Electricity Trading In Competitive Power Market: An Overview And Key Issues

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Abstract- **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. Trading arrangement is properly designed in every country to take care of other abuse of market. These arrangements are kept on changing from time to time depending on the requirement for transparent and non-discriminatory electricity market. In this paper, various financial risk hedging instruments and trading arrangements of Indian and some developed markets are discussed. The important key issues and challenges in this field are also critically analyzed.**

***Index Terms*- Bidding strategy, Electricity trading, Financial instruments, Market power, Transmission rights.**

I. Introduction

RESTRUCTURING of the power industry aims at abolishing the monopoly in the generation and trading sectors, thereby, introducing competition at various levels wherever it is possible. Generating companies may enter into contracts to supply the generated power to the power dealers/distributors or bulk consumers or sell the power in a pool in which the power brokers and customers also participate. In a power-exchange, the buyers can bid for their demands along with their willingness to pay. Power generation and trading will, thus, become free from the conventional regulations and become competitive. Electricity sector restructuring, also popularly known as deregulation is expected to draw private investment, increase efficiency, promote technical growth and improve customer satisfaction as different parties compete with each other to win their market share and remain in business.

Open access is the key to a free and fair electricity market. Power producers (sellers) and dealers/customers (buyers) have to share a common transmission network for wheeling the power from the point of generation to the point of consumption. Thus, interconnected transmission system is considered to be a natural monopoly so as to avoid the duplicity, the problem of right-of-the-way, huge investment for new infrastructure and to take the advantage of the interconnected network viz. reduced installed capacity, increased system reliability and improved system performance.

Managing risk is primary tasks of any trading system [1]. This task is perceived harder for electricity being a non-storable commodity. In competitive environment, the price is determined by stochastic supply and demand functions. The price can change at any time. As a consequence of increased volatility, a market participant could make trading contracts with other parties to hedge possible risks and get better returns. Congestion occurs when transmission lines or transformers are overloaded and this prevents the system operators from dispatching additional power from a specific generator. This may be prevented to some extent by means of reservations or rights. These rights are used to guarantee an efficient use of transmission system capacity and to allocate transmission capacity to users who value it most.

In this paper, financial contracts used in risk hedging instruments, the transmission rights used for congestion price management and trading arrangements of some developed electricity markets are discussed with special emphasis on impact of these arrangements on strategic bidding and associated market power abuse. The major key issues and challenges in electricity trading have been critically examined.

II. Derivative Instruments

A derivative is a financial instrument (contract) between two parties with opposite views on the market, who are willing to exchange certain risks [1]. Many derivative instruments are used in electricity trading, but the most common ones applied to energy risk management strategies are future, forward and option contracts. In some instances, these financial contracts can be used to accomplish what might be termed as virtual divesture.

A. Future Contracts

Future contracts include an obligation to buy or sell a specified quantity of an asset at a certain future time for a certain price. The futures are standardized contracts which are traded on and cleared by an exchange and the exchange could guarantee that the contract would be honored [2]. Note, however, that the only point of negotiation is the price. All other terms and conditions are pre-specified, thereby making it a standardized contract.

The main justification of futures contract is that it permits specialization between two elements of the economic process: the function of holding commodities and the function of bearing the risk of price changes [3]. The seller of a futures contract on a commodity does not normally intend to deliver the actual commodity nor does the buyer intend to accept delivery; each will, at some time prior to delivery specified in the contract, cancel out obligation by an offsetting purchase or

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sell. In fact, historically, less than one or two percent of futures contract have been fulfilled by actual delivery.

Robert [4] modified the future contract to create a unique resettlement mechanism which makes future contracts more useful for hedgers on both sides of market.

B. Forward Contracts

Forward contract are in some aspects similar to future contracts. They include an obligation to buy or sell a specified quantity of an asset at a certain future time for a certain price. Forward contracts are traded bilaterally or over the counter between two financial institutions or between a financial institution and one of its corporate clients and the contracted parties usually customize the contract in order to make it fit their needs [3].

Usually, in future contracts, there is a range of possible delivery date. Whereas forward contracts have a specific expiration at which the asset is delivered and payment is made [5]. The buyer of contract is called *long* whose purchase obligates him to accept delivery unless he liquidates his contract with an offsetting sale. The seller of the contract is called *short*.

C. Contract for Differences (CfDs)

CfDs, which are mechanisms to stabilize the power costs to consumers and revenues to generators, is one form of forward contract. These contracts are suggested due to the fact that the spot price set by PoolCo fluctuates over a wide range and difficult to forecast over a long periods.

A CfD can be either one way or two-way [6]. A two-way CfD is similar to financial future contract and is defined in terms of a strike price ($/MWh), and a quantity (MWh). As shown in Fig. 1, when spot price is above the strike price, the seller pays buyer an amount equal to difference between the spot price and strike price and when the spot price is below the strike price, buyer pays the seller an amount equal to the difference between strike price and spot price. Thus both parties have hedged their exposure to spot price.

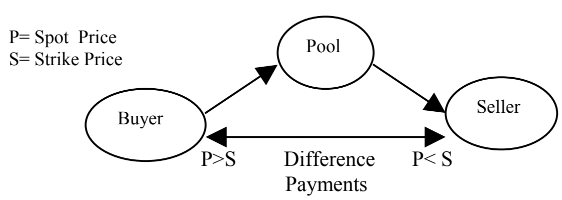

Fig. 1: Payment streams in a CfD

A one way CfD is similar to financial option contract and also include an option fee in addition to strike price and contract quantity. Under one way contract, difference payments are made only if spot price rise above the strike price.

D. Option Contracts

An option contract includes a right (not obligation) to buy or sell a specified quantity of an asset at a certain future time for a certain price. In case of futures/forwards, contract is either held for delivery or liquidity, but option contracts may be held for liquidity, delivery or expire worthlessly [1]. To enter an option contract, the buyer pays a premium to the seller of options, while in futures and forwards, the buyer does not have to pay any charges. A call option gives the holder the right to purchase the underlying asset at some future date, and a put option gives the holder the right to sell the underlying asset at some future date.

Let utility-A purchase call options from utility-B with a strike price of $8/MWh at a premium of $2/MWh. For utility-A, any future price of $8/MWh or less would result in loss equal to premium, which is $2/MWh. At a future price of $10/MWh, utility-A's profit (loss) is zero (it is called break even transaction) and at any price greater than $10/MWh, utility-A would gain up to an unlimited value. In another case let utility-A purchase put options from utility-B with a strike price of $20/MWh at a premium of $2/MWh. For utility-A, any future price at $20/MWh or more would result in a loss equal to the premium, which is $2/MWh. At a futures price of $18/MWh, utility-A's profit (loss) is zero (it is called break even transaction) and at any price less than $18/MWh, utility-A would obtain a gain.

Since option contracts are tradable, the holders have the flexibility to sell the contract in secondary market [3]. However, option contracts are financial instruments and are not directly related to physical delivery of electricity. The holder does not have to exercise this right. This fact distinguishes options from future contracts.

A new electricity forward contract bundled with bilateral financial options or optional forward contract is introduced in [7], which gives option holder a right but not an obligation to purchase or sell the contract energy at a delivery time for a given price. This allows both seller and buyer to take advantage of flexibility in generation and consumption to obtain monetary benefits while simultaneously removing the risk of market price fluctuations.

E. Vesting Contract Examples

Valuable lessons can be learned from California, where there were no vesting contracts, and from other countries like Australia, where vesting contracts were used extensively [8]. Vesting contracts are a powerful tool to allow the existing electricity industry transition to open and functional markets. The electricity market in Australian State of Victoria was deregulated in the mid-1990s. When market opened, there was a potential for exacerbated oversupply, when new owners of the privatized power plants improved capacity factor and availability. The resulting spot market prices hovered at or just above the marginal fuel cost for much of 1996 and 1997. Hedging contracts acted to shield the newly privatized generators from several financial losses.

In contrast to Victoria, the Australian State of South Australia entered the Australian National Electricity Market in late 1998 with a potential shortage of generating capacity and a high reliance on imported power from other states similar to the case of California. Spot prices were very high. Vesting contracts in South Australia insulated end-use customers from price shock as well as controlled the potential market power held by newly privatized generating stations.

One of the major causes behind crisis in California electricity market during summer 2000 was weakness and flaws in the design of electricity market including limitations on forward contracting. Taking a lesson from this, New Electricity Trading Arrangements (NETA) for England and Wales has encouraged forward and future contracts [9].

III Transmission Rights

In order to hedge the congestion prices and facilitate trading in power market few transmission rights are introduced. These include financial transmission right and physical transmission right.

A. Financial Transmission Right (FTR)

The classic financial transmission rights are called transmission congestion contract (TCC). FTR is a purchased right and can hedge congestion charges on constrained transmission paths [10]. It provides FTR owners with the right to transfer an amount of power over a constrained transmission path for a fixed price. FTRs are advantageous when designated paths are in same direction as congested flow, which also indicates that point of extraction locational marginal price (LMP) is greater than point of injection LMP. It may happen that FTR holder pays for having the FTR when the point of extraction LMP is less than point of injection LMP. In this case the monetary share is equal to MWh value of the FTR multiplied by difference in LMPs from the point of receipt to point of delivery.

The disadvantage of not holding FTR is that participants do not have a mechanism to offset the extra cost due to congestion charges. On the other hand, the holders of FTR will receive a credit that counteracts the congestion charge for specified path [11]. Each FTR holder receives a congestion credit in each congestion hour proportional to the value of FTR. This credit allocation is calculated based on preferred schedule while congestion charges are based on actual deliveries. Alomoush et al [11] suggested a combined zonal and FTR schemes to manage congestion problem. The problem of FTRs that it is requested for any two points in the system is solved using zonal scheme.

A static simulation model is proposed by R. Mendez et al [12] for congestion management. This incorporates FTR for nodal pricing under a centralized electricity market and flowgate rights (FGR) for zonal pricing under decentralized market.

B. Physical Transmission Right (PTR)

PTRs are tradable rights referred to as the right to use transmission capacity and represent a claim on physical usage of the transmission system. Unlike financial rights, they do not provide payment, and they are only useful to those actually trading power [10]. These rights are used to guarantee an efficient use of transmission system capacity and to allocate transmission capacity to users who value it the most. Usually a trade will require several rights on a number of lines. On a power line, with a capacity limit of *P* MW, at most *P* MW of physical rights can be issued in each direction. The feasible set of physical rights cannot account for counter flows.

IV. Power Trading in Different Electricity markets

A competitive electricity market should be supported by proper trading tools that take into account of special nature of electricity which is different from other commodities. A successful implementation of trading system in electric energy and its derivative markets could fulfill restructuring objectives, which include competition and customer choice and serve vital needs of electricity market participants [13].

Trading is an activity in which transactions take place directly between two participants or indirectly through an exchange. Electricity trading through an exchange started for the first time in 1996 in New York Mercantile Exchange (NYMEX). Electricity trading has two main components, i.e. physical trading and financial trading [1]. In physical trading, supply is balanced against demand and price is either determined in advance of trading or after trading. In financial trading, financial contracts take place between traders as agreements that give certainty to traders. Physical trading is generally done through an energy spot market or power pool while financial trading is through a financial market or exchange such as NYMEX or Chicago Board of Trade (CBOT).

Trading in an electricity market is a risky task because the electricity is much different from other commodities due to its special nature [1] such as non-storable, generation-demand balance, limited demand elasticity, transmission constraints and electric price related with other volatile commodities. Electricity trading arrangements in USA, UK, Australia and some Latin American countries has undergone a profound transformation in last two decades. India has also started power trading from last four years.

A. U.K. *Electricity* Market

UK has been one of the leaders in developing spot electricity market trading system, which links the physical and financial domains. The initial competitive electricity market structure involved an electricity Pool for England and Wales. After a review, a new electricity trading arrangements (NETA) evolved slowly which provides the new structure and rules for the E&W electricity market.

The transactions taking place within the NETA market are electricity price-quantity transactions on a half-hourly basis [14]. The system operator (SO) and power exchanges (PX) are central to the functioning of the E&W electricity market under NETA. Major contractual relationship NETA electricity market is shown in Fig. 2.

PXs provide contracts that are ‘cleared’ giving a guarantee against default on a contract. Trading through brokers, over the counter (OTC) trading and other financial instruments (options and futures), also form the part of market trading. The SO for E&W, National Grid (NGC), currently has two functions: firstly the management of high voltage transmission system as transmission system operator (TSO) and secondly the supply of operational services. Generation forecasting, congestion management and provision of ancillary services are managed by NGC as SO. In addition the *balancing mechanism* allows the SO to maintain local and national balances of generation and consumption in real time, thus price and volume agreements within the balancing mechanism are made directly with the SO.

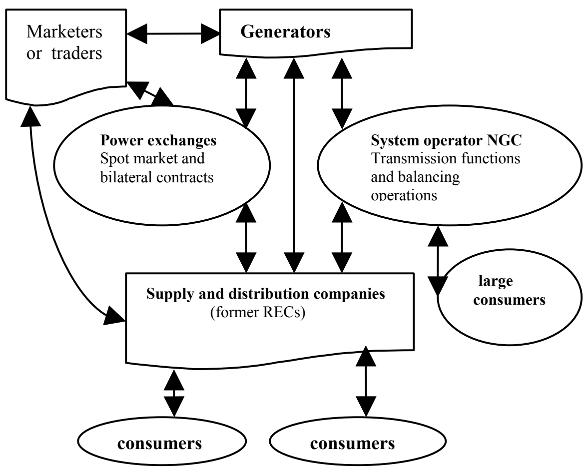

Fig. 2: NETA electricity market- major contractual relationships

B. *Nordic Electricity Market*

Nord Pool, the Nordic Power Exchange, is the world's first international commodity exchange for electrical power. The Nordic power market which trades with neighboring countries and is dominated by hydropower, can be seen to be very different from that in E&W. Fig. 3 shows the Nordic electricity market's major contractual relationships.

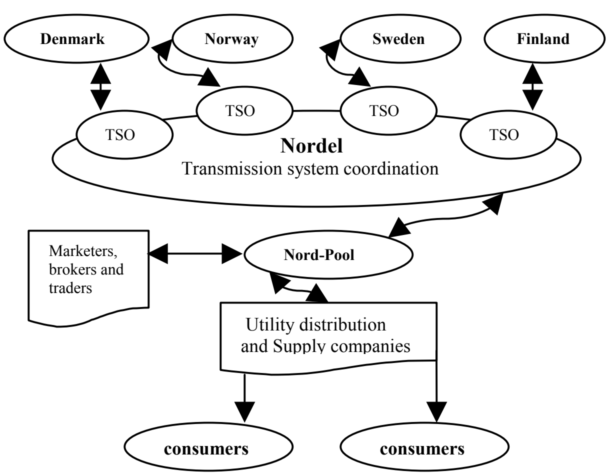

Fig. 3: Nordic electricity market- major contractual relationships

The existence of a transmission system linking Denmark, Norway, Sweden and Finland provides the basis for physical electricity exchanges organized on a national basis for these countries. The national transmission system operators (TSOs) are responsible for reliability and balance settlements. Nordel facilitates co-operation between these TSOs and deals with planning, operation and transmission pricing [14].

Nord Pool organizes trade in standardized physical and financial power contracts including clearing services to Nordic participants. The spot price for the Nordic electricity market is set by Nord Pool every hour. Elspot and Elbas are Nord Pool auction based spot market for trade in power contracts for physical delivery [15]. On Elspot, hourly power contracts are traded daily for physical delivery in the next day's 24-hour period. On Elbas, continuous adjustment trading in hourly contracts can be performed until one hour before the delivery hour. New contracts are opened after the day-ahead Elspot prices have been set. Before 2 p.m. the remaining hours of the current day are tradable and then day-ahead contracts are open for trading.

The objective of Nord Pool financial market is to provide an efficient market, with excellent liquidity and a high level of security to offer a number of financial power contracts that can be used profitably by a variety of customer groups.

C. *California* Electricity Market

The competitive electric power market of California state began operation in 1998 with the California Independent System Operator (CAISO) and now bankrupt Power Exchange (PX) as the main operationally market facilitators. The market took off smoothly, and the prices were seemingly just and reasonable until May 2000, when the first signs of market crisis emerged. California's electricity crisis was the result of the collusion of a shortage of resources, poorly designed market and inaction by regulators or "regulatory failure" [16]. The CAISO was originally designed to operate in conjunction with the PX, a day-ahead energy market that ceased to operate in January 2001. Without PX day-ahead market, all short-term balancing of supply and demand has been pushed into the more volatile real-time market. This is the result of flaws in original design and inconsistencies between the ISO's forward and real-time markets.

Now the CAISO is addressing these flaws through a comprehensive redesign effort known as Market Design 2002 (MD02). It allows the ISO to match buyers and sellers through a transparent day-ahead market that reduce reliance on the more volatile hour-ahead and real-time markets. Since the PX ceased operating there has been no transparent market for spot energy transactions to balance supply and demand ahead of real time [17]. It also allows the ISO to manage congestion on the grid the day before, rather than in real time, thus enhancing real time reliability.

D. *Indian Electricity Market [18]*

Power Trading Corporation of India Ltd. (PTC), the leading provider of power trading services, in India is trading power on a sustained basis since June 2002 through purchase from surplus utilities and sales to deficit State Electricity Boards (SEBs) at an economical price, providing best value to both the buyers and sellers and ensuring that the resources are utilized optimally.

PTC is a 'pure-play' trading entity, and does not own any generating units or transmission facilities. PTC acts as a single-window service provider that manages both financial as well as operational risks for the buyer and seller entities in its trading transactions. On the one hand timely payments are ensured to the sellers of power and on the other hand a definite quantum of power is delivered to the buyers of power in a reliable manner. For its services, PTC charges a pre-determined amount of transaction charges, worked on a per unit (KWh) basis or as a percentage of the cost of power. The pricing and margin information is known to both the counterparties in a transparent manner. In some instances PTC has both bought and sold power from the same entity at different times of the day depending upon the load profile of the entity.

PTC catalyses the development of power projects by entering into multi-year contracts for future trading of power. These Power Purchase Agreements with PTC are being recognized by lenders as security for financial closure of power projects. Typically, the counterparty contracts for these projects or Power Sale Agreements are structured with multiple buyers, through which about 80% of the power generation from the project is tied up for long term sale, and 20% is kept as reserve for the short-term market.

PTC has been identified as the nodal agency for cross border trading with neighboring countries: Bhutan, Nepal and Bangladesh, which are rich in hydro power resources. Utilities in Bhutan account for the nearly 24% trading volumes from cross-border sources. Being the pioneer in trading in India, PTC sees a developmental role for itself to increase the depth and breadth of the market under new Electricity Act 2003. PTC also views an opportunity in alliances with emerging entities for setting up their operations in the manner that the business is recognized globally. In future, it intends to set up an online trading platform similar to a power exchange.

Though the power-trading scenario in India is at a nascent stage, it is growing at a rapid pace. The power market in India has evolved over the last four years and it is expected that it is likely to grow at a faster pace – with the reforms of SEBs and building up of transmission highways across the regions to increase Inter-regional power transfer capacity from currently available 8000 MW to 30,000 MW.

V. Bidding Strategies

In a perfectly competitive electricity market, any power supplier is not a price maker. Microeconomic theory holds that the optimal bidding strategy for a supplier is to simply bid marginal cost. When a generator bids other than marginal cost, in an effort to exploit imperfections in the market to increase profits, this behavior is called strategic bidding [19].

In pool market model, there are two main sides of entities participating in the market, i.e. customer and supplier. The pool operator takes electricity transaction bids and offers from these two entities and determines the winning bid and market clearing price using predefined procedure [1]. The strategic bidding problem in electricity markets is related to pool trading in which the sealed auction is widely employed and power suppliers, and some times large consumers also, are required to offer price and quantity bid to a market operator. Power pool would implement the economic dispatch and sets a price for electricity.

In the E&W pool, generators are bidding both prices and quantities. Effectively, they are offering supply functions each day. The intersection of cumulative supply curve for the whole market and the total system demand curve gives the market price. The existence of CfD covering a very high percentage of GenCos capacities changed significantly the incentives for the GenCos in terms of how they should bid into the pool [20]. The pool price in 1991 was 25% below government's expectation at the time of privatization. The first trench of CfD expired in March 1992. Pool price in August 1992 was some 17% above those in August 1991.

In order to give a wide range of retail choices for final customers, bilateral trading is recognized as a suitable model from the point of view of short-term and long-term stability in the supply [21]. Participants are allowed to enter into bilateral contracts in most of the markets, e.g. California, Pennsylvania New Jersey Maryland (PJM), Australia and E&W. Bilateral contracts can also be used to manage risk in the market.

An active participation from demand side would make electricity markets more efficient and more competitive. It would also promote a more optimal allocation of economic resources [22]. Very low price elasticity of demand for electricity causes large price spikes and exercise of market power by generating companies. In some electricity markets such as California, New Zealand and Spain, demand side bidding is permitted for large consumers to react to electricity pricing.

VI. Market Power

There are various definitions of market power, in general market power is referred to as owning the ability of a market participant to drive price over a competitive level, control the total output or exclude competitors from a relevant market. Market power can be exercised primarily either by economic withholding or physical withholdings [23].

California was confronted with an unprecedented electricity crisis due to lack of forward contracting, inadequate demand responsiveness or lack of demand elasticity and forward scheduling that resulted in the huge reliance on the spot market. These anomalies, among others, culminated into an economy threat and consequently lead to the significant market power abuse in California.

In October 2002, the CAISO implemented a comprehensive market power mitigation plan, replacing FERC's temporary system to mitigate market power. This plan contains several elements to address physical and economic withholding at both systems wide and local levels [17]. It addressed economic withholding through damage control bid cap (DCBC) and automatic mitigation procedures (AMP). AMP automatically reduces bids that are too high when compared to historic bidding behavior and current market conditions. Since AMP has gone into effect, the market has remained stable. It addressed physical withholding through contribution of the must-run requirement.

NETA is targeted to achieve majority of electricity trading through bilateral contracts, forwards and futures with spot market trading used to adjust the contractual positions of the market players near to real time. This significantly reduces market power abuse.

VII. Key Issues and Challenges

The key issues and concerns in electricity market are much more compared to other markets due special nature of electricity and market participants. Some of the key issues and challenges are listed below:

- Emergent EM is more akin to oligopoly than perfectly competitive due to its special features such as, a limited number of producers, large investment size (barrier to entry), transmission constraints and congestion which could isolate consumers from effective reach of some generators and transmission losses which discourage consumers from purchasing from distant suppliers.
- The substantial changes in regulatory environment have created a need for several new market institutions for the power industry to manage the risks associated with the operation of extremely price volatile market of electricity.
- An opportunity to trade in power arises whenever complementary deficit-surplus situation occur in different seasons of the year, different months, or even different hours of a 24-hour period. By identifying such situations, trading of power can help in reducing the demand-supply gaps.
- Demand side bidding enhance the ability of consumers of electricity to respond to price signals and make the market to operate more efficiently and satisfactorily. Trading system should encourage this type of biding.
- In competitive power market, power quality and demand side management are still challenging issues. Trading arrangements should tackle these concerns.
- There are several contracts running behind the market which sometime leads to the economic and arbitration problems.

Since competitive electricity markets are established in several countries, a key concern has been the study of market outcomes or solutions. This study is justified from the standpoint of both the regulatory entities (to ensure true competition) and the market participants (to get maximum return on their investments).

VIII. Conclusion

This paper addresses electricity trading in competitive power market. The derivatives used in electricity market are presented with several examples. The key issues and challenges related to trading business models for electricity are critically examined. The risk management objective in the power business is much more demanding. In vertically integrated structure, risk management is primarily accomplished through ownership of generating and perhaps transmission assets and through long term power purchase agreements. Deregulation plans that recognize the potential for high spot market prices and incorporate appropriate hedging strategies that will be viable regardless of spot price and without the need of price caps. Derivatives in market play an important role in providing the price certainty for buying and selling electricity.

Power quality and demand side management issues under electricity trading are also a real challenge in electric market.

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