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Multiple power exchanges in India – a case study

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SUMMARY

One of the distinguishing features of the Power Exchange implementation in India is the operation of multiple Power Exchanges in a single market handling physical delivery. Two Power Exchanges are operational and in-principle approval has been accorded to the third Power Exchange by the Central Regulator. In India, a hierarchical model with National, Regional and State Load Despatch Centers (NLDC, RLDC and SLDC respectively) is mandated for System Operation and this has facilitated the implementation of pan-India National level Power Exchanges. Scheduling of trades discovered on multiple Power Exchanges is smooth in case adequate transfer margin is available. In the event of congestion, allocation of available transfer margins between multiple Power Exchanges is an issue which has impact on the overall economy in the grid. Multiple Power Exchanges give multiple price signals, which are showing signs of convergence. In this paper, the authors study the experience gained from the operation of multiple power exchanges in a single physical delivery market in India, allocation of available transfer margins, congestion management and interplay between the bilateral market, day-ahead market in Power Exchanges and the real time market.

KEYWORDS

Power Exchange – Congestion Management – Indian Electricity Market - Open Access – Bilateral

1.0 PREAMBLE

Indian Electricity Grid Code (IEGC) was introduced in February 2000 and the settlement system (Availability Based Tariff or ABT) was introduced in phases through 2002-2003. The ABT mechanism allows benign deviation from the schedule, which is called the Unscheduled Interchange or UI. Thus, out of the four essential pillars of electricity market design [1], i.e., Scheduling and Despatch, mechanism for handling imbalances, Congestion management and ancillary Services, two were in place prior to the introduction of several products in the Bilateral Market through Open Access [2, 16]. The Guidelines for Establishment of Power Exchange were issued by the Central Regulator i.e., Central Electricity Regulatory Commission (CERC) in February 2007 after discussion with the stakeholders and the First Power Exchange commenced operations in June 2008. India has thus progressed fast in the development of Electricity Market in a short span of four years - from an almost no organized market situation prior to 2004 to implementation of Multiple Power Exchanges in 2008.

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Structurally, the Indian Power System shares some similar characteristics, other than line lengths, with the Power System in Continental Europe [3, 4] [Figure – 1]. Firstly, the Indian Power System has a highly meshed network and power flows between two areas may not only be direct, but there may be loop flows. Secondly, the transfer capability between areas is strongly interdependent and transfer capabilities cannot be considered in isolation between any two areas. In India, a hierarchical model with National, Regional and State Load Despatch Centers (NLDC, RLDC and SLDC respectively) is mandated for System Operation and this has facilitated the implementation of pan-India National level Power Exchanges.

Figure 1: Meshed Network
(Source: Central Electricity Authority, India)

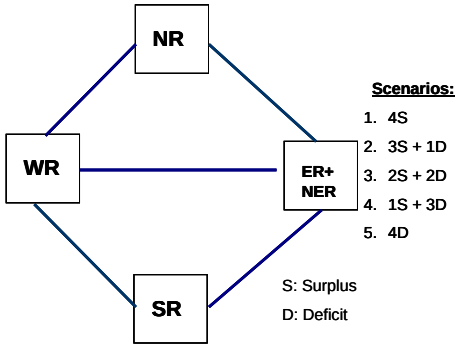


Figure 2: Skewed Market Scenario

The physical flow varies widely with changes in the load – generation balance. The effect becomes more pronounced when buyers are concentrated in one region and sellers in all other regions are trying to sell to these buyers [Figure – 2]. The declaration of the Total Transfer Capability (TTC) in advance and definition of bid areas become a complex issue in the Indian scenario and is evolving.

2.0 POWER EXCHANGE IMPLEMENTATION IN INDIA

2.1 Regulatory Framework:

Open Access Regulations had initially made provision for the Bilateral Transactions only and these were amended in April 2008 to recognise "Collective Transactions through Power Exchange" as a category of Open Access Transactions. In India, Power Exchange is a private sector initiative under the Regulatory oversight of CERC. The Regulator has adopted an approach of light handed regulation while providing an enabling framework for the development of Power Exchange [5]. The objective was to provide operational freedom to the Power Exchange within a given framework and Regulation would be minimal and restricted to requirements essential for preventing derailment of the process. Private entrepreneurship was allowed to play its role so as to facilitate provision of value added and quality service to the customers. The Power Exchanges formulate their own Business Rules, Rules and Bye Laws, subject to the approval of CERC. The CERC Guidelines for Setting up of Power Exchange, however, clearly provided for a demutualised form of Power Exchange implementation where ownership, management and participation are clearly demarcated.

2.2 Salient Features

The salient features of the Power Exchange implementation in India are Voluntary participation, Day ahead, Energy only, Physical delivery only, Double sided bidding, Hourly bids, Uniform pricing, Congestion Management by Power Exchange using Market Splitting.

2.3 Application of Transmission Charges and Losses

Postage stamp method of transmission pricing is historically prevalent in the Country. Contract path method is used for the bilateral transactions. As this is not conducive to the operation of Power

Exchanges, a methodology similar to 'point-of-connection' tariff has been adopted for Collective Transactions through Power Exchange. Under this system, both buyers and sellers have to pay transmission charges mandated by the Regulator. Likewise, transmission losses were applied in kind to both buyers and sellers. This implementation methodology specifically for Power Exchange transactions was a first of its kind in India since, both transmission losses and charges were borne exclusively by the buyers earlier. Thus, 'postage stamp', 'contract path' and 'point-of-connection' transmission pricing methodologies coexist and are evolving.

2.4 Definition Of Bid Areas

Bid areas are required to be defined as rather permanent geographically limited areas [3, 7]. The Indian Power System is demarcated into five regional grids namely, the Northern, Southern, Eastern, Western and North-Eastern Grids. Each regional grid comprises several states having geo-political demarcation as its constituent members acting as control areas. The bid areas have been defined with a pan-India perspective rather than that of individual states. The basis has been taken as the underlying physical system where structural congestions are likely to appear.

2.5 Competition Amongst Exchanges

The Regulators have provided for multiple Power Exchanges to exist simultaneously in one physical market. This allows for competition amongst the existing Power Exchanges and an automatic system of checks and balances. The market participants stand to benefit from the process of Exchanges vying with each other for providing superior quality of service.

2.6 Groups of Buyers and Sellers

A hierarchical structure is followed in India. For the purpose of scheduling and energy accounting at the Regional Level, all buyers in a regional level control area are treated as nested control areas within that respective regional level control area and are clubbed together into a separate groups. A similar treatment is given to the sellers at the Regional Level. Scheduling and energy accounting for the individual transactions for nested (embedded) control areas are handled by the respective States.

2.7 Priority and Available Margins for Collective vis-à-vis Bilateral Transactions

A variety of products are available in the Bilateral Market namely advance, first-come-first-serve, day-ahead and contingency (intra-day). Power Exchange is a neutral platform facilitating a transparent price discovery. The Collective Transactions through the Power Exchange always present a balanced portfolio to the System Operator. Hence, the Collective Transactions are given a priority and are processed before allowing day-ahead and contingency category Bilateral Transactions. In case due to congestion in real time, need arises for curtailment of Open Access Transactions, Bilateral Transactions are curtailed first before Collective Transactions.

The total available margins for short term open access transactions are assessed by the respective Regional Load Despatch Centers (RLDCs) / National Load Despatch Center (NLDC) in advance through simulation studies and made public through the respective websites [6, 15]. The balance margin available after permitting advance and first-come-first-serve transactions is used for processing the Collective Transactions through Power Exchange. It is pertinent to mention here that the available margins are not allocated in advance to the Power Exchanges. The Power Exchanges work out a provisional solution after closure of the bidding window and submit to the NLDC for validation. NLDC validates the provisional trades against the available margins and in case of congestion, limits are indicated to the Power Exchanges. The Power Exchanges then re-work out the final solution honouring the limits given by NLDC. This methodology is akin to the flow based method [7]. The window for day ahead and contingency transactions reopens after the collective transactions have been scheduled, to utilize the balance available margins, if any.

2.8 Sharing of Available Margins among Multiple Power Exchanges

Some of the possible criteria that may be considered for sharing of available margins are priority base rules, explicit auction and merging of bids obtained by all Power Exchanges [8]. The last method is the most efficient leading to overall economy and efficiency. However, in order to merge bids, there is a need to standardize parameters such as bid size, price interval, time interval, parameters for block bids, etc in addition to addressing the confidentiality issues of all the Power Exchanges involved. This also requires close cooperation between the Power Exchanges [9]. Extensive debate is being carried out for arriving at an optimal solution for sharing of available margins between Power Exchanges in India. As an interim arrangement, pro-rata based on respective requisitions has been adopted for sharing of available margins between the Power Exchanges. Pro-rata is applied on cleared trade volumes on each Area and each corridor based on the volume requisitioned by each Exchange.

3.0 EXPERIENCE OF OPERATION OF MULTIPLE POWER EXCHANGES

Hourly data from the operating Power Exchanges (Indian Energy Exchange or PX-1 and Power Exchange India or PX-2) from the date of commencement of operation to 31st October 2009 (11784 hourly data points) is analysed and discussed. Interplay between the prices in Power Exchange and the prices in the Balancing Market (UI) have also been considered.

3.1 Unconstrained Market Clearing Volume (UMCV)

The volumes in both the Power Exchanges were low initially and gradually picked up with increase in participation (Figure – 3 and Figure – 4). During the period upto May 2009 from commencement of operations, the average UMCV in PX-1 was of the order of 10 MU/day and in PX-2 was of the order of 1 MU/day. During the period June to Oct 2009, the average UMCV in PX-1 increased to about 18 MU/day and in PX-2 to 3 MU/day. It is clearly evident from the trend that PX-1 has a first mover advantage and has the larger market share.

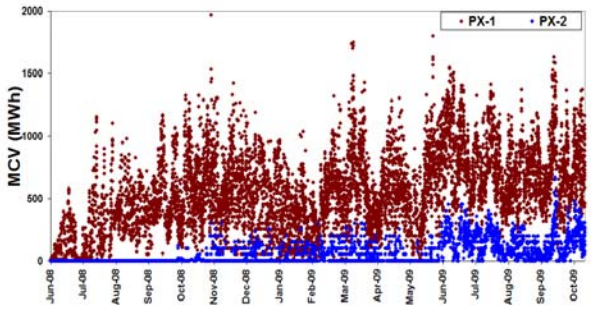


Figure – 3: Hourly UMCV

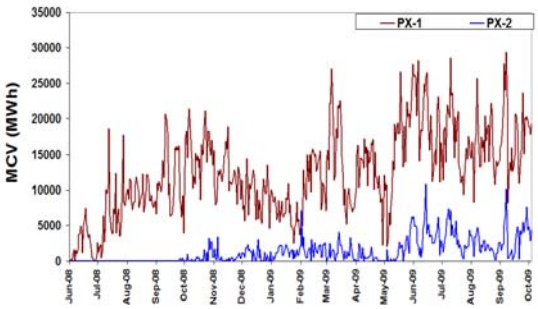


Figure – 4: Daily Total UMCV

It can be seen that the volumes through Power Exchange have steadily picked up over time. The total market share of both the Power Exchanges is presently of the order of 1% of the All India demand met in energy terms.

3.2 Unconstrained Market Clearing Prices (UMCP)

The hourly and the daily average UMCP in both the Power Exchanges is shown in Figure – 6 and Figure – 7 respectively. The correlation between the hourly UMCP and the average UMCP is shown in Table 1.

Period	Correlation in Prices Discovered	
	Hourly UMCPs	Daily Average UMCPs
22nd Oct 08 to 31st Oct 09	0.467	0.492
22nd Oct 08 to 31st May 09	0.418	0.407
1st June 09 to 31st Oct 09	0.813	0.907

Table – 1: Correlation in Market Clearing Prices in Both Power Exchanges

From Table – 1 it is seen that there is low correlation between the prices discovered in the two Power Exchanges during the period Oct 08 to Oct 09, when liquidity in one of the Exchanges was low. This resulted in divergent price signals in the market. A strong correlation in the hourly and the daily average prices discovered is observed after May 09 when liquidity in PX-2 improved. Moreover, from the trend in Figure – 5 and 6, a convergence in the prices discovered in the two Exchanges is observed during the latter period.

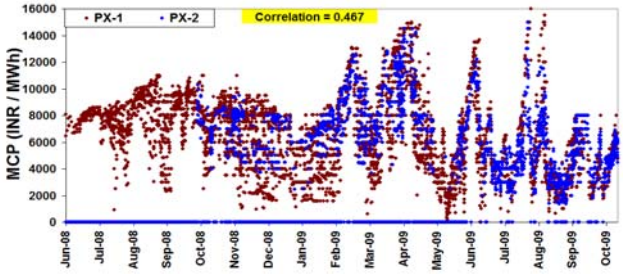


Figure – 5: Hourly UMCP

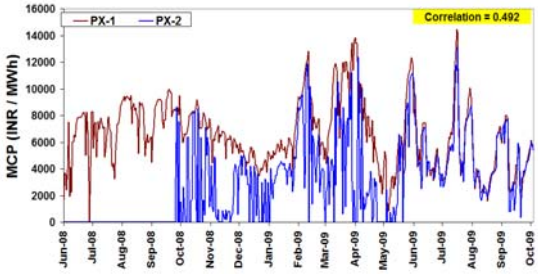


Figure – 6: Daily Average UMCP

3.3 Prices and Shortage/Surplus Scenario

A negative correlation is evident between prices discovered and the shortage/surplus scenario (sale bids – buy bids) is shown in Figure – 7.

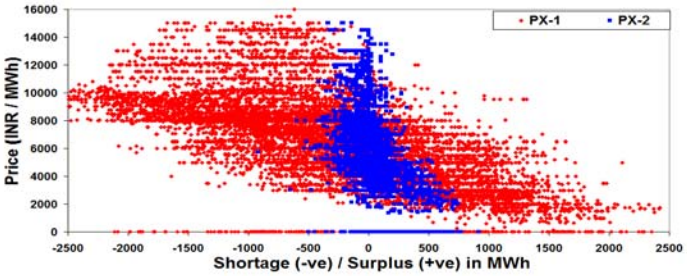


Figure – 7: Prices in Shortage / Surplus

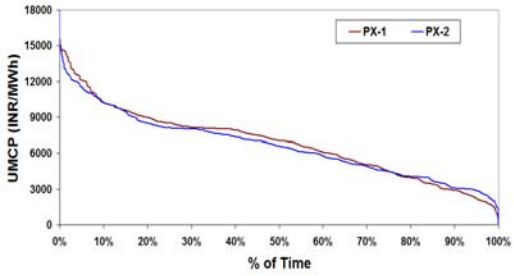


Figure – 8: Price Duration Curve

Prices show an increasing trend during scarcity (shortage) conditions and a decreasing trend during surplus conditions. The duration curve for the prices discovered in the two Power Exchanges is shown in Figure – 8.

3.4 Real Time Congestion Management – Curtailment of Power Exchange Transactions

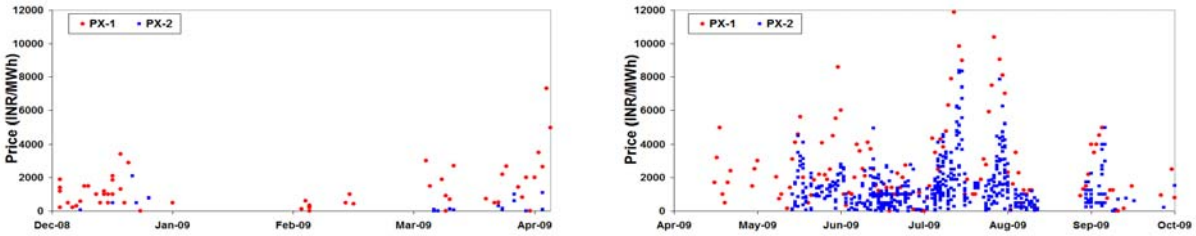
During real time, for the purpose of congestion management, even Power Exchange transactions have been curtailed. For example, on the 20th May 2009, due to stormy weather conditions in the Northern Region, many trunk 400 KV lines were under outage and the network was depleted and this necessitated curtailment of all bilateral transactions and Power Exchange transactions.

3.5 Transmission Price Discovered During Congestion

Market splitting is used in both the Power Exchanges in case of congestion. Congestion was absent till the onset of winter in 2008. Seasonal congestion towards South was experienced after mid Dec 2008 till April 2009 and towards North after mid May 2009 till end October 2009. Congestion was faced for about 1-2% of the time in import to South and around 15% of the time in import to the North. The price of transmission discovered in the two Exchanges during congestion (difference in area prices across the congested corridor) is shown in Figure – 9. Earlier, there was no discovery for transmission price in India. The average price of transmission discovered in PX-1, which has higher liquidity, is Indian Rupees (INR) 2378 per MWh when congestion is towards South and INR 2781 per MWh when congestion is towards North.

3.6 Volatility in the Prices Discovered

The Report of the Market Monitoring Cell for the period August 2008 to June 2009 [5] clearly indicates high volatility in the prices discovered during the months of May and June 2009 (above 20%). Socio- political compulsions to meet more demand during May because of Elections and high summer temperatures during June prior to onset of monsoon coupled with severe shortages are the main causes.



(a) Congestion Towards South **(b) Congestion Towards North**

Figure – 9: Transmission Price Discovered

3.7 Interplay Between Prices in Power Exchanges and the Balancing Market (UI)

As against intuitive perception, conclusive relationship cannot be directly established between the prices discovered in the Power Exchange and prices in the real time Balancing Market. This is because the participants can rely on a certain pattern of daily prices in the Power Exchange whereas the real time prices are extremely difficult to predict [9]. The prices discovered in PX-1 and those prevailing in the real time balancing market (UI) in the NEW Grid are shown in Figure – 10.

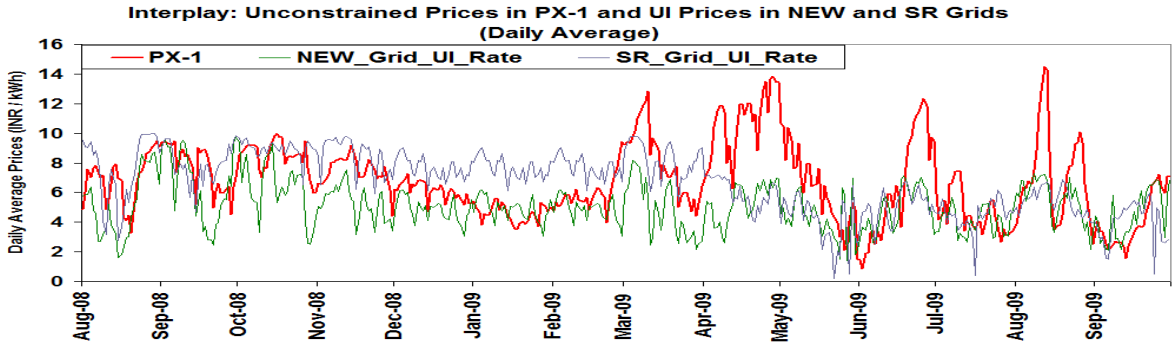


Figure – 10: Prices in PX-1 and the Balancing Market (UI)

3.8 Interplay Between the Bilateral and Exchange Traded Markets

Report of the Market Monitoring Cell for the period August 2008 to June 2009 [5] mentions a positive growth in the volume of electricity transacted through Power Exchanges (3.97%) whereas there is a negative growth in the volume of electricity transacted through the bilateral market (-0.43%) clearly indicating a shift in the preference of the market participants. The correlation between the weighted average price in the bilateral market and the prices discovered in the Power Exchanges is 0.54 and 0.42 in PX-1 and PX-2 respectively.

4.0 ISSUES AND CHALLANGES

4.1 Multiplicity of price signals

India has two 'Electrical Regions' namely NEW Grid (**N**orth, **E**ast, North-East & **W**est i.e., NEW Grid) and South Grid. The balancing market guiding vector is frequency dependent and thus there are two real time balancing market prices. Multiple Power Exchanges are implemented and each gives a price signal. Thus, in an unconstrained scenario, there are four price signals – two on a day-ahead

basis and two in the real time. In case of congestion, there is market splitting in each of the Exchanges and this makes the scenario further complex. Introduction of the third Power Exchange would increase the number of price signals. Convergence of the multiple price signals for further development of the market (derivatives) is a challenge.

4.2 Forward Physical Delivery Contracts – Regulatory Overlap

Under open access bilateral transactions, there are products such as monthly advance, first-come-first-serve which have a delivery period beyond 11 days. Both the operational Power Exchanges had approached the CERC for grant of permission for introduction of forward physical contracts also known as 'Term Ahead Contracts' in India. Forward trading in commodities is Regulated by the Forward Markets Commission (FMC) in India and 'Electricity' has been notified as a commodity. As per the laws of the land, trading in all commodities for which delivery is scheduled beyond a period of 11 days falls under the Regulatory jurisdiction of the FMC. CERC is the sector specific Regulator and there is a Regulatory Overlap. As this issue is yet to be resolved, CERC has granted approval for introduction of 'Weekly Contracts' on the Power Exchanges. These have been introduced from 15th September 2009 and little experience is available.

4.3 Price caps – Regulatory Uncertainty

Volatility in prices discovered in the Power Exchanges was high (> 20 %) during the months of May and June 2009. Regulators respond to extreme volatility primarily by proposing circuit breakers / price caps [10] and CERC too had imposed a price for a period of 45 days on all trading in the day-ahead market. Imposition of price caps resulted in a distortion of the market and introduced Regulatory uncertainty.

4.4 Transmission Pricing and Losses

Presently, 'postage stamp', 'contract path' and 'point-of-connection' transmission pricing methodologies coexist in Indian Power Market. The transmission pricing methodology needs a revamp and this is being discussed and debated by the stakeholders. The treatment of losses too is also being reviewed in order to have 'distance and direction sensitivity'.

4.5 Balancing Market Guiding Vector

The frequency dependent UI Vector is mandated by the Regulator and should ideally be based on the costliest generation at least, if not the VOLL. The UI Vector is reviewed periodically by the Central Regulator with some Regulatory lag. Dynamic indexing on the fuel cost or the market clearing price discovered on the Power Exchange, multi-dimensional UI Vector and limits on UI Volumes are issues which need to be addressed.

4.6 Available Margins for Trades through Power Exchanges

In India, both the Bilateral and Exchange traded market segments are operating which requires the distribution of available transfer capability between these market segments [11]. The issue being debated is whether some margins should be explicitly earmarked for trades through Power Exchanges. The major challenge is further allocation of the total available margins between multiple Exchanges.

4.7 Impact of Block Bids

In case of congestion selection/rejection of block bids on the Power Exchanges causes substantial change in import/export volume from the various areas and may result in a phenomenon of shifting congestion. An iterative process is required for accommodating block bids [12].

5.0 DISCUSSION

The technological interfacing of the Power Exchanges with the System Operator has been designed in-house and is fully automated. Power Exchange in India is a Private initiative and light handed regulation has allowed functional autonomy to the Power Exchanges. Competition amongst the

Exchanges has ensured innovation and a system of automatic checks and balances thereby benefiting the market participants. It is a general perception that implementation of Power Exchanges in acute shortage conditions is difficult, considering that sellers may exploit the market. However, experience in India demonstrates that prices discovered in the Power Exchange are driven by the 'value' perceived by the buyers. Implementation of Power Exchange(s) in India has provided the much needed price signals, comfort to the investors, financial institutions and has facilitated captive and merchant power plants. Coordination between the implicit auctions being carried out in the respective Power Exchanges is being done through the System Operator (NLDC) at the National level. The subject of congestion management particularly in multiple Exchange scenario, is still in its infancy and is evolving. However while facilitating trade and market operation, designing markets based on principles which complement reliability is a challenging task. Reliability of the interconnected electricity grid is of paramount importance and is non-negotiable.

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