THE UNIVERSITY OF QUEENSLAND

AUSTRALIA

Congested Power Systems in a Deregulated Environment

Muhammad Bachtiar Nappu

Bachelor of Electrical Engineering with Honors**,** B.Eng (Hons)

Master of Power Systems Engineering, M.Eng

Master of Philosophy in Power Systems & Electricity Market, M.Phil

A thesis submitted for the degree of Doctor of Philosophy at

The University of Queensland in 2013

School of Information Technology and Electrical Engineering

Abstract

Issues surrounding congested power systems have become the major consideration when introducing a competitive market in a deregulated environment. Maintaining supply-demand equilibrium in relation to the impacts of congestion on the systems, for example, creates the opportunity for some players to exercise market power. In addition, a congested power system gives rise to higher volatility in energy prices which need to be forecasted precisely. These two key issues are investigated in this research.

The first and foremost effect of transmission congestion that is observed in this research is the social impacts of congestion in the supply-demand equilibrium and the probability of market power being exercised by some players because of congestion. In the normal competitive market environment, suppliers bid at their marginal cost. However, when congestion occurs, it segregates the system, and thus may create different zones. When congestion happens, the scheduled economic dispatch should be redispatched to meet the energy balance and maintain security. The cheap suppliers from the uncongested zone cannot supply their energy into the congested zone and must reduce their outputs.

Furthermore, with a small number of competitors, suppliers in the congested zone have the opportunity to exercise their market power to achieve more profits. This is known as unintentional market power, resulting in higher electricity prices in the congested zone compared to prices if there was no transmission congestion. Transmission congestion enables some suppliers to gain more profits and means customers must pay more to buy electricity; this reduces the efficiency of the electricity market.

In order to assess the market power in a congested power system, a composite method for investigating market power in congestion conditions is proposed by introducing and formulating a new index, called the congestion-based dynamic dispatch index. The proposed index is then implemented to further analyse the implications of market power through different bidding strategies, such as the quantity-withheld and finance-withheld strategies.

The second main area of investigation is short-term locational marginal price (LMP) forecasting. Short-term LMP forecasting in a competitive electricity market is critical to consumers and producers in planning their operations and managing their price risk such as in bidding strategies and making investment decisions. In addition, it is difficult to forecast the exact value of electricity's future price because of its high level of uncertainties. One of the major complexities is the significant price volatility which brings serious economic harm to consumers, especially in the congested power system.

This price volatility conflicts with the objective of electricity industry restructuring which is to encourage competition among participants to reduce energy prices. Although it is volatile, the LMP is not random; thus, certain patterns and rules concerning market volatility can be recognised. Because high LMP volatility occurs during the congestion period, LMP forecasting holds a significant place in proper economic operations. Accordingly, the prediction of congestion rigor is crucial for LMP forecasting. By using the information about the transmission line flow and line limit, the line flow congestion and its rigor can be revealed. The effect of the line flow and line limit on price can be calculated to find the relationship between congestion and the LMP value.

In this study, therefore, the impact of congestion on LMP volatility is analysed and a new advanced method for LMP forecasting based on an adaptive neuro-fuzzy inference system is proposed. The LMP forecasting model with clustering technique is then implemented on a reliability test system. The results show that the proposed method performs more optimal prediction and provides more accurate outcomes than the comparative common artificial intelligence-based methods.