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A long-term risk management tool for electricity markets using swarm intelligence

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ABSTRACT

This paper addresses the optimal involvement in derivatives electricity markets of a power producer to hedge against the pool price volatility. To achieve this aim, a swarm intelligence meta-heuristic optimization technique for long-term risk management tool is proposed. This tool investigates the long-term opportunities for risk hedging available for electric power producers through the use of contracts with physical (spot and forward contracts) and financial (options contracts) settlement. The producer risk preference is formulated as a utility function (U) expressing the trade-off between the expectation and the variance of the return. Variance of return and the expectation are based on a forecasted scenario interval determined by a long-term price range forecasting model. This model also makes use of particle swarm optimization (PSO) to find the best parameters allow to achieve better forecasting results. On the other hand, the price estimation depends on load forecasting. This work also presents a regressive long-term load forecast model that make use of PSO to find the best parameters as well as in price estimation. The PSO technique performance has been evaluated by comparison with a Genetic Algorithm (GA) based approach. A case study is presented and the results are discussed taking into account the real price and load historical data from mainland Spanish electricity market demonstrating the effectiveness of the methodology handling this type of problems. Finally, conclusions are dully drawn.

1. Introduction

Long-term contractual decisions are the basis of an efficient risk management. On a vertical integrated electricity market, price variations were often minimal and heavily controlled by regulators. In this structure, electricity price evolution is directly dependent on the government's social and industrial policy. The price forecasting was mainly focused on the underlying costs (namely, fuel prices and technological innovation among others). Any price forecasting made on this basis was tended to be over the long-term. With electricity markets re-regulation process, aforementioned features have been changed dramatically. Thus, ownership on this activity sector becomes private rather than public or a mixture of both. Moreover, pools or power exchanges have been introduced for wholesale trading.

Price forecast on re-regulated electricity markets is a hard task due to the high pool price volatility. Charge characteristics (seasonality, mean-reversion and load stochastic growth) and producer's characteristics (technology, generation availability, fuel prices, technical restrictions, import/export, etc.) are at the origin of high price volatility in electricity markets. Several techniques have been used for short-term price forecast in electricity markets. In [1], artificial intelligent tools were proposed to forecast spot prices, namely, a combination of neural networks and fuzzy logic. Indeed, neural networks have now an extensive use in load and in price forecast [2–6]. Fuzzy techniques mixed with neural networks are used to predict possible prices range [7,8]. Stochastic processes are also used to analyze time series as ARIMA processes [9]; a class of stochastic processes was used to predict next-day electricity prices in mainland Spanish and in California markets. In [10], two forecasting tools based on dynamic regression and transfer function models are presented.

However, for the market agents who want to maximize their profits and simultaneously to practice the hedge against the market price volatility, the use of forward, futures and options contracts become a constant in developed electricity markets. Those types of contracts have a maturity that goes from 1 year to several years in the future, turning more difficult the decision process related to contracts establishment if they are not supported with a robust price forecast methodology.

Due to long delivery periods of the contracts described above that make more sense to forecast the market price mean value

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