Valuing production capacities on electricity

Juri Hinz

Institute for Operations Research, ETH Zentrum, CH–8092 Zurich, Switzerland
[hinz@ifor.math.ethz.ch]

Price risk management for electrical power is not trivial due to restrictions on storability of the underlying. Moreover, agents face high risk complexity resulting from patterns in price seasonality, time-varying volatility, and high price spikes. To be protected against price risk, consumers purchase diverse swing–type contracts, whereas contract writers try to hedge them by appropriate physical assets, for instance, by storage utilities, by transmission and/or production capacities.

Due to difficulties in valuation and hedging of electricity derivatives, option writers prefer to sell agreements which are easily replicated by appropriate physical assets. As a result, we observe that many electricity derivatives are of swing type, presenting corresponding financial counterparts of agreements on production capacities. For example, a popular instrument is the *virtual production capacity* with strike price $K > 0$ and availability period $[0, \vartheta]$, which is an American-type contract where the holder can opt any exercise policy $(q_t)_{t \in [0,\vartheta]}$ obeying

$$0 \leq q_t \leq \lambda \text{ for all } t \in [0, \vartheta], \qquad \int_0^{\vartheta} q_t dt \leq \Lambda \tag{1}$$

whereas the writer is obliged to supply a cash–flow at intensity $(q_t(E_t - K)^+)_{t \in [0,\vartheta]}$ depending on electricity price $(E_t)_{t \in [0,\vartheta]}$. Obviously, this agreement is hedged by a real production unit available within $[0, \vartheta]$ with production costs K, maximal electrical power $\lambda > 0$, and total amount of energy $\Lambda > 0$. The correct valuation of such contacts is still under lively debate.

The major part of our approach deals with the concept of risk–neutral spot price dynamics. The difficulty here is that electricity spot prices at different times are not directly related to each other, strictly speaking, E_s and E_t are to consider as prices for different commodities delivered at different dates $s \neq t$. We suggest an axiomatic setting to discuss price dynamics for contracts on a flow commodity: (i) the price evolution is described by stochastic processes with appropriate path properties, (ii) the model explains the initial forward curve, (iii) it excludes arbitrage opportunities, and (iv) it reflects restrictions on storability of the underlying. It turns out such assumptions already provide a framework where the standard change–of–numeraire transformation converts a flow commodity market into a market consisting of zero bonds and some additional risky asset. Utilizing this structure, we apply the toolkit of interest rate theory to price the availability of production capacity on electricity.

1. Miltersen, K., R., Schwartz, E., S., (1998) Pricing of options on commodity futures with stochastic term structures of convenience yields and interest rates. *The Journal of Financial and Quantitative Analysis, Vol. 33, Issue 1,.*
2. Hinz, J., von Grafenstein, L., Verschuere, M., Wilhelm, M., (2004) *Pricing electricity risk by interest rate methods.* Quantitative Finance (accepted for publication).
3. Hinz, J. (2004) *Valuing production capacities on flow commodities.* (Preprint).