Analysis of power pools in the deregulated energy market through simulation

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Abstract

The electricity market has changed rapidly in the Northern European countries. Harmonisation of the legislation and trading methods widens the market area outside national limits. Vertical integration among electricity companies is changing the traditional structure of the inner market. Successful business in this new, more volatile market requires sophisticated techniques for identifying new market opportunities and managing the increased risks.

We study the new market from the perspectives of regional distributors and power pools. We analyse the trading possibilities and profitability of different kinds of power pools, when a spot market and several new contract structures are available along with existing capacity-based long-term contracts. Different policies for allocating the common benefits of a power pool among its members are compared and a new booking algorithm for balance settlement is introduced.

To analyse the operation of different kinds of pools, we use simulation and optimisation techniques. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

The electricity market in the Northern European countries, Finland, Sweden and Norway, has encountered a fundamental change since the beginning of the 1990s. The previously regulated and monopolistic electricity industry has been deregulated and a free electricity market has been created through legislative actions. The Finnish electricity market was deregulated by the Electricity Market Act, which has been in effect as of 1st June 1995 [4]. The Act includes prerequisites for competition in power generation, foreign trade, and power sales, so that the electricity market can function efficiently. It also establishes clear rules for the grid business, which operates in a position of a natural monopoly. The business areas open to competition now have a separate accounting from those in a monopoly position. In August 1996, EL-EX, the Finnish electricity spot market, was invoked to serve large electricity producers, distributors, and industrial consumers. Competition has already resulted in dramatically lower energy prices on the spot market.

The electricity grid forms a marketplace where buyers and sellers meet. The grid companies or business units do not participate in power trading; power transmission and sales have been completely

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separated. Transfer services in the national main grid owned and operated by Fingrid, the national grid company, are based on the principle of point pricing. Regional distribution network operators must provide fairly and (within the local network) equally priced services to all customers. A customer connected anywhere to the grid has thus the right to use the entire Finnish grid from the main grid to the distribution network. A single contract gives access to all grid services.

Similar changes have been introduced in Sweden and Norway with the objective to later create a common Nordic electricity market, which makes it possible to buy and sell electricity in any Nordic country. There are also plans to combine the Swedish–Norwegian spot market Nord Pool [13] with EL-EX. Several actors operate already in both EL-EX and Nord Pool causing Finnish and Swedish–Norwegian spot price curves to almost coincide.

Deregulation along with more sophisticated metering and accounting technologies makes way for various new types of electricity contracts and derivatives. New contract types and the lowered price level have serious effects on old capacity-based long-term contracts that are thus currently highly over-priced. While most of the old long-term contracts expire by year 2000, they are gradually being replaced with new energy-based contracts, short-term contracts, and spot market trade. During the transition phase, the actors have the challenging problem of managing very complex portfolios of new and old contracts.

Deregulation opens new possibilities for co-operation between electricity market actors. Different kinds of coalitions or *pools* can more efficiently utilise the various types of trading possibilities than individual companies. During the last few years,
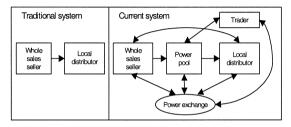
several pools have indeed been formed in Finland. The market structure transition is depicted in Fig. 1.

In this paper, we discuss why and how power pools are formed, and analyse the management of different types of pools with and without access to spot market instruments. We apply a simulation model for long-term market analysis. The model is based on the commercial EHTO energy optimisation software that is reported in Ref. [9]. We use the simulation model to compute the benefits of different types of pools and to compare different policies for sharing the benefits among pool members. We also introduce a balance booking algorithm to allocate the pool benefits on an hourly basis, overcoming thus the traditional problems of allocation. Simulation data is based on a real-life example.

2. Old and new contracts and financial instruments

2.1. Old contracts in a new world

Up to deregulation of the electricity market, the basic type of contracts in Finland has been the open long-term multi-tariff contract with capacity limits and separate capacity and energy fees. The duration of long-term contracts is typically from one to several years. The cost function $C(p)$ of open multi-tariff contracts is modelled as

$$C(p) = c_0 + \sum_{k=1}^{K} \left(c_k^{\max} p_k^{\max} + \sum_{t \in T} c_k^t p_k^t \right),$$

s.t.

$$0 \le p^t \le \sum_{k=1}^{K} p_k^t \qquad \forall t \in T, \tag{1}$$

$$0 \le p_k^t \le p_k^{\max} \qquad k = 1, \ldots, K, \qquad \forall t \in T,$$

where $p = [p^t]$ is the vector of hourly power traded through the contract, T is the set of hours for the duration of the contract, p_k^t is the partition of p^t into tariff components, c_0 is the fixed contract fee, $c_k^{\max}$ is the capacity fee of tariff component k and c_k^t is the hourly energy fee. The energy fee typically varies according to a few time zones such as day/night and winter/summer. The seller sets the fees, which may depend on official indices (fuel

Fig. 1. The traditional and new market structure.