of the power plant. This general idea appears promising for applications to other network industries.

Another important lesson is to customize generic analytical tools. I must admit, this is rather self-serving. I am a consultant, and do this for a living. But this lesson is based upon many hours of sweat equity. We started out using adaptations of the standard Black-Scholes formula. They did not work for a variety of reasons. We ended up with a solution tailored to our particular application. The real options methodology is a generic methodology. Make it your own. Focus on the particular business problem you face, and tailor the solution to the problem.