



Energy bidding strategies for restructured electricity market



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ABSTRACT

Many countries around the world have changed the economics of their electricity markets from monopolies to oligopolies in an effort to increase competition. The restructured electricity markets have introduced risk and uncertainty into a sector of the economy that was traditionally state-owned. Suppliers and customers use financial methods to manage the risk from market prices. The maximization of profit for power companies is highly associated with the bidding strategies. In order to maximize the profit, participants need suitable bidding models. In an open access electricity market, the bidding problem is a complicated task because of producer's uncertain behaviors and demand fluctuation. Therefore, developing bidding strategy is extremely important for electricity market participants to achieve the maximum profit. This paper analyses a comprehensive literature on the state of the art research of bidding strategies in restructured electric power market.

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Introduction

Electricity is an essential commodity in day to day life. The proper utilization of electric power and management of power supply lead to economical growth in the country. During early days, electricity was supplied by vertically integrated monopolies to consumers. Vertically integrated utilities are responsible for generation, transmission and distribution of power to consumers. Regulation of the electric utility industry was built on the belief that economics of scale render the power generation business naturally monopolistic. The success of privatization in the air line and telecommunication industries has encouraged restructuring in the power industry also. Now the traditionally regulated electric power industry has been undergoing a restructuring. The basic idea of restructuring includes introducing competitive energy markets, unbundling electricity services and opening access to the network. The objective of restructuring is to provide better options for industrial contributors and to introduce revolutions with improved quality service and choice to the customers at economical prices [1]. Restructuring comprises different activities; changing existing companies corporation, privatization and dissociation. The market surviving between generating companies and distribution companies, retailers or large consumers is called the wholesale marketplace. Transmission companies commonly neither buy nor sell energy, but charge a fee for transmitting electricity from one point to another. The market existing between retailers, distribution

companies and end users is called the retail marketplace. Generally electricity markets can be classified into three broad categories: perfect competition, oligopoly and monopoly. Due to limited numbers of power producers, long period of power plant construction, large size of capital investment, transmission constraints and transmission losses, the restructured power market behaves more like an imperfect competitive market. This imperfect nature of the electric industry makes generating companies bid at higher prices than their marginal production costs and increase their profits. The generating companies may achieve benefits by bidding at a price higher than their marginal production cost. This is called as a strategic bidding problem [2].

In this paper, the related literature is organized as follows. Section 'Power trading in world markets' presents restructuring experience in different countries. Section 'Strategic bidding' discusses the market structure and basic idea of bidding strategies. Section 'Solution methodology' employs the various pricing mechanisms adopted under liberalized atmosphere. Different solution methods are proposed to solve the bidding strategy problem in Section 'Pricing methods'. The bidding process with congestion management is discussed in Section 'Bidding strategies based on congestion'. Section 'Bidding strategies in ancillary service market' investigates the bidding strategies in ancillary services market. Finally the conclusion of the paper is summarized in Section 'Numerical studies'.

Power trading in world markets

Electric power trading is an activity in which transactions take place directly between two participants or indirectly through an

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exchange. Electricity market reform started in the middle of 1980s in Chile and UK and have spread to many parts of the world [3]. This section employs a comprehensive review and analysis of existing competitive electricity market in different continents. By studying country wise analysis between market rules, market structure and the behavior of market prices, understanding can be gained about the incentives for the exercise of market power for a given electricity market.

South America

In South America, a major transformation took place throughout the country from 1980. In 1982, new electric sector regulations were introduced in Chile. Chile was a pioneer in the world to introduce market oriented reforms throughout society. Electricity sector regulations promoting market competition have been introduced in Argentina in 1992, Peru in 1993, Bolivia and Colombia in 1994, Brazil in 1996 and the Central American countries in 1997. In Argentina, the wholesale electricity market determines prices on the basis of bids that can only be changed every six months. In Brazil, the structure of wholesale electricity markets are organized by a spot market representing 24 h look ahead market and a long term market. Colombia has been an exception in South America in its working with the British model, which views all generation as being at a single point [4].

Europe

Liberalisation of the electric power market in continental Europe was started in the late 1990s and is still going on. The United Kingdom was one of the first European countries to introduce reforms electricity sectors. An organization called Nordel was formed for making power trading between Norway, Sweden, Finland and Denmark. Norway's market, Nord pool, was originally founded in Norway and operated for the first time in 1993. Germany has the biggest market in Europe based on electricity demand. The European Energy Exchange (EEX) currently covers three bidding areas: Germany/Austria, France and Switzerland. Currently in German market design, four transmission system operators are responsible for providing real time balancing energy. The European transmission operators association has recognized three main ancillary services: primary control, secondary control, minute reserve [5,6].

Australia

In Australia, restructuring in the electricity supply industry began in 1998. As part of this process, the National Electricity Market (NEM) was created in order to increase competition at every stage in electricity production and distribution. It is a wholesale market through which generators sell electricity in eastern and southern Australia. The NEM covers six dominions, Queensland, New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania that are physically linked by an interconnected transmission network. In Australia, two distinct financial markets support the wholesale electricity market [7].

North America

In the US, the states of Pennsylvania–New Jersey–Maryland (PJM) power pool, the New England power pool and the New York power pool have established plans for the introduction of region wide pool co model to facilitate wholesale competition in the generation market. California restructured wholesale electricity market opened in 1998. The California PX operates a day ahead market for energy, which is followed by ISO markets for

transmission and ancillary services. New York has an ISO which is responsible for operating the state's bulk electric system and administering its whole sale electricity markets. ISO New England (ISO-NE) established in 1997, operates the regions power grid and whole sale electric markets (i.e.) energy market, interim mechanism forward reserves market, regulation market and financial transmission rights market. PJM power market began operating in 1997. PJM market operates energy and ancillary services. In the Texas, wholesale electricity market, mostly trading occurs via bilateral agreements. The Electric Reliability Council of Texas (ERCOT) is one of the eight independent ISO in North America. Many generators sell power both the bilateral market and balancing market in ERCOT [8].

Asia

The electricity market was underwent a reform in some countries of Asia too. China initiated its electricity sector reform in the 1990s. The most economically powerful country of the region, Japan, started a restructuring process in early 1990s. In the Japanese spot market 30 min products for the next day are traded. The New Zealand electricity market is a wholesale market traded through the central pool, with the exception of small generating stations of less than 10 MW. Iranian electricity market is whole sale, three days ahead market. Each generation company submits maximum ten hourly price and quantity pairs for every generation unit. In India, Electricity Act 2003 predicts Electricity Regulators at State level (State Electricity Regulatory Commission, SERC) to take care of intra-state activities while the Central Electricity Regulatory Commission (CERC) takes care of inter-state difficulties. Currently, two power exchanges viz., Indian Energy Exchange (IEX) and power exchange of India Ltd. (PXIL) are functioning with guidance from CERC and one is under implementation. It currently operates a day ahead market based on closed auctions with double sided bidding and clearing at a market clearing price [9,10].

Africa

Africa's power sector is dominated by South Africa in Southern Africa, Egypt and Morocco in North Africa and Nigeria in West Africa. The electricity market is dominated by Eskom, South Africa's vertically integrated public utility. Eskom also owns and controls the high voltage transmission grid and supplies about half of the electricity directly to customers. Compared to the other regions of the world, eastern Africa's power sector reforms have been slow. Countries linked through the Southern African power pool (SAPP) network are South Africa, Mozambique, Zimbabwe, Zambia, Namibia, Botswana, the Democratic Republic of Congo, Swaziland, Tanzania, Lesotho and Malawi. Kenya and Tanzania have recently been discussing a connection to the Zambian power grid, which would bring Kenya into the SAPP [11].

Important websites

Some of the important websites/links related to the system operator and power exchanges are:

<http://www.nemmco.com.au>.
<http://www.pjm.com>.
<http://www.caiso.com>.
<http://www.nordpool.com>.
<http://www.elecpool.com>.
<http://www.open.gov.uk/offer/offer.htm>.
<http://www.ngc.co.uk>.
<http://www.iexindia.com>.
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