

# An Electric Power Trading Model for Indian Electricity Market

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**Abstract**— In electric industry restructuring process, the main issue is to run the system in free and fair manner ensuring the desired quality of power to the consumers at most economical price through safe, secure and reliable operation of the power system. Although a number of market models are prevalent in the International arena, the same could not be directly adopted for Indian markets. 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. With the enactment of Electricity Act 2003, along with other recent initiatives, Government of India has outlined the counters of a suitable enabling framework for the overall development of wholesale electricity market by introducing competition at various sectors. A restructured power trading model for Indian scenario within the boundary of legal framework is proposed in this research work. The proposed model is developed after in-depth discussions with major power traders in Indian electricity market to overcome most of the major issues currently faced by them.

**Index Terms**—Indian electricity market, Power system restructuring, Power exchange, Trading model.

## I. INTRODUCTION

**E**LECTRICITY Industry, throughout the world, is currently undergoing restructuring and adopting the deregulated industry structure for better utilization of the resources and for providing choice and quality service to the consumers at economical prices. The deregulated structure is envisaged to create some sort of an electricity market and introducing competition at various levels of electricity related transactions (other than transmission, which is natural monopoly). Under this structure, a competitive market of electricity is created to enable the generators to compete with each other by availing open access to the network. This is achieved by delicensing the generation and permitting the generators to supply power to the wholesale customers of their choice by entering into bilateral agreements with or without help of a separate market like power exchange.

Over the past two decades a number of countries have restructured their electricity industry by significantly reducing the government's role in the ownership and management of domestic electricity industries. It has seen as necessary conditions for increasing the efficiency of electric energy production and distribution, offering a lower price, higher quality and secured supply. The forces behind electric sector deregulation taking place worldwide are different in different countries. These deregulation processes have been developed after debate and opposition by private and state monopolies

that have defended the vertically integrated model. Asian countries including India, China, South Korea, Singapore, Japan and Thailand have also taken historic steps to restructure their electricity industry.

The vertically integrated utilities could recover their cost regardless of whether they are operated efficiently or not. However with the introduction of competition there has been an important shift from this approach. Producers have ceased to be protected by their exclusive rights to generate and supply electricity. Competitive markets are providing the driving force for generators to innovate and operate in most efficient and economic manner in order to remain in business and recover their cost. Other benefits of competitive market include customer benefits, generation economies of scale and investment signals.

Operation and control of restructured electricity market poses technical challenges far more complex than the conventional monopolistic market. The complexity arises due to involvement of several market entities, many types of contractual obligations, separation of primary and ancillary services and varying models of market management. Some of the technical challenges include congestion management, market power, price volatility and ancillary services management.

In this paper, a electricity trading model in competitive power market has been proposed by taking consideration of the major issues faced by present power traders in Indian electricity market. Some works [1]-[4] have suggested some restructuring models to introduce competition in Indian electricity market, but this paper focuses on trading arrangements and operation of power exchange in Indian electricity market. Section II, reviews the development and present market structure of Indian electricity market. In section III, proposed restructured power trading model is described. Finally, summary is presented in section IV.

## II. INDIAN ELECTRICITY MARKET

### A. Evolution of Electricity Industry

In the pre-independence time power sector [3] consisted of small private players to meet the local needs of the smaller area around them under the provision of Indian Electricity Act 1910. In 1947, the electricity industry in the UK was nationalized. India followed suit in 1948 and except for some pockets such as Mumbai, Kolkata, Ahmedabad and Surat. The entire industry was nationalized by virtue of the a foresaid Act of 1948, which laid down the structure of electricity industry in the independent India. This Act triggered the formation of State Electricity Boards (SEBs) to handle generation, transmission and distribution of electricity within the states. Subsequently central sector stepped in to support the

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development of the sector focusing on establishing of large power projects and to allocate the generation from these projects to various states.

Concerned by steady deterioration of financial health and operational inefficiency of SEBs and need for huge investment in the sector, the reform process took birth. One of the key objectives of reform was to attract private investment in the power generation. Central sector generation and transmission business separated during 1992-93. Distribution of electricity, however, remained a monopoly in the hands of SEBs that continued to function as vertically integrated utilities.

Till 2001, eight states unbundled their respective SEBs into separate corporate entities for generation, transmission and distribution. However, all the supply from within the state, external supply from central utility and the power purchased through trading are pooled either by a residual SEB or state-owned transmission company and distributed based on the requirements distribution companies in a pro rata manner. As a result, industry structure consisted of an inter-connected chain of monopolies referred to as a 'single buyer model' where the benefits of competition have been elusive. This model does not give autonomy to distribution companies to explore sellers or buyers at competitive rates and maximize their earnings.

The independent regulatory bodies have been formed at central level and also in most of the states. These regulatory bodies have been established primarily for rationalization of electricity tariff, formulation of transparent policies regarding subsidies and promotion of efficient and environmentally benign policies. Further, private sector is now permitted to invest in all three facets of electricity industry.

### *B. Recent Initiatives*

Reform of power sector during 1990s failed to make material improvement in its quality and viability. For a successful re-structuring an effective and credible regulatory reform at the national and state level is necessary [4]. The Government therefore decided to make a fresh look at the industry with a view to evolving a new law based on emerging best practices. The Government of India, enacted a comprehensive legislation (revamping the 1910 and 1948 laws), Electricity Act (EA) 2003 to put together in one place all the legislative measures required to push the sector on a trajectory of sound commercial growth. It took into account the movement towards a competitive scenario, where, the concept of consumer choice enabled by non-discriminatory open access to transmission network found place.

The Electricity Act 2003 makes thermal power generation a de-licensed activity, freely permits captive generation and makes the setting up of state regulatory commissions mandatory. It recognizes the trading as a distinct commercial activity and suggests measures like preparation of National Electricity Policy for planned development of the sector. In line with the policy objectives, the act provides a thrust to complete rural electrification and provide for management of rural distribution by cooperative societies, non-government organization, franchisees etc. The progressive policies would open new opportunities for setting up merchant generators, utilization of captive generation and electricity market development. A load dispatch center at the national level, i.e.

National Load Dispatch Center (NLDC) is also planned to facilitate inter-regional transfer of power and for optimum scheduling and dispatch of electricity among the Regional Load Dispatch Centers (RLDCs).

Given these various changes, the industry structure will be transformed from the current 'single-buyer model' to 'multi-buyer model'. In a multi-buyer model, the distribution entities are totally autonomous in procuring and dispatching their supply. This model would lead to better operation and lower cost to the end consumers [5]. On an overall basis, Electricity Act 2003 is comprehensive and provides for progressive development of a market-based regime in Indian power sector through competition. The benefits will, however, start reflecting after a period of 4-5 years.

### *C. Current Structure*

Currently, State Load Dispatch Centers (SLDCs) are carrying out the optimum scheduling of the state generating units and the RLDCs are responsible for scheduling of central sector generating units only. SLDCs send the requisition to the RLDCs against their entitlements out of available power from central sector generation (CGS) and the RLDCs allocate total available power to various states in the ratio of their entitlements. Day-to-day operation of the regional grid is carried out by RLDCs, which are under the operational control of Central Transmission Utility (CTU), i.e. Power Grid Corporation of India Ltd.

Apart from above, a small amount of power (about 2.5% of total generation) is being traded at wholesale level through either bilaterally or with the help of power traders. But presently, trading is mostly restricted to players such as SEBs and utilities. Power trading has generated considerable interest among power players, as it is evident from the brisk line-up for licenses at Central Electricity Regulatory Commission (CERC). Presently there are seventeen trading licensees to whom CERC has granted license for inter-state trading in electricity. These traders apply for open access on behalf of suppliers and buyers to the nodal RLDC depending upon transaction requirement. CERC has made the regulations for open access in inter-state transmission and inter-state trading. The market structure of current Indian electricity industry is shown in Fig.1, depicting energy flow and money flow separately.

### *D. Key Issues*

The wholesale electric power trading in India, though a nascent activity, is poised to develop a market and pave the way for creation of power exchange for economic pricing and optimal utilization of generation capacity. However, power trading has barely got off the ground in India, there are some major issues related to power trading, which need to be addressed for structural development of electricity market in India. These key issues include:

1) *Non-existence of Power Exchange:* Presently power traders are just matchmakers. They are lacking formal market and real-time information because at present, no power exchange for power trading in the pattern of stock exchange really exists in the country. Trading is mostly restricted to

layers such as SEBs and utilities. It is a predetermined contracted transaction and there is non-existent of spot market.

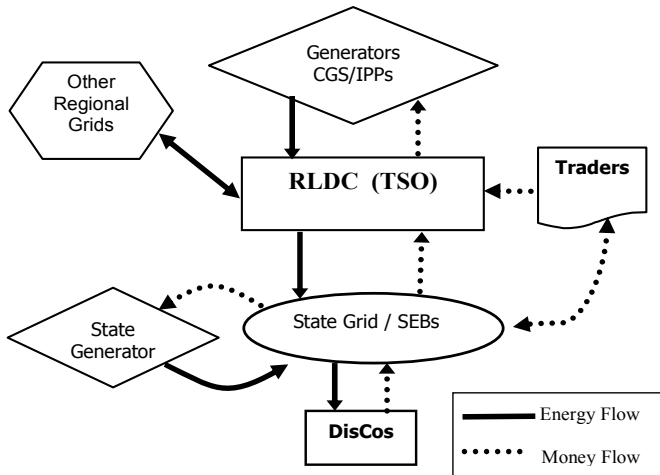


Fig.1 Current Indian Power Market Structure

2) *Lack of Pricing Mechanism:* CERC has fixed the trading profit margin as 0.02 Rs/kWh but there is no uniform method for price calculation of traded power. Traders simply negotiate the energy price between suppliers and purchasers and then add the trading margin. There is a need of market driven pricing mechanism.

3) *Reliability of Supply and Off-take:* Contractual obligations are not always honored. There is need of an institution/authority which can guarantee supply side delivery and buy side payment. A clearing system based on pledge accounts can minimize the risk for market participants.

4) *Lack of Information:* Traders are lacking equal and same-time information about the market. Participants need information to evaluate his options and pick the most competitive deal. Setting up an online bulletin board offering real-time information for market participants would help.

5) *Risk Management:* Electricity market is highly price volatile because of dependence on fuel prices and network constraints during peak hours. Spot price variation in electricity market can be hedged with the help of risk hedging derivative instruments, which can be traded in financial markets for electricity.

### III. PROPOSED POWER TRADING MODEL

Development of electricity markets around the world through reforms motivated with country's need has provided various market concepts applicable to unique social, political and economic conditions. All successfully developed electricity market models and ongoing electricity sector reforms in developing countries depict one most important and common feature; that is creating competition in industry. Competition is necessary for eradication of inefficiency but it should be introduced gradually in the phased manner. With the enactment of EA 2003, along with other recent initiatives, Government of India has outlined the counters of a suitable enabling framework for the overall development of wholesale electricity market by introducing competition. A restructured power market model for Indian scenario within the boundary of legal framework is presented in this section of paper.

#### A. Trading Arrangements

The proposed national power market model is based on the decentralized trading arrangement to obtain its objectives with the least impact on existing procedures and practices for the states and regional system operators. Such a market concept is compliant with the existing hierarchical industry structure of state versus regional/national levels in India and also reasonable and rational for Indian power market. In the decentralized trading arrangement, market operator will be a separate entity from the system operator but it will have strong co-ordination with Load dispatch centers for Available Transfer Capacity (ATC) information, dispatch of Day-Ahead (DA) schedules for transactions cleared through Power Exchange (PX) and imbalance settlement under Unscheduled Interchange (UI) mechanism.

UI is a commercial pricing mechanism for unscheduled energy inter-change. UI rate is related to grid frequency in a manner to encourage grid discipline. The UI mechanism facilitates the spot sale or purchase of electricity into or out of the electricity grid as it provides a sort of benchmark real-time spot price for the trading of electricity. This unique feature of UI mechanism fulfills the need of real-time spot market as all the imbalance settlements can be done through UI rate. In Indian context, real-time balancing market is inherently provided by this UI mechanism.

The most suitable market model for Indian power market will be long term Bilateral market plus Spot market model. So that all unregulated generating companies can trade their power in DA spot market through National PX and also can have long-term bilateral contracts with SEBs/ Distribution Companies (Discos) or bulk consumers. Transactions through PX will develop the market and provide confidence among the participants. Higher number of participants will further provide the strength to the market. On the other hand, bilateral transactions are necessary to avoid the risk associated with generating companies due to market exposure. Also the National Electricity Policy (Feb.2005), which aims at laying guidelines for accelerated development of the Indian power sector have addressed this issue in Sec.5.7.1 by mentioning that, "To promote market development, a part of new generating capacities, say 15% may be sold outside long term Power Purchase Agreements (PPAs). This will increase the depth of power markets and provide alternatives for both generators and licensees/consumers and in long run would lead to reduction in tariff".

#### B. Power Exchange

A national power exchange as a supplementary market for DA balancing is proposed for promotion inter-regional trading and maximum utilization of available resources. The proposed Power Exchange (PX) concept is *national wholesale electricity market* where all eligible participants will submit *portfolio based bids* for each hour on *Day-Ahead (DA)* basis. The PX characterize by *hourly cleared physical delivery* market should have *uniform price double auction* system with option of *block bidding*. The existing PPAs should be honored, means PX should be only a supplementary market to match unallocated surplus with likely requirements through DA auction based market.

Fig.2 illustrates a simplified, theoretical model of the proposed national power market having different interactions between the relevant actors that participate in electricity market. The financial flows that result from electricity trade referred as ‘commercial transactions’ and the physical electricity flows referred as ‘physical transactions’ are depicted in upper and lower part of Fig. 2 respectively. All the market participants will electronically submit their bids and offers to the PX and PX will clear the market by determining Market Clearing Price (MCP) from intersection of aggregated supply and demand curves. If this market settlement causes congestion in transmission networks then PX splits the market and determines area wise MCP with transmission constraints settlement. The PX will get the ATC information from NLDC on DA basis for congestion management and prepares the final DA schedule for the transactions to be cleared. Then PX submits this schedule to NLDC for real-time implementation. Next day 00h00 to 24h00 power will be delivered and financial clearing can be done once a week.

1) *Role and Responsibilities:* In decentralized trading arrangement, PX has to be a separate entity from system operator, as an independent market operator. But PX should have strong co-ordination with system operators (NLDC/RLDCs) for ATC information, dispatch of DA schedules and imbalance settlement through UI mechanism.

To communicate with electronic trading system of PX, participants have to get passwords and then only authorized participants can communicate with PX through Internet based trading platform. The participants will submit their bids/offers through this and PX will publish daily market results called price index on this On-line bulletin board. In the proposed DA auction based market, PX should have time specific step-by-step activities, which are listed below;

- Step I:** Participants submit sale/purchase bids by means of an electronic trading system for each hour or block to PX
- Step II:** PX check for bid validation/elimination
- Step III:** Participants do bid revision/withdrawal
- Step IV:** PX gets day-ahead ATC information from NLDC
- Step V:** PX determines MCP with unconstrained market settlement
- Step VI:** PX performs congestion management by market splitting and determines area wise MCP with constrained settlement
- Step VII:** PX prepares and sends DA generation and drawl schedules to respective participants and publish price index on website
- Step VIII:** PX submits DA schedule to NLDC for implementation
- Step IX:** Next day 00h00 to 24h00 power is delivered and financial clearing is done once a week

*C. System Operator Model*

Independent system operator (ISO) model is better option for restructured electricity market in India. The unbundling of transmission and system operation is essentially required to address the possibility of the transmission utility exerting market power through the system operator. Common management of two functions could potentially result in conflict of interest. Sometimes there is conflict of interest between RLDC and STU on the issue of maintenance scheduling of transmission lines.

While option exists under EA 2003, to organizationally separate the transmission and system operation function, this can be deferred for the short term. In effect the system operation function should operate as a separate division within

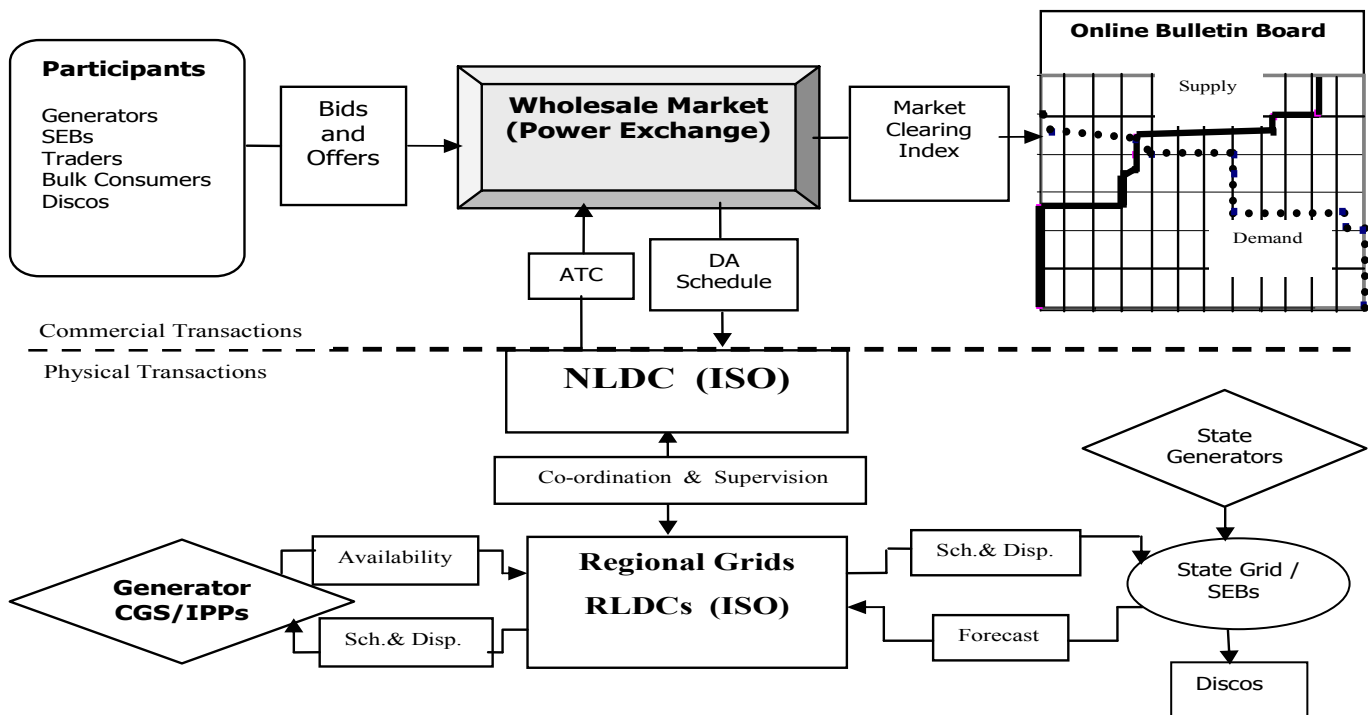


Fig.2, Proposed National Power Market Structure

transmission utility till these are organizationally separated. It is preferable that power market model should be established first before separation of transmission and system operation is undertaken.

#### D. Discussions

The present market structure of power trading is essentially rudimentary. It does not have instruments with settlement mechanisms, nor do we have clear information regarding prices, sales and trading volume. This can only be possible by creating a power exchange in a wholesale electricity market.

There is every indication that the power market in India will develop into a vibrant and efficient mechanism for optimization of power costs and increase in competition, efficiency and choice. This is also evident from large number of trading licensees participating in inter-state trading in a very short time span of 3- 4 years.

Power sector reform has a relatively short history of success as well as failure anywhere in the world, however, over the years, with increasing competition, the prices in deregulated electricity market have gradually reduced and have more or less stabilized [6], [7].

#### IV. CONCLUSION

The proposed power market model overcomes most of the major issues currently faced by the traders in Indian electricity market. PX as a market operator will operate the proposed DA auction market with uniform price clearing in a price area. PX will provide equal and same-time information to all the market participants through on-line bulletin board. Power exchange, as an institution, is able to pool risks and can create liquidity (through physical and financial products), thereby limiting the adverse exposure to traders within reasonable limits. In addition, such institution facilitates efficient clearing and settlement in cooperation with the system operator.

There are some components of reforms, other than unbundling and corporatization, which require active research for complete and successful reform in Indian electricity industry. Some current and impending issues generate the scope for future research work which include issues regarding, shortcomings in current Availability Based Tariff (ABT) mechanism and its future (modified) version, opportunities and threats for forthcoming Merchant Power Plants (MPPs), frequency stabilization through time-differential tariff, strategic bidding for generators under competitive market environment, separate market for ancillary services and finally development of retail electricity market model.

The restructuring process as a whole is a very complex process and India is not ready for all around complete restructuring of electricity sector. In the immediate future after enactment of EA 2003, it is envisaged that prevailing conditions in the country is ripe only for wholesale competition and not for retail competition. The retail market will require strong electric distribution system and Indian electric distribution system is very weak due to heavy

technical and commercial losses (present estimation 20-25%). Distribution Automation (DA) system and Energy Management System (EMS) are necessary prerequisites for retail competition in electricity market. Information flow is also one of the main concerns along with the Distribution Management System (DMS), which is presently at a very nascent stage. These must be properly addressed before adopting competition at retail level.

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#### VII. BIOGRAPHIES

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