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Generation companies decision-making modeling by linear control theory

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ABSTRACT

This paper proposes four decision-making procedures to be employed by electric generating companies as part of their bidding strategies when competing in an ologopolistic market: naïve, forward, adaptive, and moving average expectations. Decision-making is formulated in a dynamic framework by using linear control theory. The results reveal that interactions among all GENCOs affect market dynamics. Several numerical examples are reported, and conclusions are presented.

1. Introduction

Generation companies (GENCOs) are the competitive players in today's liberalized electricity markets. The competition and interactions among them are the major sources of market dynamics. Analyzing their interactions and decision-making processes becomes particularly important when electricity markets are ologopolistic and there are few market players. To survive and succeed under such circumstances, GENCOs analyze the market behavior and expected output of their competitors by comparing actual market outcomes with forecasted outcomes based on simulations or static analyses. GENCOs must adaptively adjust market strategies as each new piece of information is gathered and understood to maximize profits, and will utilize several methods to accomplish this learning process, i.e. forward expectation, moving average expectation, and adaptive expectation [1,2].

Expectation plays a very important role in electric market dynamic analysis to understand dynamic interactions between players. The strategies one player anticipates other players may use will determine its decision and action in one of the next periods. Different expectations by market participants lead to different actions and market transitions.

Several models that attempt to formally model expectations in an effort to better understand decision-making in a world of uncertainty have been reported in the literature. Various limited information estimation methods applied to models within the framework of standard econometric estimators are reported in [2]. Game theory, evolutionary game theory, stochastic simulation, and agent-based modeling have been used to model the behavior of players and the impacts of their decision on market dynamics [3–5]. Maiorano et al. [6] and Yu et al. [7] studied dynamics of non-collusive oligopolistic electric markets. In [8] the authors present a theory and method for estimating the conjectural variations (CV) of GENCOs. CV is a game-theoretical concept in which players have a conjecture about the behavior of their opponents [16]. Based on these estimates of CV in an actual electricity market, an empirical methodology is also proposed to analyze the dynamic oligopoly behaviors underlying market power. Recently, there has been considerable interest in oligopoly models with "consistent" CV. A CV is considered consistent if it is equivalent to the optimal response of the other firms at the equilibrium defined by that conjecture. A new unified framework of electricity market analysis based on coevolutionary computation for both the one-shot and the repeated games of oligopolistic electricity markets is presented in [4]. Discrete event system simulation (DESS) has also been applied to model competition to study the effect of some control policies [7]. DESS is very useful when one is including a decision support system (DSS) as part of the trader's support via front, middle, or back office support software. DSS are often considered a database of rules to be applied to the observed conditions to authorize certain trader actions. DESS facilitates the study of transitions and changes in variables over time. Additional properties, controllability, and observability are also useful for monitoring market performance and for DSS rule analysis. Yang and Sheblé [1] introduced the expectations of GENCOs and electricity consumers and studied market dynamics in a discrete-time setting. Later, the authors modeled the electricity

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