Dynamics of Day-Ahead Trading of Electricity in India

Mathur, Kritika and Sinha, Pankaj

Faculty of Management Studies, University of Delhi

15 November 2014

Dynamics of Day-Ahead Trading of Electricity in India

Kritika Mathur and Pankaj Sinha

Faculty of Management Studies

University of Delhi

Abstract

Electricity is a commodity and has a characteristic of being non-storable; it must be consumed once it is produced. In India, the Electricity Act (2003) tries to promote competition by unbundling and treating generation, transmission and distribution as separate entities. In order to address the needs of the power sector, the last decade has seen the setting up of markets for bilateral trading of electricity followed by trading of power on power exchanges in 2008. Power exchanges are able to mitigate risks arising from price volatility for the participants to a large extent. Power exchanges offer short term trading of electricity, of which day-ahead electricity trading on power exchanges forms a significant component. Day-ahead electricity markets allow exchange of contracts with delivery of electricity for the twenty four hours of the next day. The study examines the trading of day-ahead electricity contracts in India.

Keywords: power exchanges, day- ahead electricity trading, trading mechanism

JEL Codes: Q41, Q48, D44

1. Introduction

Electricity is a commodity and has a characteristic of being non-storable, it must be consumed once it is produced. The total electricity generated in India was 639.2 Billion Units from April-November 2013. Out of the total electricity generated, two thirds of the electricity generated in the country was from thermal power plants. The installed power generation capacity for India was 2,33,929.94 MW as on December 31, 2013. Table 1 illustrates the all India installed power generation capacity as of December 31, 2013. Of the thermal installed power generation capacity of 1,59,793.99 MW, 86.4% is from coal based power plants while the remaining capacity is from gas (12.7%) and diesel (0.07%) based plants.

Table 1: Installed power generation capacity as of December 31, 2013

Source	Capacity (MW)	As percentage of Total Capacity (%)
Thermal	1,59,793.99	68.31
Hydropower	39,893.40	17.05
Nuclear	4,780.00	2.04
Renewable Energy Sources	29,462.55	12.59

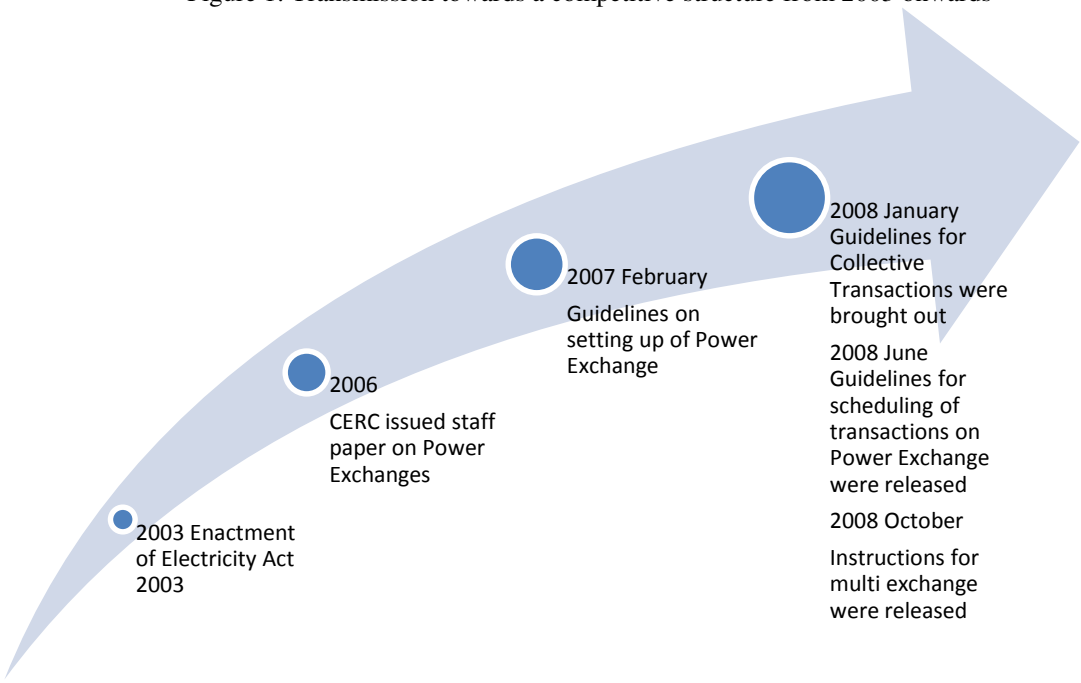
Source: Authors calculation based on Annual Report of Ministry of Power

Since, coal continues to be the main stay of electricity generated in the country and thus to meet the demand coal had to be imported, 82 Million Tonne was imported for the year 2013-14. In a Supreme Court Verdict, which came out on August 25, 2014, of the 218 coal blocks allocated between 1993-2011, 214 had been deallocated. The four functional coal blocks which had been exempted from deallocation include two ultra mega power projects, one power project operated by NTPL (NLC Tamil Nadu Power Limited) and another by SAIL (Steel Authority of India Limited). Coal allocations will be made only through auctions by competitive bidding. The deallocation of coal blocks is likely to lead to an acute shortage of coal and may adversely affect the economy. Currently, imported thermal coal futures are available on MCX and NCDEX.

The power supply situation in the country is still not satisfactory. The energy requirement in 2013-14 (Upto November 2014) was 671229 MU, but the energy available during the period was 640834 MU, leading to a shortage of energy of 30395 MU amounting to 4.5% of energy shortage as percentage of total energy required in the country.

In order to address the needs of the power sector, last decade has seen the setting up of markets for bilateral trading of electricity followed by trading of power on power exchanges in 2008. One of the major initiatives is the Electricity Act, 2003 which tries to promote competition by unbundling and treating generation, transmission and distribution as separate entities. A tariff policy has been set up for determination of tariff through competitive bidding. Suitable amendments have been made to the Electricity Act in order to improve grid security, improvement in distribution of electricity, dynamic regulatory framework. Under the Act, regulations for open access at inter-state as well as intra-state level lead to opening up of avenues for active participation from private owners, state owned generators and industrial consumers. Section 66 of the act relates to the development of power markets including trading of electricity. The limit of Foreign Direct Investment in the power sector is upto a maximum of 26% and Foreign Investment upto a limit of 23% of the paid up capital though power exchanges. Power exchanges are involved in short term trading of electricity. Figure 1 discusses the transition of Indian Power Sector towards a more competitive market structure.

Figure 1: Transmission towards a competitive structure from 2003 onwards



Source: Indian Energy Exchange (IEX) Report (2014)

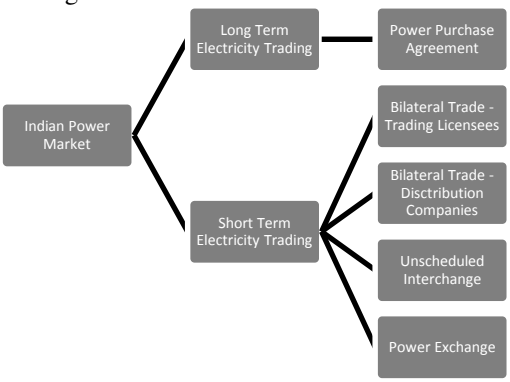
The size of the power exchange based markets has grown to 3% of the total electricity generated in the country since 2008. Day-ahead electricity markets allow exchange of contracts with

deliveries beyond one day on power exchanges. In the current study, the day-ahead electricity markets are studied within the broader framework of short term electricity markets.

2. Short Term Trading of Electricity in India

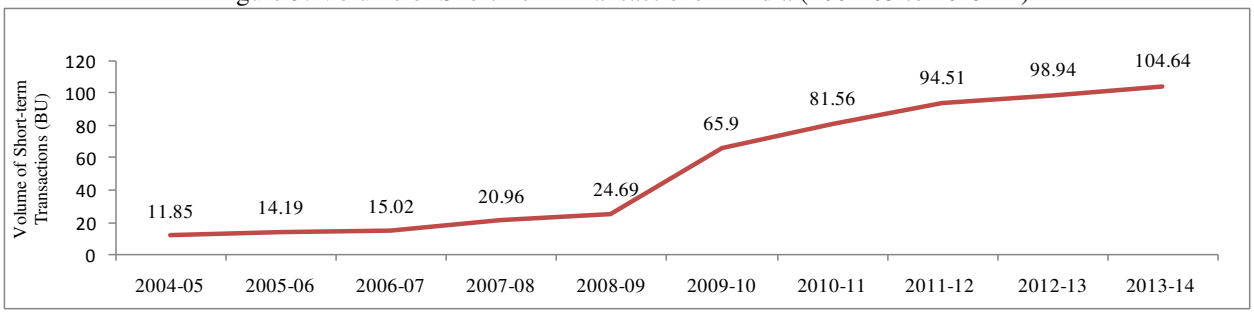
The short term trading of electricity is expected to meet the unplanned requirements of buyers and enable producers of electricity to sell surplus power as electricity is a non-storable commodity. Short term electricity markets help in improving the reliability of the systems by taking care of intermediate load requirements. This section discusses the short term trading of electricity in the Indian power market. Figure 2 throws light on the structure of Indian Power Market.

Figure 2 Structure of Indian Power Market



Short Term Trading of Electricity Market refers to the electricity contracts with a maturity of less than one year. Of the total electricity generated in India in 2013-14, 11% was traded via short term power market. The total volume of short term transactions was 104.64 Billion Units, which in monetary terms is equivalent to a value of INR 23,952 crore. The total volume of electricity traded through short term transactions has been on the rise since 2004-05, Figure 3 indicates the increase in volume of transactions from 11.85 BU in 2004-05 to 104.64 BU in the year 2013-14.

Figure 3: Volume of Short Term Transactions in India (2004-05 to 2013-14)



Source: Authors calculation based on Central Electricity Regulatory Commission (CERC) Report, various issues

Short term electricity trading in India is through:

a. Bilateral transactions through Inter-State Trading Licensees

b. Electricity traded directly by Distribution Companies

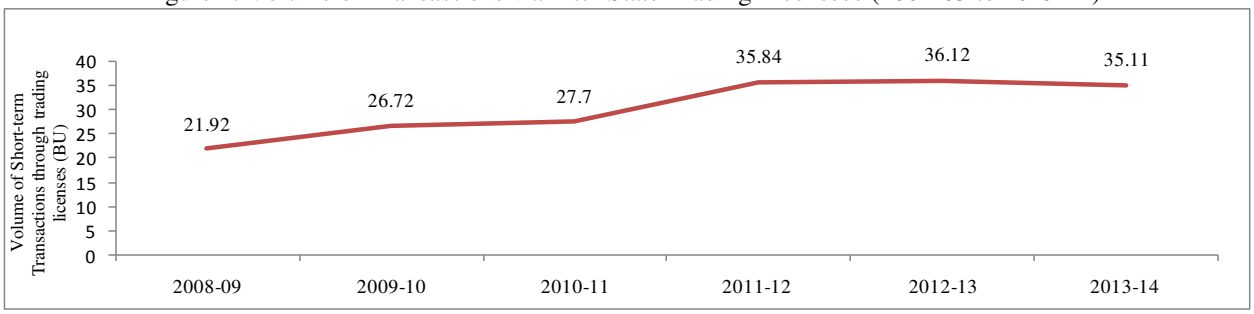
c. Unscheduled Interchange, and

d. Electricity traded through Power Exchanges

In the year 2013-14, 33.6% and 16.6% of short term trading of electricity was via Bilateral transactions through Inter-State Trading Licensees and Bilateral transactions through Distribution Companies respectively. Whereas, 29.3% and 20.5% of the short term trading of electricity took place through power exchanges and unscheduled interchange respectively.

Bilateral transactions through Inter-State Trading Licensees have been undertaken in India since 2004. As of March, 2014 there were a total of 42 Inter-State Trading Licensees in India out of which 23 trading licensees were actively involved in the process of trading. Figure 4 describes the increase in volume of transactions over the period of the last ten years. A steep rise can be observed from a value of 27.7 BU in 2010-11 to 35.11 BU in 2013-14 which in percentage terms amounts to an increase of 26.75% in just one year.

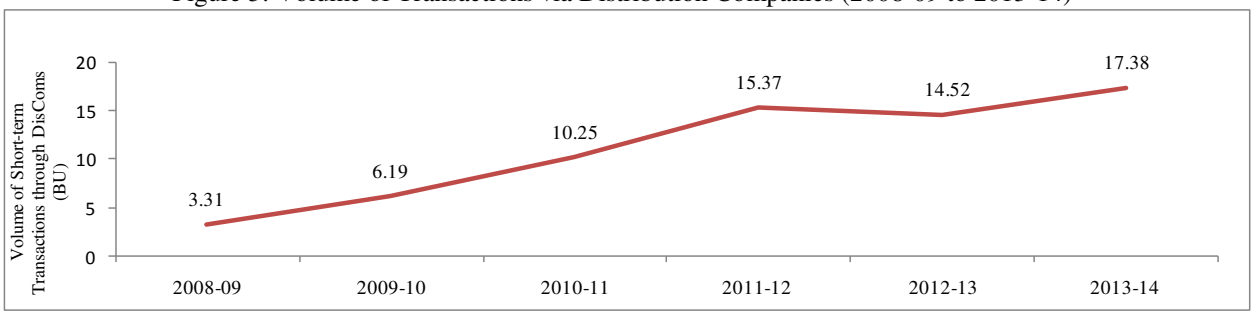
Figure 4: Volume of Transactions via Inter State Trading Licensees (2004-05 to 2013-14)



Source: Authors calculation based on Central Electricity Regulatory Commission (CERC) Report, various issues

Bilateral transactions of electricity traded by Distribution Companies began in August 2008. These transactions account for 15% of the volume of short term transactions in 2013-14. Figure 5 describes the increase in transaction from 2008-09 to 2013-14. Over the span of time chosen for description of volume of transactions via Distribution Companies a growth of 425.07% from 2008-09 to the year 2013-14.

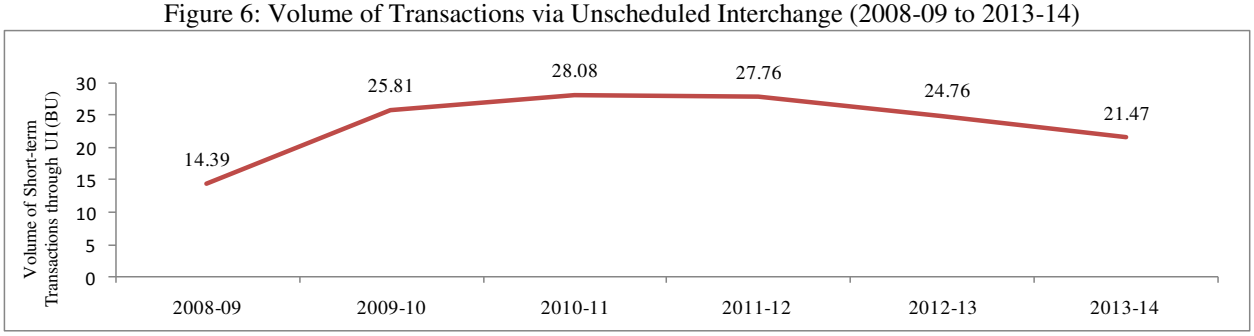
Figure 5: Volume of Transactions via Distribution Companies (2008-09 to 2013-14)



Source: Authors calculation based on Central Electricity Regulatory Commission (CERC) Report, various issues

Power traded via unscheduled interchange in 2013-13 comprised 21% of the total volume of short term electricity traded. Figure 6 illustrates the trend in the volume of electricity traded via unscheduled interchange over the period from 2008-09 to 2013-14. It can be observed from the figure that a rise in volume of transactions via Unscheduled Interchange took place from 2008-09 to 2010-11 which can be attributed to the fall in price of UI from 6.70 Rs/kWh in 2008-09 to 3.91 Rs/kWh in 2010-11. This rise in volume has been followed by a decline from 2010-11 to 2013-14 in volume of electricity traded by unscheduled interchange by as much as 23.54%.

Figure 6: Volume of Transactions via Unscheduled Interchange (2008-09 to 2013-14)



Source: Authors calculation based on Central Electricity Regulatory Commission (CERC) Report, various issues

In 2013-14, short term electricity traded via power exchange was 30.67 BU which was 29.31% of the short term electricity traded in India. The short term electricity traded via power exchanges is discussed extensively in Section 3.

3. Contribution of Power Exchanges in Short Term Trading of Electricity – International and Indian Experience

3.1 International Experience

Electricity began to be traded via a power exchange in the year 1996 in New York Mercantile Exchange (NYMEX) which also deals with trading of other commodities. Electricity can be

traded both physically as well as financially. India only allows physical trading of electricity even though many countries have permitted their exchanges to allow financial trading of electricity. Many power exchanges provide both power futures (base futures and peak futures) and options to traders. Currently, a number of power exchanges are operating successfully across the world which include: Australia Energy Market Operator (AEMO) of Australia, Amsterdam Power Exchange (APX) Power UK of United Kingdom, European Energy Exchange (EEX) of Germany, Powernext of France, Nordpool of Scandinavian Countries.

The first dedicated power exchange of the world is Nord Pool, Nordic Power Exchange in Scandinavia which is involved in trading of electricity with neighbouring countries was set up in the year 1996 and majority of the electricity traded on Nord Pool is hydroelectric. The countries that benefit from Nord Pool include Denmark, Norway, Sweden, and Finland. It offers power contracts to its participants in both physical as well as financial form. The spot based power contracts are available on Elspot and Elbas of Nord Pool. Half hourly contracts are traded prior to the actual day of delivery are traded on Elspot whereas Elbas offers adjustment of trading in hourly contracts on a continuous basis until one hour before the delivery hour of the contract. Nord Pool offers exante settlement of price and provides the same price for every acceptable bid i.e. follows uniform pricing. The price is set for every zone without inner congestion. In 2012, the total volume traded at Nord Pool Spot was 432 TWh equivalent to 77% of the electricity consumption of Nordic/Baltic region.

Other countries of Europe where there is existence of power exchanges include the following – Estonia, Luxembourg, Germany, Belgium, France, Spain, Netherlands, Portugal, Britain, Ireland, Austria and Italy. Table 2 gives an overview of the power exchanges and the products offered by the exchanges in Europe.

Table 2 Overview of power exchanges in Europe

Power Exchange	Offers Products in the country	Products offered by power exchange			
		Physical Trading		Financial Trading	
		Day-Ahead Auction	Intraday Spot Trading	Futures Base	Futures Peak
APX-ENDEX	United Kingdom, Netherlands, Belgium	Yes	Yes	No	No
N2EX	United Kingdom	Yes	Yes	Yes	No
ICE	United Kingdom	No	No	Yes	Yes
Nord Pool	Denmark, Norway, Sweden, Finland, Estonia	Yes	Yes	Yes	No
EPEX	France and Germany	Yes (also covers Switzerland and Austria)	No	No	No
EEX	France and Germany	No	No	Yes	No
MIBEL	Spain and Portugal	Yes	Yes	Yes	No
GME	Italy	Yes	Yes	No	No
IDEM	Italy	No	No	Yes	No

Source: Imran and Kockar (2014)

In North American power exchanges, apart from providing day-ahead, intra-day power contracts there is a provision for a Financial Transmission Right (FTR) which does not entitle the holder physical delivery of power but entitles the holder to a payment for the charges incurred due to congestion. A number of exchanges in North America offer Financial Transmission Rights which includes ISO New England, Midwest ISO, Pennsylvania-Jersey-Maryland Interconnection (PJM), New York ISO, California ISO, Electric Reliability Council of Texas and Southwest Power Pool. In North America, market participation in ISOs is mandatory or incentive based. The Pennsylvania-Jersey-Maryland (PJM) Interconnection also offers hourly contracts and the price is calculated at each node i.e. the exchange offers nodal pricing.

Victorian Power Exchange was set up in 1994 and was the first power exchange to operate in Australia. The Victorian Power Exchange was closed in 1998 and NEMMCO was established. In 2009, NEMMCO ceased operations and its responsibilities were transitioned to Austrlian Energy Market Operator (AEMO). Currently, AEMO manages the trading in the National Electricity Market which publishes half-hourly electricity pool price for each region (regions include New South Wales, Victoria, Queensland, South Australia and Tasmania). Electricity derivatives offered by AEMO are cash settled and do not involve physical delivery of electricity.

Next, we discuss the role of power exchanges in India.

3.2 Indian Experience

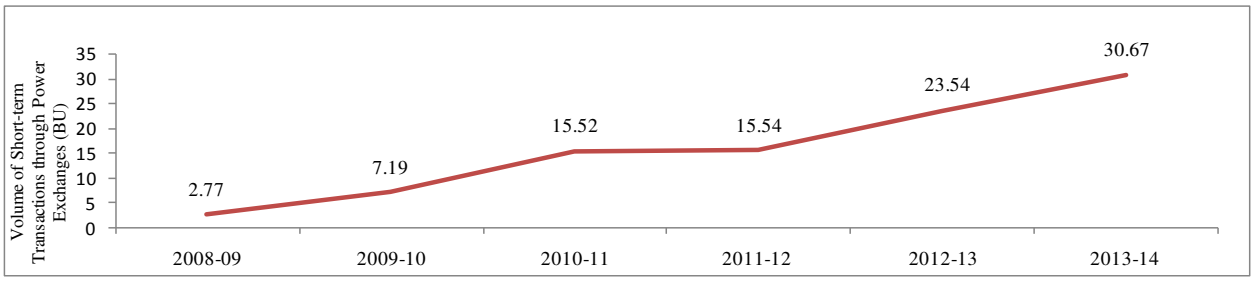
The Central Electricity Regulatory Commission (CERC) had issued guidelines for the setting up and operation of power exchanges in the month of February in 2007 and trading of electricity in India via power exchanges has began in June 2008. Currently, there are two power exchanges in operation in India - Indian Energy Exchange (IEX) and Power Exchange of India Limited (PXIL). These power exchanges are able to facilitate the optimum utilisation of electricity generation capacity of the country.

The Indian Energy Exchange headquartered in New Delhi is India's leading power exchange with a market share of more than 90%. It offers products in three segments of the electricity market consisting of day-ahead market, term ahead market, renewable energy certificates. The exchange is about to launch energy saving certificates in order to incentivise energy efficiency in large intensive industries. IEX started their operation in June 2008.

The second power exchange in India, Power Exchange of India Limited, offers a number of products including day-ahead spot contracts, day-ahead contingency contracts, weekly contracts and renewable energy certificates. It commenced its operations in October 2008 with the introduction of contracts in day-ahead electricity market with double side bidding and clearing at uniform price.

Power exchanges have been able to provide time and cost savings to its participants. Besides efficiency, it has lead to better utilisation of electricity generated in plants across the various parts of the country. Since 2008, the electricity transacted via power exchanges has been rising, the volume of transactions via Power Exchanges was 2.77 BU in 2008-09 which rose to 30.67 BU in the year 2013-14. Figure 7 shows the historical growth in the volume of transactions via power exchanges from 2008-09 to 2013-14. There has been a remarkable progress in terms of volume of transactions via power exchanges, with a growth of 30.29% in the last year 2012-13 to 2013-14.

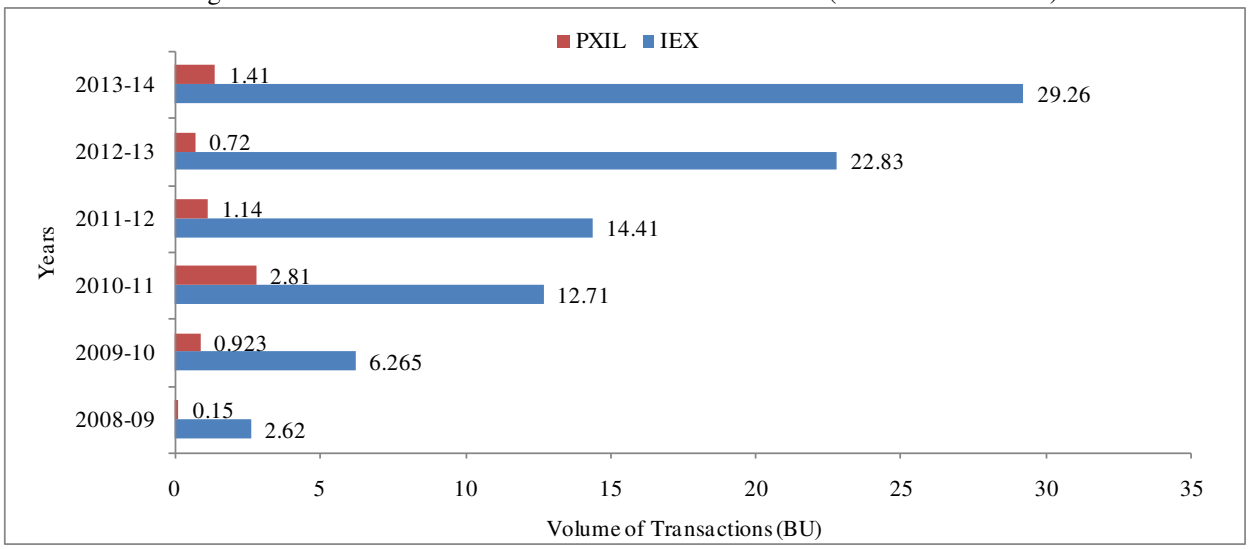
Figure 7: Volume of Transactions via Power Exchanges (2008-09 to 2013-14)



Source: Authors calculation based on Central Electricity Regulatory Commission (CERC) Report, various issues

Figure 8 examines the volume of transactions traded by IEX and PXIL from 2008-09 to 2013-14 respectively. IEX has continued to remain the leader in the volume of transactions traded on exchanges with a growth of 101.67% from 2008-09 to 2013-14.

Figure 8: Volume of Transactions traded via IEX and PXIL (2008-09 to 2013-14)



Source: Authors calculation based on Central Electricity Regulatory Commission (CERC) Report, various issues

Table 3 differentiates volume of electricity traded by the products offered by IEX and PXIL in terms of transactions of Day-Ahead market and Term Ahead Market over the period of time (2008-09 to 2013-14). The volume traded on both the power exchanges is significantly higher in the day-ahead electricity market compared to term ahead market.

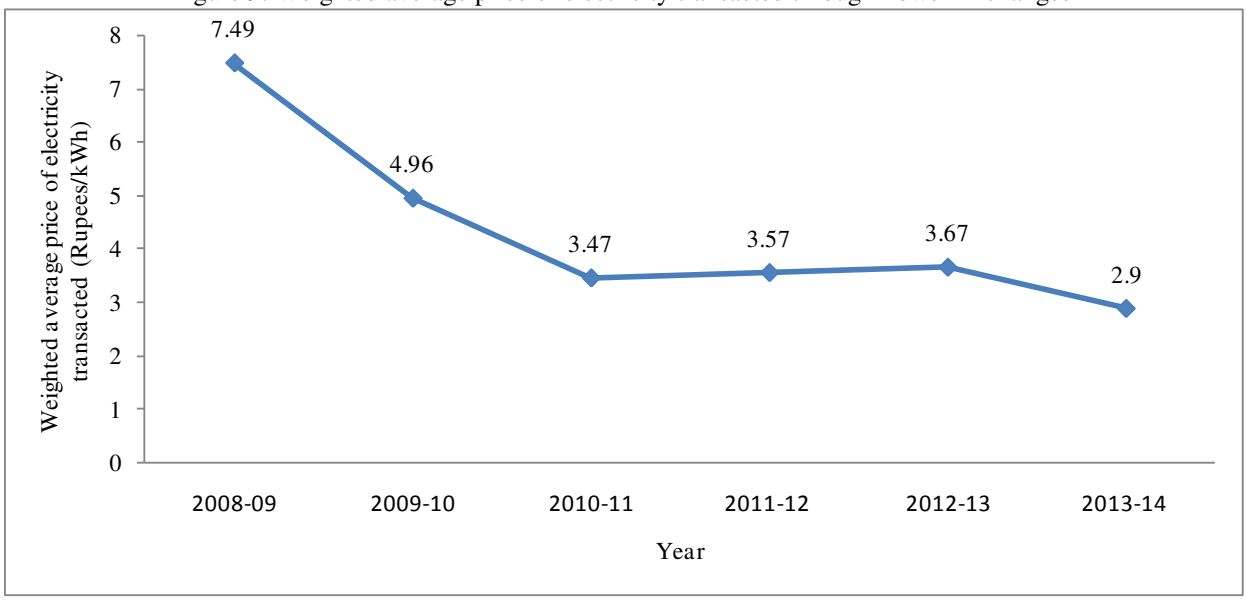
Table 3: Electricity traded via Day-Ahead Market and Term Ahead by IEX and PXIL respectively (BU)

	Volume of Transactions at IEX (BU)		Volume of Transactions at PXIL (BU)	
Year	**Day Ahead Market**	**Term Ahead Market**	**Day Ahead Market**	**Term Ahead Market**
2008-09	2.62	0	0.15	0
2009-10	6.17	0.095	0.92	0.003
2010-11	11.8	0.91	1.74	1.07
2011-12	13.79	0.62	1.03	0.11
2012-13	22.35	0.48	0.68	0.04
2013-14	28.92	0.34	1.11	0.3

Source: Central Electricity Regulatory Commission (CERC) Report, various issues

Figure 9 describes the weighted average price of electricity transacted through Power Exchanges (day-ahead market and term ahead market) over the last five years (2008-09 to 2013-14). The drastic fall in average price of electricity transacted at power exchanges from 7.49 Rs/kWh in 2008-09 to 2.9 Rs/kWh in 2013-14 can be attributed to the slump in demand from bankrupt distribution utilities, transmission constraints and increase in power generation capacity.

Figure 9: Weighted average price of electricity transacted through Power Exchanges



Source: Authors calculation based on Central Electricity Regulatory Commission (CERC) Report, various issues

Using the weighted average price of electricity transacted and the volume of electricity traded, the size of the power exchange market can be calculated for the period from 2008-09 to 2013-14. This can be seen in the Table 4. There has been a rise in the size of power exchange market from 2008-09 to 2013-14 witnessing a growth of 328.69% from 2008-09 to 2013-14.

Table 4: Size of Power Exchange Market (INR. Crore)

Year	Size of Power Exchange Market (INR Crore)
2008-09	2074
2009-10	3563
2010-11	5389
2011-12	5553
2012-13	8648
2013-14	8891

Source: Central Electricity Regulatory Commission (CERC) Report, various issues

Renewable Energy Certificates (RECs) are given in lieu of 1 MWh of electricity injected into the grid generated from renewable energy sources. In India, RECs can only be exchanged at Power Exchanges. The first REC trading session was held at the Power Exchanges in March 2011. Table 5 gives the market clearing volume of RECs (Solar and Non Solar) transacted through IEX and PXIL from 2012-13 to 2013-14, indicating a growth of 136.99% in non solar market clearing volume of RECs at PXIL.

Table 5: Market Clearing Volume of RECs at IEX and PXIL

Year	IEX		PXIL	
	Solar	Non Solar	Solar	Non Solar
2012-13	10443	1980546	3570	595255
2013-14	53056	1271267	13624	1410747

Source: Central Electricity Regulatory Commission (CERC) Report, various issues

4. Status of Day-Ahead Electricity Contracts in India

4.1 Trading Mechanism of Day-Ahead Electricity Trading in India

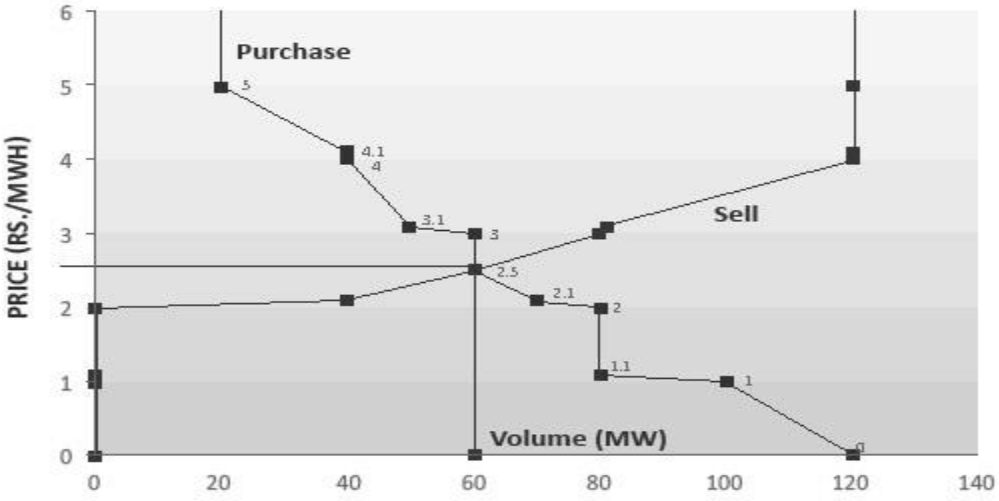
The day-ahead electricity trading on power exchanges forms a significant component of short term trading in India. In the day-ahead market, a price contract for electricity is determined on Monday which will be delivered on Tuesday.

Within the day-ahead electricity market, out of the two power exchanges (Indian Energy Exchange, IEX and Power Exchange of India Limited, PXIL) operating in India, IEX is the dominant player. Thus, we discuss the process of Day-Ahead Electricity contracts as traded on IEX in detail.

IEX has been involved in day-ahead trading of electricity since 2008 and is a physical delivery based market. For the day-ahead market, IEX offers a double side close auction for delivery on the next day. The power exchange receives offers from producers for the provision of electricity and their minimum selling price. Similarly, retailers submit bids to the power exchange for consumption of electricity and the maximum price they would be willing to buy it at. Bids for 96 blocks of 15 minutes each can be entered. The bids are accumulated by IEX from 10am to 12 noon. The bids entered between 10am and 12 noon can be revised or cancelled only till 12 noon.

At the end of the bidding session, the exchange utilises an algorithm to determine the market clearing price, production and consumption schedule for each hour of the market horizon. The aggregate supply and demand curves are drawn on Price Quantity axes. The intersection point of the supply and demand curves determines the Market Clearing Price (MCP) and Market Clearing Volume (MCV). Prices are reported in INR per Mega Watt hour. Bids are matched for each 15 minute block (See Figure 10).

Figure 10: Demand Supply graph utilised for determining MCP and MCV

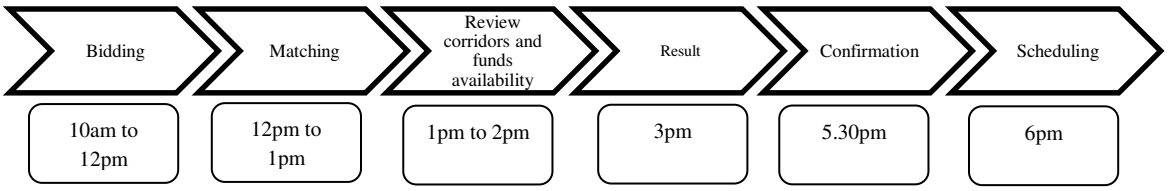


Source: IEX Website

After the prices are determined, members of the exchange whose bids have been executed fully or partially are provided the information regarding the contract traded. On the basis of the market clearing price and volume, IEX gives an unconstrained scenario of the day-ahead market.

After checking of settlement funds of members and requisite capacity with National Load Dispatch Center (NLDC), fresh iterations are run at 2.30pm, after which the final market clearing price and volume are determined by the power exchange. In case there is congestion, the market is split and the members in different bid areas end up paying different prices. On receipt of the final results, obligations are sent to banks for payment for the consumption bids of retailers. This is followed by sending of final results for confirmation and applications of collective transactions are sent to NLDC. A scheduled transaction is considered to be deemed for delivery. The entire Day-Ahead Market Trading process used at IEX is described in Figure 11.

Figure 11: The Day-Ahead Market Trading Process at IEX



Source: IEX Website

The exchange has divided its operations into 12 bid areas (see Table 6). The minimum bid allowed on IEX is Re.1 for 0.1MWh. The two types of bids allowed on IEX include single order bids and block orders. Single bids are fifteen minute bids for different pairs of price and quantity, partial execution of the entered bids by participants is possible whereas Block orders include a series of fifteen minute blocks during the same day but there is no provision of partial execution in block orders at IEX.

Table 6: IEX Bid Areas

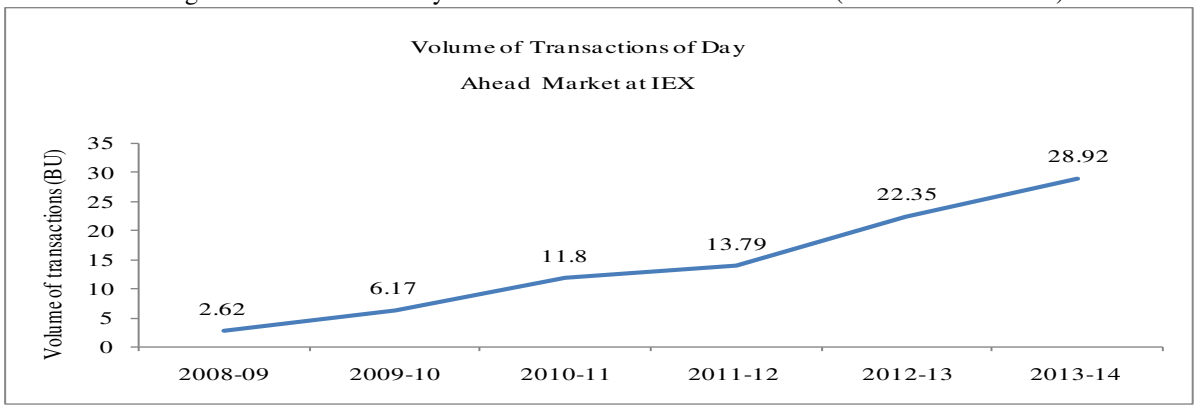
S.No	Bid Area	Region	States covered under the Bid Area
1	N1	North Region	Jammu and Kashmir, Himachal Pradesh, Chandigarh, Haryana
2	N2	North Region	Uttar Pradesh , Uttaranchal, Rajasthan, Delhi
3	N3	North Region	Punjab
4	E1	East Region	West Bengal, Sikkim, Bihar, Jharkhand
5	E2	East Region	Orissa
6	W1	West Region	Madhya Pradesh
7	W2	West Region	Maharashtra, Gujarat, Daman and Diu, Dadar and Nagar Haveli, North Goa
8	W3	West Region	Chhattisgarh
9	S1	South Region	Andhra Pradesh, Karnataka, Pondicherry (Yanam), South Goa
10	S2	South Region	Tamil Nadu, Kerala, Pondicherry (Puducherry), Pondicherry (Karaikal), Pondicherry (Mahe)
11	A1	North East Region	Tripura, Meghalaya, Manipur, Mizoram, Nagaland
12	A2	North East Region	Assam, Arunachal Pradesh

Source: IEX Website

4.2 Characteristics of Day-Ahead Electricity Futures Trading in India

This section tries to describe the characteristics of Day-Ahead Electricity Traded at the Indian Energy Exchange which is the dominant player (92% market share in 2013-14). We begin with discussing the volume of transactions of day-ahead trading of electricity at IEX from 2008-09 to 2013-14. Figure 12 illustrates the rise in volume of transactions over the period (2008-2014) .The figure illustrates a growth of 29.39% from 2012-13 to 2013-14.

Figure 12: Volume of Day-Ahead Market Transactions at IEX (2008-09 to 2013-14)



Source: Central Electricity Regulatory Commission (CERC) Report, various issues

As discussed in the previous section, IEX has 12 bid areas for day-ahead trading of electricity, Table 7 shows details of bids received annually for buying and selling from each of the 12 bid areas from 2008-09 to 2013-14.

Table 7: Yearly volume in the twelve bid areas of IEX (2008-09 to 2013-14) (in MWh)

Bid Areas	Years	2008 - 09	2009 – 10	2010 - 11	2011 – 12	2012 - 13	2013 – 14
A1	Buy	2902.38	61034.08	23643.01	8827.8	82440.29	126022.54
	Sell	87178.87	76124.57	234977.50	232922.61	171300.72	415909.89
A2	Buy	200.00	25705.24	41182.17	215756.79	313222.75	291912.31
	Sell	48460.41	11049.27	144372.42	174732.4	108538.03	298443.03
E1	Buy	1178.07	28678.64	136012.50	518873.13	442593.66	824371.77
	Sell	566726.27	711742.11	1130818.09	1214620.1	1229323.1	2251678.6
E2	Buy	484.50	25192.25	210.19	81996.88	35509.65	81779.68
	Sell	27355.87	26405.48	173711.57	327668.77	307737.73	1293793.6
N1	Buy	110193.36	540053.47	3514773.68	2227133.5	1417912	2475280.7
	Sell	437767.83	450971.28	913377.50	2169421	4372785	5378394.7
N2	Buy	57557.25	2696358.62	2691173.16	2383627.2	5648411.5	6401146.7
	Sell	477931.46	639286.04	2381395.12	2413119.9	3646381.3	4269449.2
N3	Buy	-	-	-	1656991.7	2794005.1	2381974
	Sell	-	-	-	190234.56	39061.36	122281.63
S1	Buy	981966.47	555730.69	460979.59	1100288.5	2034858.9	3631882.5
	Sell	63687.56	1067563.91	1488835.04	1266638.3	3814424.1	2917368.2
S2	Buy	647055.83	1341100.98	2827247.34	2340879.7	2474069.8	997036.87
	Sell	1339.11	19251.14	23075.75	5559.17	661.82	325427.93
W1	Buy	127339.87	472.43	135033.19	567659.22	426531.47	459732.88
	Sell	646707.55	2081824.87	2504331.54	1097492.1	1432092.3	2810881.4
W2	Buy	687331.05	896611.38	1970323.89	2690599.5	6627307.3	10693517
	Sell	261508.07	1086719.11	2805684.19	3436981.5	2936003.9	5277812.1
W3	Buy	-	-	-	5466.76	77970.02	560234.83
	Sell	-	-	-	1268645.5	4316513.4	3563445

Source: IEX Website

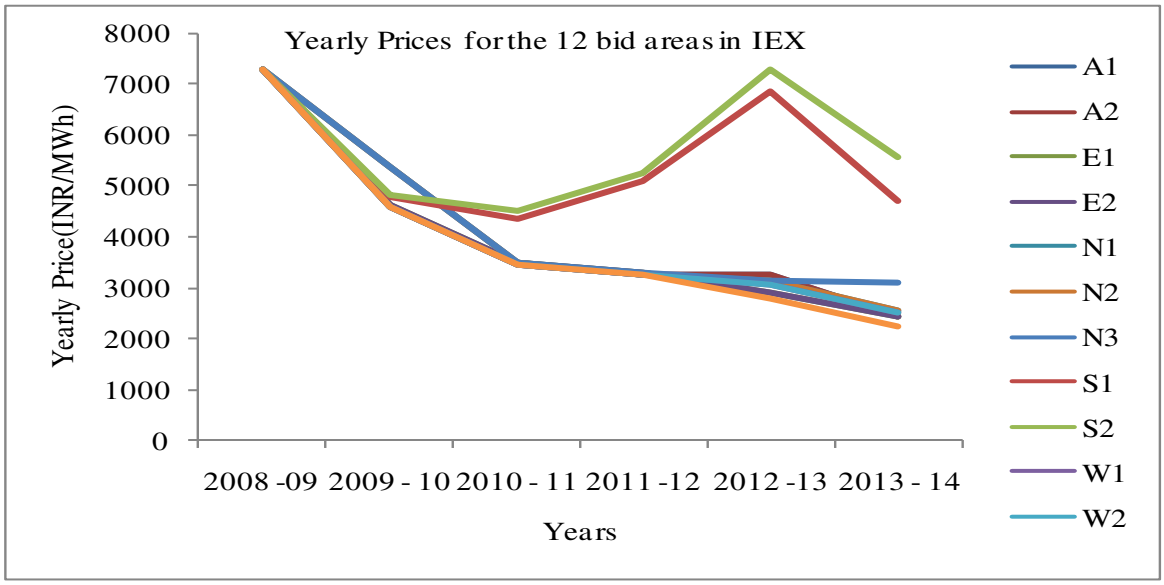
The Table above clearly indicates that there has been a rise in the number of bids in most of the bid areas over the period. In terms of volume, bid area W2 (Maharashtra, Gujarat, Daman and Diu, Dadar and Nagar Haveli, North Goa) and bid area N2 (Uttar Pradesh , Uttaranchal, Rajasthan, Delhi) are leading.

Participants from various sectors were involved in trading of electricity through day-ahead market at the power exchange, these included: captive power, plants, industrial consumers owning captive power plants, industrial consumers, independent power producers, state utilities

and private distribution licensees. At the end of March 2014, 2958 Open Access Consumers were purchasing power and procured 17575 MU of electricity from IEX in 2013-14.

Moving on to prices, Figure 13 illustrates the yearly price of power available for the 12 bid areas via day-ahead trading at IEX.

Figure 13: Yearly prices of power for 12 bid areas in IEX (INR/MWh)

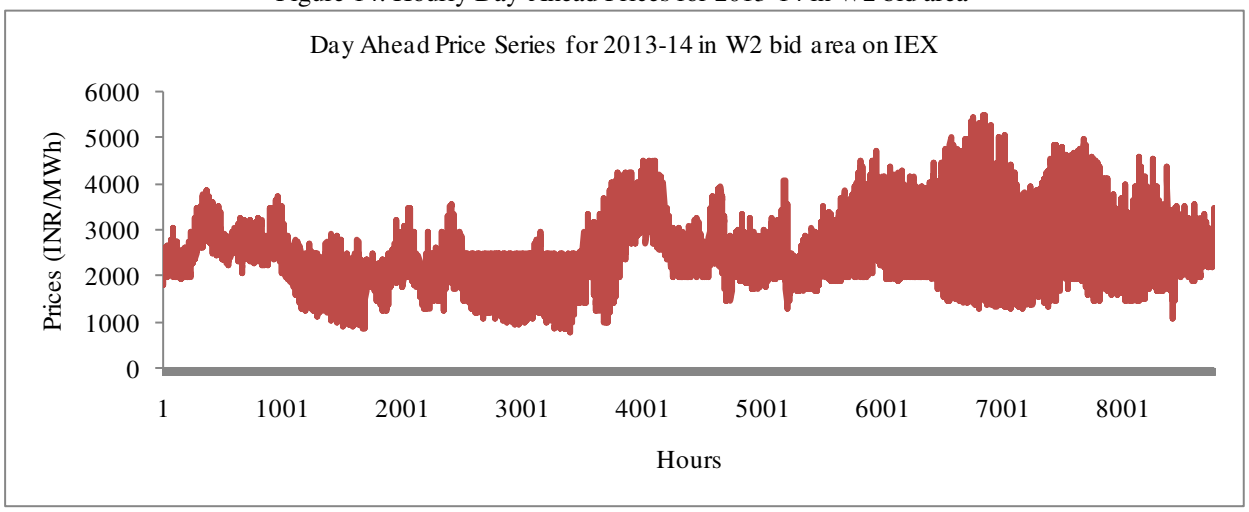


Source: IEX Website

The figure above clearly suggests that the prices in bid area S1 (Andhra Pradesh, Karnataka, Pondicherry (Yanam), South Goa) and bid area S2 (Tamil Nadu, Kerala, Pondicherry (Puducherry), Pondicherry (Karaikal), Pondicherry (Mahe)) remained on the higher side compared to other bid areas. This could be attributed to high demand for electricity in the Southern Region and unavailability of transmission corridor in these regions due to constraints on the Southern grid in the second quarter of 2013.

The most active bid area is considered to be W2, in the next few paragraphs we discuss the hourly prices of day-ahead electricity contracts which were available at IEX in 2013-14.Figure 14 depicts the movement of hourly day-ahead prices during the period from April 2013 to March 2014. It can be seen that the price series is extremely volatile, with price varying from a minimum of 800.12INR/MWh in August, 2013 to a maximum of 5504.94INR/MWh in January 2014. On an average, the price hovered around 2518 .1 in the period.

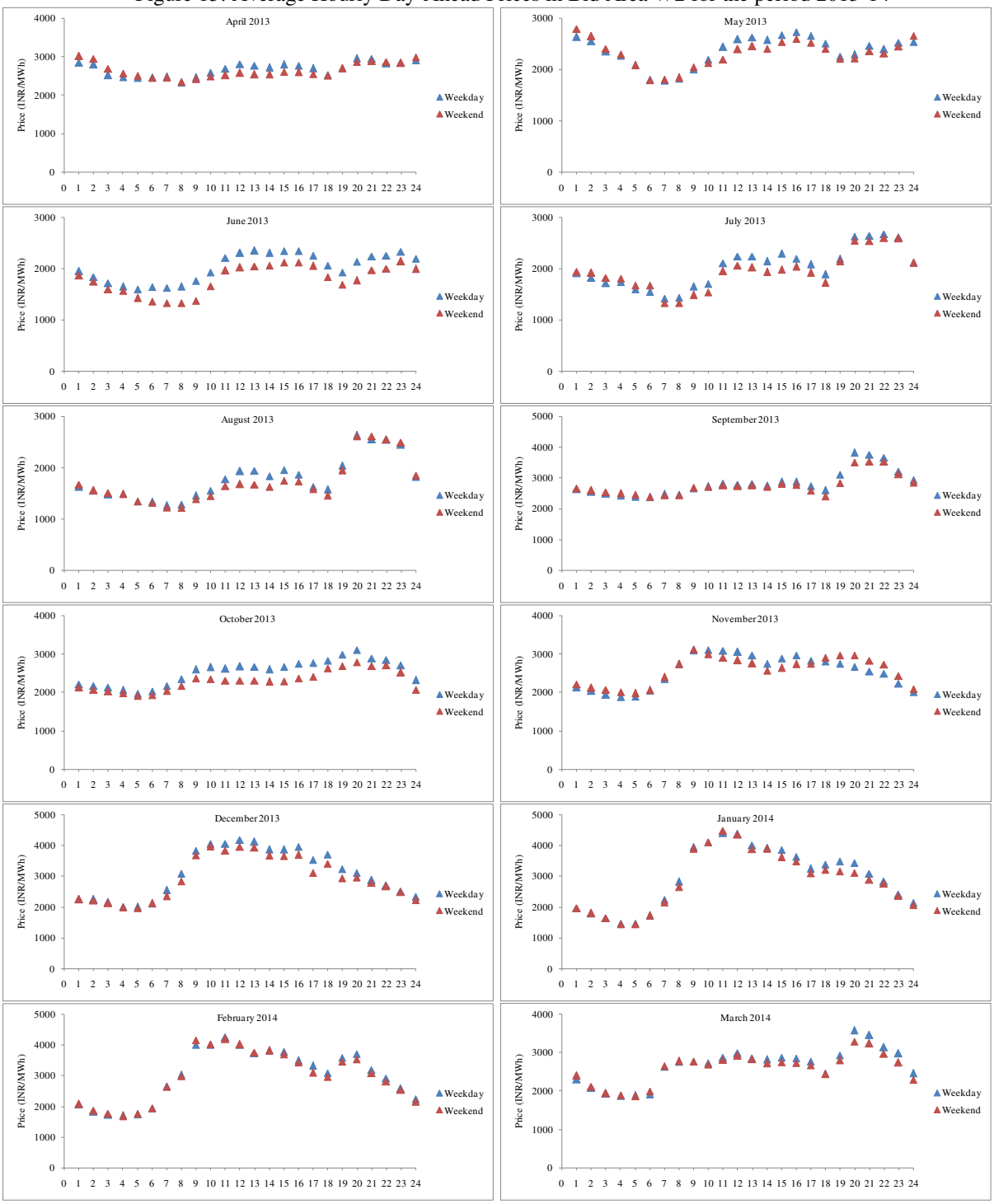
Figure 14: Hourly Day-Ahead Prices for 2013-14 in W2 bid area



Source: Authors calculations

By calculating the average of the price for each hour separately for weekdays (includes Monday, Tuesday, Wednesday, Thursday and Friday) and weekends (Saturdays and Sundays) for each month (for example – hourly prices for April are computed by calculating the arithmetic mean of hourly prices for all the days in April 2013), we try to differentiate between the average hourly day-ahead price for weekdays and average hourly day-ahead price for weekends for each month (April 2013 to March 2014) for W2 bid area in Figure 15. It is found that during the day (11-17 hours) for all months except September 2013 and January 2014, there is a sharp increase in prices on weekdays compared to weekends. This could be attributed to the lack of demand from factories and industries on Saturdays and Sundays. For all months except in May 2013, it can be observed that the prices are lower in the early morning hours. The steep increase in May 2013 in early hours could be attributed to the extremely high temperatures witnessed in summer in the region leading to requirement of airconditioning.

Figure 15: Average Hourly Day-Ahead Prices in Bid Area W2 for the period 2013-14



Source: Authors calculations

We also calculate the summary statistics of the price for each hour over the entire period, for example – mean of price for hour 00-01 for all the days from April 2013 to March 2014. Here all days are included to calculate the statistic, we are not distinguishing between weekdays and

weekends. Table 8 gives the summary statistics for the price for each hour from April 2013 to March 2014.

Table 8: Summary Statistics for the price for each hour

Hour	**00 – 01**	**01 - 02**	**02 - 03**	**03 - 04**	**04 - 05**	**05 – 06**	**06 - 07**	**07 – 08**
Observations	365	365	365	365	365	365	365	365
Minimum	924.76	809.65	800.86	800.88	800.12	887.18	869.40	884.12
Maximum	3800.29	3792.57	3499.97	3250.24	3249.95	3400.85	3540.36	3900.51
Mean	2221.89	2113.13	1991.09	1924.73	1865.47	1903.79	2111.39	2281.74
Standard Deviation	512.78	511.08	470.39	465.56	469.76	461.52	609.30	715.19
Skewness	0.70	0.74	0.45	0.45	0.51	0.16	-0.25	-0.28
Kurtosis	3.73	3.85	3.46	3.45	3.33	3.15	2.28	2.08

Hour	**08 – 09**	**09 - 10**	**10 - 11**	**11 - 12**	**12 - 13**	**13 – 14**	**14 - 15**	**15 – 16**
Observations	365	365	365	365	365	365	365	365
Minimum	905.26	992.98	965.99	999.27	999.12	999.14	999.16	999.19
Maximum	5081.05	5130.31	5504.94	5380.14	5262.78	5263.81	4850.57	4476.79
Mean	2658.67	2744.57	2895.51	2942.10	2869.97	2794.14	2845.70	2817.80
Standard Deviation	991.60	990.42	962.49	898.87	816.17	804.60	749.71	708.17
Skewness	0.29	0.42	0.69	0.61	0.56	0.52	0.35	0.15
Kurtosis	2.42	2.42	2.90	2.80	2.89	2.99	2.88	2.67

Hour	**16 – 17**	**17 - 18**	**18 - 19**	**19 - 20**	**20 – 21**	**21 – 22**	**22 - 23**	**23 – 24**
Observations	365	365	365	365	365	365	365	365
Minimum	943.10	941.28	924.54	954.52	899.89	956.44	1188.01	1062.13
Maximum	4000.63	4078.74	4207.37	4600.25	4502.53	4500.56	4042.44	4250.69
Mean	2657.36	2582.76	2724.41	2957.86	2856.25	2755.44	2600.39	2318.42
Standard Deviation	611.82	680.67	645.07	676.77	565.08	498.17	418.34	515.92
Skewness	-0.30	-0.11	-0.17	0.05	0.33	0.52	0.64	0.99
Kurtosis	2.83	2.57	2.76	3.24	3.96	5.47	4.85	4.00

Source: Authors calculations

It can be observed from Table 8 that lowest price is in the early hours of the day from 02-03,03-04 and 04-05 hours, while the highest price is in the 09-10,10-11,12-13 and 13-14 hours. Maximum volatility is seen in the 08-09th hour which could be attributed to the increased peak demand.

5. Policy Suggestions and Concluding Remarks

Given the thrust on the deregulation of electricity markets in India since 2003, the short term electricity market with power exchanges in particular have evolved rapidly to support the growth of the power markets in an efficient manner. Since the year of their inception- year 2008, power exchanges are now more efficient and are able to mitigate risks arising from price volatility for the participants to a large extent. The two power exchanges IEX and PXIL have aided in better utilisation of electricity generated in the country and have taken care of unmet demand for power. Volumes on the power exchange have grown almost 14 times. But the short term market in India is yet to achieve potential. In 2013-14, the two power exchanges witnessed constraints on the volume of electricity due to congestion in transmission. During the year 2013-14, the actual transacted volume on power exchanges was 30029.62 MU whereas unconstrained volume was 35621.04MU, leading to a gap of 5591.42 MU amounting to 16% as a percentage of the unconstrained volume.

In light of the evolving nature of the Indian power sector, power exchanges are expected to play a critical role in the process. Power exchanges are expected to play the role of not only taking care of intermediate load requirements but that of providing price signals and a platform for risk mitigation. Currently only 3% of the total electricity generated is traded via power exchange based electricity markets in order to increase the trading it is necessary to allocate scare transmission resources and a need for depth in trading in the power exchange market. An extension of the market session to an evening market (in addition to the existing 10-12PM) and extended intra-day contracts, if launched in the Indian power market, may be able to provide the much needed liquidity in the short term trading of electricity.

It may be possible to increase the depth by introducing longer term futures contract – say week long or fornight long electricity contracts on power exchanges and increasing the level of participation by players. An expansion of product portfolio on power exchanges would increase the liquidity in the market and ensure transparency in the discovery of price. As of now, the two power exchanges provide only physical delivery linked products, in time to come, they could consider providing hedging instruments in order to square of their positions as available in the commodity exchanges. Even though, this may lead to speculation in the market, it will act as a

safe guard for the buyer in case of non-delivery of electricity. Such products have been introduced in developed power exchanges including Nord Pool, where financial products were introduced in the year 1995, there is no provision for physical delivery of financial market power contracts.

Thus to conclude one can say power exchanges are playing a significant role in the electricity market, but it has become imperative to deepen the short term electricity markets in order to increase the efficiency.

6. References

1. Bajpai, P., & Singh, S. N. (2009). Effective market monitoring for surveillance of the Indian electricity market. *International Journal of Energy Sector Management*, Vol. 3, Issue 3, pp.275-292.
2. Balijepalli, V. M., Khaparde, S. A., Gupta, R. P., & Pradeep, Y. (2010). SmartGrid initiatives and power market in India. Power and Energy Society General Meeting, IEEE (pp. 1-7).
3. Bhattacharyya, S. C. (2005). The Electricity Act 2003: Will It Transform The Indian Power Sector? *Utilities Policy*, Vol. 13, Issue (3), pp.260-272.
4. Central Electrical Authority (2013-14), Monthly Executive Summary of Power Sector, available at: http://www.cea.nic.in/.
5. Central Electricity Regulatory Commission (2008-09 to 2013-14), Annual Reports, available at: http://www.cercind.gov.in/.
6. Imran, K., & Kockar, I. (2014). A technical comparison of wholesale electricity markets in North America and Europe. *Electric Power Systems Research*, 108, 59-67.
7. Indian Energy Exchange (2012), "Bye-laws, rules and business rules", available at: www.iexindia.com/.
8. Indian Energy Exchange (2014), "Indian Power Market – Journey so far and way forward", available at: www.iexindia.com/.
9. Mediratta, R. K., Pandya, V., & Khaparde, S. A. (2008) Power Markets Across the Globe and Indian Power Market. Fifteenth National Power System Conference
10. Ministry of Coal, India (2013-14, 2012-13), Annual Report, available at: www.**coal**.nic.in/.
11. Ministry of Power, India (2013-14, 2012-13), Annual Report, available at: www.powermin.nic.in/.
12. Prabavathi, M., & Gnanadass, R. (2015). Energy bidding strategies for restructured electricity market. *International Journal of Electrical Power & Energy Systems*, 64, 956-966.
13. Shukla, U. K., & Thampy, A. (2011). Analysis of competition and market power in the wholesale electricity market in India. *Energy Policy*, Vol. 39, Issue 5, pp.2699-2710.
14. Singh, A. (2010). Towards a competitive market for electricity and consumer choice in the Indian power sector. *Energy Policy*, Vol.38, Issue 8, pp. 4196-4208.