Mathematical models and methods for analysis of distributed power generation on market conditions

The liberalisation of electricity markets around the world which has taken place in recent years – and is still ongoing – has had several consequences for the various players in the markets affected. Typically, the tasks of production, transmission, and distribution of electricity which were often handled by so-called vertically integrated monopolies have been separated to varying degrees and are in liberalised systems handled by different players. In the Nordic system, electricity is traded as a commodity on a day-ahead spot market where suppliers and consumers submit their bids for the following day and a common hourly electricity spot price is found. Intra-day markets for balancing power also exist. The raison d’être for this type of market is that although supply and demand are balanced on a day-ahead basis, actual demand is impossible to forecast with complete accuracy. Thus on the day of operation actual demand and planned supply never match precisely. The system operator must then procure so-called balancing power in the intra-day market to maintain the physical balance of the system at all times. The present thesis considers the effects of large amounts of distributed electricity generation in a power system subject to a liberalised market. In particular, the Danish electricity system is analysed in terms of four different focus topics which are considered in the six research papers presented and commented on in the thesis. The analyses range from planning the operation and/or bidding of single-technology units such as wind power turbines and local combined heat and power plants to analyses from a system point of view such as the interaction between the natural gas, district heating, and electricity systems, and the system operator dilemma of procuring reserve power well in advance as opposed to purchasing the needed volumes in the intra-day balancing market. The thesis itself provides an introduction to the Nordic power system and market with emphasis on the Danish situation. After presenting a few classic topics in power system operation, the situation post-liberalisation of the electricity markets is analysed and a literature review is given of the major topics of the thesis, setting the contributions of the thesis into perspective of previous work on related topics. Subsequently, the papers included in the thesis are summarised and commented upon and the main contributions are listed, before the thesis is concluded upon.

A Stochastic Unit Commitment Model for a Local CHP Plant

Local CHP development in Denmark has during the 90’s been characterised by large growth primarily due to government subsidies in the form of feed-in tariffs. In line with the liberalisation process in the EU, Danish local CHPs of a certain size must operate on market terms from 2005. This paper presents a stochastic unit commitment model for a single local CHP plant (consisting of CHP unit, boiler, and heat storage facility) which takes into account varying spot prices. Further, additional technology is implemented in the model in the form of an immersion heater. Simulations are conducted using the spot prices of the years 2001-2003, both with and without the immersion heater included in the model, and the results are compared to the full information case.
Modelling Danish local CHP on market conditions

In Denmark, the development of local combined heat and power (CHP) plants has been characterised by large growth throughout the nineties, based in part on government subsidies in the form of feed-in tariffs. Simultaneously, there has been a significant growth of wind power, particularly in the Western Danish system. As both the power produced by the local CHPs and the wind power are prioritised, the production of these types of power is occasionally sufficient to meet the total demand in the system, causing the market price to drop dramatically, sometimes even to zero-level. In line with the liberalisation process of the energy sectors of the EU countries, it is however anticipated that Danish local CHP are to begin operating on market conditions within the year 2005. This means that the income that the local CHPs previously gained from selling electricity at the feed-in tariff is replaced in part by income gained from selling electricity on the Nordic spot market, Nord Pool. Thus, the production quantities of the local CHPs will depend on the market price. This paper analyses the new situation. This is done by creating a model for the supply function of a local CHP, which takes into account the local heat demand as well as technical factors such as heat storage facilities and production unit characteristics. Based on an adaptive prognosis for electricity spot prices, bids for the spot market are made in accordance with the rules of the Nord Pool 24-hour cycle. The paper will discuss the consequences of acting in a liberalised market for a given CHP plant, based on the abovementioned bottom-up model. The key assumption determining the bottom line is the electricity spot price. The formation of the spot price in the Nordic area depends heavily upon the state of the water reservoirs in Norway and Sweden. For this reason, the analysis is undertaken as a parametric study of the electricity spot price.
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Phd Student:
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