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Congestion management considering hydro–thermal combined operation in a pool based electricity market

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ABSTRACT

This paper proposes a novel congestion management strategy for a pool based electricity market considering combined operation of hydro and thermal generator companies. The proposed congestion management problem is formulated as mixed binary nonlinear programming problem to minimize the cost of re-dispatching the hydro and thermal generator companies to alleviate congestion subject to operational, line overloading and water availability constraints. A piecewise-linearized unit performance curve is used in this formulation, which takes into account its non-concave nature. The effectiveness of the proposed technique is demonstrated by solving the modified IEEE 57-bus and IEEE 118-bus systems for congestion management under line outages.

1. Introduction

The advent of deregulation in electricity sector has created an environment of competitiveness among various market players. In a pool based electricity market, the independent system operator (ISO) takes energy bids from producers and consumers and determines market clearing price and power production and consumption schedules of producers and consumers respectively, for every hour on day-ahead basis [1]. However, in case the day-ahead schedule may not be implemented in a particular hour due to congested system conditions, the ISO can alter the day-ahead schedule for that particular hour for congestion management [2].

Conventionally, the congestion re-dispatch is invoked to move from an infeasible to feasible state based on the adjustment bids of producers and consumers, usually with the objective of minimizing cost of such adjustments. Bompard et al. [3] have presented a comparative analysis of five congestion management schemes followed by different markets around the world. Sensitivity based congestion management methods are discussed in [4–6]. Congestion management using Particle Swarm Optimization based methods are presented in [7,8]. Congestion management and price volatility reduction using demand response programs are explored in [9–11]. In the pool based electricity markets, the market clearing price is decided by the scheduling of thermal generator companies and hydro generator companies are considered to be price takers, which can maximize their revenue by bidding their energy at a price close to but smaller than estimated "System Marginal Price" in each hour [12]. In general, the hydro generator companies can perform self-scheduling for selling their energy produced in day-ahead market to maximize their own profit [13,14]. This is somewhat justified on the ground that consideration of hydro generator companies as price makers would create complexities due to the involvement of inter-temporal stochastic constraints. On the other hand the time span of congestion management process is 1 h and congestion re-dispatch is considered hour by hour [2], so the bids and constraints corresponding to hydro generator companies can easily be incorporated in congestion relieving re-dispatch. Ladurantaye et al. [15] have presented a stochastic programming model for profit maximization of a hydroelectricity producer considering its strategic bidding in terms of stack of quantities and prices for deregulated markets.

In earlier congestion management approaches [2–8], the congestion management problem is formulated to adjust the scheduled generations and demands, generally treating the power generation as a fully deterministic quantity. However, for hydro generation companies, the power produced is constrained by availability of water [16,17]. The hydro generators are characterized by quick start up and lower operational costs and are used in many countries for meeting the peak and emergency demands. Therefore, the objective and constraints of hydro generation companies should also be modeled in the congestion management problem formulation.

The present paper proposes a congestion management re-dispatch methodology considering the combined operation of hydro and thermal generating companies in a pool based energy market on hourly basis. A congestion management problem is formulated to minimize the cost of re-dispatching the hydro

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