November 2004

Executive Seminar: "Mastering Electricity Markets and Derivatives"

By Dr. Stefano Fiorenzani, Edison Spa, Milan, Italy

Since the early '90s, the electrical energy sector has undergone profound and dramatic changes. More and more countries moved towards the deregulation of their energy sectors, from a regulated and monopolistic industry to one were the market forces of supply and demand determine the unit price of electricity. The first case of energy sector deregulation in Europe was recorded when the United Kingdom with the Electricity Act of 1990 created the electricity pool for England and Wales. Norway soon followed suit (Norwegian Energy Act of 1991) and set up the Norwegian Pool in 1993, which eventually became the Nord Pool in 1996. At the same year, the European Union issued its Electricity Directive according to which the electricity markets of all EU countries should be open for competition by 2003, with the exceptions of Greece and Ireland which were granted a one year extension [1].

The Deregulation Process

Deregulating a country's energy sector is a complicated and difficult task. The typical power utility operation is divided into three main functions: electricity generation, its transmission over the power grid and finally the distribution to the end users. Deregulation stipulates that all three functions should be open to competition. In particular, new and existing power generation utilities/companies should be able to compete with each other at a wholesale level. For this to be possible though, the access to the power grid should be offered with the same terms to all players. The only way to avoid any bias or conflict of interest is to ensure that the generation, transmission and distribution of electricity is either run by different companies, or under different management (unbundling). Furthermore, the electricity distribution sector may also be segmented for different geographical areas. The actual trading of electricity, either the physical asset itself or financial products on it, is organised and takes place in a formal power exchange, or pool [1].

Deregulation of the energy sector is all the more challenging due to the particular characteristics of electricity that differentiate it from other traded commodities; namely limited storability and transportability. Electrical energy cannot be stored after it has been produced, except in the case of hydro plants where electricity is notionally stored indirectly in the form of the water kept in the reservoirs. Even in this case though, high demand can be satisfied for a limited time only, while the use of larger in size and/or number reservoirs is either unfeasible or uneconomical. Hence, since electricity cannot be stored, localised supply and demand should always in balance in order to avoid compromising the integrity of the whole grid. Thus, the deregulated energy sector calls for three types of activities : generation, transmission and ancillary services [2].

In different markets or countries, these three activities are implemented differently. A common feature though, is the existence of an Independent System Operator (ISO) whose role is to oversee and maintain the system. The services are then managed either under the full control and authority of the ISO, or through a sequence of bilateral contracts which in effect render the ISO's role limited. For example, in some markets the ISO manages the electricity provision, contracts and infrastructure for all the activities while in others, the ISO is involved only in the generation leaving the transmission and balancing to the bilateral markets [2].

Mastering Electricity Markets and Derivatives Seminar

This seminar was aimed at presenting to the attendants the basic theoretical background and tools for understanding Risk Management problems in the electricity markets, both from the Bank's and the Utility's perspective. Risk management problems appear in the electricity industry in both liberalised and monopolistic markets. However, in the first situation risk management is more of a crucial issue as traditional quantitative financial analysis cannot be applied in a straightforward way for electricity market analysis and derivative instruments valuation.

In monopolistic regimes the price of electricity is established by a governative authority so that the monopolistic producer covers its fixed and variable costs and has a certain profit margin guaranteed which is usually fixed and barely volatile. Such types of markets are rarely able to efficiently allocate the energy resources, especially when the market is intrinsically undersupplied. A liberalised system coupled with a well established organised market for electricity trading may represent the best alternative to overcome the problems of the monopolistic regime. However, a liberalised market introduces a negative effect on the price of electricity which now becomes much more volatile. This pronounced volatility adversely affects both the final consumers and the utility and producer's margins. The price risk can be diversified away, or drastically reduced, by means of electricity derivatives which can be considered as a tool to reconcile the agent's economic exigencies with the electricity market's natural characteristics.

An intrinsic feature of the electricity price process is the presence of spikes, i.e. an abrupt price jump followed by a steep downward move of approximately the same magnitude. These jumps appear to be a function of either how quickly the supply side of the market can react to events that cause supply and demand imbalances, or how quickly the events fade away [3]. The spiky behaviour is a unique feature of the electricity markets due to the lack of inventories [4]. Electricity prices tend to revert rapidly from spikes to a mean level. This mean level can be constant, periodic, or periodic with a trend and depends on the average electricity consumption level across the year which in turn, is highly correlated with the climatologically conditions in the specific region of analysis [4]. Furthermore, aggregate residential demand is a cause for seasonality. These seasonality effects can be seen in the historical spot price data and through observation of the forward price markets [3]. All energy markets exhibit seasonal patterns of electricity demand over the course of a day, week and year [4]. This regular pattern has to do with seasonal changes in climate along the year that which influences the heating and cooling needs and also the daylight length that influences lighting needs [5].

For all the above reasons it is necessary to develop custom mathematical models which are able to describe realistically and accurately these particularities. The mathematical complexity associated with this kind of modelling is higher than that for traditional financial models. Classical derivative pricing arguments and hypothesis, cannot be applied directly to electricity derivatives pricing. As we have already seen, electricity is a "non storable" commodity and so classical pricing arguments based on continuous time replication of the derivative product by means of a dynamic and self financing trading strategies involving the underlying asset (electricity price), are not applicable. Moreover, electricity derivative markets exhibit characteristics found in a category of markets referred to in the literature as "incomplete markets" which are inherently very difficult and complex to analyse and model.

At a first glance, we may be tempted to think that all the problems related with electricity derivatives pricing and risk measurement affect only the financial trading activities. In fact, traditional electricity physical delivery contracts incorporate embedded options which allow both parties of the contract to enjoy some electricity volume and delivery price flexibility. Those margins need to be accurately evaluated and represented by an effective and efficient risk and trading strategy involving both physical and financial products. Real assets, such as electricity generation utilities or fuel storage facilities, are regarded as potentially profitable business opportunities, but also involve market and operational risks. In practice, the asset's operational flexibilities and constraints can be modelled within a Real Options theoretical framework. Consequently, they have to be evaluated, budgeted and managed with a financial optimisation perspective in mind which cannot overlook the financial risk inherently present in every business activity. Apart from introducing the quantitative methodologies for risk analysis and measurement in electricity markets, the scope of the seminar was also to present the philosophy which identifies Enterprise Wide Risk Management as a tool for shareholder's value protection.

Finally, we had the opportunity to see how the transition from a regulated to a liberalised market environment exposed the classical utility company to a broad spectrum of financial risks which were previously ignored. Hence, risk management is not just a necessary operational activity, but is also strategically relevant and has to be taken in consideration in every planning and decision process affecting each business activity.

References

1. Mork E., (2001): Emergence of financial markets for electricity: a European perspective, Energy Policy, 29: 7 - 15.
2. Eydeland A. and Wolyniec K., (2003): Energy and Power Risk Management: New developments in Modeling, Pricing, and Hedging, Willey Finance, John Willey & Sons, USA.
3. Filipovic D., (1998): Energy Risk, McGraw - Hill, USA.
4. Burger M., Klar B., Muller A. and Schindlmayr G., (2003): A Spot Market Model for Pricing Derivatives in Electricity Markets, Submitted to: Journal of Quantitative Finance.
5. Lucia J. J. and Schwartz E. S., (2002): Electricity Prices and Power Derivatives: Evidence from the Nordic Power Exchange, Review of derivatives Research, 5: 5 50.