Finally…. A realistic model of power prices: The FEA Power Sector Model

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Introduction

In this article, we will present an overview of the FEA Power Sector Model. The model was specifically designed to help energy market participants in integrating price and volume risk, and valuing and measuring the risk of a wide range of contracts and assets whose value is contingent on the inter-dependence between weather, load, fuel and power prices.

Practitioners generally rely on fundamental or stochastic price processes to model energy spot and forward prices for derivatives valuation and risk management. We will argue that hybrid models such as the one presented here bring a new dimension into the analysis, and should become the key weapon in the arsenal of energy contract valuation and risk management tools.

Building on the Traditional Approach

The traditional approach to modeling the economics of generation and tolling contracts is to treat the “real option” features of the plant as a strip of spark-spread options. This option’s payoff is a function of time-dependent power and fuel prices, as well as the heat rate and the costs of running the facility. Indeed this approach allows one to obtain quick, ballpark estimates for the financial payoff of a generation asset. However, this simplistic approach avoids several key components that can adversely effect the operation and risk-management of the power plant. With the abundance of raw data and the speed of modern computation, the task of more accurately simulating the details of the contract can be addressed.

Incorporation of Weather

While the traditional approach implicitly incorporates weather via seasonality in the forward price curve of fuel and power, a more realistic model will treat weather as a fundamental stochastic driver. In this way, we can model the contingency of weather into the dynamics of load, as for instance, weather events “out-of-season” can be explicitly captured. Contracts written to weather-specific regions within a global pricing market are also permittted for ease of portfolio management and profit maximization.

Load as a Stochastic Factor

By incorporating weather as a stochastic factor, we grant load a degree of randomness. From this perspective, a treatment wherein load is stochastic can serve to address the intent of other economic strategies and value load-dependent instruments.

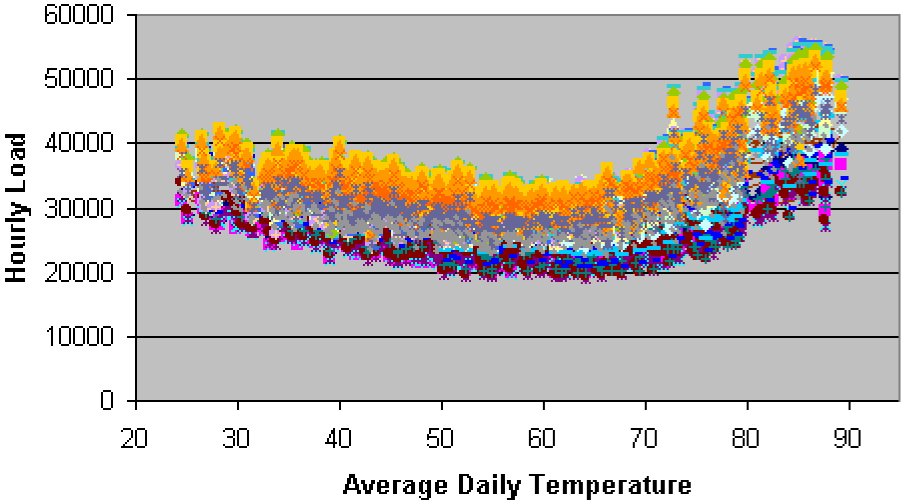

Figure 1: Illustration of transient load-temperature correlation in Philadelphia power market 2002

Incorporation of Jump-diffusion, Mean-reversion and price floors

Although it is possible to incorporate jumps, mean-reversion, and price floors into both the power and fuel prices in the traditional approach, they do not capture the physical nature of extreme power price changes. For example, sharp changes in weather can adversely affect the load demand, causing a corresponding jump in the power price. A hybrid model should accommodate the implied correlation of power price jump events and instantaneous weather and load changes, as well as arbitrary power price floors.

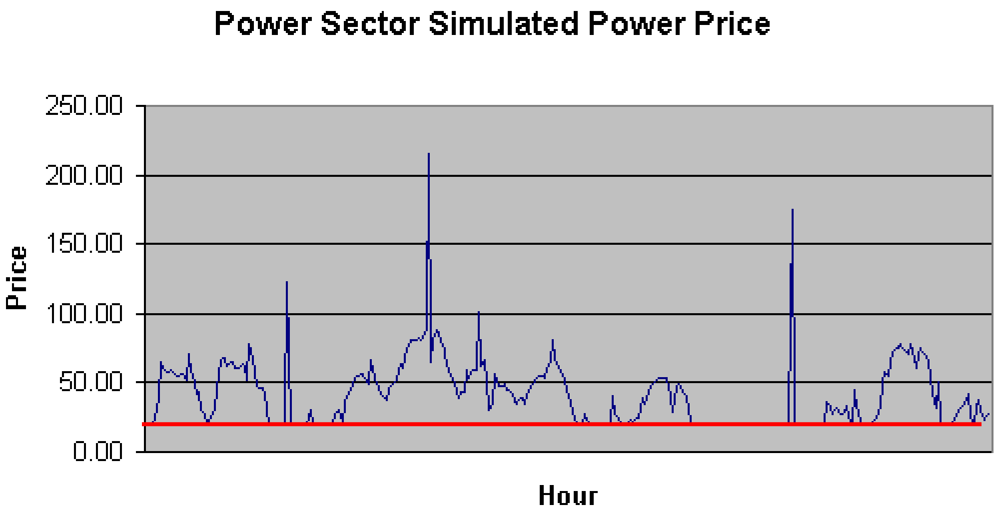

Figure 2: Illustration of hourly power price with several jumps, mean-reversion, and a price floor (Red)

Marginal Heat-rate

In terms of the plant itself, rare events, such as outages, and entrance into upper regions of the supply stack, can be regarded as jump events within the heat-rate. To model these events, which are crucial from a risk management perspective, the heat rate can be modeled as the time-dependent ratio of power to fuel prices, plus a random normal draw to describe the distribution of values, plus a Poisson jump component to capture the economics of outage and dramatic changes to the production price.

Correlations

To realistically account for the vast number of correlations between weather, load, power and fuel would be a burden. Additionally, the incorporation of a single correlation coefficient, to describe the degree of co-movement between the different factors, fails to account for the nonlinear nature of power prices under different load environments. The FEA Power Sector describes a weather-based contingency of load, which in turn drives the power prices, combined with an implicit modeling of the fuel-to-power correlation through the marginal heat rate.

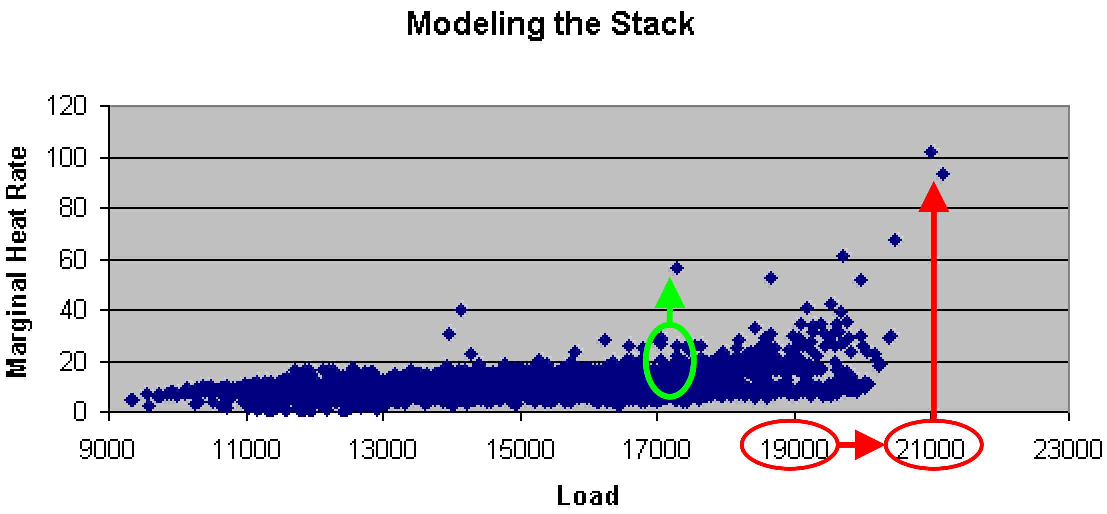

Figure 3: Distribution of Heat Rate with jump characteristic (Green) and Load jump forcing production at a higher heat rate of the stack (Red)

Model Calibration

One crucial step in the simulation is to identify the seasonal components of the relationships between the variables. For example, the same weather conditions can be associated with different load patterns for weekdays versus weekends, or on-peak versus off-peak periods. The specification of the relationship between different variables should be as flexible as possible, and allow for alternative model specifications for the different components.

In the next article of this series, we will present a more detailed description of how the FEA Power Sector model calibrates the relationship between weather and load and, in particular, a way to simulate load through weather-based contingency, using Principal Component Analysis. In future articles, we will analyze the relationship between load, fuel prices and power prices, and introduce an enhanced jump model taking into account those relationships, and current market forward prices.

Implications for Derivatives Valuation and Risk Management

Once we have calibrated the relationships between weather, load, fuel prices and power prices, we just need to simulate those drivers simultaneously to price or measure the risk of instruments and assets whose payoffs depend on the joint evolution of those variables. In order to measure gross margins, or perform value-at-risk calculations for institutions that have risk exposures to both volume and price, an integrated model is an absolute must.

Valuing “double” and “triple” trigger contracts

Price risk is just one side of the equation. Most companies’ true exposure is a combination of prices versus the volume that they will be transacting at those prices. To minimize the cost of hedging certain business risks, many companies are trading contracts with “triggers” or “contingencies”. If a contract includes a certain number of triggers in determining the payoff (e.g. weather, power prices, and outage of a certain magnitude), that implies that it will be more targeted to hedge a specific risk, and therefore, the premium will be lower.

A joint simulation of the variables allows risk managers to determine the marginal risk reduction of entering into contracts designed not to hedge a particular risk, but combinations of them. The joint simulation of state variables can help risk managers to determine what is the right type of structure that would minimize risk at the lowest premium.

Realistic Costs and Constraints

In valuing a generation asset, accounting for variable costs and revenues (e.g. emissions, Icap, ancilliary services, etc.) as well as state-dependent constraints (e.g. ramp times, minimum run times, etc.) can be easily implemented with a Monte Carlo simulation tool, such as FEA's Power Sector. The plant, though a dispatch algorithm, can be accurately simulated and real physical operating statistics can be extracted and examined. Seasonal operating parameters and maintenance schedules are readily incorporated in such a setting.

Conclusion

Price process models lie at the heart of derivatives pricing models and risk management systems. If the price process chosen inadequately captures the nonlinear characteristics of electricity prices, the results from the model are likely to be unreliable. Traditional models, due to their explicit reliance on correlation, are unable to capture many of the unique characteristics of power prices, and jump-enhanced models and fail to take into account the dynamics between weather, load, fuel prices and power prices.

FEA's Power Sector model attempts to remedy these problems by taking a unified approach to power price modeling. In a future series of publications, we will provide a more detailed account of the model details and applications.

Bibliography

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