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Research Paper on Power Trading Model for Competitive Deregulated Electricity Markets

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ABSTRACT

Throughout the world, restructuring and competition are being introduced into the electric power industry. The main issue is to run the system in free and fair manner ensuring quality power to the consumer's at most economical price through safe, secure and reliable operation of the power system resulting in transparent price discovery. Although a number of market models are prevalent in the International arena, the same could not be directly adopted for Indian cross border power market. Rather, a careful study of the existing models is to be carried out to evolve a model suitable to Indian conditions, which is easy to adopt, sustain and to take care of existing participants. This paper could be guide line for the policy makers, power systems designers and market operators to promote the cross border power trade in neighboring countries of India with system reliability and security.

Keywords: Gencos, Transcos, Transcos, Discos, Consumer, Power Pool.

1. INTRODUCTION

This paper presents the concept of Cross border Power Trading Model for Deregulated Electricity Market. In India Power development has been carried out predominantly by the State controlled electricity boards. The Ministry of Power (MOP) is overall authorizing authority for power sector development & regulatory change. The role of MOP include formulating policies, plans, processing power projects for investment decisions, research and development, formulating legislation pertaining to power generation and supply, and providing the required linkages between other ministries and departments in the Central government, State governments and the planning commission. The Electricity Act 2003 will ensure the competition in the electricity market at the wholesale level, i.e., the bulk consumers and distribution companies will now be permitted to buy power directly from any generating companies [1].

The area of India along with its cross border neighboring countries is controlled and maintained by SAARC (South Asian Association for Regional Co-operation). The SAARC was established in December 8, 1985 by the head of state or government of Bangladesh, Bhutan Nepal, India, Pakistan, Maldives and Sri Lanka.

In this paper the design concept of cross border power trading model in competitive power market has been introduced by taking consideration of major issues faced by present power traders in Indian electricity market. This paper focuses on trading arrangements, operation of power exchange and effectiveness of proposed pricing mechanism which is tested on linear demand and supply side bidding scenarios of market model.

2. LITRATURE REVIEW

As power trading has emerged as the biggest instrument in the India power market in facilitating competition, hence the future of power trading in India is very bright. The Indian power trading market is rapidly growing both in physical and financial, short and long term size and volume. The implementation of futures, options, forwards and contracts for differences in the process of hedging in the power market will make the power trading business as the most beneficial trading business for the companies involved in power trading business in Indian power market.

With the present condition of huge cry for the reduction of emission and climate safety all over the globe, the trading of green power will materialize the demand for emission reduction and building of green environment by giving the opportunity for fostering and generating green power in large amount.

S.N. Singh et.al [1] discussed about Power industry restructuring, around the world, has a strong impact on Asian power industry as well. Indian power industry restructuring with a limited level of competition, since 1991, has already been introduced at generation level by allowing participation of Independent Power Producers (IPPs). Chai Chompoo-inwai et.al [2] gives the information about the model of deregulated electricity market in Thiland. Transmission congestion management (TCM) plays a significant role in power-system operation under today's deregulated environment. S. N. Singhet.al [14] discuss about the wind competitive electricity market the Electricity market presents challenges to power system plannersand operators. It is not possible for wind generators to bid intothe competitive electricity market due to high cost andintermittent nature of available power. Subrata Mukhopadhyay et.al [22] discusses the status of real time grid operation in India with regulatory mechanism in place. Open access to transmission is encouraging short term and long term bilateral / multi-lateral contract in power market creating de facto a platform for power exchange to operate with various participants – buyers, sellers and traders in position.

P. Bajpaiet.al [23] a robust trading system is very important for free and fair competitive electricity market operation. Trading system should be capable of risk hedging associated with price volatility and other unexpected changes. Operating behavior of a competitive power market is significantly affected by the trading arrangements, strategic bidding, market model and rule.

2. PROPOSED SCHEME

Cross border power trading sector is in constant evolution therefore players on the market need to keep up-to-date with the latest development in regional projects and within the regulation framework which will enable power plant operator to trade in a more efficient way. There have been very few instances of power import from across the border in the recent past. One of them is the Tala transmission project, which brings power from Bhutan to Delhi. This is being developed by Tata Power for Power Grid Corporation of India Ltd (PGCIL), the country's largest power transmission company. The reason for deregulation is different for different countries. Many countries made the changes as a result of failure of the state to adequately manage electricity companies. In other countries, the force behind this has been the lack of public resources to finance the required investment for the development.

Figure 1 Shows the typically structure of a vertically integrated utility where links of information flow existed only between the generators and the transmission system. Similarly, money (cash) flow was unidirectional, from the consumer to the electric utility.

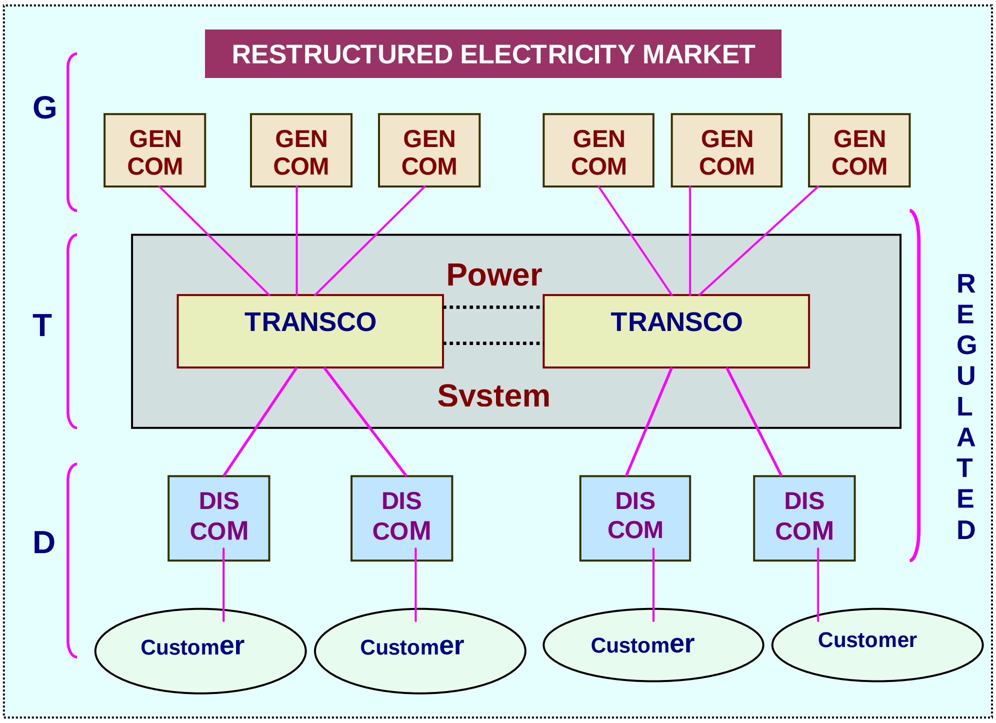

Figure 1 Restructured Electricity Market

Generating Companies (Gencos):

The generators produce and sell electricity. This may refer either to individual generating units or more often to a group of generating units within a single company ownership structure with the sole objective of producing power, and commonly referred to as Independent Power Producers (IPP). Different markets may classify generators based on their rated capacity or in the way the generators have been contracted to operate in the market.

Transmission Companies (Transcos):

The transmission companies are those entities, which own and operate the transmission wires their prime responsibility is to transport the electricity from the generators to consumers, and making available the transmission wires to all entities into the system. For their services, they levy the transmission tariff. In some systems, these Transcos are classified according to the operating voltage levels, such as national Transcos (at 400KV and 220 KV), regional Transcos (at 132 KV).

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Distribution Companies (Discos):

The distribution companies are usually those entities owning and operate the local distribution network in an area. They buy wholesale electricity either through the spot-markets or through direct contracts with Gencos and supply electricity to the end user consumers.

Consumer:

A consumer is entity consuming electricity. In the deregulated markets, the consumer has several options for buying electricity. It may choose to buy electricity from the spot-markets by bidding for purchase, or may buy directly from a genco or even from the local distribution company.

Figure 2 shows the typical structure of a deregulated electricity system with links of information and money (cash) flow between various players.

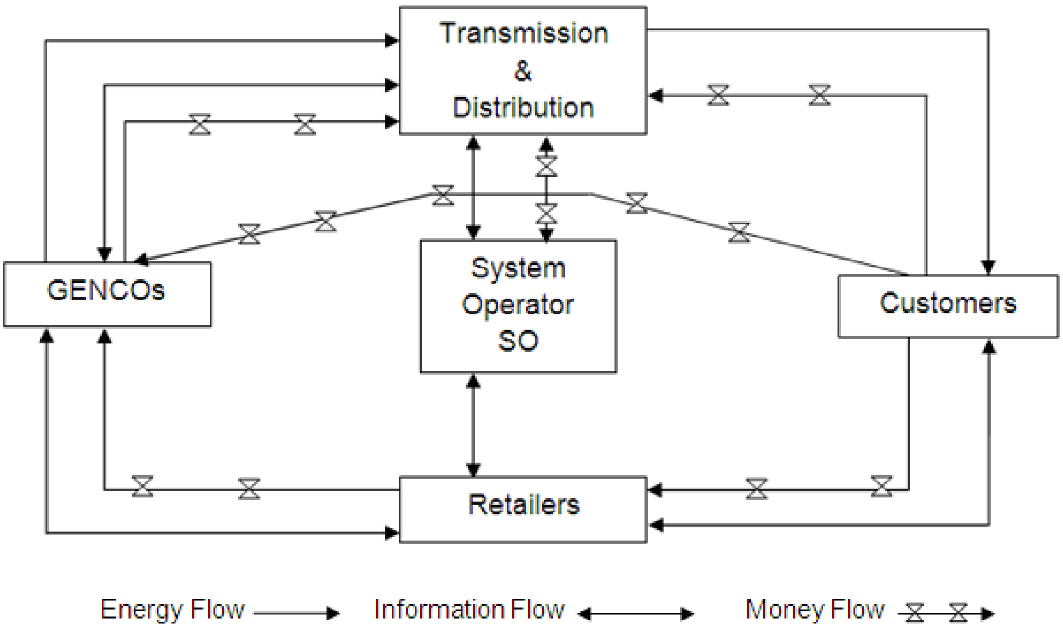

Figure 2 Deregulated Electricity Market Structure

Power Pool:

The power pool is used to create an efficient market place for trading electricity. The power pool is usually operated by a centralized, independent organization that defines the standard for electricity price bids and the evaluation of these bids. In India power exchange controls the power pool [17].

4. RESULT & SIMULATION

Trading electricity using a common power system is the only way for a large group of consumers to buy electricity from a large group of producers. The objective of the electricity trading system is that all the consumers pay for the amount of electricity they have consumed and at the same time all the producers get paid for their generation.

Cross-border electricity trading with India is limited. Electricity trade in India is restricted to wheeling and selling power to states within India. Moreover, cross-border power trading is done only through Power Trading Corporation of India (PTC), through bulk power transmission services agreements with Power Grid Corporation of India Ltd. (PGCIL)[29]. Fig. 3 shows Cross Border Power Trading model as below:

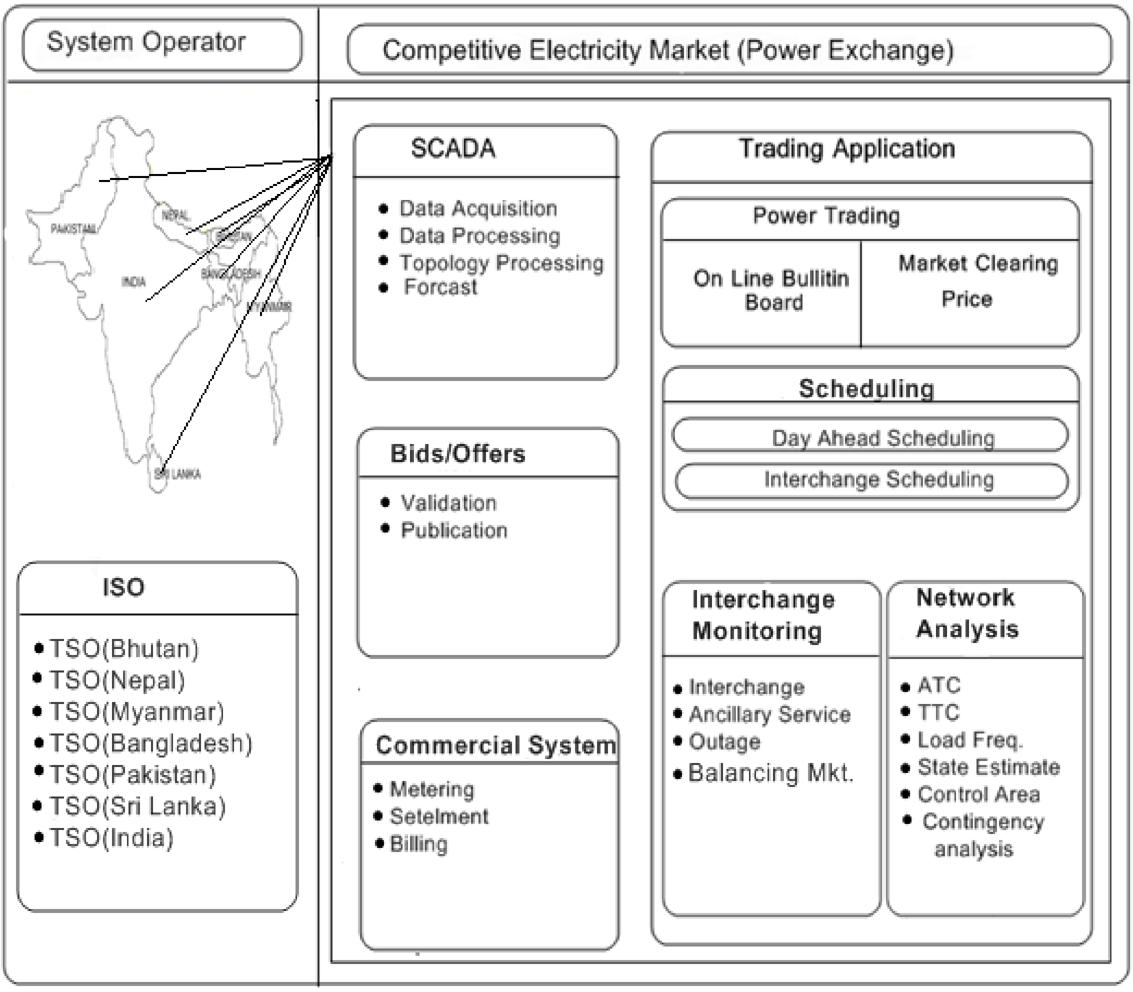

Figure 3: Cross Border Power Trading model

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 consumers 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 consumers are allowed to bid into the market, it is known as a double-sided bidding mechanism. The bidders can be allowed to bid their outputs or demands in the linear form [14, 15] as shown in Figure 4.

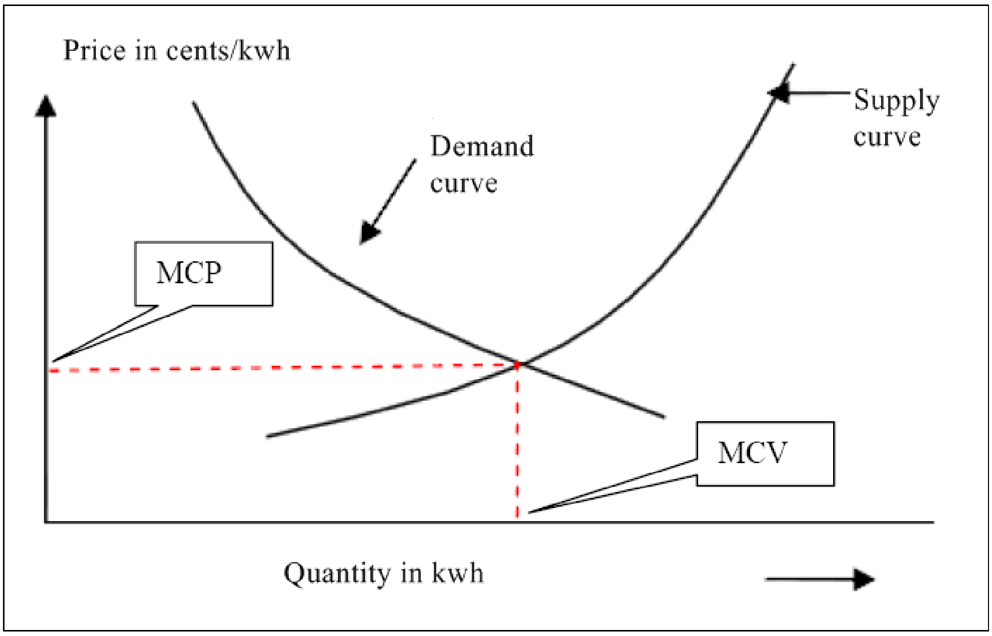

Figure 4: Linear Demand and Supply curve

Single Side Bidding:

The bidding is done only by the suppliers and the demand is fixed then this is called single side bidding. In a linear bid model, a supply curve that is a function of the market price (MCP) of any bidder i can be expressed as:

$$Q_i\ (p) = \frac{p}{msi}\ (1)$$

Where, msi is the slope of supply curve as shown in Fig.5.1, Qi(p) is quantity of the i^{th} supply curve, p is the price in cents/KWh.

If there is Ns no. of suppliers who bid into market, the combined supply curve will be given by the following equation.

$$Qi(p) = p\sum_{i=1}^{Ns}\frac{1}{msi} \qquad (2)$$

For the fixed demand D, the MCP will be obtained by following equation.

$$MCP = \frac{D}{\sum_{i=1}^{Ns}\frac{1}{msi}}\ Ns = 1, 2\ \dots n \qquad (3)$$

In this, it is assumed that bidders have enough capacity. Capacity of any individual supplier can be included accordingly. If the i^{th}generator has the minimum (Qimin) and maximum (Qimax) power output limits & u is unit function, the supplycurve defined in equation (1) will become

$$Qi(p) = \left(\frac{p}{msi}\right)[u(Qi - Qimin) - u(Qi - Qimax)] \qquad (4)$$

If the capacity limit – both minimum generation (Qmin) and maximum generation (Qmax) is specified then combined supply curve would be

$$Qi(p) = p\sum_{i=1}^{Ns}\frac{1}{msi}[u(Qi - Qimin) - u(Qi - Qimax)] \qquad (5)$$

Ns=1, 2… n

Where functions, u(Qi-Qmin) = 1, when Q≥Qmin = 0, when Q<Qmin

And u(Q-Qmax) = 1, when Q≥Qmax

= 0, when Q<Qmax

In the study Linear supply bid with fixed demand (i.e., single sided bid market) has been considered. A constant demand of 180 KW is considered. Analysis is performed for the following cases:

(a) First, the power generated from India is not available. Demand is met only by the other six cross border locations. MCP is obtained from the intersection of the cumulative supply curve of bidders 1, 2, 3, 4, 5, 6 respectively and fixed demand line of 180 KW, as shown in Figure 5 based on their high capital cost & Maintenance cost.

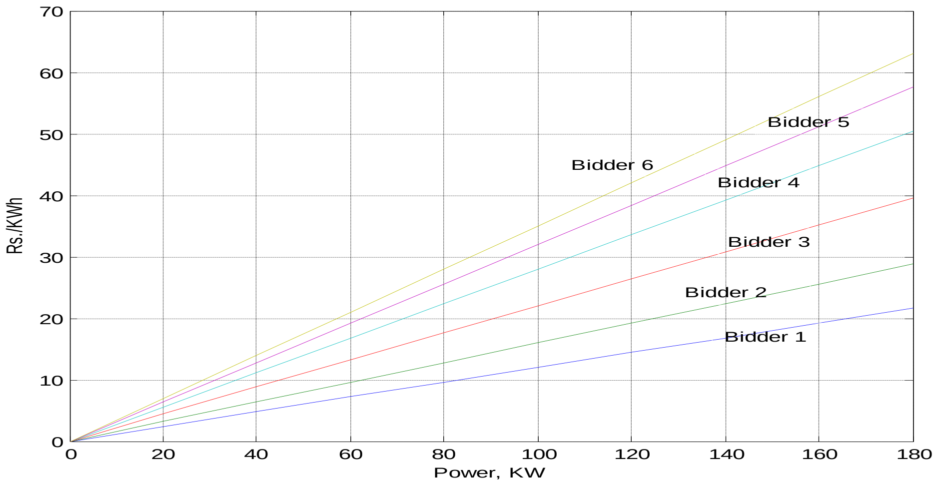

Figure 5: Linear Supply Curve

As from Figure 5 the MCP= 6.2756

Now consider the power generated from India is available upto 30 KW and partly demand is met by the other six cross border locations. Therefore, Indian generation only reduces the bidders (i.e., 1, 2, 3, 4, 5 & 6) total dispatch from 180 KW to 150 KW. The corresponding MCP is now 5.2297cents /KWh (as per Figure 5.3). Since MCP is reduced, it may not be possible torecover the cost of Indian generator hence output of bidders would be reduced by

$$\Delta Q_i = \frac{\Delta p}{msi} \qquad (6)$$

(i) Impact of bidding of Indian Generator: The congestion into the system is uncertain so output variation of Indian power as well as MCP with the different bidding rates are shown in Figure 6.

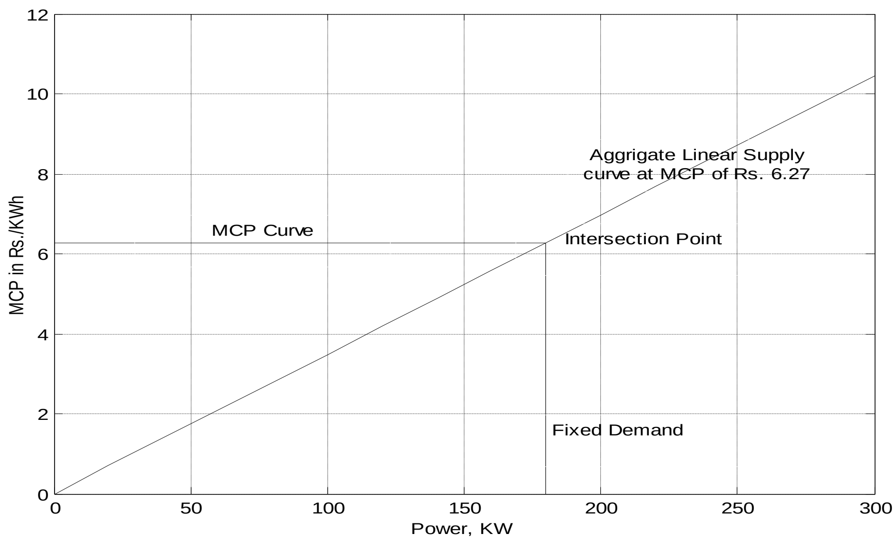

Figure 6: MCP at Diff. Bid Rate

There are two situations shown in the Figure 6

(i) Restricted Indian Generator: If the Indian gen. bid at zero, it will be completely dispatched and MCP will be 6.2756 Rs./KWh.

(ii) Unrestricted Indian Power: The MCP with restricted Indian power (i.e., 30 KW) is 5.2297 Rs./KWh which is not same as MCP at the unrestricted Indian power. Maximum and minimum MCP can be found out by Equation (5) with respect to bidding rate (ms) and then equating to zero. For various bidding rate (ms) varying from 0 to 10, payments and output are shown in the Table 5.2 for the following two options:

Option 1: with fixed Indian Power of 30 KW, MCP=5.2297 Rs./KWh when ms<1

Option 2: When ms between 1 and 10, MCP calculated without Indian Power and output of bidders 1, 2, 3, 4, 5, 6 as adjusted by Eq. (9) are shown in Table 1.

Table 1: Output and Payment at Different Cases

Bidders	Output KW At 6.2756	Payment At 6.2756	Output KW At 5.229	Payment At 5.2297	Payment At 6.2756
	$m_s<1$		$1<m_s<10$		
Bidder-1	52.29	328.19	43.5808	227.914275	273.49
Bidder-2	39.22	246.14	32.6856	170.935707	205.12
Bidder-3	28.52	179.01	23.7713	124.316878	149.17
Bidder-4	22.41	140.65	18.6775	97.6775466	117.21
Bidder-5	19.61	123.07	16.3428	85.4678533	102.56
Bidder-6	17.93	112.52	14.942	78.1420373	93.77
Indian Generator	0	0	30	156.891	188.26
Total	180	1129.61	180	941.34	1129.61

There are six bidders one bidder from each country, these bidders meet a fixed demand of 180 KW and the MCP will be 6.2756 cents as shown in Figure 5.2. Table 5.2 shows the bidding quantity of each supply bidder and the total amount of money at MCP 6.2756 cents is Rs. 1129.61. When 30 KW power taken from a local Indian generator then the MCP will be reduced to Rs. 5.229 as shown in Figure 5.3 and local area price will be 5.229. The total quantity supplied by each supply bidder is also reduced and the total amount of money at MCP of Rs. 5.229 is Rs. 941.34. If we consider the supply quantity at Unrestricted Indian generator power to meet the demand of 180 KW and MCP of Restricted Indian generator power then total amount of money paid to supply bidders is Rs. 1129.61 as shown in Table 5.2. There is a possibility of monopoly into the single sided market bidding.

CONCLUSION AND FUTURE SCOPE

This paper presents the various market strategies in cross border competitive power market. A proper use of such model can avoid the congestion in competitive power market by which efficiency and reliability of the market can be increased. The power taken from the cross border can play a vital role in mitigation of market power, ancillary services but their cost must be recovered for successful promotion of cross border power trading energy. This paper also guide line for the policy makers, power systems designers and market operators to promote the cross border power market with system reliability and security.

By concluding this paper, the following are scope of further research: This paper focuses on trading arrangements, operation of power exchange and effectiveness of proposed pricing mechanism which is tested on linear demand and supply side bidding scenarios of market model. Suitable mathematical models are developed for calculations of market clearing price (MCP) and market clearing volume (MCP) simulations. This thesis could be guide line for the policy makers, power systems designers and market operators to promote the cross border power trade in South Asian countries with system reliability and security.Such type of model can be applied to the South Asia by promoting competition. Each country in south Asia has different peak load .timings. So such type of model can also be used in importing and exporting the electricity in South Asia.

REFERENCES

[1]. S.N. Singh and S.C. Srivastava, "Electric Power Industry Restructuring in India:Present Scenario and Future Prospect" IEEE Intemational Conference on Electric Utility Deregulation, Restructuring and Power Technologies (DRPT2004) Hong Kong April 2004.
[2]. Chai Chompoo-inwai, ChitraYingvivatanapong and PraditFuangfoo, "Transmission congestion Management During Transition Period of Electricity Deregulation in Thiland" IEEE Transactions on Industry Applications, Vol. 43, No.6, pp. 1483-1490, November/December 2007.
[3]. S. N. Singh and I. Erlich, "Strategies for Wind Power Trading in Competitive Electricity Markets" IEEE Transactions on Energy Conversion, Vol. 23, No. 1, pp. 249-256, March 2008.
[4]. I. Androcec, I. Wangensteen, S. Krajcar, "Impact of Cross-Border Electricity Trading on Market Participants" Power Engineering conference Lisbon, Portugal, March 18-20,IEEE 2009.
[5]. SubrataMukhopadhyay, and Sudhindra K Dube, "Status of Power Exchange in India: Trading, Scheduling, and Real Time Operation of Regional Grids" Power Engineering Society General Meeting, IEEE 2005.
[6]. P. Bajpai and S. N. Singh, "Electricity Trading in Competitive Power Market: An Overview And Key Issues" International Conference on Power Systems, ICPS 2004, Kathmandu, Nepal (p110).
[7]. USAID SARI/Energy Program, "Regional Energy and Trade Laws in South Asia Volume I", September 2004.
[8]. A book of Power System Restructuring and Deregulation by Loi Lei Lai, John Wiley & Sons, LTD. 2001.
[9]. A book Of Operation of Restructured Power System By Kankar Bhattacharya, Math H.J. Bollen and Jaap E. Daaldar, Kluwer Acadmic Publications 2001.
[10]. A book of Power System Engineering By SK Gupta, Umesh Publication First Edition 2009.
[11]. A Book of Power System Engineering By SS Rao.
[12]. A book of Power Generation, Operation and Control By Allen J. Wood and Bruce F. Wollenberg, Second Edition Wiley India Publications 2007.
[13]. O.I. Elgard, Electric Energy System Theory, TMH Edition 1982.
[14]. Haadisadat Power System Analysis, TMH Edition, 2002.