International Journal of Natural and Engineering Sciences 8 (1): 15-17, 2014
ISSN: 1307-1149, E-ISSN: 2146-0086, www.nobel.gen.tr

Evaluation of Bilateral Transactions in Electricity Market

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Received: February 03, 2014
Accepted: March 10, 2014

Abstract

Bilateral transactions are very crucial in electricity market environment because these contracts let two parties to have the price stability and certainty necessary to perform long-term planning and to make rational and socially optimal investments. This paper deals with bilateral transactions in electricity market and investigates the effects of bilateral transactions on the market performance. IEEE six-bus test system is considered as test system and a bilateral between two parties is defined. Then, the effects of the proposed bilateral contract on the system performance and locational marginal prices is simulated and studied. The simulation results show the great effect of bilateral transactions on the performance of deregulated power system.

Keywords: Bilateral Transactions; Electricity Market; Locational Marginal Pricing; Independent System Operator

INTRODUCTION

Historical Background

A bilateral transaction in deregulated electricity market is a contract between two parties (producer and consumer) to exchange electricity, rights to generating capacity, or a related product under mutually agreeable terms for a specified period. This issue has been widely investigated and evaluated. The effects of such a contract are mainly crucial and sophisticated in deregulated environments. A wholesale electricity market exists when competing generators offer their electricity output to retailers [1-10]. The retailers then re-price the electricity and take it to market. While wholesale pricing used to be the exclusive domain of large retail suppliers, increasingly markets like New England are beginning to open up to end-users. Large end-users seeking to cut out unnecessary overhead in their energy costs are beginning to recognize the advantages inherent in such a purchasing move. Consumers buying electricity directly from generators is a relatively recent phenomenon. Buying wholesale electricity is not without its drawbacks (market uncertainty, membership costs, set up fees, collateral investment, and organization costs, as electricity would need to be bought on a daily basis), however, the larger the end user's electrical load, the greater the benefit and incentive to make the switch. For an economically efficient electricity wholesale market to flourish it is essential that a number of criteria are met, namely the existence of a coordinated spot market that has "bid-based, security-constrained, economic dispatch with nodal prices" [7-10]. These criteria have been largely adopted in the US, Australia and New Zealand. The system price in the day-ahead market is, in principle, determined by matching offers from generators to bids from consumers at each node to develop a classic supply and demand equilibrium price, usually on an hourly interval, and is calculated separately for subregions in which the system operator's load flow model indicates that constraints will bind transmission imports. The theoretical prices of electricity at each node on the network is a calculated "shadow price", in which it is assumed that one additional kilowatt-hour is demanded at the node in question, and the hypothetical incremental cost to the system that would result from the optimized redispatch of available units establishes the hypothetical production cost of the hypothetical kilowatt-hour. This is known as locational marginal pricing (LMP) or nodal pricing and is used in some deregulated markets, most notably in the PJM Interconnection, ERCOT, New York, and New England markets in the USA and in New Zealand. In practice, the LMP algorithm described above is run, incorporating a security-constrained, least-cost dispatch calculation (see below) with supply based on the generators that submitted offers in the day-ahead market, and demand based on bids from load-serving entities draining supplies at the nodes in question. While in theory the LMP concepts are useful and not evidently subject to manipulation, in practice system operators have substantial discretion over LMP results through the ability to classify units as running in "out-of-merit dispatch", which are thereby excluded from the LMP calculation [7-10]. In most systems, units that are dispatched to provide reactive power to support transmission grids are declared to be "out-of-merit" (even though these are typically the same units that are located in constrained areas and would otherwise result in scarcity signals). System operators also normally bring units online to hold as "spinning-reserve" to protect against sudden outages or unexpectedly rapid ramps in demand, and declare them "out-of-merit". The result is often a substantial reduction in clearing price at a time when increasing demand would otherwise result in escalating prices. Researchers have noted that a variety of factors, including energy price caps set well below the putative scarcity value of energy, the impact of "out-of-merit" dispatch, the use of techniques such as voltage reductions during scarcity periods with no corresponding scarcity price signal, etc., results in a "missing money" problem. The consequence is that prices paid to suppliers in the "market" are substantially below the levels required to stimulate new entry. The markets have therefore been useful in bringing efficiencies to short-term system operations and dispatch, but have been a failure in what was advertised as a principal benefit: stimulating suitable new investment where it is needed, when it is needed. In LMP markets, where constraints exist on a transmission network, there is a need for more expensive generation to be dispatched on the downstream side of the constraint. Prices on either side of the constraint separate giving rise to congestion pricing and constraint rentals. A constraint can be caused when a particular branch of a network reaches its thermal limit or when a potential overload will occur due to a contingent event (e.g., failure of a generator or transformer or a line outage) on another part of the network. The latter is referred to as a security constraint. Transmission systems are operated to allow for continuity of supply even if a contingent event, like the loss of a line, were to occur. This is known as a security constrained system. In most systems the algorithm used is a "DC" model rather than an "AC" model, so constraints and redispatch resulting from thermal limits are identified/predicted, but constraints and redispatch resulting from reactive power deficiencies are not. Some systems take marginal losses into account. The prices in the real-time market are determined by the LMP algorithm described above, balancing supply from available units. This process is carried out for each 5-minute, half-hour or hour (depending on the market) interval at each node on the transmission grid. The hypothetical redispatch calculation that determines the LMP must respect security constraints and the redispatch calculation must leave sufficient margin to maintain system stability in the event of an unplanned outage anywhere on the system. This results in a spot market with "bid-based, security-constrained, economic dispatch with nodal prices". Since the introduction of the market, New Zealand has experienced shortages in 2001 and 2003, high prices all through 2005 and even higher prices and the risk of a severe shortage in 2006 (as of April 2006). These problems arose because New Zealand is at risk from drought due to its high proportion of electricity generated from hydro [1-10].

This paper deals with bilateral transactions in electricity market and investigates the effects of bilateral transactions on the market performance.

MATERIALS AND METHODS

Bilateral Transactions

A bilateral contract in an electricity market is an agreement between a willing buyer and a willing seller to exchange electricity, rights to generating capacity, or a related product under mutually agreeable terms for a specified period of time. Most economists agree that such arrangements are crucial to the functioning of electricity markets, because they allow both parties to have the price stability and certainty necessary to perform long-term planning and to make rational and socially optimal investments [11]. To design an efficient transmission tariff, recently transmission pricing has become one of major research topics in power industries. From the economic point of view, estimate of accurate costs is needed to provide the correct price signals. Paper [12] aims to present a transmission pricing methodology for bilateral transactions in a voluntary net pool under competitive environment. To demonstrate the effectiveness of the proposed transmission pricing method, an IEEE 30-bus RTS system and integrated Nepal power system (INPS) consisting 58 buses, 18 generators, and 91 branches have been used for numerical simulation.

Test System

In order to assess the effects of bilateral transactions on the LMP, a six-bus test system is considered as case study and this system is depicted in Figure 1. The system data are listed at Tables 1 to 3. The bilateral transaction is also defined as 40 MW contract between generator at bus 6 and load at bus 5 and this power is transferred through direct line between the proposed buses.

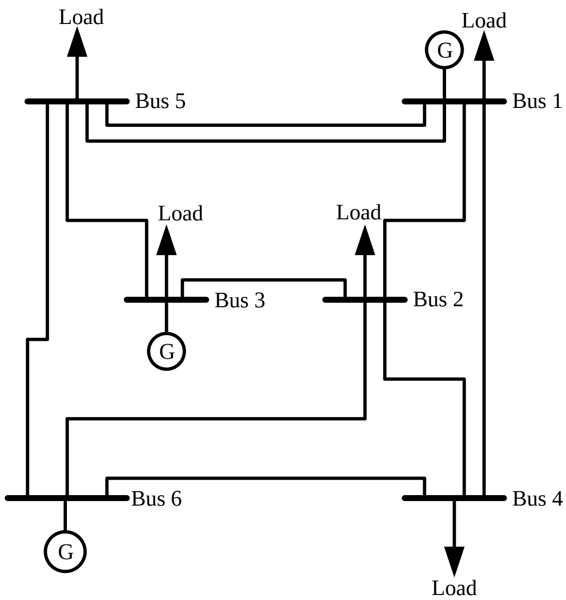

Figure 1. Six bus test system

Table 1. The generators data of six-bus test system (All data per MW)

Bus	Type	P_L	Q_L	$P_{G\,max}$	$P_{G\,min}$	$Q_{G\,max}$	$Q_{G\,min}$
1	VΘ	80	16	200	0	50	10
2	PQ	240	48	-	-	-	-
3	PV	40	8	400	0	100	10
4	PQ	160	32	-	-	-	-
5	PQ	240	48	-	-	-	-
6	PV	0	0	600	0	180	10

Table 2. The branches data of six-bus test system

Bus From	Bus To	r_{ij}[p.u.]	x_{ij}[p.u.]	b_{ij}^{sh} [p.u.]	s_{ij}^{max} [MVA]
1	2	0.040	0.400	0.00	120
1	3	0.038	0.380	0.00	120
1	4	0.060	0.600	0.00	100
1	5	0.020	0.200	0.00	120
1	6	0.068	0.680	0.00	90
2	3	0.020	0.200	0.00	120
2	4	0.040	0.400	0.00	120
2	5	0.031	0.310	0.00	120
2	6	0.030	0.300	0.00	120
3	4	0.059	0.590	0.00	120
3	5	0.020	0.200	0.00	120
3	6	0.048	0.480	0.00	120
4	5	0.063	0.630	0.00	95
4	6	0.030	0.300	0.00	120
5	6	0.061	0.610	0.00	98

Table 3. The system data for market studies

Bus	MW offer	Offer Price [$/MW]
1	200	9
3	400	20
6	600	15

RESULTS AND DISCUSSION

The proposed bilateral transaction is simulated on the test system and simulation results are listed at Table 4. In addition, the results without the proposed bilateral transaction are also listed at Table 4. It is clear that the proposed bilateral transaction has a great effect on the system performance and LMPs. Where, the LMP at bus 5 is significantly reduced following the proposed bilateral transactions.

According to the provided results, the independent system operator (ISO) can uses several bilateral transactions to provide suitable performance at the network and reducing the LMPs.

Table 4. The system LMP

Bus No.	LMPs without bilateral transaction	LMPs with bilateral transaction
1	25.6876	19.3534
2	22.1899	20.1151
3	20.0000	20.0000
4	21.5004	21.8100
5	46.9410	21.4898
6	15.0000	15.0000

CONCLUSION

The effect of bilateral transactions on the LMPs in electricity market was investigated in this paper. IEEE six-bus test system was considered as test system and a bilateral between two parties was defined. Then, the effects of the proposed bilateral contract on the system performance and locational marginal prices was simulated and studied. The simulation results showed the great effect of bilateral transactions on the performance of deregulated power system.

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