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Analysis of Market Clearing Price (MCP) in Deregulated Electricity Market

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Abstract— The electricity market has been restructuring throughout the world for maximum utilization of the resource and system is expended to maximize social welfare. The reason for the competitive electricity market is to serve the consumers at a reduced price. The main purpose of this paper is to discuss the price determination based on demand and supply side bidding strategies . MCP has been analyzed in both supply side and demand side bidding scenarios for linear bid trading models. MCP calculations have been based on Labview.

.**Index Terms:** Competitive Electricity market, bidding, Market clearing price(MCP).

With the introduction of the restructuring into the electric power industry, the price of electricity has been the focus of all activities in the power market[1]. In general the price of commodity is determined by supply and demand. reducing the price paid by consumer for electricity is in invariably the first reason given for introducing competitive electricity market. This paper has been considered an active participation of both supply and demand side and thus shown a power trading model as in fig.1 [2]. Two important market settlement techniques are generally adopted in the electricity market i.e. day ahead energy market(DA) and real time market. The day ahead energy market is designed for market participations with the day ahead prices. After the DA market bidding period closes , the system operator calculates the DA market clearing prices (MCP) based on bids, offers , and schedules submitted based on least cost, and makes the day ahead scheduling for each hour of the next operating day.the real time market is designed to provide opportunities for generators that are available but not selected in the day ahead scheduling.a good trading mechanism is a basic need for the market but due to oligopolistic nature of the electricity market there are fair chances of having the market power and market abuse which reduce the market efficiency[8].Saroha and Verma [3] had developed a cross border power trading model for South asian regional power pool.

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Pamigrahi et al. [4] has discussed the various marketing strategies such as bidding , spot marketing ,pricing etc. that can be applied to predict and ensure the economic viability of the microgrid scenario.Singh and Enlinch [5] has analyzed the MCP with or without wind power inboth the supply side and demand side bidding for a linear bid trading model. Bajpai and Singh [6] developed an electric powr trading model for Indian electricity markets and Verma[7] has introduced a new term MCP index , the MCP index calculation has been done on Matrix Laboratory but none of the researcher have used the LabView to determine the MCP for day ahead markets. This paper focuses on trading arrangements and effectiveness of proposed pricing mechanism which is tested on demand and supply side bidding of market model using labview for the MCP Simulation. Labview software are efficient, less costly user friendly and configurable.

2. COMPETITIVE POWER TRADING MODEL:

Pamigrahi et al. [4] has discussed the various electric industry restructuring process, the main issue is to run the system in free and fair manner eusuring the desired quality of power to the consumers at most economical price through safe, secure and reliable operation of the power system. A typical competitive power trading model with its stake holders is shown in fig.1.

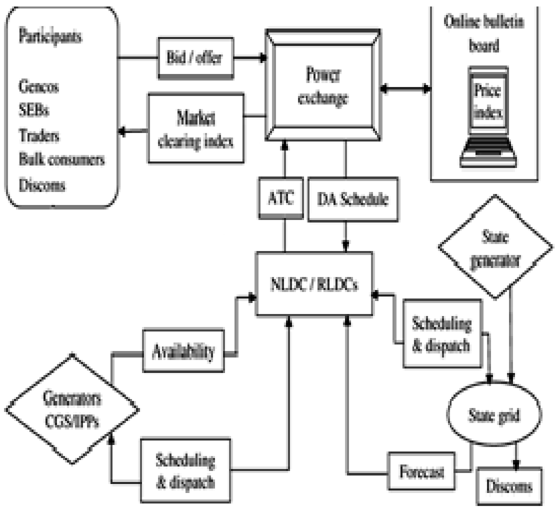

Fig. 1Competitive power trading model

3.CONCEPT OF MARKET CLEARING PRICE(MCP):

In electricity markets there are three important pricing rules for electricity auction, but only two of them are generally used in real time markets-1) single or uniform price market rules 2)pay as bid market clearing rules[2]. First one is very common in electricity auction market. In this process the sellers would receive the MCP for their electricity even if they bid less than that price and all customers would pay the MCP even if they bid more than that price.With the introduction of the deregulation in the power sector the implementation of the uniform pricing system came as a natural choice since it is believed to offer to the bidders the incentives to reveal their true cost.

4.FORMULATION OF OF MARKET CLEARING PRICE(MCP):

The MCP (Market Clearing Price) is the lowest price obtained at the point of intersection of aggregated supply and demand curves and volume of power at the point of intersection is called MCV (Market Clearing Volume). At this price both suppliers of generation and customers are satisfied and would provide enough electricity from accepted sales bids to satisfy all the accepted purchase bids. At MCP, total sales bids in their merit order would be equal to the total purchase bids down to that price in their merit order. That price would be the MCP. Two types of markets exist based on the bidding mechanism. If bidding is done only by the suppliers, it is termed as a single-sided bidding, whereas, if both suppliers and customers are allowed to bid into the market, it is known as a double-sided bidding mechanism[1][2].the bidder can be allowed to bid their output and demand in linear form as shown in fig.2

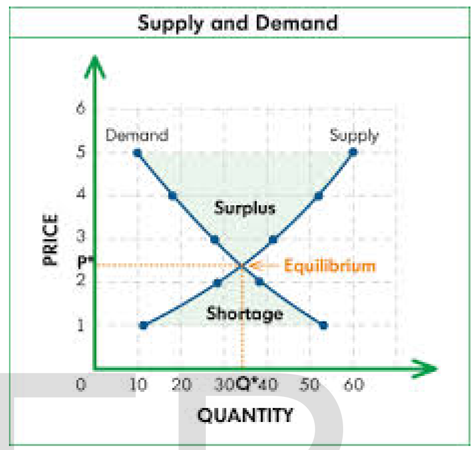

Fig. 2 Linear Supply and Demand Curve

5.DETERMINATION OF MCP:

In this paper detail analysis of MCP have been presented in the competitive market for linear bid cases. The power exchange(PX) determines the MCP which are based on the following equations:

$$Q_1(p) = \text{MW generated by Bidder 1 at a price'p' \$ /MWH}$$

$$Q_1(p) = \frac{p}{m_{s1}}$$

Where m_{s1} is the slope of linear supply curve of bidder 1. Similarly

$$Q_2(p) = \frac{p}{m_{s2}}$$

Where

$$\mathrm{Q_2(p)} = \text{MW generated by Bidder2 at a price'p'\$ /MWH}$$

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Likewise, combined supply curve for 'N' bidders will be

$$Q(p) = Q_1(p) + Q_2(p) + \dots\dots\dots\dots upto\ N$$

$$= \frac{p}{m_{s1}} + \frac{p}{m_{s2}} + \dots\dots\dots\dots\dots\dots . upto\ N$$

$$= p \sum_{i=1}^{N_s} \frac{1}{m_{si}} \quad \dots\dots\dots\dots (3)$$

Where N_s is No. of suppliers

m_{si} is the slope of supply curve

for the fixed demand D, the market clearing price (p^*) will be obtained by solving the following equations .

$$D = p * \sum_{i=1}^{N_s} \frac{1}{m_{si}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \ (4)$$

If there are N_d customers who bid into the market clearing price (p^*) can be obtained by solving the equation.

$$\text{market clearing price } (p^*) = \frac{\sum_{i=1}^{N_d} \frac{Q_o}{m_{di}}}{\sum_{i=1}^{N_s} \frac{1}{m_{si}} + \sum_{i=1}^{N_d} \frac{1}{m_{di}}} \dots\dots\dots\dots\dots\dots\dots (5)$$

Where m_{di} is slope of demand curve

Q_o is the price axis interecept of demand curve varies with types of consumers.

6.CASE STUDY AND ANALYSIS: In this paper a uniform pricing approach has been considered. Here four cases has been taken with different number of bidders[1].

Case 1: variable demand with 3 bidders (table 1)

Case 1: variable demand with 5 bidders (table 2)

Case 2: variable demand with 7 bidders (table 3)

Case 3: variable demand with 10 bidders (table 4)

Table 1,2,3and 4 shows the m_{si} i.e. slopes of supply curves .The lower and upper limit of different generators bidder are also given.

Case 5: linear bid data for demand with 4 consumer given (table 5)

Table 6 gives the cumulative supply slope with variable demand for 3,5,7and 10 bidders.

Table No-1 msi with 3 bidders

	m_{si}($/MWH$^{2)}$)	Q_{max}(MW)	Q_{MIN}(MW)
Bidder -1	.21	100	10
Bidder-2	.24	50	05
Bidder-3	.26	50	07

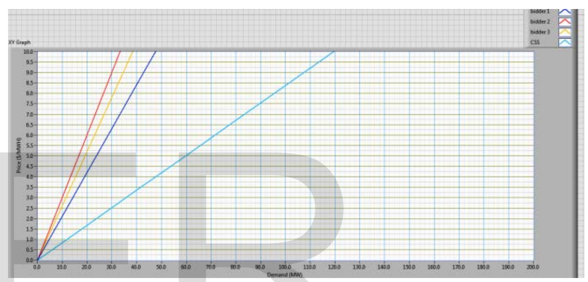

Fig. 3 supply side curve for 3 bidder

Table No-2 msi with 5 bidders

	m_{si}	Q_{max}(MW)	Q_{MIN}(MW)
Bidder -1	.21	100	10
Bidder-2	.24	50	05
Bidder-3	.26	50	07
Bidder-4	.27	50	07
Bidder-5	.29	50	05

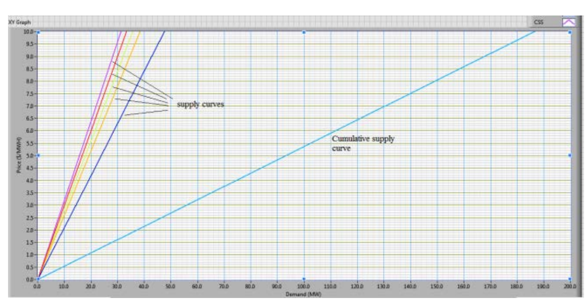

Fig. 4 supply side curve for 5 bidder

Table No-3 msi with 7 bidders

	m_{si}	Q_{max}(MW)	Q_{MIN}(MW)
Bidder -1	.25	50	07
Bidder-2	.20	100	10
Bidder-3	.22	100	10
Bidder-4	.24	50	05
Bidder-5	.26	50	07
Bidder-6	.28	100	10
Bidder-7	.30	100	10

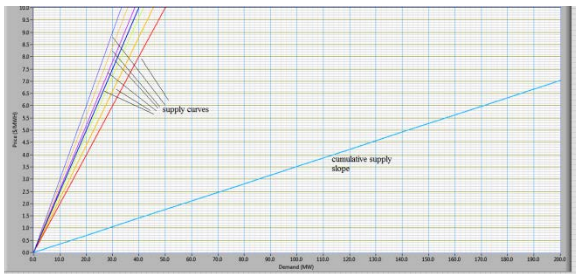

Fig. 5 supply side curve for 7-Bidder

Table no-4 msi with 10 bidders

	m_{si}	Q_{max}(MW)	Q_{MIN}(MW)
Bidder 1	.22	50	10
Bidder-2	.24	50	05
Bidder-3	.26	100	10
Bidder-4	.28	100	10
Bidder-5	.30	50	05
Bidder-6	.32	50	07
Bidder 7	.34	100	10
Bidder-8	.36	100	10
Bidder-9	.38	50	05
Bidder-10	.40	50	05

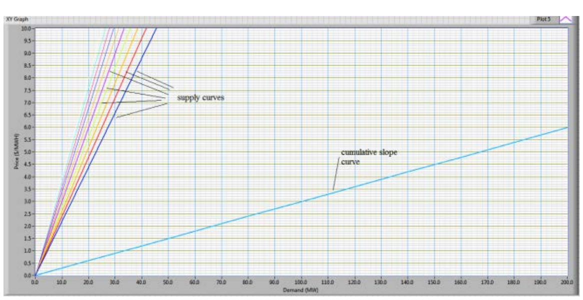

Fig. 6 supply curve for 10 bidder

Table no-5 m_{di} with 4 consumers

	m_{di}($/MWh^{2})	Q_o($/MWh)
customer -1	0..080	9
customer-2	0..075	8
customer-3	0..050	7
Customer-4	0.060	6

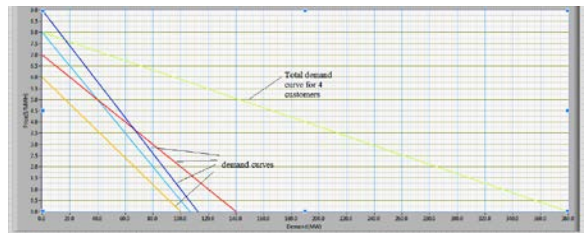

Fig. 7 demand curve for 4 consumers

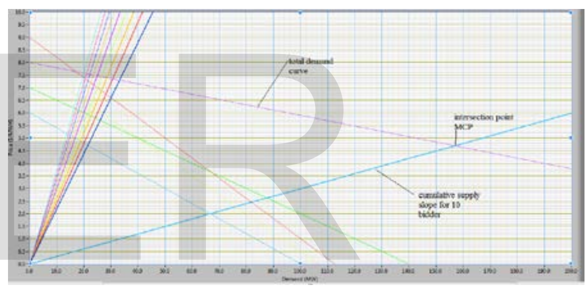

Fig.8 supply and demand curve

At 156MW MCP is 4.7880

Table no-6

Cumulative supply curve with different demand for 3,5,7,10 Bidders

		D=100	D=150	D=200
	CSS	P^*(MCP)	P^*(MCP)	P^*(MCP)
Case-1	12.76	7.8369	11.7554	15.6739
Case-2	19.09	5.2383	7.8575	10.4766
Case-3	27.62	3.6205	5.4308	7.2411
Case-4	32.58	3.0693	4.6040	6.1387

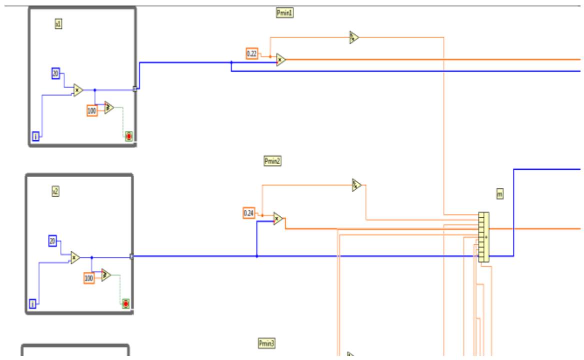

Fig. 9 Block Diagram used for supply and demand curve

As from table no 6 there is a reduction in the MCP as number of bidders increases which gives the transparency in the power market. For a demand of 200 MW the MCP for case 1, case 2,case 3 and case4are15.6739,10.4766,7.2411and6.1387respectivel y.

7.RESULTS AND DISCUSSION: It can be analyzed from the above result that MCP is decreasing as the number of bidders are increasing with the different demand. Table 1,2,3 and 4 shows the slope of supply curve of 3 bidders, 5 bidders , 7 bidders and 10 bidders respectively. Table 5 shows the slope of 4 consumers. In table 6, in the single side bidding, the cumulative supply curves shows, as the demand increases, the MCP also increases. Fig. 7 shows the demand curves with 4 customers & the MCP is calculated with the intersection of total Demand Curve and cumulative supply curve. Fig. 8 shows the double side bidding i.e. supply side bidding and demand side bidding. The line from intersection point terminates at Y-axis give the double side bidding MCP. Table 6 we observe that as the number of bidders increases, the MCP decreases. The MCP at 200 MW is 6.1387 for 10 bidder. The block diagram used in labview to plot supply and demand used shown in fig.9. .

8. CONCLUSION: The growth of power demand in india is very high. In this paper MCP for different bidders are calculated. Calculations and plotting of for various bidders are done with the help of LABVIEW. This paper may be helpful for electricity market transparency.

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