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Risk-constrained self-scheduling of a fuel and emission constrained power producer using rolling window procedure

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ABSTRACT

This work addresses a relevant methodology for self-scheduling of a price-taker fuel and emission constrained power producer in day-ahead correlated energy, spinning reserve and fuel markets to achieve a trade-off between the expected profit and the risk versus different risk levels based on Markowitz's seminal work in the area of portfolio selection. Here, a set of uncertainties including price forecasting errors and available fuel uncertainty are considered. The latter uncertainty arises because of uncertainties in being called for reserve deployment in the spinning reserve market and availability of power plant. To tackle the price forecasting errors, variances of energy, spinning reserve and fuel prices along with their covariances which are due to markets correlation are taken into account using relevant historical data. In order to tackle available fuel uncertainty, a framework for self-scheduling referred to as rolling window is proposed. This risk-constrained self-scheduling framework is therefore formulated and solved as a mixed-integer non-linear programming problem. Furthermore, numerical results for a case study are discussed.

1. Introduction

Power producers participate in the power pool trading aim to maximize their profit in day-ahead (DA) energy and ancillary service markets. In a pool-based environment, power producers face challenging problems with the ultimate goal of maximizing their profits. One of those problems is consist of determining, in the short term, the optimal self-schedule of the units belonging to the generating company by means of which production offers in the energy and the ancillary service markets are submitted based on the forecasted market clearing-prices (*MCP*s) and other considerations such as fuel and emission constraints, power plant availability and risks. In fact, the profit from participating in the energy and the ancillary service markets is maximized without regarding the power balance in the system [1]. This problem is referred to as self-scheduling (SS), and it is the problem addressed in this paper.

Recently, some works have been presented in which SS has been solved based on the DA forecasted prices, and ignoring all the uncertainties which may be observed in the electricity power markets [2–5]. Furthermore, a risk-constrained SS approach in the energy market has also been proposed where the variance of revenues was used to model the risk [6,7]. Haghighat et al. [8] have extended the risk-based SS problem adding the forced outage ratio (FOR) and the generation reallocation (GR) impacts on the objective function of SS problem. Also, a robust SS problem has been solved under the energy price uncertainty using conditional value-at-risk (CVaR) [9]. To manage the risks due to price uncertainty, a different methodology has recently been applied based on fuzzy logic [10,11]. In aforementioned works, fuel and emission constraints that can severely affect the results of SS problem have not been contemplated. Yamin and Shahidehpour have studied the problem of fuel and emission constraints considering simple constraints have been incorporated into the SS problem of thermal power plants [12]. In their work, no uncertainty has been observed, hence their objective function has been determined without considering any risk term. There are also several contributions in the literature dealing with the SS problem of hydro-electric and pumped-storage plants with limited energy resource constraints [13–16]. According to our literature survey, although there are so many articles developed for SS problem of price-taker generators, the problem of primary energy resources and emission constraints have not widely been addressed previously.

This paper addresses a relevant risk-constrained self-scheduling methodology for a single power producer participating in energy, spinning reserve and fuel markets under an uncertain competitive framework. A rolling horizon is used to accommodate day-ahead offers into a 7-days time interval, which is more appropriate for fuel and emission constraints. The idea of addressing the self-scheduling problem taking into account fuel and emission constraints within a risk-based framework is the main contribution of this paper.

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