Issue No. 2
April 2009

NERA
Economic Consulting

Energy Market Insights

Valuing Fossil Fuel Generation Assets in a Green Economy

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From the Editor

This second EMI focuses on the quantitative assessment of key risks affecting the valuation of electricity generation assets. Mike King and Jim Heidell outline the stochastic model NERA has developed to help investors gain insights into the critical valuation issues surrounding fossil fuel generation plants. Challenges for valuing fossil fuel plants will increase going forward as the result of the potential impact of greenhouse gas regulation and policies designed to encourage the development of renewable generating technology. These environmental policies are prominent in many jurisdictions world-wide, providing wide applicability for the techniques discussed in this edition.

—Ann Whitfield, Editor

Introduction

Despite the fact that hundreds of gigawatts of generation assets have been sold in the US during this decade, valuation of these assets remains as much of an art as a science. Valuations have shifted dramatically as a result of changes in: supply and demand, generation replacement costs, fuel prices and fuel price expectations, and the structure of wholesale power markets. Looking ahead, not only is there no resolution to these drivers of uncertainty, but the potential development of a new "green" economy exacerbates uncertainty regarding fossil fuel plants' value. Challenges for valuing fossil fuel generation assets will arise as a result of current plans to: a) regulate greenhouse gas emissions; b) increase the penetration of renewable resources; c) advance energy efficiency and demand side management (DSM) goals; d) reduce oil use and increase electricity use in the transportation sector; and e) promote new generation technologies (including distributed generation). A greening of the power sector raises a number of new questions with respect to valuing conventional fossil fuel power plants:

- How does greenhouse gas regulation impact the value of coal plants? How does uncertainty in relation to such regulation affect the economics of extending the life of these assets and/or retrofitting them with advanced pollution control measures?
- How do the capacity factors and economics of intermediate power plants change as a result of additions of significant amounts of renewable resources and energy efficiency measures?
- How does the value change for flexible resources that can provide ramping and balancing requirements to integrate intermittent resources?
- How will new generation technologies, energy efficiency and DSM impact the requirements for new fossil fuel power plants?

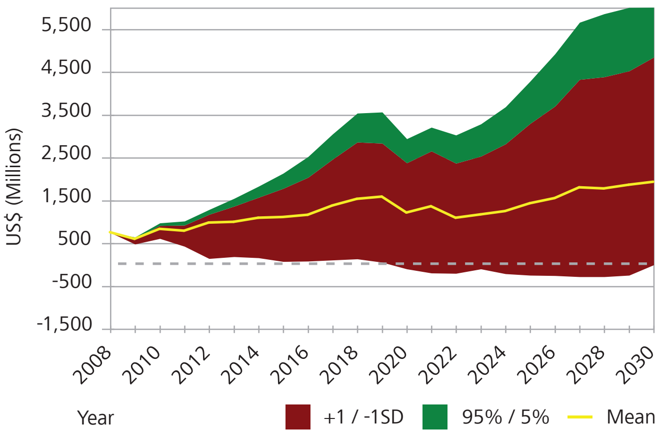
In this context, NERA has developed a stochastic model to help investors gain insights into the critical valuation issues surrounding fossil fuel generation plants. This issue of Energy Market Insights highlights some of the key value drivers and issues in valuing fossil fuel generation plants, based upon recent work analyzing coal and combined-cycle power plants in the Pennsylvania-Jersey-Maryland (PJM) region.

Reliance on Point Forecasts in a World of Significant Uncertainty

The future for power generators is highly uncertain given the volatility of fuel prices, uncertainty about the role of emerging generation technologies, the role of energy efficiency and DSM and the impact of environmental regulations. Nevertheless, the decision to buy, sell or extend the life of an asset is a binary decision: go or no-go.[1] Investors, utilities and entrepreneurs therefore need ways to not only understand the range of outcomes, but also to distill the information so that they can make an informed decision. Unfortunately, investment decisions too often rely on point forecasts or a limited number of forecast scenarios that inevitably truncate the true distribution of the risk/reward payoff.

The allure of the "base" case and limited scenarios approach is its simplicity. However, this simplicity can ultimately have significant costs. Figure 1 illustrates the considerable variability in relation to the potential value of a portfolio of coal and gas generation assets in the PJM region, which would be missed under a simplified analysis. The variation in value reflected in Figure 1 represents only some of the major dimensions of risk, such as uncertainty related to fuel prices, Renewable Portfolio Standards (RPS),[2] greenhouse gas regulation and generation replacement costs.

Figure 1. Distribution of EBITDA



Source: NERA analysis.

Understanding the key drivers of value, and how changes in those drivers impact the value of the portfolio, provides insights into: 1) the structure of the risk; 2) the comparison of alternative generation assets on a risk-adjusted basis; and 3) potential strategies to mitigate the inherent risks.

Modelling the Long-Term Value of Generation Assets

NERA uses a proprietary model to value the financial performance of individual or portfolios of generation assets in the US merchant power markets. The model integrates our fundamental dispatch methodology used for price formation with a dispatch model used to evaluate generator performance and a combined Markov chain/Monte Carlo analysis to assess the portfolio risk. This approach allows the risk and robustness of alternative strategies to be assessed, in the light of the significant uncertainty around the future operating environment. Our analysis typically consists of five major steps, which are set out below.

Step 1: Frame the Uncertainty

In this step, we define the key portfolio value drivers. A typical analysis considers seven key drivers: fuel prices, load growth, the cost of new generation, greenhouse gas allowance prices, emission credits, RPS standards and supply/demand equilibrium. Scenarios are created for a number of permutations associated with these drivers. For example, the uncertainty surrounding fuel prices can be represented by low, medium and high price scenarios. We typically limit the number of scenarios for computational efficiency, based on expectations about the marginal value of incremental scenarios. For example, if we assume seven key drivers and three scenarios for each driver, we create 2,187 different permutations or "cases."

Step 2: Specify the Uncertainty

A Markov chain/Monte Carlo process allows the financial analysis to switch between "states" each year. Each of the cases defined in step 1 constitutes a "state". In practice this means that a simulated financial forecast is not limited to a single scenario over the time horizon of the study. For example, the assessment is not limited to a "low gas case" over a 20-year period. Instead, the analysis reflects the reality that gas prices might be lower than the expected value in some years and higher than expected in other years.

In other words, our method traces different "paths" through the combination of the "cases" (recall the 2,187 cases identified above). Looking only at gas and carbon prices, year one might have high gas prices and low carbon prices for a particular path, year two might have high gas prices and moderate carbon prices, year three might have low gas prices and high carbon prices. We create thousands of paths through the cases. These paths are created by constructing a state transition matrix, which describes the probability (in a given year) of moving from the current state (or case) to all other states (or cases) in the next year. Using Monte Carlo simulation, we can then use the Markov Chain to construct literally tens of thousands of paths through the 2,187 cases identified above.

We construct the state transition matrix by defining the probability of each key driver scenario. For example, if there are three scenarios for gas prices (low, medium and high) then it is necessary to define 1) the probability of each of those forecasts and 2) the conditional probability of prices being low, medium or high in year two if they are medium in year one. A transition matrix is used to characterize all the probabilities of all the permutations of switching, including the covariance (or correlation) amongst the key drivers.

The definition of probabilities for each scenario and the transitional probabilities will shape the distribution of value of the generation portfolio. Our typical process involves a Delphi approach for establishing the probabilities. It is also relatively simple to test the sensitivity of the results to our assignment of probabilities by running multiple simulations with alternative probability distributions.

Step 3: Construct the Electricity Market Price Forecast for Each Case

A market price forecast for each case is constructed based upon the key driver assumptions (from step 1) and other data that do not vary by case. The hourly price forecast is based upon the short-run marginal cost of the last generation unit required to meet the load for the given hour. The capacity price is based upon the cost of new entry less the infra-marginal revenues that a new unit can recover in the energy market and a downward sloping demand curve adjustment, based upon the relationship between the simulated reserve margin and the required reserve margin.

Step 4: Value the Generation Portfolio for Each Case

A dispatch model is used to forecast the gross margins of each generation unit in the portfolio of interest. Generation dispatch and associated revenues and costs are based upon the dispatch of the generator, subject to performance constraints, against the hourly market prices developed in step 3. Financial pro formas of EBITDA are constructed for each generator and for the portfolio in total.

Step 5: Perform the Risk Analysis

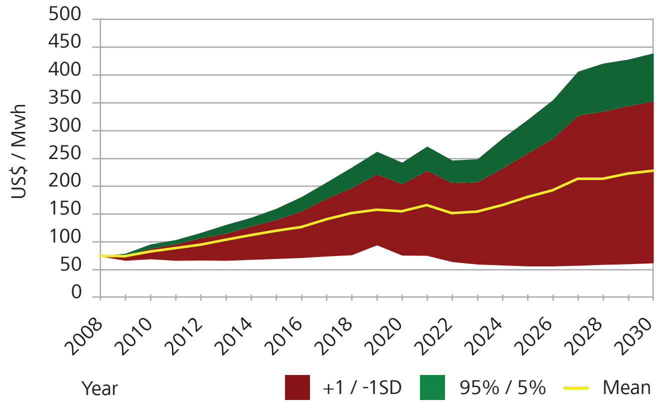
The final step is to perform a Monte Carlo simulation of the portfolio based upon the annual financial pro formas for each case analyzed. A financial analysis is constructed for each year over the 20-year time horizon by drawing an annual pro forma from one of the simulated permutations. The financial pro forma for each year reflects the probabilities associated with each case, and the subsequent year's financial pro forma is based upon the transitional probabilities. The Monte Carlo analysis is used to construct thousands of possible portfolio performance results.

Case Study

The following case study highlights our assessment process for an actual portfolio of coal-fired and gas-peaking plants located in the PJM region. On a MW basis, the existing portfolio consists of approximately two-thirds coal-fired assets and one-third peaking assets. Our case study incorporates uncertainty related to fossil fuel prices, RPS standards, greenhouse gas regulations, load growth and power plant replacement costs. In the case study, each of the key variables had three associated forecasts. This created 729 potential permutations or cases.

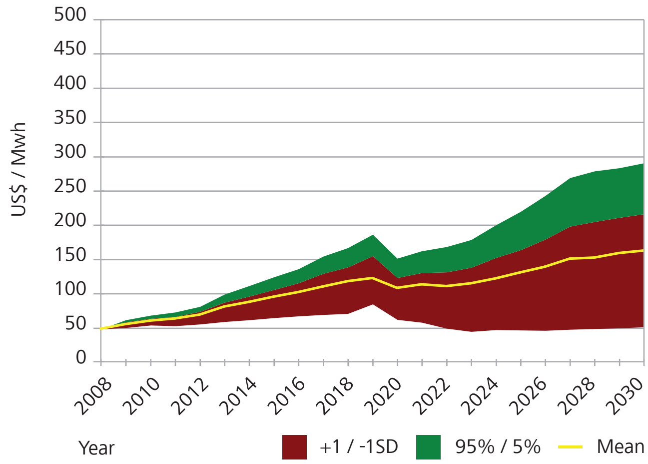
The resulting distributions of on- and off-peak prices are shown in Figures 2 and 3. The distributions are based upon 5,000 Monte Carlo simulations where prices in each successive year are dependent on the prices in the prior year (the Markov Chain process). As expected, uncertainty related to the distribution of PJM prices increases over time. Our profile of the price distributions is, of course, a result of our assumptions. However, our modeling process allows us to adjust the assumptions to gain insights into how we might be either over-stating or truncating the realistic distribution of results. In our example case we find a relatively symmetric distribution at one standard deviation, but asymmetric risk in the tails as a result of the combined impacts of stricter greenhouse gas regulations and higher capital costs creating more upside price opportunity than downside pressure.

Figure 2. Distribution of On-Peak Prices



Source: NERA analysis.

Figure 3. Distribution of Off-Peak Prices

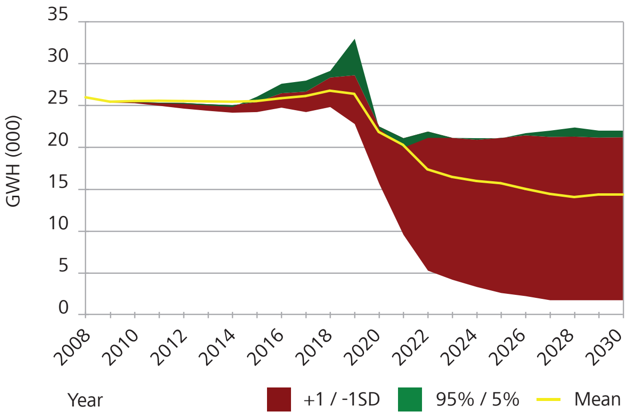


Source: NERA analysis.

The price distributions reflect our assumptions about load, the mix of generation to meet load and variations in fuel cost. These assumptions impact the market clearing price.

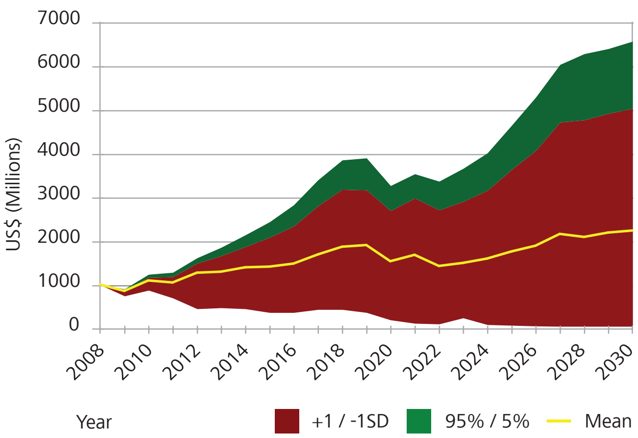
The resulting aggregate performance of the case study's generation portfolio based upon the simulation cases is shown in Figure 4. The variation in generation output is primarily a function of the competitiveness of the coal generation units, as the peaking units tend not to be dispatched to a significant extent in the vast majority of scenarios. Key factors driving the capacity factors of the coal units included the penetration of renewable resources in the market and the potential costs associated with greenhouse gas regulation. As the generation output of the coal units declines, an additional risk (market structure risk) becomes apparent, as the gross margins of the portfolio become more dependent on the availability of the separate market capacity payment system (the PJM Reliability Pricing Model, or RPM) as opposed to exclusive reliance on the energy market for project revenues. Even though the gross margins are relatively constant in a "base case" scenario, Figure 5 illustrates that it is appropriate to factor in a significant likelihood of financial distress into the overall financial and debt structure analysis.

Figure 4. Forecast of Portfolio Generation



Source: NERA analysis.

Figure 5. Forecast of Portfolio Gross Margins



Source: NERA analysis.

The fact that the results indicate a significant amount of risk in the portfolio should not be a surprise, although the quantification of the level of risk and potential for financial distress may be more than expected. One of the keys to the analysis is translating the data into a strategy to reduce down-side risk (i.e., semi-variance) of the portfolio.

Implications

A detailed review of the decomposition of the overall components of risk is beyond the scope of this article. However, our case study suggests that a conventional portfolio of gas- and coal-fired resources is subject to significant economic performance risk under a number of reasonably likely scenarios. The analysis shows that the key risk factors include:

- Significant additions of renewable resources resulting from RPS standards in conjunction with greenhouse gas regulation. Tax and regulatory policies that encourage renewable resources will adversely impact the capacity factors of the portfolio.
- Future margins will be highly dependent on a separate capacity compensation market mechanism that does not discriminate against fossil fuel resources.
- The combination of RPS standards and greenhouse gas regulation will adversely impact the coal power projects in the portfolio.

Conclusions

It is important that valuations of electricity generation assets move beyond an implicit acknowledgment that the ongoing changes in the industry will have material impacts on profitability. An explicit quantification of the key risks is critical to developing strategies for long-term capital preservation. The approach for quantifying the risks should emphasize the key unknowns that are most likely to influence value and provide insights into the magnitude of the risks. Our analysis demonstrates how key assumptions can have profound impacts on the valuation of generation assets. Furthermore, most experienced analysts recognize that there is significant uncertainty with regard to these assumptions. As a result we caution investors and decision makers not to get lost in detailed operational issues (i.e., minimum run times and outage schedules), that have relatively small impacts on value. Instead, investors and decision makers should concentrate on the key drivers of long-term value and strategies to mitigate risk.

EndNotes

1 Real options, American Options and a host of other tools create flexibility and potentially reduce risk but the decision to invest or divest inevitably remains.

2 A Renewable Portfolio Standard is a regulatory policy that requires the increased production of electricity from renewable energy sources such as wind, solar, biomass, and geothermal.

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