Electric Power Systems Research 150 (2017) 11–23

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

Applying modern portfolio theory for a dynamic energy portfolio allocation in electricity markets

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ARTICLE INFO

Article history:
Received 24 November 2016
Received in revised form 22 March 2017
Accepted 24 April 2017

Keywords:
Portfolio theory
Electricity market
Mean variance
Conditional Value at Risk

ABSTRACT

In deregulated electricity markets, a Generation Company (Genco) has to optimally allocate their energy among different markets including spot, local and bilateral contract markets. Modern portfolio theory (MPT) allows a Genco to achieve their goal by maximizing their profit and decreasing their associated risk. Combining MPT with an adequate tool to forecast energy prices makes it possible for a Genco to vary the optimal allocation of their portfolio even on a daily basis. This paper proposes two MPT models, one applying the Mean Variance Criterion (MVC) and the other one the Conditional Value at Risk (CVaR). The MPT models are combined with a generalized autoregressive conditional heteroskedastic (GARCH) prediction technique for a Genco to optimally diversify their energy portfolio. The two models are applied to a real PJM electricity market showing not only their capabilities but also useful comparisons between them in order to help decision makers to use them as decision-aid tools.

1. Introduction

New energy markets undergoing deregulation induce participants to face increasing competition and volatility, where the objective of a Generation Company (Genco) is to maximize their profit while minimizing their associated risk. In an electricity market, risk results from uncertainty due to different factors including price volatility, unit outages, transmission congestion and demand changes.

In particular, the risk of price fluctuations can be considered one of the most important risks in spot electricity markets. However, there are other sources of risk such as demand changes and changes in intermittent generation. These other sources of risk could definitely affect the price fluctuations possibly making prices more volatile, and this behavior is captured by the GARCH model applied in this research. In order to deal with price risk, market participants can apply risk management techniques to control risk while maximizing their profits, where diversification is a financial approach to control risk. Diversification in energy trading means that energy is traded among different markets to minimize the total risk. In this work, the diversification technique applied is called energy portfolio optimization.

Various risk management methodologies have been applied in electricity markets in the past. Previous works have demonstrated that forward contracts provide hedging to minimize risk of spot prices for market participants [1–4]. The usefulness of applying future contracts in electricity markets and the valuation of different contracts have also been considered before [5–11]. Decision analysis and Monte Carlo simulation have been applied to find the optimal contract combination [12–15].

Among the existing models that deal with risk in electricity markets, bidding portfolio optimization of a Genco is one of the most important due to its economic consequences. When bidding, a Genco decides its optimal portfolio to sell its energy, usually including day-ahead market, future market and others. In this regard, there are two techniques that have received a lot of attention: mean-variance models based on the Markowitz portfolio, and CVaR models. The main difference between them is the way in which they define risk. Mean-variance models penalize risk in the objective function, where the measure of risk is the variance of the profit, and CVaR models use their own risk definition based on the probability of reaching a minimum profit. There are other techniques based on the Value at Risk (VaR) that have already been implemented in electricity markets [16–19]. However, they do not enjoy the same

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http://dx.doi.org/10.1016/j.epsr.2017.04.026
0378-7796/