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Designing Electricity Market Auction: Discriminatory Auction or Uniform Pricing Auction

[1]J. Olamaei [2]R. Jahani [1]A.H. Araskalaei [1]M. Hajinasiri [3]M. Mahvy

[1]Electrical Engineering Department Islamic Azad University South Tehran Branch, Tehran, Iran.
[2]Young Researchers Club, Islamic Azad University, South Tehran Branch, Iran.
[3]Department of Electrical Engineering, Amirkabir University of Technology (Tehran Polytechnic), Tehran, Iran.

Abstract: This study compares discriminatory auction and uniform pricing auction through structural and behavioral indices of electricity market. A five- node test case is used and the results of simulation for two settlement system (discriminatory and uniform pricing auction) are compared through market share, Herfindahl-Hirschman Index (HHI) and Lerner Index (LI) indices. The results showed comparative advantage of uniform pricing auction to discriminatory auction, but, this is not conclusive and needs for combination of different settlement systems to present a perfect and detailed model of electricity market.

Key words: Electricity Markets, Discriminatory Auction, Uniform Pricing Auction, PAB, LMP, Market Indices;

INTRODUCTION

Electricity market is naturally a dynamic and incomplete market supposition of a perfect competitive market which is used in many articles, conflicts with many market realities. And it can't present reliable results to market regulation association. Recently several studies have been conducted in on discriminatory and uniform pricing auction in electricity markets. Because of using market clearing price (MCP) methods and inefficiency of these methods in delay simulation in system dynamism, supposing the market in stable state, decreasing descriptive ability of presented models have been seen. Also in plenty of research, limiting the study to a particular framework leads the results of these studies into having low analytic capability. And in some cases it causes contradiction between gained results.

In first sight, from market regulator association's perspective, discriminatory auction seems more realistic in consumer auspices and also in system exploiting cost reduction. Though it's not easy to present a reliable model of electricity market without combining various methods.

The structure of this study is organized as follows. In the second section we'll discuss the literature review of the subject, in the third and the forth section the network will be studied and in the sixth section results will be presented. And finally in the seventh section results will be discussed.

II. Literature Review:

In the context of price levels, in discriminatory and uniform pricing auction plenty of studies have been conducted but there's no consensus on the issue that in which structure price levels are higher. In references (Mount, T.D *et al.* 2001), (Rassenti, Stephen *et al.* 2003), (Abbink, *et al.* 2003), using experimental economy they realized that , using discriminatory auction causes market price increasing I comparison to uniform pricing auction. Discriminatory auction results lower price level rather than uniform pricing auction.

References (Fabra, Natalia, *et al.* 2002) and (Federico, Giulio, *et al.* 2003) using theatrical analysis auction structure impact on market results, they realized that in a perfect competitive condition, in discriminatory auction structure in sort-time , market price levels are lower than price levels in uniform pricing auction. Although other studied haven't presented a comprehensive model to be applied in the real world.

Kelemperer (Klemperer, *et al.* 1999) finds that discriminatory auction result in decreased tacit collusion in electricity market, but also finds it as a risk of investment incentive decrease in industry.

Some studies claim that the mechanism of discriminatory auction independent form price levels causes price unstableness reduction of electricity wholesale market. (Mount, T., 2000)

Corresponding Author: Rouzbeh Jahani, Young Researchers Club, Islamic Azad University, South Tehran Branch, Iran
Email: Rjahanih@gmail.com

Since in discriminatory auctions the GenCos try to predict market prices and present closer offer, system supply curve in discriminatory auction is almost horizontal.

Hence, system demand variation, make less change in market fixed price. In the other side market fixed price is defined in discriminatory auction as the weighted average of GenCos offer price that defeats the others in the auction. (Mount, T.D *et al.* 2001)

Demand changes which cause increase in allocated generation of generation company (GenCo) and also entering some expensive GenCos in orbit, has less impact on market fixed price. (Oren, S., 2000) The effect of auction type on investment incentive in generation is an issue without a clear response. Although discriminatory auction causes decline in market unstableness, active institutes can cover these risks by applying financial tools. In addition, price volatility can cause investment development in peaky GenCos which entering the orbit even for a few hours can bring them an acceptable internal return rate. Some studies claim that the discriminatory auction cause tacit collusion reduction, among power plants in order to increase market prices (Friedman, Daniel *et al.* 1994).

Therefore using discriminatory auction in market mechanism can cause GenCos to intentionally supply insufficient power in order to change the electricity price, and a decline in applying rigid controlling mechanism by market regulation association.

III. Uniform Pricing Auction:

In fig.1 GenCos offer ordering in discriminatory and uniform pricing auction has been demonstrated in electricity market. These offers show the generation amount of each GenCo which will be sold to the market operator.

On the left you'll see the offers to the market using uniform pricing auction which are in ascending order. after receiving the offers and putting them in an ascending order and finding it's intersection with system curve , Market operator calculate marking clearing price (MCP).

In this type of auction, regardless of offered price, MCP is paid to all GenCos that win the auction. The direct result of this structure is that all GenCos to make them motivated not to offer a price, higher than their own marginal cost. Indisputably offering a lower price than their own marginal is an improbability, and since market fixed price would be given to all winning GenCos, offering a higher price increases the risk of losing the auction in the market. In this auction type except for the last winning GenCo (which determine the market fixed price), all winning GenCos would be given a higher offer than their own offering price.

IV. Discriminatory Auction:

In this structure, GenCo A that knows, it will be paid an exact amount of money which it has offered, by predicting the last winning offer of the market and representing a lower offer than that, in addition to winning the auction tries to gain the highest rate of profit. In fact in discriminatory structure, GenCos offer a higher rate than their final possible offer.

In discriminatory auction which is shown on the right side of fig.1, each winner GenCo will be paid commensurate with the offer that, they have represented to market operator.

This offer in this auction type is not necessarily equal to GenCos marginal cost and each one of GenCos try to predict the market price and gain higher profit out of the market. Hence system supply curve is almost horizontal and does not demonstrate the marginal cost of productive technologies.

The first thing that seems to be done to reduce the costs is that, instead of paying the same amount of money to all winning GenCos we could pay each GenCo its own offer price and this could lead to lower prices for consumers. If we paid their own offer price to those GenCos, wouldn't the consumer costs be lower? As it is demonstrated in fig.1 if market operator paid GenCo A it's exact marginal cost, the amount of money paid to power plants would decline, and eventually the final consumer cost would decrease. Nevertheless this idea is very ridiculous! On the right side of fig.1 you see that. By changing the auction structure and amount of money paid to GenCos it will absolutely lead the GenCos to change their strategies.

V. The Studied Network:

Fig.2 represents a network which is used for simulation. The network includes five generators that are in nodes 1, 2 and 3 and three consumers are connected to nodes 2, 3 and 4. In tables 1 and 2 network data is presented.

VI. Simulation Results and Indices Comparison:

VI.1. Market Share Index:

This index is defined as the proportion of each GenCo on the whole generation. GenCos that have higher market share, have greater market power. Fig.4 exhibits the hourly market share (proportion of each GenCo on the whole generation.

As it seems G5 market share (which is one of the major GenCos) has obvious decline in LMP system and on the other side G1 and G2 which are minor GenCos have rise, and this means a power decline in major company's power.

VI.2. Herfindahl Index-Hirschman (HHI):

This index is defined as the sum of squared of GenCos market share. If this index is less than 0.1, the market is un-concentrated, if it is between 0.1 and 0.18 the market is rather concentrated and if it is above 0.18, the market is intensively concentrated and potential of market power exercise is higher. Fig.5 shows the hourly HHL index for the two clearing systems, LMP and PAB, in which for 24-hrs of day, LMP system is less than PAB system and as a result, potential of market power exercise is less.

VI.3. Lerner Index (LI):

In a competitive market, flexible price markets should offer the market their marginal cost. Therefore it is an important scale to have a comparison between the GenCos offer and their marginal cost to determine the potential if market power exercise. For this purpose Lerner index is defined as proportion of price difference between market cost and the marginal cost on the market price (Charles Goldman *et al.* 2001).

Fig.6 shows all GenCos in two different market clearing systems. Its clear that for the major GenCos, G3 and G5, this index is lower in PAB system and for the two minor GenCos, G1 and G2, this index is higher than LMP system. It means in PAB system, potential of market exercise power is less.

VI.4. Gencos Allocated Generation:

In fig.7 generation of each GenCo has been demonstrated. It's clear that in LMP market, participators (especially minor GenCos like G1 and G2) are able to keep their generation in high levels, while in PAB system, only in a few hours their generation can be in highest level.

VI.5. Market Profit:

Fig.8 and fig.9 show the hourly GenCos profit and market total profit for the two LMP and PAB systems. It is shown that in LMP system GenCos profit is more in comparison to PAB system. It means LMP settlement system is proper for GenCos and PAB settlement system is proper for demand side. Because consumer expenditure in this system is less than LMP system. Beside, because global welfare is higher in the LMP settlement system, therefore, in this system, investment in generation would be more than the others.

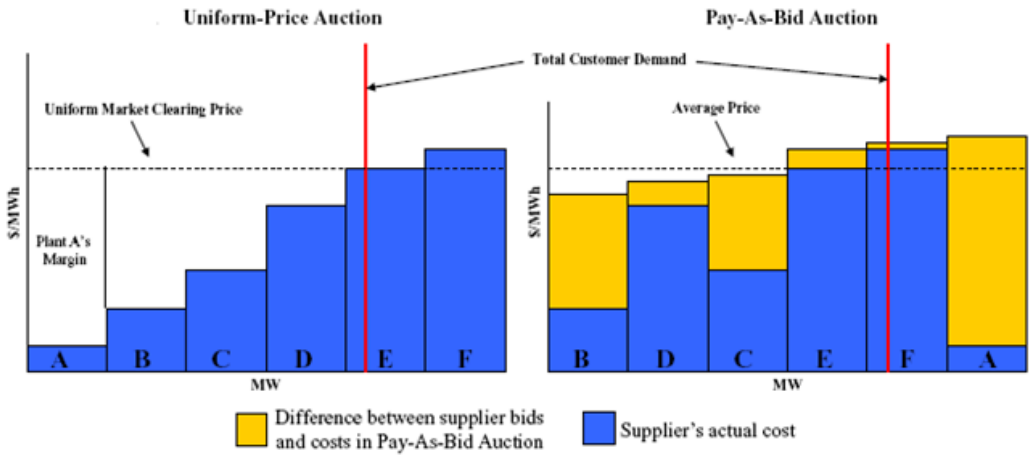

Fig. 1: Determination of Gencos reward in uniform price and discriminatory auction.

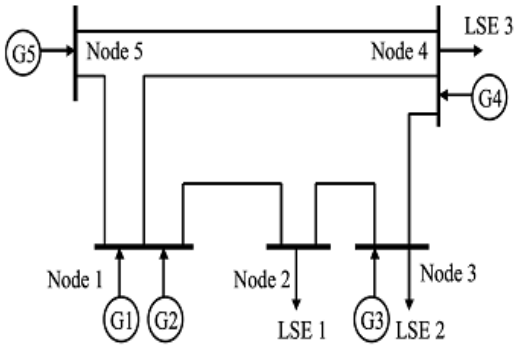

Fig. 2: Five Generators Network.

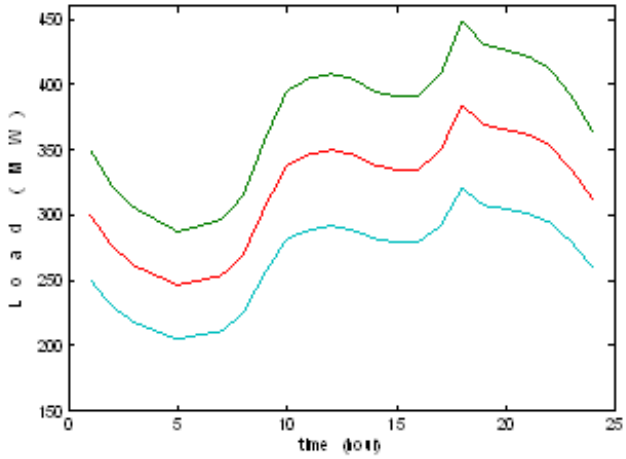

Fig. 3: Hourly Network Load (green: bus 2, red: bus 3, blue: bus 4).

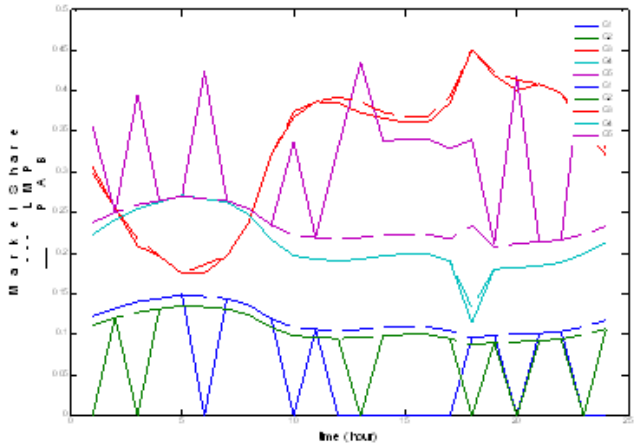

Fig. 4: Hourly market share.

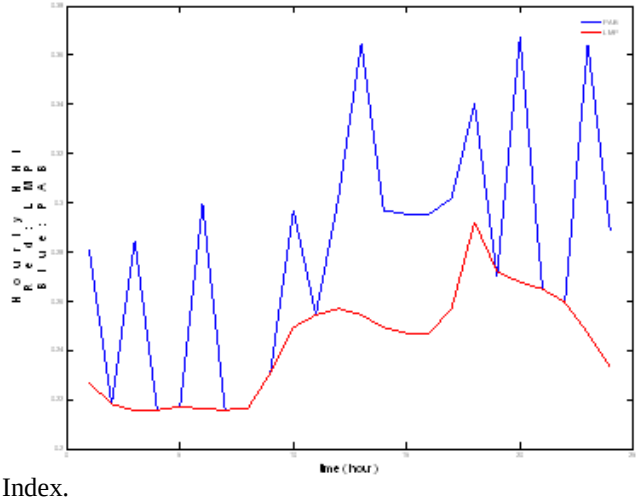

Fig. 5: Hourly HHL Index.

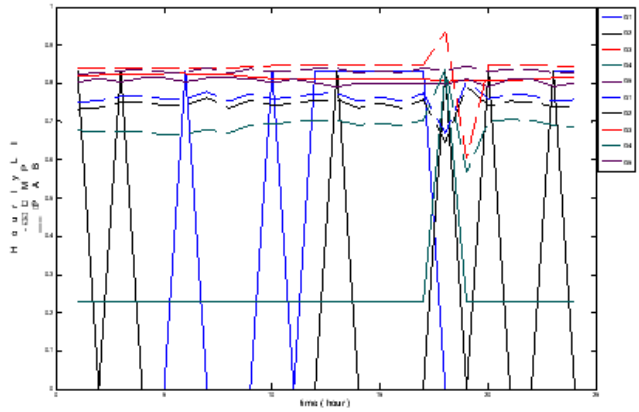

Fig. 6: All GenCos in two different market clearing systems.

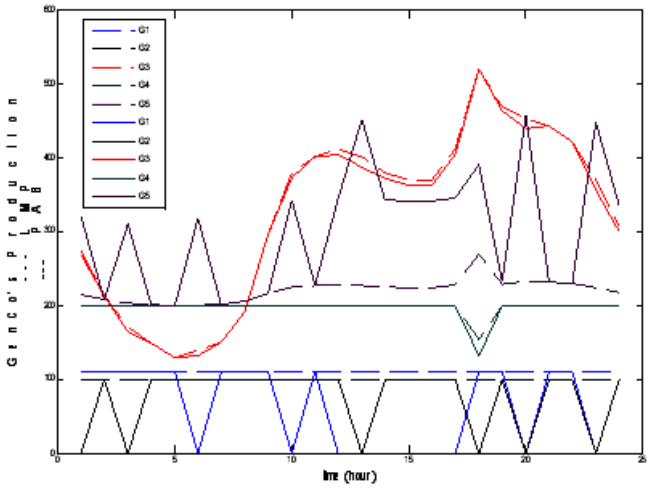

Fig. 7: Generation of each GenCo for the two LMP and PAB systems.

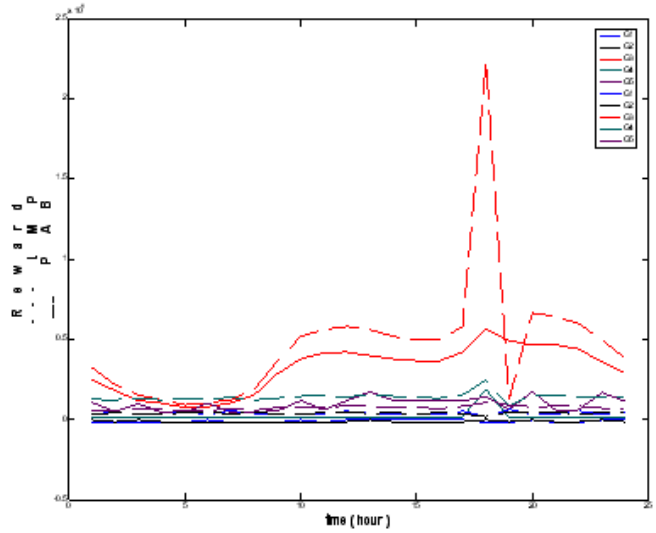

Fig. 8: Hourly GenCos profit for the two LMP and PAB systems.

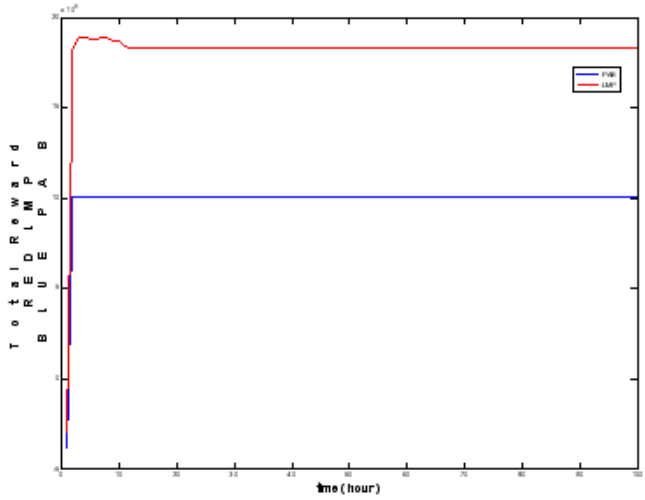

Fig. 9: Market total profit for the two LMP and PAB systems.

Table 1: Network Data .

Line Reactance(ohm)	Line Capacity (MW)	Line
0.0281	250	1-2
0.0304	150	1-4
0.0064	400	1-5
0.0108	350	2-3
0.0297	240	3-4
0.0297	240	4-5

Table 2: Generators Data.

ID	Node	C	a	b	Lower Cap (MW)	Upper Cap (MW)
1	1	1600	14	0.005	0	110
2	1	1200	15	0.006	0	100
3	3	8500	25	0.010	0	520
4	4	1000	30	0.012	0	200
5	5	5400	10	0.007	0	600

Conclusion:

In this paper we compared discriminatory and uniform pricing auction system, using some structural and behavioral indices of the market. The study was based on five bus based dynamic network. The two clearing systems are compared by means of market share indices, Herfindahl – Hirschman index and Lerner index. Results demonstrate the partial superiority of LMP system and its advantage over PAB system. It's not easy to present a reliable model of electricity market without combining various methods.

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