Chapter 6.3
Artificial Intelligence in Electricity Market Operations and Management

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ABSTRACT

This chapter introduces advanced techniques such as artificial neural networks, wavelet decomposition, support vector machines, and data-mining techniques in electricity market demand and price forecasts. It argues that various techniques can offer different advantages in providing satisfactory demand and price signal forecast results for a deregulated electricity market, depending on the specific needs in forecasting. Furthermore, the authors hope that an understanding of these techniques and their application will help the reader to form a comprehensive view of electricity market data analysis needs, not only for the traditional time-series based forecast, but also the new correlation-based, price spike analysis.

INTRODUCTION

Power systems worldwide have experienced significant deregulation and reorganization in the past decade. The objective of deregulation is to enhance competition among electricity energy suppliers, to provide electricity consumers' with a choice of providers and to maximize overall social welfare. As a result the vertically integrated power industry has been deregulated into generation companies, transmission companies and distribution companies. The transmission services still operate under different regulations because of their natural monopoly characteristic within the regulatory system. Generation and distribution companies are market participants in either pool, bilateral, or more popular, hybrid type markets supporting both pool transactions

and bilateral contracts. The electricity market has several unique features that differentiate it from other markets. A key feature is that electricity needs to be traded immediately after being generated in order to maintain a supply and demand balance. A further limitation is that the delivery of energy has to follow the physical constraints of the power system. Deregulation may appear quite straightforward and economically attractive. However, there have been a number of difficulties in the process, with the most significant ones being reliable market operations and planning to meet the increasing demands for electricity through the competitive electricity market. The introduction of the electricity market to traditional power systems has, in many cases, pushed the power system to run close to the limit of reliable and secure supply, creating numerous new challenges to the power industry in operations and management. Since its introduction, there have been continuing discussions on how to achieve profit maximization objectives from the generation companies while maintaining the system security and reliability in the electricity market. Numerical market rules and designs have been proposed and tested in the major electricity markets worldwide. The essential issues for power systems in a deregulated environment are power system operations, management and planning. These tasks require the system to be reliable and secure while satisfying the market objective of profit maximization for generation companies or social welfare maximization for the system operator. Forecasting of system demand and price is at the foundation of these tasks in a competitive electricity market. From the market operations point of view, proper demand and price forecasting is essential for development of risk management plans for the participating companies in the electricity market. In a competitive market, a generation company may lose its whole year's revenue because of unexpected events (Wu & Varaiya, 1999). Market participants use different instruments to control and minimize the risks because of market clearing price volatility. In Victoria, Australia, generators and retailers can use vesting contracts and contestable contracts to hedge against pool price volatility risks (Wolak, 1998). With better estimates of electricity market demand and clearing price prediction, generators and retailers can reduce their risks and maximize their outcomes further.

The significance of proper forecasting is equally important for planning within the electricity market. Recent major blackouts, attracting attention to electricity market operations and management, caused demands for solutions to the various problems concerning the power industry. In August 2003, the power grid of North America, including parts of Canada, experienced the most serious blackout in the history of power supply so far (Sweet, 2003). Subsequent blackouts in the UK and Italy further illustrated the challenges and significance of deregulation on power market operations and management. The reasons for these blackouts cover a wide variety of issues. However, the main causes for the North America blackout was insufficient capacity of the power grid to meet the demand given underestimated demand growth, which resulted in under-investment in the power system through system planning. This fact clearly reflects the importance of accurate market forecasting for efficient and reliable market operations.

Traditionally, econometric regression models and the least-cost approach are employed in power system demand forecasting and planning. However, the regression approach relies on historical data and uses mostly linear models. The technique is limited when emerging factors in the electricity market impact upon demand and/or price, but there is limited historical data to demonstrate possible impacts upon demand and/or price signals. Regression models such as ARMA have been widely used in demand forecasting. However the natural nonlinearity and complexity of the demand and price signals in a competitive electricity market often introduce significant errors to traditional forecasting methods.