Report on Short-term Power Market in India: 2016-17

Economics Division
Central Electricity Regulatory Commission

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Preface

The Electricity Act, 2003 consolidated the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies, etc. This is further strengthened by the regulatory moves of the Electricity Regulatory Commissions through various regulations and orders required to enable a framework for a robust and healthy power market in the country.

The Central Electricity Regulatory Commission sets the regulatory process in motion through Trading License Regulations, 2004, Open Access Regulations, 2004 and Power Market Regulations, 2010. Under these regulations, short-term power market covers contracts of less than a year for electricity transacted through inter-State Trading Licensees and directly by the Distribution Licensees, Power Exchanges and Deviation Settlement Mechanism. The short-term power market as an integral part of the power sector has been beneficial for meeting the short-term needs of the consumers, suppliers and the sector as a whole. It constitutes about 10 per cent of the total electricity generation in India in the year 2016-17.

The annual report on short-term power market in India provides a snapshot on the short-term transactions of electricity through different instruments used by various market participants. The Central Electricity Regulatory Commission brings out the report to keep market participants and other stakeholders aware and updated on the state of the power market. Dissemination of information through the report is one of the key elements to ensure efficiency and competition in the sector and for stakeholders and consumers to maintain faith in the system. This report covers overview of power sector, trends in short-term transactions of electricity on annual, monthly and daily basis, time of the day variation in volume and price of electricity, trading margin for bilateral transactions, analysis of transactions carried out by various types of participants, effect of congestion on volume of electricity traded on power exchanges and ancillary services operations. It also

covers tariff of long-term sources of power and analysis of transactions of Renewable Energy Certificates.

In order to ensure ease of access, this report is also made available on the CERC website www.cercind.gov.in. We are confident that market participants and stakeholders will find the Report on Short-term Power Market in India, 2016-17 useful.

Abbreviations

Abbreviation	Expanded Version
AC	Alternating Current
ACE	Area Control Error
APSPDCL	Andhra Pradesh Southern Power Distribution Company Limited
AT&C	Aggregate Technical and Commercial
Block	15 Minutes Time Block
BSPHCL	Bihar State Power Holding Company Limited
BU	Billion Units (Billion kWh)
CAGR	Compound Annual Growth Rate
CCGT	Combined Cycle Gas Turbine
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CESC	Calcutta Electric Supply Corporation
CGS	Central Generating Station
Ckm	Circuit km
CPP	Captive Power Producer/Plant
CTU	Central Transmission Utility
DAM	Day Ahead Market
DDUGJY	Deendayal Upadhyaya Gram Jyoti Yojana
DISCOMs	Distribution Companies
DSM	Deviation Settlement Mechanism
DVC	Damodar Valley Corporation
ER	Eastern Region
FCAS	Frequency Control Ancillary Services
FGUTPP	Firoz Gandhi Unchahar Thermal Power Project
GOHP/GoHP	Government of Himachal Pradesh
GPS	Gas Power Station
GUVNL	Gujarat Urja Vikas Nigam Limited
HEP	Hydro Electric Project
HHI	Herfindahl-Hirschman Index
HNGIL	Hindusthan National Glass & Industries Ltd
HPP	Hydro Power Plant
HPSEB	Himachal Pradesh State Electricity Board

Abbreviation	Expanded Version
HVDC	High-Voltage Direct Current
IEGC	Indian Electricity Grid Code
IEX	Indian Energy Exchange
IPDS	Integrated Power Development Scheme
IPP	Indipendent Power Producers
ISGS	Inter State Generating Station
J&K PDD	J&K Power Development Department
JIPTL	Jindal India Thermal Power Limited
KSEB	Kerala State Electricity Board
KV	Kilovolt
kWh	Kilo Watt Hour
KWPCL	Korba West Power Company Limited
Ltd	Limited
MCCPL	Maruti Clean Coal & Power Limited
MCP	Market Clearing Price
MPPMCL	Madhya Pradesh Power Management Company Limited
MPPTCL	Madhya Pradesh Power Trading Company Limited
MU	Million Units
MVA	Mega Volt Ampere
MW	Mega Watts
MWh	Mega Watt Hour
N1	Northern Region 1
N2	Northern Region 2
N3	Northern Region 3
NCAS	Network Control Ancillary Services
NCTP	National Capital Thermal Power Plant
NEEPCO	North Eastern Electric Power Corporation Limited
NER	North Eastern Region
NHDC	National Hydro Development Corporation Limited
NHPC	National Hydro-Electric Power Corporation Limited
NLC	Neyveli Lignite Corporation Limited
NLDC	National Load Dispatch Centre
NPCL	Noida Power Company Limited
NR	Northern Region

Abbreviation	Expanded Version
NRSS	Northern Region Strengthening Scheme
NSGM	National Smart Grid Mission
NTPC	National Thermal Power Corporation Limited
OA	Open Access
OAC	Open Access Consumer
OTP	Other than RTC and Peak period
OTPC	ONGC Tripura Power Company
PFC	Power Finance Corporation
PGCIL	Power Grid Corporation of India Limited
PX	Power Exchange
PXIL	Power Exchange India Limited
REC	Renewable Energy Certificate
RES	Renewable Energy Sources
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RGPPL	Ratnagiri Gas and Power Private limited
RLDC	Regional Load Despatch Centre
ROR	Run of River
RPC	Regional Power Committee
RPO	Renewable Purchase Obligation
RRAS	Reserves Regulation Ancillary Services
RTC	Round The Clock
S1	Southern Region 1
S2	Southern Region 2
S3	Southern Region 3
SEB	State Electricity Board
SJVNL	Satluj Jal Vidyut Nigam Limited
SRAS	System Restart Ancillary Services
St	Stage
STPP	Super Thermal Power Plant
STPS	Super Thermal Power Station
TAM	Term Ahead Market
THDC	Tehri Hydro Development Corporation Limited
TNEB	Tamil Nadu Electricity Board
TPS	Thermal Power Station

Abbreviation	Expanded Version
TSSPDCL	Telangana State Southern Power Distribution Company
TSPCC	Telangana State Power Coordination Committee
UDAY	Ujwal DISCOM Assurance Yojana
UPCL	Uttarakhand Power Corporation Limited
UPPCL	Uttar Pradesh Power Corporation Limited
UT	Union Territory
VAE	Virtual Ancillary Entity
W1	Western Region 1
W2	Western Region 2
W3	Western Region 3
WBSEDCL	West Bengal State Electricity Distribution Company Ltd
WR	Western Region

Executive Summary

The report comprises of overview of the power sector, short-term power market in India, tariff of long-term sources of power and transactions of renewable energy certificates. Overview of power sector highlights electricity generation, transmission and distribution including revenue gap of state electricity distribution companies (DISCOMs)/SEBs and the measures taken by the Government of India in the recent years. The salient features of the power sector are as under:

1. Coal is an important source of electricity generation in India, contributing about 58.8% of the total capacity of generation in 2016-17, followed by Renewable Energy Source (17.5%), Hydro (13.6%), Gas (7.7%), Nuclear (2.1%) and Diesel (0.3%).

2. The Compound Annual Growth Rate (CAGR) of total installed generation capacity was 9.5% during the period from 2006-07 to 2016-17.

3. During the period from 2006-07 to 2016-17, share of state sector in the total installed generation capacity declined from 56% to 32% and share of central sector has declined from 32% to 25%, while share of private sector increased from 13% to 44%. However, the public sector continues to be the largest owner, holding 57% share in 2016-17.

4. Increase in the installed capacity resulted in decrease in the demand shortage (energy and peak shortage). The energy shortage decreased from 10.1% in 2009-10 to about 0.7% in 2016-17. During the period, the peak shortage decreased from 12.7% to 1.6%.

5. Gross electricity generation in India increased from 768.4 BU in 2009-10 to 1159.8 BU in 2016-17.

6. During 2012-17, the annual growth in the bulk transmission was between 6% and 9%, while the annual growth in the transmission capacity of substations was between 11% and 15%.

7. All India average cost of supply and average revenue (without subsidy) increased from ₹3.40/kWh and ₹2.63/kwh, respectively, in 2008-09 to ₹5.20/kWh and ₹4.12/kWh, respectively, in 2014-15. During the period, average revenue gap registered an

increasing trend upto 2012-13, however, it declined from ₹1.27/kWh in 2012-13 to ₹1.08/kWh in 2014-15.

'Short-term transactions of electricity' refers to contracts of less than one year period for electricity transacted under bilateral transactions through Inter-State Trading Licensees (only inter-state part) and directly by the Distribution Licensees (also referred as Distribution Companies or DISCOMs), Power Exchanges (Indian Energy Exchange Ltd (IEX) and Power Exchange India Ltd (PXIL)), and Deviation Settlement Mechanism (DSM). The analysis includes (i) yearly/monthly/daily trends in short-term transactions of electricity; (ii) time of the day variation in volume and price of electricity transacted through traders and power exchanges; (iii) trading margin charged by trading licensees for bilateral transactions (iv) analysis of open access consumers on power exchanges; (v) major sellers and buyers of electricity in the short term market; (vi) effect of congestion on volume of electricity transacted through power exchanges. The report also covers analysis on tariff of long-term sources of power, and transactions of renewable energy certificates (RECs) through power exchanges. Salient features of the short-term power market are as under:

1. Of the total electricity procured in India in 2016-17, the short-term power market comprised 10%. The balance 90% of generation was procured mainly by distribution companies through long-term contracts and short-term intra-state transactions.

2. In terms of volume, the size of the short-term market in India was 119.23BU (Billion Units) in the year 2016-17. As compared to the volume of electricity transacted through short-term market in the year 2015-16 (115.23BU), this was about 3% higher. The growth in volume of 4BU was accounted mainly by the positive growth in transactions through power exchanges (6.12 BU) and transactions through DSM (2.46 BU).

3. Excluding DSM and direct bilateral sale between the DISCOMs, the volume of electricity transacted was 74.63BU in 2016-17. This was about 6% higher than in 2015-16. Volume of electricity transacted through power exchanges witnessed an increase of about 17%, whereas the volume of electricity transacted through inter-state trading licensees witnessed a decrease of about 5% over 2015-16. In monetary terms,

the size of this segment of the short-term market was ₹22,124 crore in the year 2016-17[1], which was 8% less than in the year 2015-16. The decline in size of the market can be attributed to lower electricity prices in 2016-17.

4. The volume of DSM in 2016-17 increased by 12% over 2015-16. The share of DSM as a percentage of total volume of short-term transactions of electricity continued a downward trend in past years and it declined from 39% in 2009-10 to 19% in 2016-17.

5. In terms of volume, the direct bilateral transactions between DISCOMs witnessed a decrease of about 11% in 2016-17 as compared to 2015-16. The share of direct bilateral transactions between DISCOMs as a percentage of total short term transaction volume increased from 9% in 2009-10 to 18% in 2016-17.

6. The weighted average price of electricity transacted through power exchanges was ₹2.50/kWh and through trading licensees it was ₹3.53/kWh in 2016-17. The corresponding values for the year 2015-16 were ₹2.72/kWh and ₹4.11/kWh, respectively. In the year 2016-17, the weighted average price of electricity transacted through Day Ahead Market sub-segment of the power exchanges was ₹2.48/kWh and that through Term Ahead Market sub-segment was ₹3.09/kWh.

7. During 2016-17, about 98% of the volume of electricity transacted through traders was at a price less than ₹6/kWh. About 71% of the volume was transacted at a price less than ₹4/kWh.

8. During 2016-17, IEX transacted 100% of the volume of electricity at a price less than ₹6/kWh while about 98% of the volume was transacted at a price less than ₹4/kWh. During the year, PXIL transacted 100% of the volume of electricity at a price less than ₹6/kWh while about 99% of the volume was transacted at less than ₹4/kWh.

9. During 2016-17, of the total electricity bought under bilateral transactions from traders, 85% was on round the clock (RTC) basis, followed by 14% in periods other than RTC and peak (OTP) and 1% was during peak hours. The per unit price of electricity

[1]*Excluding transactions pertaining to banking transactions.*

procured during RTC was high (₹3.63/kWh) when compared with the price during Peak period (₹2.98/kWh) and OTP (₹2.78/kWh).

10. It is observed from the block-wise and region-wise prices of electricity transacted through power exchanges in 2016-17 that the price of electricity in Southern Region (S2 and S3 regions) was high when compared to the price in other regions in both the power exchanges.

11. Competition among the trading licensees was shown for the period from 2004-05 to 2016-17. During the period, number of traders who were undertaking trading increased from 4 to 25 and concentration of market power (HHI based on volume of trade undertaken by the licensees) declined from high concentration (HHI of 0.5512) to non-concentration (HHI of 0.1534). The competition among the trading licensees resulted an increase in volume and decrease in prices in the short-term bilateral market.

12. The weighted average trading margin charged by the trading licensees in 2016-17 was ₹0.03/kWh, which is in line with the CERC Trading Margin Regulations, 2010.

13. The procurement of power by the industrial consumers through power exchanges began in the year 2009. In both power exchanges, Open Access industrial consumers bought 24.05BU of electricity, which formed 60% of the total day ahead volume transacted in the power exchanges during 2016-17.

14. The weighted average price of electricity bought by open access consumers at IEX was lower (₹2.43/kWh) compared to the weighted average price of total electricity transacted through IEX (₹2.48/kWh). The weighted average price of electricity bought by open access consumers at PXIL was lower (₹2.29/kWh) compared to the weighted average price of total electricity transacted through PXIL (₹2.56/kWh).

15. The year also witnessed constraints on the volume of electricity transacted through power exchanges, mainly due to transmission congestion. During 2016-17, the actual transacted volume was about 4% less than the unconstrained volume. Because of

congestion and the splitting of day ahead market at both the power exchanges, the congestion amount collected during the year was ₹306.08 crore.

16. NLDC, in coordidation with RLDCs, has started ancillary services operations w.e.f. April 12, 2016. In 2016-17, the NLDC has issued 2128 RRAS Up/Down Instructions on account of various triggering criteria. Of the total, there were 1758 RRAS Up Instructions and 370 RRAS Down Instructions. Majority of the Regulation Up Instructions were on account of Trend of load met followed by multiple reasons, while majority of the Regulation Down Instructions were on account of High Frequency followed by extreme weather condition. During the year, maximum power despatched in a block was 3746 MW in July 2016 while the maximum power regulated was 2249 MW in March 2017.

17. In 2016-17, the number of Solar RECs transacted on IEX and PXIL were 4,04,081 and 1,52,933 respectively and the market clearing price of these RECs was ₹3500/MWh on both IEX and PXIL. During the year, market clearing volume of Non-Solar RECs transacted on IEX and PXIL were 42,14,538 and 17,16,187 respectively and the market clearing price of these RECs was ₹1500/MWh on both IEX and PXIL.

Chapter-I

Overview of Power Sector

India's power sector is well diversified with market dynamics. Power generation ranges from conventional sources such as coal, lignite, natural gas, oil, hydro and nuclear power to viable non-conventional sources such as wind, solar, and agricultural and domestic waste. Electricity demand in the country has increased rapidly and is expected to rise further in the years to come. In order to meet the increasing demand for electricity in the country, the electricity supply chain consisting of generation, transmission and distribution has undergone a phase of transformation to competitiveness.

1. Generation

Sources of electricity generation are of two types i.e. conventional and non-conventional. The conventional sources of power generation are coal, lignite, natural gas, oil, hydro and nuclear power, and non-conventional sources of power generation are wind, solar, agricultural and domestic waste etc. Table-1 and Figure-1 show the installed electricity generation capacity in India by source.

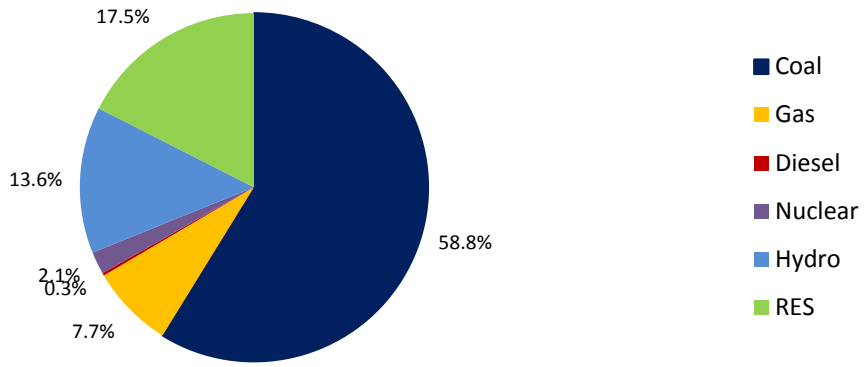
Table-1: Installed Electricity Generation Capacity in India by Source (MW), 2006-07 to 2016-17

Year	Thermal				Nuclear	Hydro	RES	Grand Total
	Coal	Gas	Diesel	Total				
2006-07	71121	13692	1202	86015	3900	34654	7760	132329
2011-12	112022	18381	1200	131603	4780	38990	24504	199876
2012-13	130221	20110	1200	151531	4780	39491	27542	223343
2013-14	145273	21782	1200	168255	4780	40532	31692	245259
2014-15	164636	23062	1200	188898	5780	41267	35777	271722
2015-16	185173	24509	994	210675	5780	42783	42849	302088
2016-17	192163	25329	838	218330	6780	44478	57260	326849
Percentage of Installed Generation Capacity								
2006-07	53.7%	10.3%	0.9%	65.0%	2.9%	26.2%	5.9%	100%
2011-12	56.0%	9.2%	0.6%	65.8%	2.4%	19.5%	12.3%	100%
2012-13	58.3%	9.0%	0.5%	67.8%	2.1%	17.7%	12.3%	100%
2013-14	59.2%	8.9%	0.5%	68.6%	1.9%	16.5%	12.9%	100%

2014-15	60.6%	8.5%	0.4%	69.5%	2.1%	15.2%	13.2%	100%
2015-16	61.3%	8.1%	0.3%	69.7%	1.9%	14.2%	14.2%	100%
2016-17	58.8%	7.7%	0.3%	66.8%	2.1%	13.6%	17.5%	100%

Source: CEA, Monthly Reports.

Figure-1: Installed Electricity Generation Capacity in India, 2016-17



As can be seen in Figure-1, coal is the most important source of electricity generation in India, contributing about 58.8% of the total capacity of generation in 2016-17, followed by Renewable Energy Source (17.5%), Hydro (13.6%), Gas (7.7%), Nuclear (2.1%) and Diesel (0.3%). The percentage of coal based generation capacity increased from 53.7% in 2006-07 to 58.8% in 2016-17. During the period, hydro based generation capacity decreased from 26.2% to 13.6% whereas renewables based generation capacity increased from 5.9% to 17.5%.

The Electricity Act of 2003 liberalised the generation sector through a license-free regime. As a result, the entry of private players into the generation segment significantly increased their share in the total electricity generation.

The players in the generation segment can be divided into three types based on ownership and operations. These are (i) Central public sector undertakings includes National Thermal Power Corporation, National Hydroelectric Power Corporation, and similar organizations. (ii) State public sector undertakings/State Electricity Boards; and (iii) Private sector enterprises includes Tata Power Company Ltd, Reliance Power Ltd, Adani Power Ltd., and similar entities.

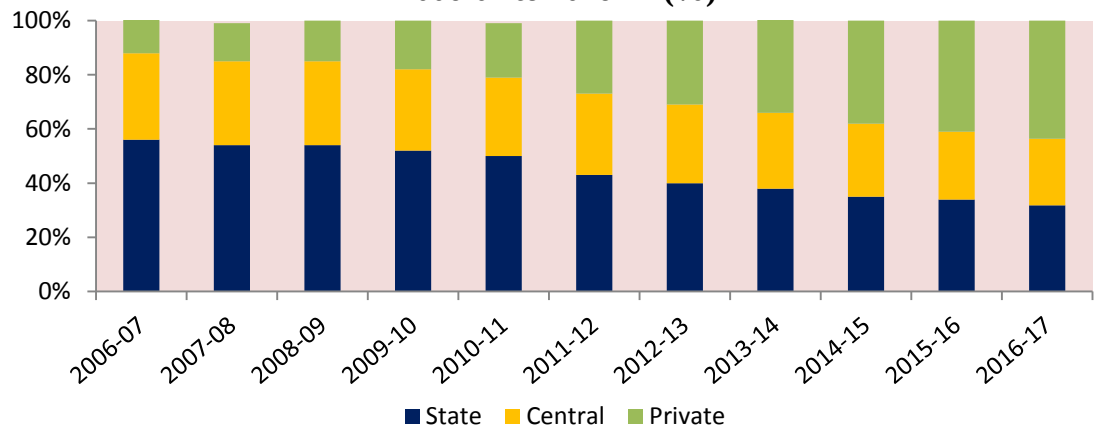
Sector-wise growth of installed generation capacity has been shown in Table-2 and Figure-2. It is observed from the table that CAGR of total installed generation capacity was 9.5% during the period from 2006-07 to 2016-17. During the period, the share of state sector in the total installed generation capacity has declined from 56% to 32% and the share of central sector has declined from 32% to 25%. The share of private sector has increased from 13% to 44%. However, the public sector continues to be the largest owner, holding 57% share in 2016-17.

Table-2: Sector-wise Growth of Installed Generation Capacity, 2006-07 to 2016-17

Year	Installed Generation Capacity (MW)				% of Installed Generation Capacity		
	State	Central	Private	Total	State	Central	Private
2006-07	73579	42037	16713	132329	56%	32%	13%
2007-08	77523	45027	20511	143061	54%	31%	14%
2008-09	79309	45777	22879	147965	54%	31%	15%
2009-10	82905	47479	29014	159398	52%	30%	18%
2010-11	87417	50759	35450	173626	50%	29%	20%
2011-12	85919	59682	54276	199877	43%	30%	27%
2012-13	89125	65360	68859	223344	40%	29%	31%
2013-14	92265	68126	84868	245259	38%	28%	35%
2014-15	95079	72521	104122	271722	35%	27%	38%
2015-16	101790	76297	124001	302088	34%	25%	41%
2016-17	103967	80257	142624	326849	32%	25%	44%

Source: CEA, Monthly Reports.

Figure-2: Sector-wise Growth of Installed Generation Capacity, 2006-07 to 2016-17 (%)



As shown in the above table, the total installed electricity generation capacity of India increased from 1,32,329MW in 2006-07 to 3,26,849 MW in 2016-17. Increase in installed electricity generation capacity made an impact on the power supply position shown in Table-3. Increase in the installed capacity resulted in decrease in the demand shortage (energy and peak shortage). The energy shortage decreased from 10.1% in 2009-10 to about 0.7% in 2016-17. During the period, the peak shortage decreased from 12.7% to 1.6%.

Table-3: Power Supply Position in India, 2009-10 to 2016-17

Year	Energy (MU)			Peak (MW)		
	Require-ment	Availability	Deficit (%)	Peak Demand	Peak Met	Deficit (%)
2009-10	830594	746644	-10.1%	119166	104009	-12.7%
2010-11	861591	788355	-8.5%	122287	110256	-9.8%
2011-12	937199	857886	-8.5%	130006	116191	-10.6%
2012-13	995557	908652	-8.7%	135453	123294	-9.0%
2013-14	1002257	959829	-4.2%	135918	129815	-4.5%
2014-15	1068923	1030785	-3.6%	148166	141160	-4.7%
2015-16	1114408	1090850	-2.1%	153366	148463	-3.2%
2016-17	1142929	1135334	-0.7%	159542	156934	-1.6%

Source: Ministry of Power

Electricity generation is shown in Table-4. It is observed from the table that total gross electricity generation in India has increased from 768.4 BU in 2009-10 to 1159.8 BU in 2016-17. During the period, the CAGR of gross electricity generation was 6%.

Table-4: Gross Electricity Generation in India (Mode-wise) (BU), 2009-10 to 2016-17

Year	Thermal	Hydro	Nuclear	Bhutan Import	Total
2009-10	640.5	103.9	18.6	5.4	768.4
2010-11	665.0	114.3	26.3	5.6	811.1
2011-12	708.8	130.5	32.3	5.3	876.9
2012-13	760.7	113.7	32.9	4.8	912.1
2013-14	792.5	134.8	34.2	5.6	967.2
2014-15	878.3	129.2	36.1	5.0	1048.7
2015-16	943.8	121.4	37.4	5.2	1107.8
2016-17	994.2	122.3	37.7	5.6	1159.8

Source: CEA, Monthly Reports.

2. Transmission

The transmission sector was opened for private investments in 1998. The Central Transmission Uility (CTU) is the nodal agency for providing the medium-term (3 months to 5 years) and long-term (exceeding 7 years) access (the right to use the inter-state transmission system) typically required by a generating station or a trader acting on the station‘s behalf. The PGCIL is responsible for inter-state transmission and development of the national grid, and it acts as the CTU. The RLDCs are the nodal agencies for grants of short-term open access (upto 3 months). The nodal agency providing transmission access to the power exchanges is the NLDC.

Open Access refers to the right to generators of electricity [Captive Power Plants[2] (CPP)/Independent Power Producers (IPP)] and bulk consumers[3] to sell the generated electricity at a certain transmission surcharge and to access the transmission and distribution networks of any generator without any discrimination by the distribution/transmission line owners. The principle of open access is based on the premise that while it is uneconomical to lay down multiple transmission lines in the same region because of the large sunk costs involved, it is still best to give consumers a choice to decide which firm‘s electricity they want to consume.

Table-5 shows the growth of transmission lines and transmission capacity in India during the period from 2011-12 to 2016-17.

Table-5: Growth of Transmission Sector in India, 2011-12 to 2016-17

Trans-mission System Type	AC Transmission lines (ckm)				HVDC (ckm)	Total (AC+ HVDC) (ckm)	Annual Growth (%)	AC Substations Transformation Capacity (MVA)				Annual Growth (%)
Voltage (KV) level	765	400	220	Total				765	400	220	Total	
As on 31.3.2012	5250	106819	135980	248049	9432	257481	-	25000	151027	223774	399801	-
As on 31.3.2013	6459	118180	140517	265156	9432	274588	7%	49000	167822	242894	459716	15%
As on 31.3.2014	11096	125957	144851	281904	9432	291336	6%	83000	177452	256594	517046	12%

[2] *Captive Power refers to generation from a unit set up by industry for its own consumption*

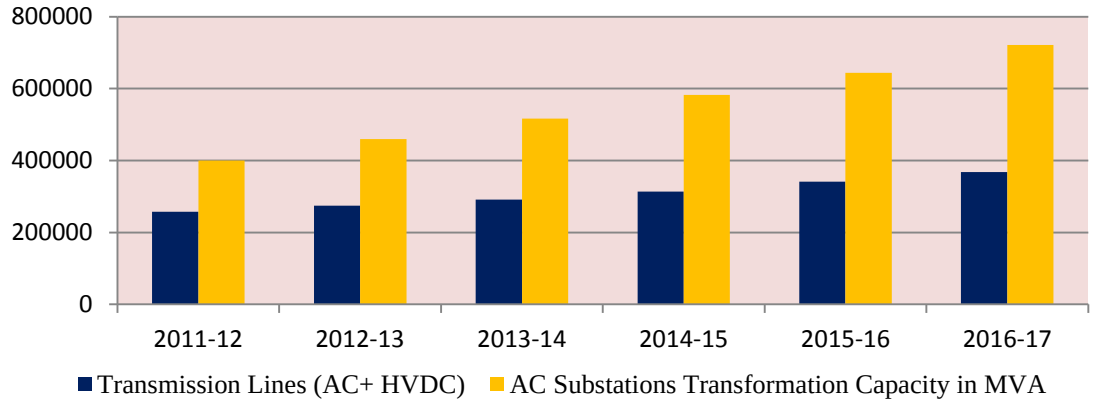
[3] *Bulk consumers are consumers with power requirement of 1MW or above*

As on 31.3.2015	18644	135949	149412	304005	9432	313437	8%	121500	192422	268678	582600	13%
As on 31.3.2016	24245	147130	157238	328613	12938	341551	9%	141000	209467	293482	643949	11%
As on 31.3.2017	31240	157787	163268	352295	15556	367851	8%	167500	240807	312958	721265	12%

Source: CEA, Monthly Reports.

It is observed from the table that bulk transmission (transmission lines upto 220kv) has increased from 2,57,481 ckm as on 31.3.2012 to 3,67,851 ckm as on 31.3.2017. During the period, annual growth in the bulk transmission was varying from 6% to 9%. The transmission capacity of substations has also increased from 3,99,801 MVA as on 31.3.2012 to 7,21,265 MVA as on 31.3.2017. During the period, annual growth in the transmission capacity of substations was varying from 11% to 15%. There is a significant growth in the transmission capacity during the last five years. The year-wise bulk transmission and the transmission capacity of substations has been shown in Figure-3.

Figure-3: Growth of Transmission Sector in India, 2011-12 to 2016-17



The sector is having natural monopoly as there are high sunk costs in investing in the infrastructure needed to transmit electricity, such as transmission lines. Because of these characteristics, non-public entities also face entry barriers, and private investments are allowed in projects only after approval from CERC. Although the transmission market is largely dominated by the public sector, there are many lines including High-Voltage Direct Current (HVDC) lines owned by private players. There are about 47 Inter-state transmission licensees as on 31.3.2017 granted by CERC (Annexure-I).

3. Distribution

State Electricity Distribution Companies (DISCOMs)/State Electricity Boards (SEBs) own the majority of the distribution segment in the electricity supply chain. In order to boost competition and make the sector more efficient, the government is emphasizing the importance of a well-performing distribution sector and has been focusing on the improvement of the financial health of utilities. This is necessary to meet the goal of providing people a reliable and good-quality power and universal access to electricity.

The DISCOMs have been facing losses because they sell electricity below cost or provide power free/subsidized rates for the agriculture and rural sectors. Average cost of supply, average revenue and revenue gap (i.e. Rupees per unit) of all the state power utilities has been shown for the period from 2008-09 to 2014-15 in Table-6.

Table-6: Average Cost of Supply, Average Revenue and Revenue Gap of State Power Utilities, 2008-09 to 2014-15

Year	Average Cost of Supply (₹/kWh)	Average Revenue (without subsidy) (₹/kWh)	Revenue Gap (₹/kWh) (-)
2008 - 09	3.40	2.63	0.77
2009 - 10	3.55	2.68	0.87
2010 - 11	3.98	3.03	0.95
2011 - 12	4.55	3.30	1.25
2012 - 13	5.03	3.76	1.27
2013 - 14	5.18	4.00	1.18
2014 - 15	5.20	4.12	1.08
Source: PFC, "Report on The Performance of State Power Utilities".			

All India average cost of supply and average revenue (without subsidy) increased from ₹3.40/kWh and ₹2.63/kwh, respectively, in 2008-09 to ₹5.20/kWh and ₹4.12/kWh, respectively, in 2014-15. During the period, average revenue gap registered an increasing trend upto 2012-13, however, it declined from ₹1.27/kWh in 2012-13 to ₹1.08/kWh in 2014-15.

The DISCOMs in the country are trapped in a vicious cycle with huge operational losses and outstanding debt due to legacy issues. Financially stressed DISCOMs are not able to supply adequate power at affordable rates. To improve their financial health, several policy initiatives have been taken by the Union Government during last few years like Ujwal DISCOM Assurance Yojana (UDAY, launched in 2015), Integrated Power Development Scheme (IPDS, launched in 2014), National Smart Grid Mission (NSGM), etc. UDAY is being implemented in various states for the financial turnaround and revival of the DISCOMs through four initiatives (i) improving operational efficiencies of DISCOMS; (ii) reduction of cost of power purchase; (iii) reduction in interest cost of DISCOMs; (iv) enforcing financial discipline on DISCOMs through alignment with State finances.

The IPDS works with the objectives of reducing AT&C losses, establishment of IT enabled energy accounting/auditing system, improvement in billed energy based on metered consumption and improvement in collection efficiency. While the IPDS is focused on urban areas, the Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY , launched in 2014) is centred on improving distribution and electrification in rural areas. The scheme includes the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) as a key component of the rural electrification initiative.

The implementation of the above mentioned programmes has led to considerable improvements in the distribution segment. However, the achievements have remained much below the targets. AT&C losses have come down to about 20 per cent, which is still way higher than the 15 per cent target. The schemes have also received a push from the UDAY which has set strict loss reduction targets for discoms.

Chapter-II

Short-term Power Market in India

1. Introduction

Prior to the Electricity Act 2003, the electricity industry recognized generation, transmission and supply as three principal activities, and the legal provisions were also woven around these concepts. Bulk purchase and sale is a regular phenomenon between DISCOMs and licensees that was construed as part of the activity of supply of electricity. It is with the enactment of the Electricity Act, that the transaction involving purchase and sale of electricity has been recognized as a distinct licensed activity. Recognition of trading as a separate activity is in sync with the overall framework of encouraging competition in all segments of the electricity industry. The Electricity Act 2003 laid down provisions for promoting competition in the Indian power market. Introduction of non-discriminatory open access in electricity sector provided further impetus for enhancing competition in the market. The responsibility of developing the market in electricity has been vested with the Regulatory Commissions. The open access regulations, inter-state trading regulations, trading margin regulations, power market regulations etc., of the Central Commission have facilitated power trading in an organized manner.

Bulk electric power supply in India is mainly tied in long-term contracts. The DISCOMs who have the obligation to provide electricity to their consumers mainly rely on supplies from these long-term contracts. Nevertheless, to meet the short-term requirements of the market participants, short term trading plays an important role in the power market.

A brief analysis of the short-term transactions of electricity in India has been done in this Report[4] for the year 2016-17. Here, "short-term transactions of electricity" refers to the contracts less than one year for the following trades:

[4]*Although Deviation Settlement Mechanism (DSM) is not a market mechanism, electricity transacted under DSM is often considered a part of short-term transaction. Also,*

(a) Electricity traded under bilateral transactions through Inter-State Trading Licensees (only inter-state trades),

(b) Electricity traded directly by the Distribution Licensees (also referred as Distribution Companies or DISCOMs),

(c) Electricity traded through Power Exchanges (Indian Energy Exchange Ltd (IEX) and Power Exchange India Ltd (PXIL)), and

(d) Electricity transacted through Deviation Settlement Mechanism(DSM).

The analysis includes:

(i) Yearly/monthly/daily trends in short-term transactions of electricity;

(ii) Time of the day variation in volume and price of electricity transacted through traders and power exchanges;

(iii) Trading margin charged by trading licensees for bilateral transactions;

(iv) Analysis of open access consumers on power exchanges;

(v) Major sellers and buyers of electricity in the short term market;

(vi) Effect of congestion on volume of electricity transacted through power exchanges; and

(vii) Ancillary services operations

2. Yearly Trends in Short-term Transactions of Electricity (2008-09 to 2016-17)

The analysis on yearly trends in short-term transactions includes the electricity transacted through the following segments:

- trading licensees (inter-state part only) under bilateral transactions or "bilateral trader" segment ,
- power exchange segment with transactions in both Day Ahead and Term Ahead Markets,
- DSM segment, and
- Direct transactions of electricity between DISCOMs.

electricity transacted bilaterally directly between the distribution companies (without involving trading licensees or power exchanges) is also considered a part of short-term market. In the year 2016-17, the volume of DSM was about 23.22BU and that between distribution companies was about 21.38BU.

Inter-state trading licensees (traders) have been undertaking trading in electricity since 2004 and the power exchanges started operating since 2008. The two power exchanges, IEX and PXIL started their operations in June 2008 and October 2008 respectively. As of March 2017, there were 33 inter-state trading licensees (list is enclosed at Annexure-II) and two power exchanges.

2.1 Total Short-term Transactions of Electricity with respect to Total Electricity Generation

Total volume of short-term transactions of electricity increased from 65.90BU in 2009-10 to 119.23BU in 2016-17. Except in 2014-15, there was a positive growth in the volume of short-term transactions of electricity during the period. During the period, there was 81% growth in volume despite negative growth of 5% witnessed in 2014-15. The volume of short-term transactions of electricity as percentage of total electricity generation varied from 9% to 11% during the period from 2009-10 to 2016-17 (Table-7).

Table-7: Volume of Short-term Transactions of Electricity with respect to Total Electricity Generation

Year	Volume of Short-term Transactions of Electricity (BU)	Total Electricity Generation (BU)	Volume of Short-term Transactions of Electricity as % of Total Electricity Generation
2009-10	65.90	768.43	9%
2010-11	81.56	811.14	10%
2011-12	94.51	876.89	11%
2012-13	98.94	912.06	11%
2013-14	104.64	967.15	11%
2014-15	98.99	1048.67	9%
2015-16	115.23	1107.82	10%
2016-17	119.23	1157.94	10%

Source: NLDC & CEA

The analysis of yearly trends of short-term transactions of electricity for various segments, i.e. electricity transacted through traders and power exchanges, DSM, and directly between DISCOMs is included in the sections that follow.

2.1.1 Electricity Transacted through Traders and Power Exchanges

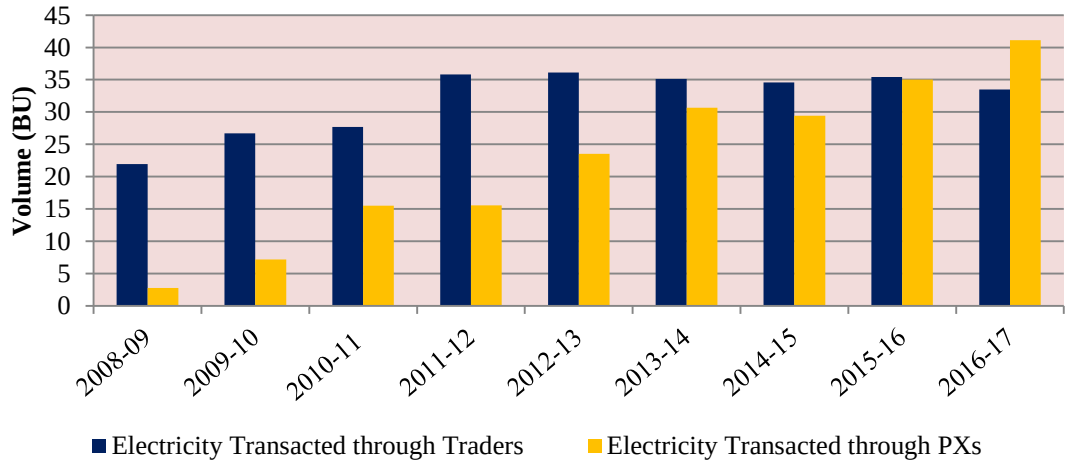
Table-8, Table-9, Figure-4 & Figure-5 show details of volume of electricity transacted through traders under bilateral transactions and through power exchanges for the period from 2008-09 to 2016-17. The volume of electricity transacted through traders and power exchanges increased from 24.69BU in 2008-09 to 74.63BU in 2016-17. The share of electricity transacted through traders and power exchanges as a percentage of total short-term transactions of electricity has increased from 51.45% in 2009-10 to 62.60% in 2016-17. The growth in volume for this segment during the year 2016-17 was 6%.

Table-8: Volume of Electricity Transacted through Traders and Power Exchanges

Year	Electricity Transacted through Traders (BUs)	Electricity Transacted through IEX (BUs)		Electricity Transacted through PXIL (BUs)		Electricity Transacted through IEX and PXIL (BUs)	Total (BUs)
		Day Ahead Market	Term Ahead Market	Day Ahead Market	Term Ahead Market		
2008-09	21.92	2.62		0.15		2.77	24.69
2009-10	26.72	6.17	0.095	0.92	0.003	7.19	33.91
2010-11	27.70	11.80	0.91	1.74	1.07	15.52	43.22
2011-12	35.84	13.79	0.62	1.03	0.11	15.54	51.38
2012-13	36.12	22.35	0.48	0.68	0.04	23.54	59.66
2013-14	35.11	28.92	0.34	1.11	0.30	30.67	65.78
2014-15	34.56	28.12	0.22	0.34	0.72	29.40	63.96
2015-16	35.43	33.96	0.33	0.14	0.58	35.01	70.43
2016-17	33.51	39.78	0.74	0.25	0.35	41.12	74.63

Note1: The volume of electricity transacted through traders in 2008-09 (April to July 2008) includes cross border trading and intra-state trading volume.

Figure-4: Volume of Electricity Transacted through Traders and Power Exchanges

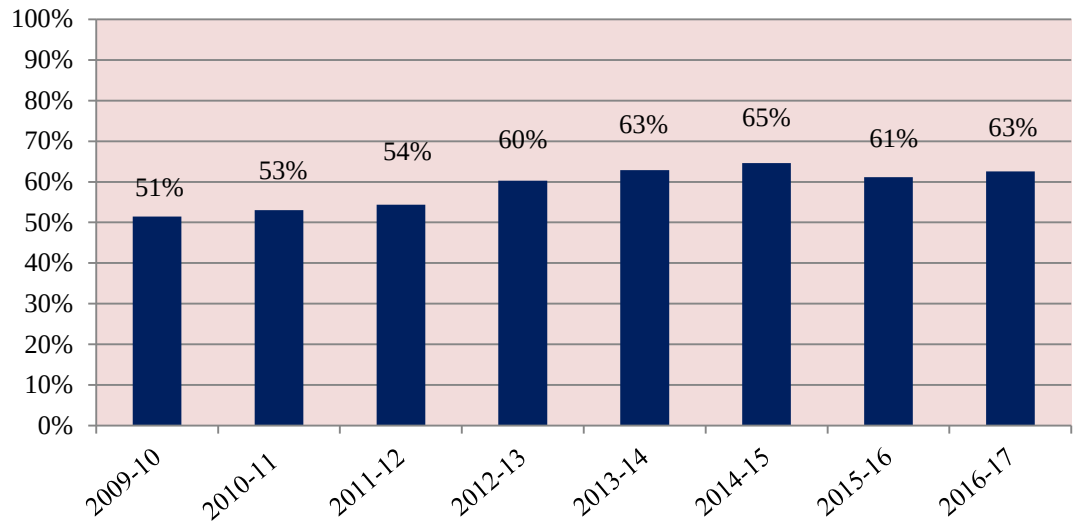


A comparison between the volume of electricity transacted through traders and power exchanges has been shown in Figure-4. It is observed from the figure that there was no significant variation in the volume of electricity transacted through traders during the period from 2011-12 to 2016-17. However, there was an increasing trend in the volume of electricity transacted through power exchanges. The volume of electricity transacted through power exchanges was almost equal in 2015-16 and it was relatively higher in 2016-17 when compared with the volume of electricity transacted through traders. This shows that there was more demand for DAM of power exchanges than the bilateral transactions of traders.

Table-9: Electricity Transacted through Traders and Power Exchanges as percentage of Total Short-term Transactions

Year	Electricity Transacted through Traders & Power Exchanges (BUs)	Total Short-term Transactions of Electricity (BUs)	Electricity Transacted through traders & PXs as % to Total Short-term Transactions
2009-10	33.91	65.90	51.45%
2010-11	43.22	81.56	53.00%
2011-12	51.38	94.51	54.37%
2012-13	59.66	98.94	60.30%
2013-14	65.78	104.64	62.87%
2014-15	63.96	98.99	64.62%
2015-16	70.43	115.23	61.12%
2016-17	74.63	119.23	62.60%

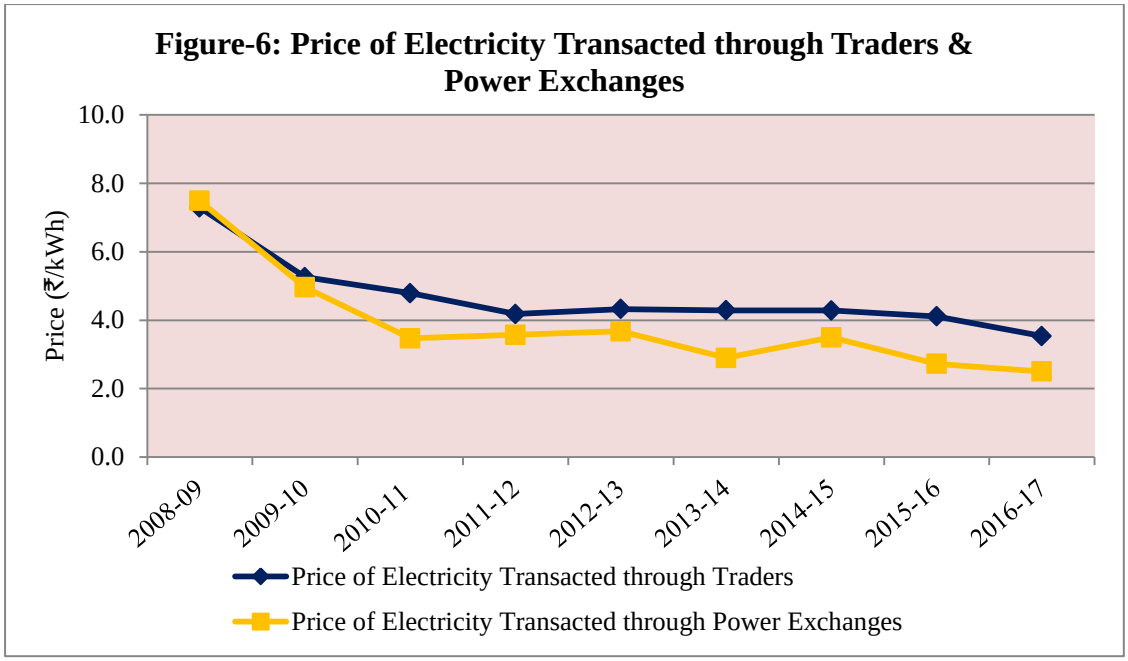
Figure-5: Electricity Transacted through Traders & Power Exchanges as Percentage of Total Short-term Transactions



The prices of electricity transacted through traders and Power Exchanges are shown in Table-10 and Figure-6. The weighted average price of electricity transacted through traders and power exchanges declined from₹7.29/kWh and ₹7.49/kWh respectively in 2008-09 to ₹3.53/kWh and ₹2.50/kWh respectively in 2016-17.

Table-10: Price of Electricity Transacted through Traders & Power Exchanges

Year	Price of Electricity transacted through Traders (₹/kWh)	Price of Electricity transacted through Power Exchanges (DAM+TAM) (₹/kWh)
2008-09	7.29	7.49
2009-10	5.26	4.96
2010-11	4.79	3.47
2011-12	4.18	3.57
2012-13	4.33	3.67
2013-14	4.29	2.90
2014-15	4.28	3.50
2015-16	4.11	2.72
2016-17	3.53	2.50



Variation in volume and price affected the size of bilateral and power exchange market and the size of this market increased by 26% during 2009-10 to 2016-17 (Table-11). Volume of electricity transacted registered a positive growth of 6% (i.e. combining of both bilateral power exchange) in the year 2016-17 compared to 2015-16, while price of electricity declined in both bilateral and power exchange during the period. This lead to overall decline in the size of the market by about 8% in 2016-17 compared to 2015-16.

Table-11: Size of Short-term Power Market (Bilateral and Power Exchange)

Year	Electricity Transacted through trading Licensees (BU)	Price of Electricity Transacted through Trading licensees (₹/kWh)	Size of bilateral trader Market in ₹ Crore	Electricity Transacted through Power Exchanges (BU)	Price of Electricity Transacted through Power Exchanges (₹/kWh)	Size of Power Exchange Market in ₹ Crore	Total Size of the bilateral trader + Power Exchange Market (₹ Crore)
2009-10	26.72	5.26	14055	7.19	4.96	3563	17617
2010-11	27.70	4.79	13268	15.52	3.47	5389	18657
2011-12	35.84	4.18	14979	15.54	3.57	5553	20532
2012-13	36.12	4.33	15624	23.54	3.67	8648	24272
2013-14	35.11	4.29	15061	30.67	2.90	8891	23952
2014-15	34.56	4.28	14801	29.40	3.50	10288	25089
2015-16	35.43	4.11	14557	35.01	2.72	9539	24096
2016-17	33.51	3.53	11844	41.12	2.50	10280	22124

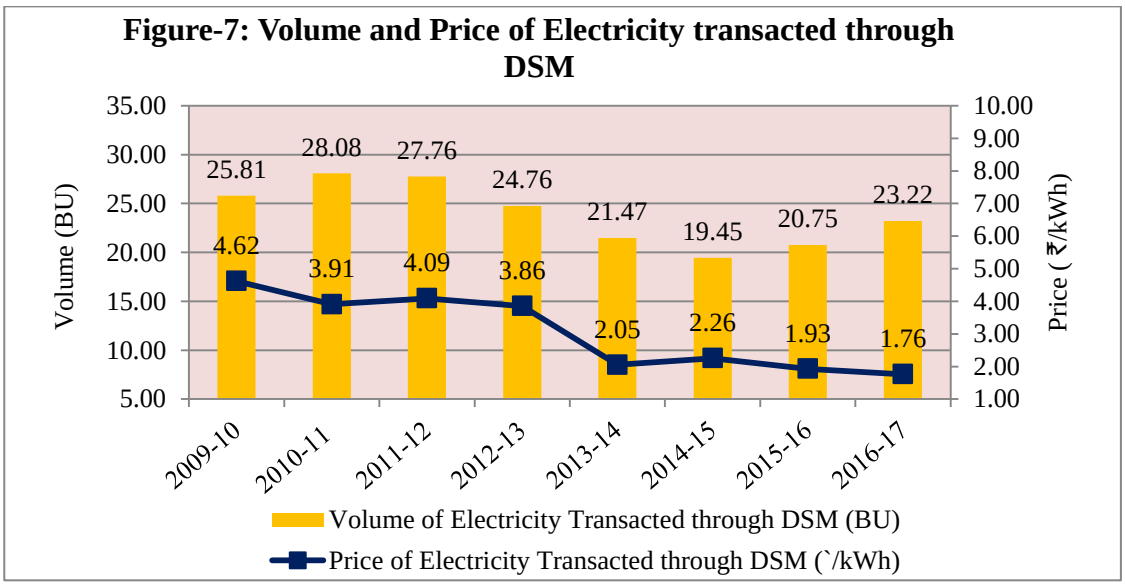
2.1.2 Electricity Transacted through DSM

The volume and price of electricity transacted through DSM is shown in Table-12 and Figure-7. It can be observed from the table that there was a declining trend in the volume of electricity transacted through DSM from 2010-11 to 2014-15 and there was an increasing trend from 2014-15 to 2016-17. However, the volume of DSM as percentage of total short-term volume declined to 19% in 2016-17 from 39% in 2009-10. It can also be observed from the table that the average price of DSM declined from ₹4.62/kWh in 2009-10 to ₹1.76/kWh in 2016-17. This was mainly due to changes in in DSM regulations.

Table-12: Volume and Price of Electricity transacted through DSM

Year	Volume of Electricity Transacted through DSM (BU)	Total Volume of Short term (BU)	Volume of DSM as % of total volume of Short term	Price of Electricity Transacted through DSM (₹/kWh)
2009-10	25.81	65.90	39%	4.62
2010-11	28.08	81.56	34%	3.91
2011-12	27.76	94.51	29%	4.09
2012-13	24.76	98.94	25%	3.86
2013-14	21.47	104.64	21%	2.05
2014-15	19.45	98.99	20%	2.26
2015-16	20.75	115.23	18%	1.93
2016-17	23.22	119.23	19%	1.76

Figure-7: Volume and Price of Electricity transacted through DSM

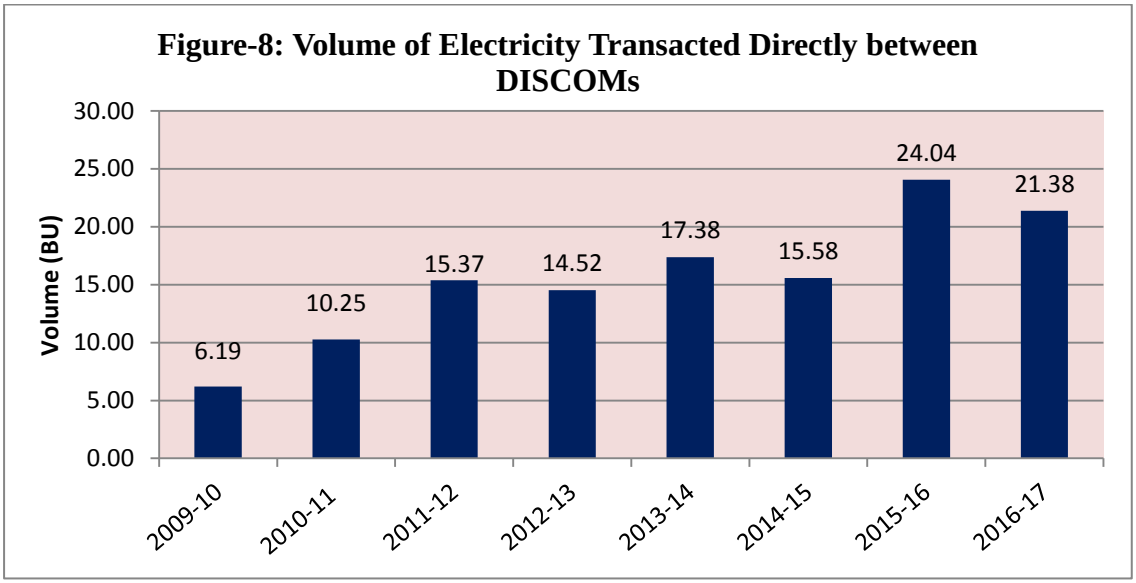


2.1.3 Electricity Transacted Directly Between DISCOMs

The volume of electricity transacted directly between DISCOMs is shown in Table-13 and Figure-8. It can be observed from the table that the volume of electricity transacted directly between DISCOMs increased from 6.19 BU in 2009-10 to 21.38 BU in 2016-17. It can also be observed that the share of electricity transacted directly between DISCOMs as percentage to total volume of short-term transaction of electricity also increased from 9% to 18% in the same period. In 2016-17, the volume of electricity transacted directly between DISCOMs as well as its share in total volume of short-term transaction of electricity declined.

Table-13: Volume of Electricity Transacted Directly between DISCOMs

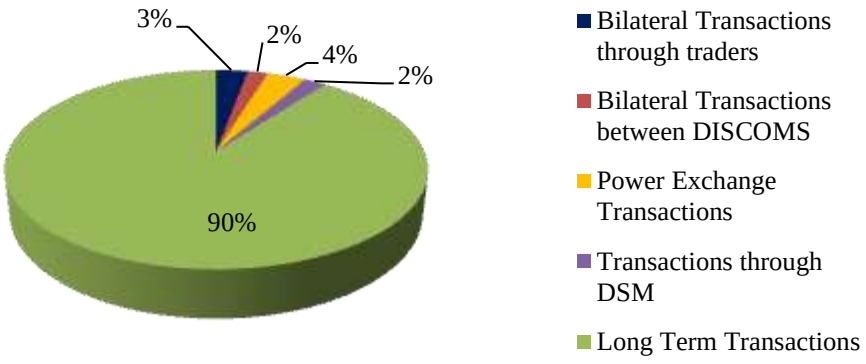
Year	Volume of Electricity Transacted Directly between DISCOMs (BU)	Total Volume of Short term (BU)	Volume of Bilateral Direct as % of total volume of Short term
2009-10	6.19	65.9	9%
2010-11	10.25	81.56	13%
2011-12	15.37	94.51	16%
2012-13	14.52	98.94	15%
2013-14	17.38	104.64	15%
2014-15	15.58	98.99	16%
2015-16	24.04	115.23	21%
2016-17	21.38	119.23	18%



3. Monthly Trends in Short-term Transactions of Electricity (April 2016-March 2017)

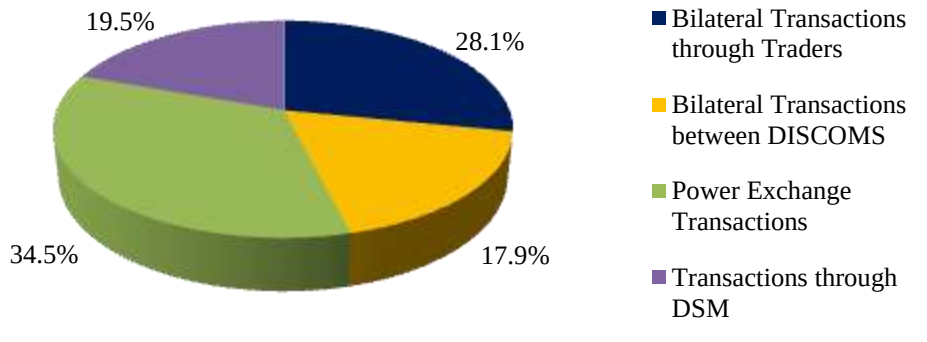
During 2016-17, the share of the total short-term transactions in volume terms, including DSM, as a percentage of total electricity generation in the country was about 10% (Figure-9 and Table-14).

Figure-9: Share of Market Segments in Total Electricity Generation, 2016-17



The share of different market segments within the total short-term transaction for the year 2016-17 has been shown in the Figure-10 below.

Figure-10: Share of Different Market Segments in Short Term Transactions, 2016-17



3.1 Volume of Short-term Transactions of Electricity

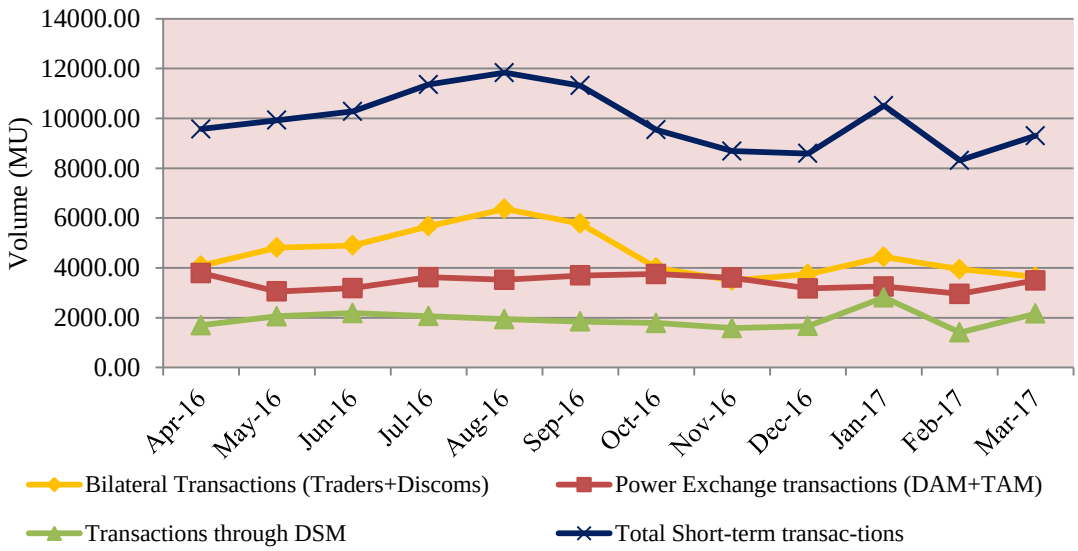
The volume of short-term transactions of electricity during different months of 2016-17 with break-up for different segments is shown in Table-14 and Figure-11.

Table-14: Volume of Short-term Transactions of Electricity (MU), 2016-17

Period	Bilateral through Traders	Bilateral between DISCOMS	Total Bilateral transac-tions	Power Exchange transac-tions (DAM+TAM)	Transactions through DSM	Total Short-term transac-tions	Total Electricity Generation
Apr-16	2324.21	1760.85	4085.06	3791.38	1698.65	9575.09	99393.01
May-16	3169.49	1644.04	4813.53	3054.70	2055.13	9923.36	99833.67
Jun-16	2976.24	1929.70	4905.94	3185.55	2188.93	10280.42	97254.66
Jul-16	3840.32	1832.50	5672.82	3627.96	2061.28	11362.06	94582.69
Aug-16	4241.68	2127.09	6368.77	3520.54	1945.12	11834.43	95275.93
Sep-16	3710.17	2064.20	5774.37	3694.65	1842.73	11311.75	97822.38
Oct-16	2208.89	1795.31	4004.20	3751.53	1786.77	9542.50	99706.83
Nov-16	1861.86	1635.81	3497.67	3608.55	1581.36	8687.58	93165.44
Dec-16	1891.60	1853.86	3745.46	3177.25	1665.16	8587.87	95019.55
Jan-17	2487.79	1954.80	4442.59	3252.76	2813.57	10508.92	95112.72
Feb-17	2709.54	1233.46	3943.00	2958.27	1410.32	8311.59	88972.84
Mar-17	2088.57	1547.67	3636.24	3499.53	2169.01	9304.78	101798.42
Total	**33510.36**	**21379.29**	**54889.65**	**41122.67**	**23218.03**	**119230.35**	**1157938.14**
% share in total genera-tion	**3%**	**2%**	**5%**	**4%**	**2%**	**10%**	**100%**
% share in Short-term Volume	**28.1%**	**17.9%**	**46.0%**	**34.5%**	**19.5%**	**100%**	

It is observed from Figure-11 that there is a cyclical trend in the monthly volume of short-term transactions of electricity. A similar trend is also observed in the volume of bilateral transations. It is also observed from the figure that the volume of all other segments of the short-term transactions of electricity reflect irregular trend.

Figure-11: Volume of Short-term Transactions of Electricity, 2016-17



The volume of short-term transactions of electricity as percentage of total electricity generation varied between 9.04% and 12.42% during the months from April 2016 to March 2017 (Table-15).

Table-15: Volume of Short-term Transactions of Electricity as % of Total Electricity Generation, 2016-17

Period	Short-term transactions as % of total electricity generation
Apr-16	9.63%
May-16	9.94%
Jun-16	10.57%
Jul-16	12.01%
Aug-16	12.42%
Sep-16	11.56%
Oct-16	9.57%
Nov-16	9.32%
Dec-16	9.04%
Jan-17	11.05%
Feb-17	9.34%
Mar-17	9.14%

There were 33 inter-state trading licensees as on 31.3.2017. Of the total, 25 trading licensees actively undertook trading during the year 2016-17 (Table-16).

The volume of electricity transacted through traders (traders inter-state bilateral transactions + traders transactions through Power Exchanges) has been analysed using the Herfindahl-Hirschman Index (HHI) for measuring competition among the traders (Table-16). Increase in the HHI generally indicates a decrease in competition and an increase of market power, whereas decrease indicates the opposite. HHI value below 0.15 indicates unconcentration of market power, the value between 0.15 to 0.25 indicates moderate concentration, the value above 0.25 indicates high concentration of market power. The HHI, based on the volume of electricity transacted through traders during 2016-17 was 0.1534, which indicates moderate concentration of market power among the traders.

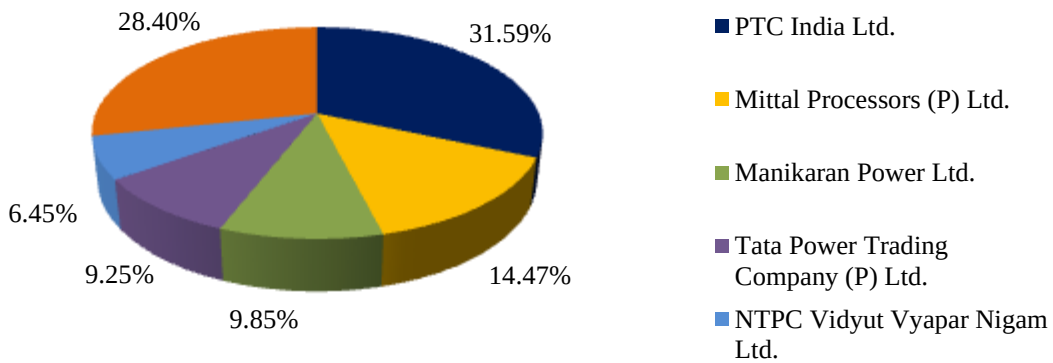
Table-16: Share of Electricity Transacted by Traders and HHI, 2016-17

Sr No	Name of the Trading Licensee	Share of Electricity transacted by Traders in 2016-17	Herfindahl-Hirschman Index (HHI)
1	PTC India Ltd.	31.59%	0.0998
2	Mittal Processors (P) Ltd.	14.47%	0.0209
3	Manikaran Power Ltd.	9.85%	0.0097
4	Tata Power Trading Company (P) Ltd.	9.25%	0.0085
5	NTPC Vidyut Vyapar Nigam Ltd.	6.45%	0.0042
6	Adani Enterprises Ltd.	5.67%	0.0032
7	Arunachal Pradesh Power Corporation (P) ltd	5.21%	0.0027
8	GMR Energy Trading Ltd.	4.35%	0.0019
9	JSW Power Trading Company Ltd	3.43%	0.0012
10	Knowledge Infrastructure Systems (P) Ltd	2.12%	0.0005
11	Jaiprakash Associates Ltd.	2.05%	0.0004
12	National Energy Trading & Services Ltd.	1.14%	0.0001
13	RPG Power Trading Company Ltd.	0.87%	0.0001
14	Instinct Infra & Power Ltd.	0.73%	0.0001
15	Statkraft Markets Pvt. Ltd.	0.63%	0.0000
16	My Home Power Private Ltd.	0.51%	0.0000
17	Shree Cement Ltd.	0.47%	0.0000
18	Customized Energy Solutions India (P) Ltd.	0.30%	0.0000
19	Gita Power & Infrastructure Private Ltd	0.27%	0.0000
20	Essar Electric Power Development Corp. Ltd.	0.18%	0.0000

21	Parshavanath Power Projects (P) Ltd.	0.11%	0.0000
22	Shyam Indus Power Solutions (P) Ltd.	0.11%	0.0000
23	Phillip Commodities India Pvt Ltd	0.10%	0.0000
24	IPCL Power trading Private Ltd	0.08%	0.0000
25	Ambitious Power Trading Company Ltd.	0.07%	0.0000
Total Volume		100.00%	**0.1534**
Share of the Top 5 Traders		**71.60%**	
Note: Percentage share in total volume traded by Licensees in 2016-17 computed based on the volume which includes the volume traded by inter-state trading licensees through bilateral and power exchanges.			
Source: Information submitted by Trading Licensees.			

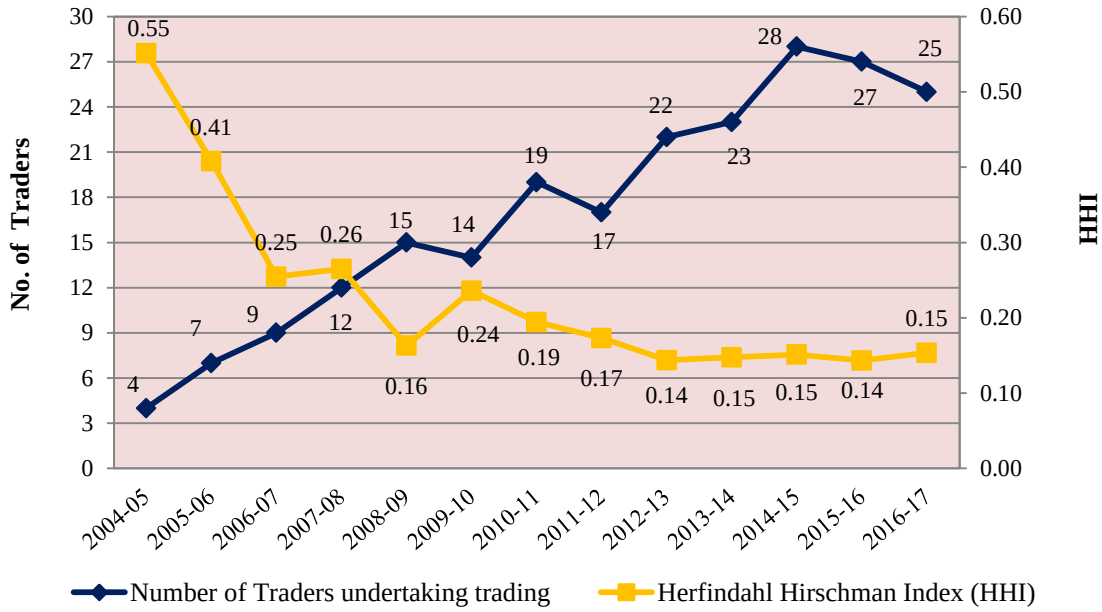
The percentage share of electricity transacted by major traders in the total volume of electricity transacted by all the traders is shown in Figure-12.

Figure-12: Share of Electricity Transacted by Traders, 2016-17



Competition among the traders (HHI based on volume of trade undertaken by the traders) is shown in Figure-13 for the period 2004-05 to 2016-17. Number of traders, who were undertaking trading bilaterally or through power exchanges or through both, increased from 4 in 2004-05 to 25 in 2016-17. It can be observed from the figure that there is an inverse relationship between number of traders and the HHI. The concentration of market power declined from high concentration (HHI of 0.55) in 2004-05 to moderate concentration (HHI of 0.15) in 2016-17. The competition among the traders resulted in increase in volume and decrease in prices in the short-term bilateral market (Table-10).

Figure-13: Concentration of Market Power: Number of traders and HHI, 2004-05 to 2016-17



3.2 Price of Short-term Transactions of Electricity

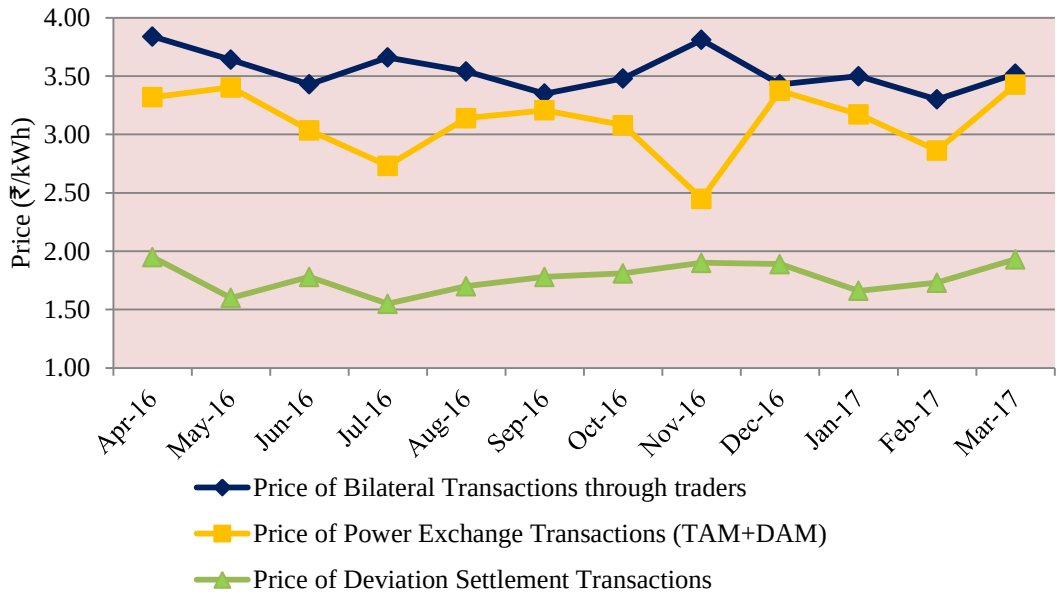
The monthly trends in price of short-term transactions of electricity are shown in Table-17 and Figure-14&15. The price analysis is mainly based on the average price of DSM and the weighted average price of other short-term transactions of electricity. The price of bilateral trader transactions represents the price of electricity transacted through traders. The trends in price of electricity transacted through traders(bilateral trader transactions) were studied separately for total transactions as well as for the transactions undertaken during Round the Clock (RTC), Peak and Off-peak periods.

Table-17: Price of Short-term Transactions of Electricity (₹/KWh), 2016-17

Period	Bilateral through Traders				Power Exchange		DSM
	RTC	Peak	Off-peak	Total	IEX	PXIL	All India Grid
Apr-16	3.91	2.99	3.14	3.84	2.93	2.73	1.95
May-16	3.7	3.4	3.08	3.64	2.45	2.61	1.60
Jun-16	3.5	-	2.76	3.43	2.42	2.31	1.78
Jul-16	3.68	2.58	2.33	3.66	2.19	2.33	1.55
Aug-16	3.8	3.65	2.57	3.54	2.19	2.14	1.70
Sep-16	3.66	2.99	2.85	3.35	2.50	2.39	1.78

Oct-16	3.64	3.15	3.05	3.48	2.43	1.97	1.81
Nov-16	3.98	-	2.92	3.81	2.48	2.84	1.90
Dec-16	3.49	4.37	2.75	3.43	2.37	3.01	1.89
Jan-17	3.80	4.19	2.81	3.50	2.57	2.65	1.66
Feb-17	3.37	4.11	2.74	3.30	2.64	2.69	1.73
Mar-17	3.65	3.04	2.78	3.52	2.65	2.80	1.93

Figure-14: Comparison of prices of Bilateral, Power Exchange and DSM Transactions in 2016-17



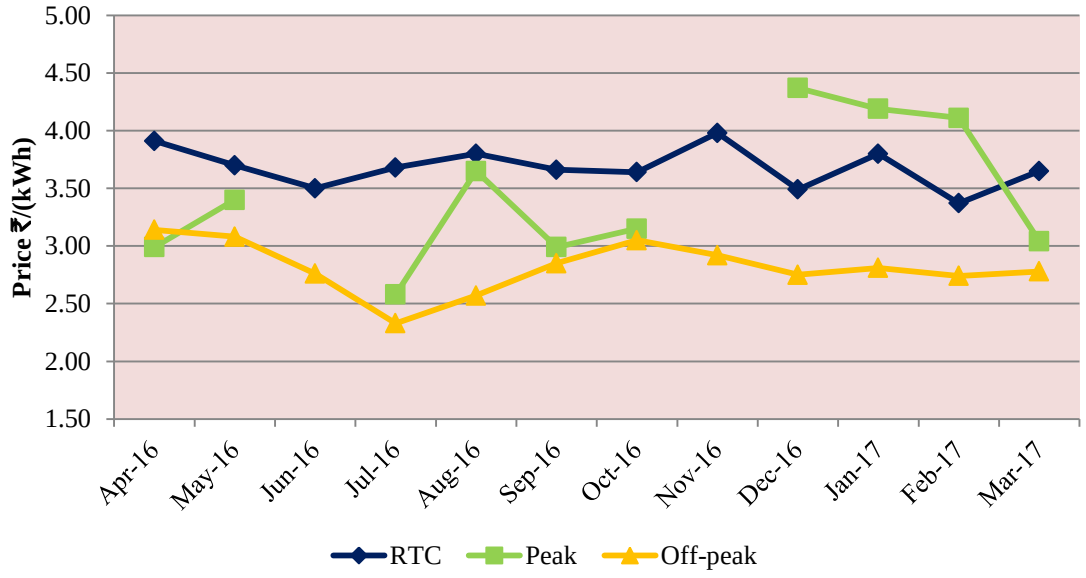
It can be observed from the above figure that the price of electricity transacted through traders was relatively high when compared with the price of electricity transacted through power exchanges and DSM during all the months in 2016-17[5] The price of electricity transacted through power exchanges was relatively high when compared with the price of electricity transacted through DSM.

The trends in price of electricity transacted by traders during RTC, Peak and Off-peak periods are shown in Table-17 & Figure-15. It can be observed from the figure that the price of electricity during peak period was higher in December 2016, January 2017 and February 2017 when compared with the price during RTC and off

[5] The comparison between the price of power exchanges and the price of bilateral transactions should also be seen in the light that the delivery point for transactions of power exchanges is the periphery of regional transmission system in which the grid connected entity is located whereas the delivery point for bilateral transactions may vary from transaction to transaction. The delivery point may be state or regional periphery or any other point as per the contract executed.

peak periods. The price of electricity during RTC was relatively high in all the months when compared with the price during off peak period.

Figure-15: Price of Electricity Transacted through Traders during Round the Clock, Peak and Off Peak periods

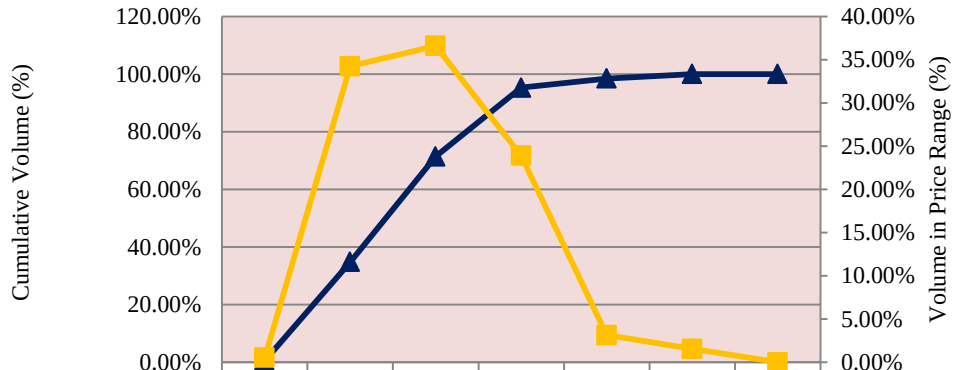


3.3 Volume of Electricity Transacted in Various Price Slabs

Volume of electricity transacted in various price slabs is shown for bilateral trader segment and power exchange segment separately. In the case of power exchanges, Day Ahead Market sub-segment has been considered.

Volume of bilateral transactions at different price slabs in 2016-17 is depicted in Figure -16. The figure shows that 71% of the volume of electricity was transacted through traders at less than ₹4/kWh and 98% of the volume was transacted through traders at less than ₹6/kWh.

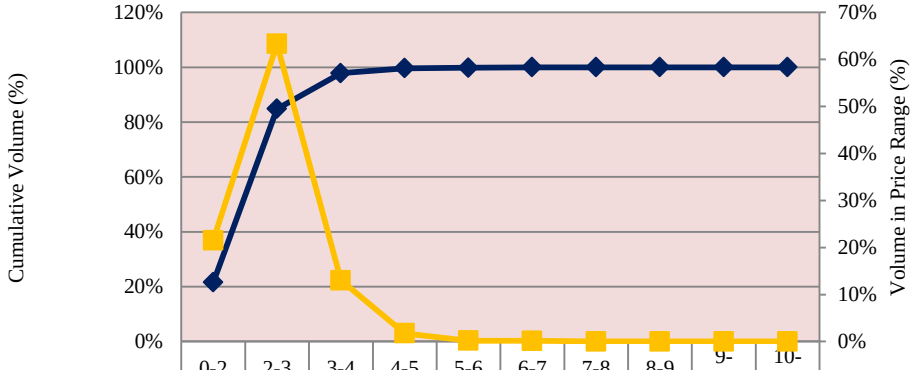
Figure-16: Volume of Bilateral Transactions at different Price Slabs, 2016-17



	0-2	2-3	3-4	4-5	5-6	6-7	7-8
Cumulative Volume (%)	0.56%	34.80%	71.39%	95.30%	98.45%	100.00%	100.00%
Volume in Price Range (%)	0.56%	34.24%	36.59%	23.90%	3.15%	1.55%	0.00%

Volume of IEX transactions at different price slabs in 2016-17 is depicted in Figure -17. The figure shows that 98% of the volume of electricity was transacted through IEX at less than ₹4/kWh and 100% of the volume was transacted through IEX at less than ₹6/kWh.

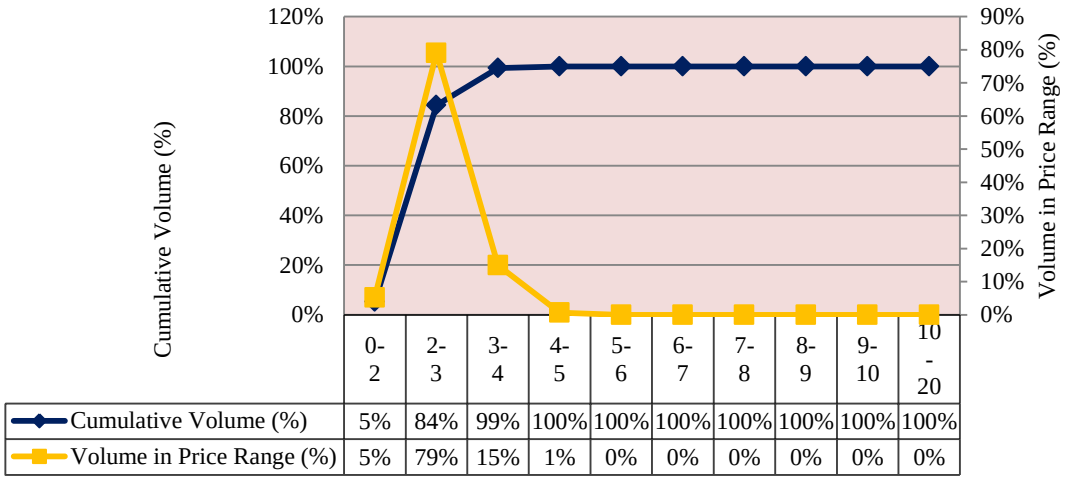
Figure-17: Volume of IEX Transactions at different Price Slabs, 2016-17



	0-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-20
Cumulative Volume (%)	22%	85%	98%	100%	100%	100%	100%	100%	100%	100%
Volume in Price Range (%)	22%	63%	13%	2%	0%	0%	0%	0%	0%	0%

Volume of PXIL transactions at different price slabs in 2016-17 is depicted in Figure -18. The figure shows that 99% of the volume of electricity was transacted through PXIL at less than ₹4/kWh and 100% of the volume was transacted through PXIL at less than ₹6/kWh.

Figure-18: Volume of PXIL Transactions at different Price Slabs, 2016-17



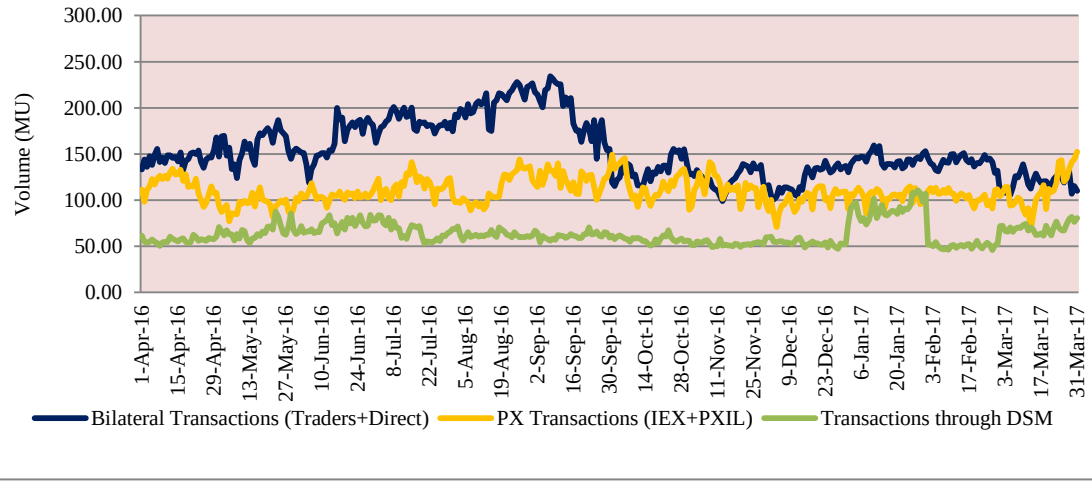
	0-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-20
Cumulative Volume (%)	5%	84%	99%	100%	100%	100%	100%	100%	100%	100%
Volume in Price Range (%)	5%	79%	15%	1%	0%	0%	0%	0%	0%	0%

4. Daily Trends in Short-term Transactions of Electricity (1st April 2016 to 31st March 2017)

4.1 Volume of Short-term Transactions of Electricity

Trends in daily volume of short-term transactions are shown in Figure-19. It can be observed from the figure that there was a cyclical trend in the volume of electricity transacted through bilateral transactions during 2016-17. It can also be observed that there was irregular trend in the volume of electricity transacted through power exchanges and through DSM during the year.

Figure-19: Volume of Short-term Transactions of Electricity, 2016-17



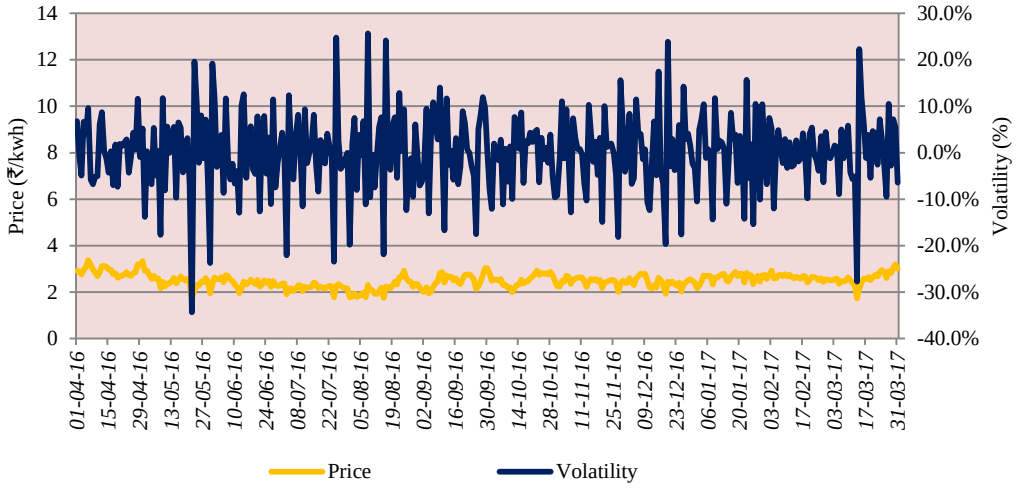
4.2 Price of Short-term Transactions of Electricity

Trends in daily price of short-term transactions have been illustrated in this section for power exchanges and DSM.

4.2.1 Trends in Price of Electricity Transacted through Power Exchanges

The weighted average price of electricity transacted through IEX and its volatility is shown in Figure-20. Volatility in the Price of electricity transacted through IEX has been computed using daily data for 2016-17 and it works out to 8.17%. (See Annexure-II for historic volatility formula).

Figure-20: Price and its Volatility in IEX during 2016-17



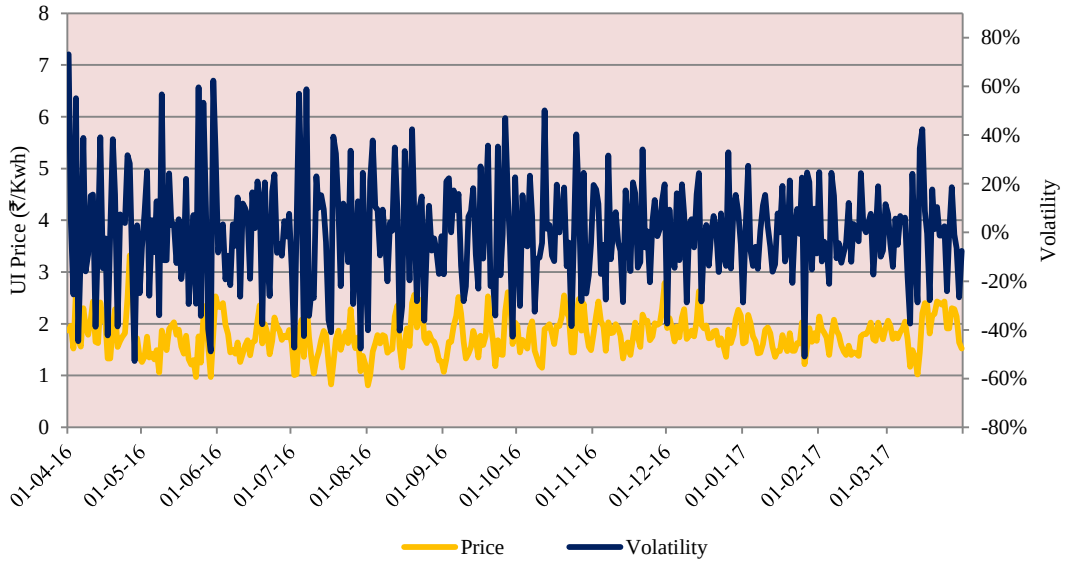
The weighted average price of electricity transacted through PXIL and its volatility is shown in Figure-21. Volatility in the price of electricity transacted through PXIL has been computed using daily data for 2016-17 and it works out to 8.11%.

Figure-21: Price and its Volatility in PXIL during 2016-17

4.2.2 *Trends in Price of Electricity Transacted through DSM*

The average price of electricity transacted through DSM and its volatility is shown in Figure-22. Volatility in the price of electricity transacted through DSM has been computed using daily data for 2016-17 and it works out 21.52%.

Figure-22: Price and its Volatility in DSM during 2016-17



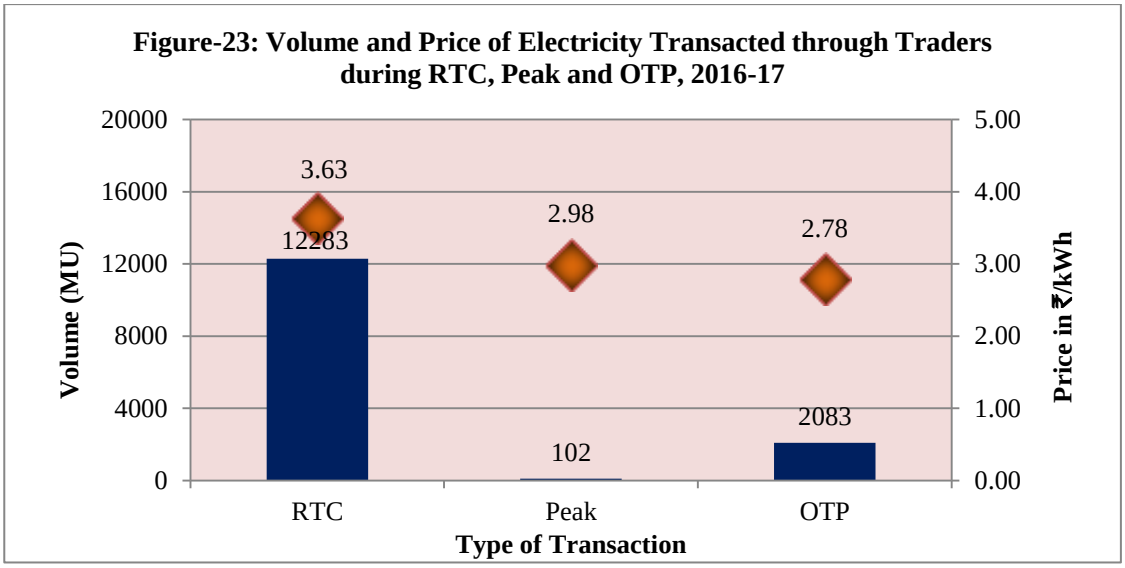
5. Time of the Day Variation in Volume and Price of Electricity Transacted through Traders and Power Exchanges

In this section, time of the day variation in volume and price of electricity transacted through traders has been illustrated for RTC (Round the Clock), Peak period and other than RTC & Peak period. Time of the day variation in volume and price of electricity transacted through power exchanges is shown block-wise. Price of electricity transacted through power exchanges is also shown region-wise and block-wise.

5.1 Time of the Day Variation in Volume and Price of Electricity Transacted through Traders

Time of the day variation in volume and price of electricity transacted through bilateral traders' transactions during 2016-17 is shown in Figure-23. The volume of electricity transacted through traders represent inter-state transactions i.e. excluding banking transactions. Time of the day variation in volume is shown during RTC (Round the Clock), Peak period and OTP (other than RTC & Peak period). Of the total volume, 85% was transacted during RTC followed by 14% during OTP, and 1% during peak period. It can be observed from the figure that there is hardly any volume transacted during peak period. It can also be observed that the weighted average price during RTC is high (₹3.63/kWh), when compared with the price during Peak period (₹2.98/kWh) and OTP (₹2.78/kWh).

Figure-23: Volume and Price of Electricity Transacted through Traders during RTC, Peak and OTP, 2016-17



5.2 Time of the Day Variation in Volume and Price of Electricity Transacted through Power Exchanges

Time of the day variation in volume and price of electricity transacted through IEX and PXIL (Day ahead market) during 2016-17 are shown block-wise in Figure-24 and Figure-25. It can be observed from the figure that the weighted average price in both the power exchanges was higher during peak period (between hours 18:00 to 23:00), when compared to the weighted average price in rest of the hours.

Figure-24: Block-wise Market Clearing Volume and Price in IEX during 2016-17

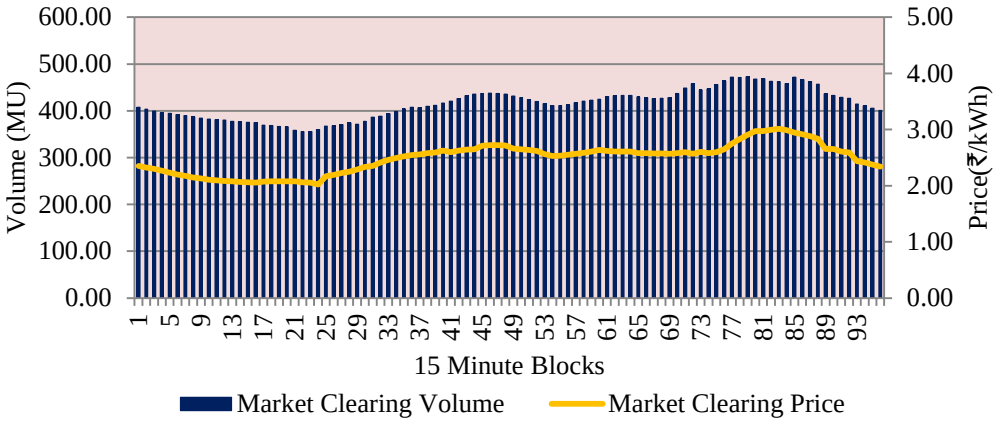
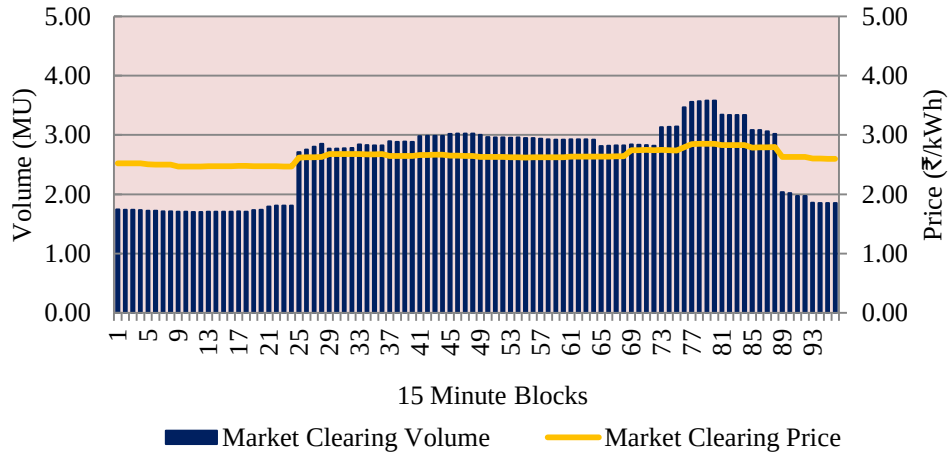


Figure-25: Block-wise Market Clearing Volume and Price in PXIL during 2016-17



Region-wise and hour-wise prices of electricity transacted through power exchanges are shown in Figure-26 and Figure-27. It can be observed from the figures that during 2016-17, the price of electricity in Southern region (S2 and S3 regions) was relatively high when compared with the price in other regions in both the power exchanges. It can also be observed that in the evening peak period, the price in the Southern region was even much higher in both the power exchanges when compared with other regions. This is mainly due to high demand for electricity in the southern region. The prices were high due to congestion between southern region and rest of the regions, accompanied by market splitting on the power exchanges.

Figure-26: Region-wise and Block-wise Price of Electricity Transacted through IEX, 2016-17

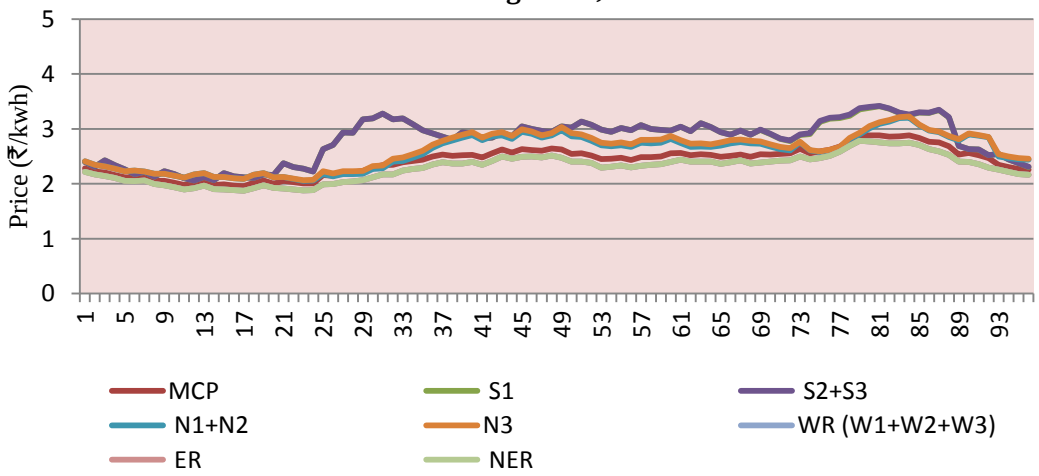
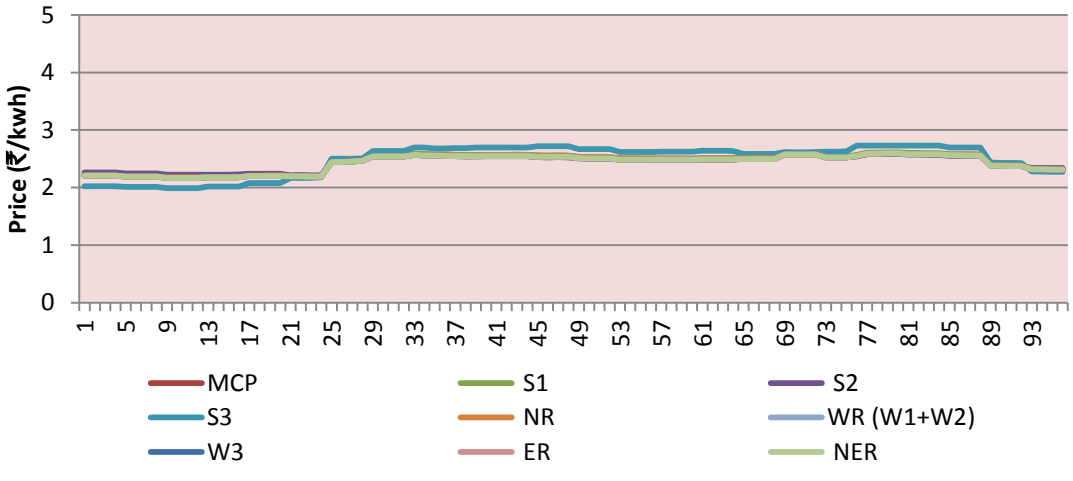


Figure-27: Region-wise and Block-wise Price of Electricity Transacted through PXIL, 2016-17



6. Trading Margin Charged by Trading Licensees

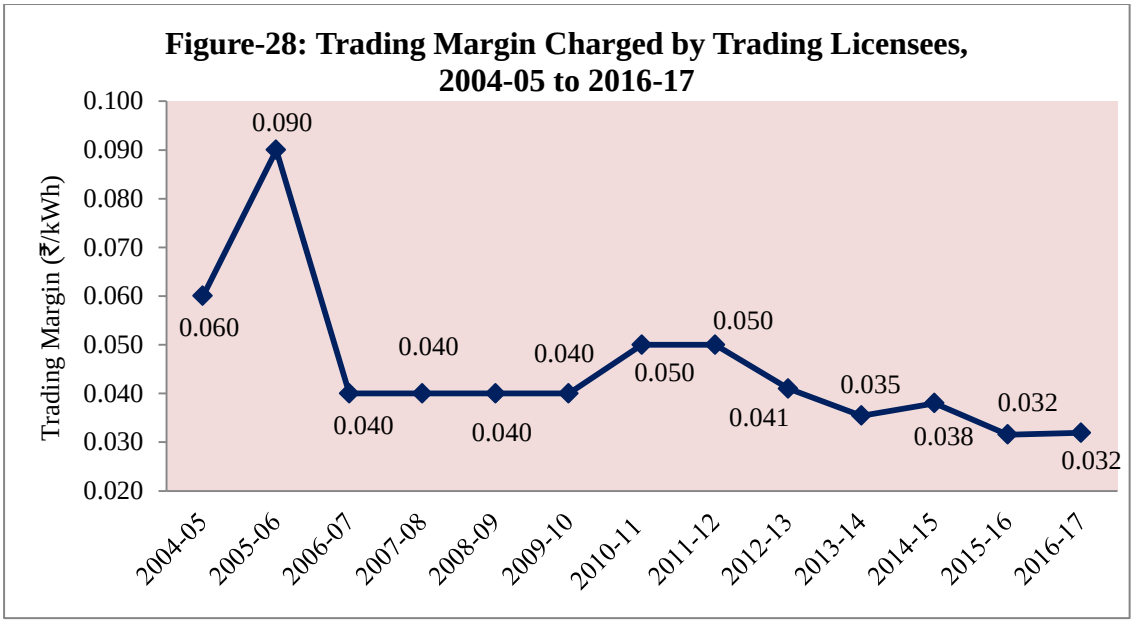
During the year 2004-05 (when trading started through licensees), the licensees voluntarily charged 5 paise/kWh or less as the trading margin for bilateral transactions. However, trading margin increased in 2005 and the weighted average trading margin charged by the licensees went up to 10 paise/kWh during April to September 2005 period. This has lead to regulate the margin and the trading margin was fixed at 4 paise/kWh vide "CERC (Fixation of Trading Margin) Regulations" notification dated 26.1.2006. As a result of these trading margin regulations, the licensees charged trading margin of 4 paise or less from 26.1.2006 onwards until revised Trading Margin Regulations, 2010 came into existence on 11.1.2010 (Table-18 & Figure-28).

Based on feedback and experience gained from 2006 Regulations and considering various risks associated with the electricity trading business, CERC revised the trading margin in 2010. As per the CERC (Fixation of Trading Margin) Regulations, 2010, the trading licensees are allowed to charge trading margin up to 7 paise/kWh in case the sale price exceeds ₹3/kWh, and 4 paise/kWh where the sale price is less than or equal to ₹3/kWh. The trading licensees have been charging the trading margin accordingly, and weighted average trading margin for bilateral transactions during 2004-05 to 2016-17 is given in Table-18.

Table -18: Trading Margin Charged by Trading Licensees, 2004-05 to 2016-17

Period	Trading Margin (₹/kWh)
2004-05	0.06
2005-06	0.09
2006-07	0.04
2007-08	0.04
2008-09	0.04
2009-10	0.04
2010-11	0.05
2011-12	0.05
2012-13	0.04
2013-14	0.04
2014-15	0.04
2015-16	0.03

2016-17	0.03
Note 1: Weighted Average Trading Margin is computed based on all Inter-state Trading Transactions excluding Banking Transactions	



Weighted average trading margin charged by the trading licensees for bilateral transactions for different sale price ranges during 2016-17 is provided in Table-19 below.

Table -19: Trading Margin Charged by Trading Licensees, 2016-17

Sale Price of Electricity Transacted by Trading Licensees(₹/kWh)	Weighted Average Trading Margin Charged by Trading Licensees(₹/kWh)
When Sale Price is less than or Equal to ₹3/kWh	0.024
When Sale Price is greater than ₹3/kWh	0.036
Note 1: Weighted Average Trading Margin is computed based on all Inter-state Trading Transactions excluding Banking Transactions	

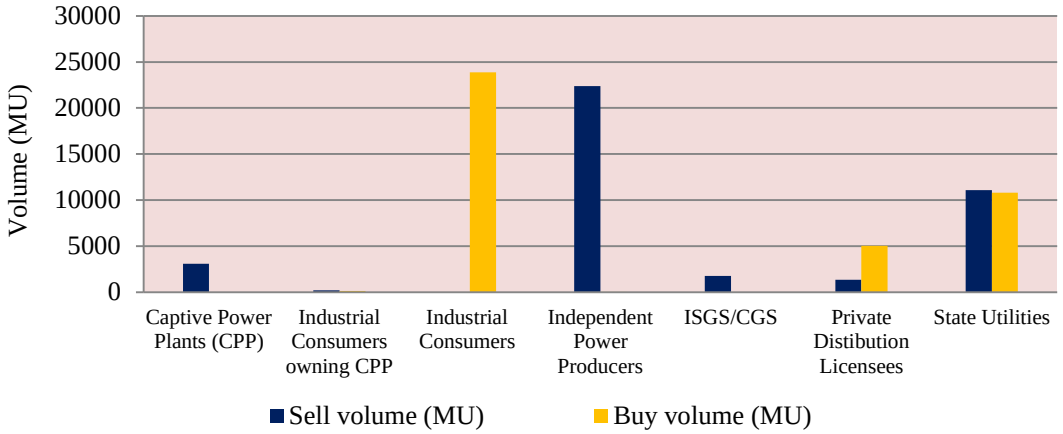
7. Open Access Consumers on Power Exchanges

This section contains analysis of various types of participants and analysis of open access consumers in day ahead market of power exchanges.

7.1 Types of Participants on Power Exchanges

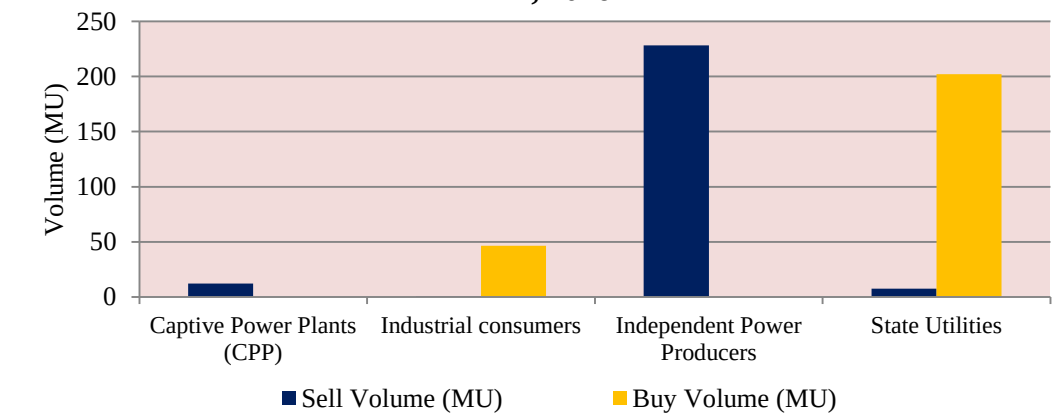
There are seven types of participants in IEX, as shown in Figure-29. It can be observed from the figure that major sellers of electricity through IEX were independent power producers followed by state utilities, and captive power plants. It can also be observed that major buyers of electricity through IEX were industrial consumers followed by state utilities, and private distribution licensees.

Figure-29: Sell and Buy Volume of Various Types of Participants in IEX, 2016-17



There are four types of participants in PXIL, as shown in Figure-30. It can be observed from the figure that major sellers of electricity through PXIL were Inddpendent Power Producers. It can also be observed that major buyers of electricity through PXIL were state utilities and industrial consumers.

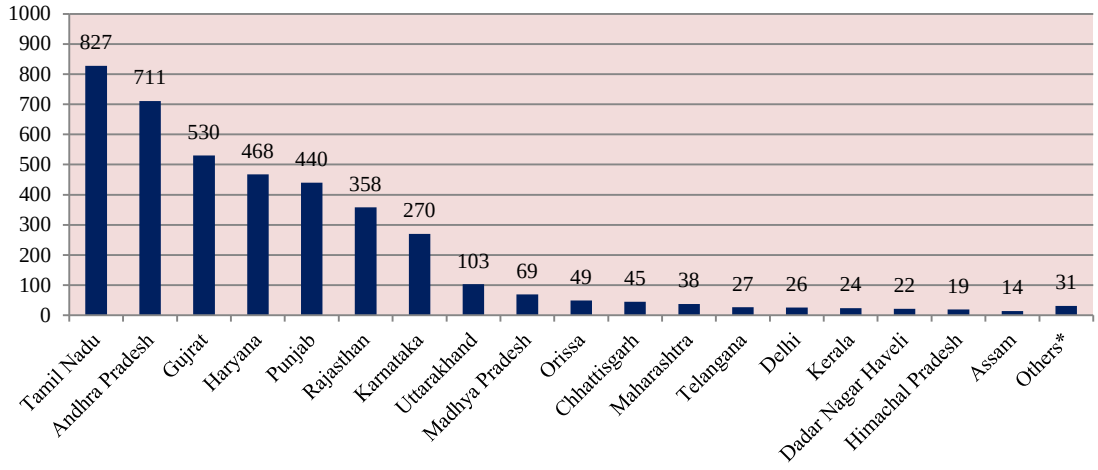
Figure-30: Sell and Buy Volume of Various Types of Participants in PXIL, 2016-17



7.2 Analysis of Open Access Consumers on Power Exchanges

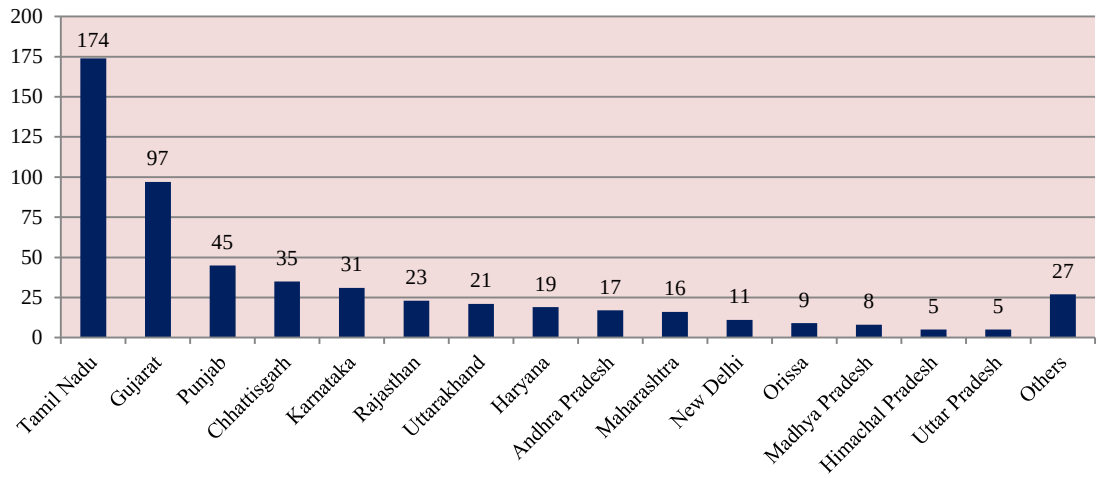
The year 2010-11 witnessed collective open access transactions, a significant development in procurement of power by the industrial consumers through power exchanges. It can be observed that 4071 Open Access (OA) Consumers were procuring part of their power requirements through IEX at the end of March 2017. These consumers were mostly located in Tamil Nadu, Andhra Pradesh, Gujarat, Haryana, Punjab, Rajasthan, Karnataka and Uttarakhand (Figure-31). During the year 2016-17, these OA consumers procured 24000MU of electricity through IEX. In 2016-17, the weighted average price of electricity bought by OA consumers at IEX was lower (₹2.43/kWh) when compared to the weighted average price of total electricity transacted through IEX (₹2.48/kWh).

Figure-31: State-wise Number of Open Access Consumers in IEX as on March, 2017



About 542 OA consumers procured a part of their power requirements through PXIL. These consumers were mostly located in Tamil Nadu, Gujarat and Punjab (Figure-32). During the year, these OA consumers procured about 44MU of electricity through PXIL. In 2016-17, the weighted average price of electricity bought by open access consumers at PXIL was lower (₹2.29/kWh) when compared to the weighted average price of total electricity transacted through PXIL (₹2.56/kWh).

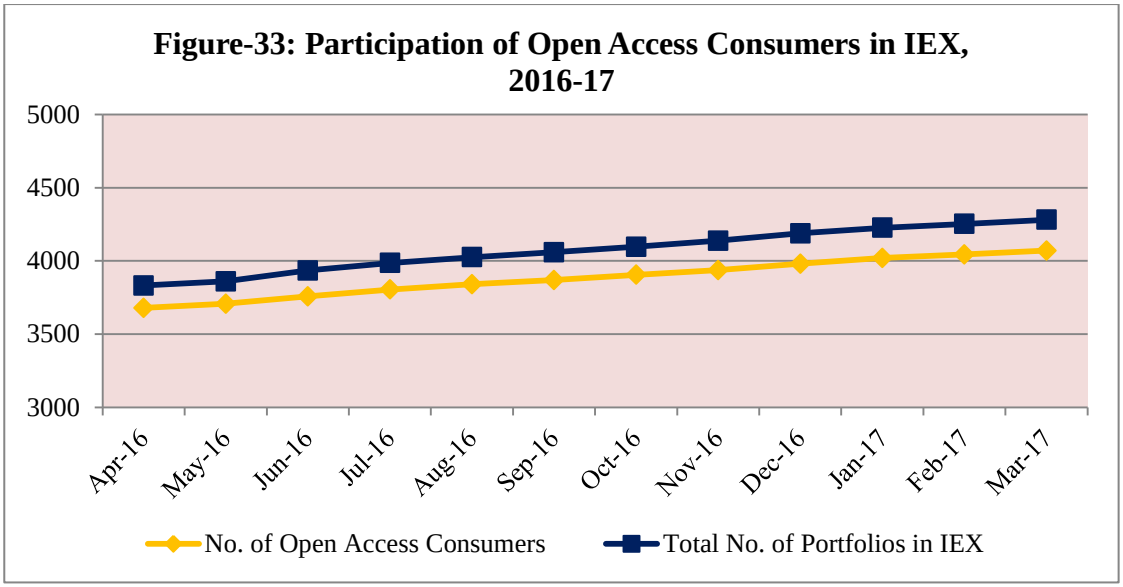
Figure-32: State-wise Number of Open Access Consumers in PXIL as on March, 2017



In Table-20 & Figure-33, a month-wise comparison is made between the number of OA consumer participants and the total number of portfolios in IEX. It can be seen that the number of OA consumers as a percentage of total number of portfolios in IEX was varying from 95.06% to 96.01% during 2016-17. It can be observed from the figure that there is an increasing trend in the number of OA consumers and total number of portfolios in IEX.

Table-20: Number of Open Access Consumers in IEX, 2016-17

Month	No. of Open Access Consumers	Total No. of Portfolios in IEX	% of Open Access Consumers
Apr-16	3679	3832	96.01%
May-16	3707	3861	96.01%
Jun-16	3758	3935	95.50%
Jul-16	3805	3986	95.46%
Aug-16	3841	4026	95.40%
Sep-16	3869	4059	95.32%
Oct-16	3905	4097	95.31%
Nov-16	3937	4138	95.14%
Dec-16	3981	4188	95.06%
Jan-17	4020	4227	95.10%
Feb-17	4044	4253	95.09%
Mar-17	4071	4281	95.09%

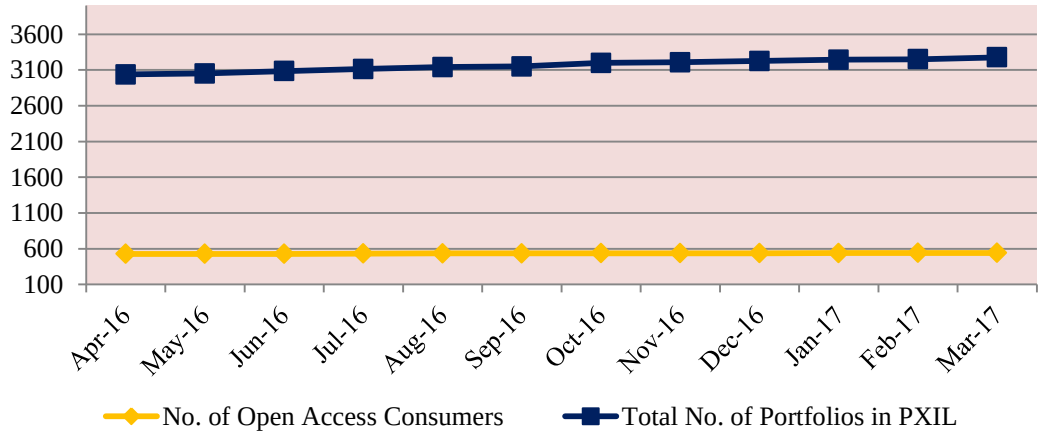


In Table-21 & Figure-34, month-wise comparison is made between the number of OA consumer participants and the total number of portfolios in PXIL. It can be seen that the number of OA consumers as a percentage of total number of portfolios in PXILwas varying from 16.54% to 17.39% during 2016-17. It can be observed from the figure that there is an increasing trend in the number of OA consumers and total number of portfolios in PXIL.

Table-21: Number of Open Access Consumers in PXIL, 2016-17

Month	No. of Open Access Consumers	Total No. of Portfolios in PXIL	% of Open Access Consumers
Apr-16	528	3037	17.39%
May-16	528	3051	17.31%
Jun-16	529	3085	17.15%
Jul-16	532	3114	17.08%
Aug-16	534	3141	17.00%
Sep-16	534	3151	16.95%
Oct-16	537	3199	16.79%
Nov-16	538	3209	16.77%
Dec-16	538	3227	16.67%
Jan-17	540	3243	16.65%
Feb-17	542	3250	16.68%
Mar-17	542	3277	16.54%

Figure-34: Participation of Open Access Consumers in PXIL, 2016-17

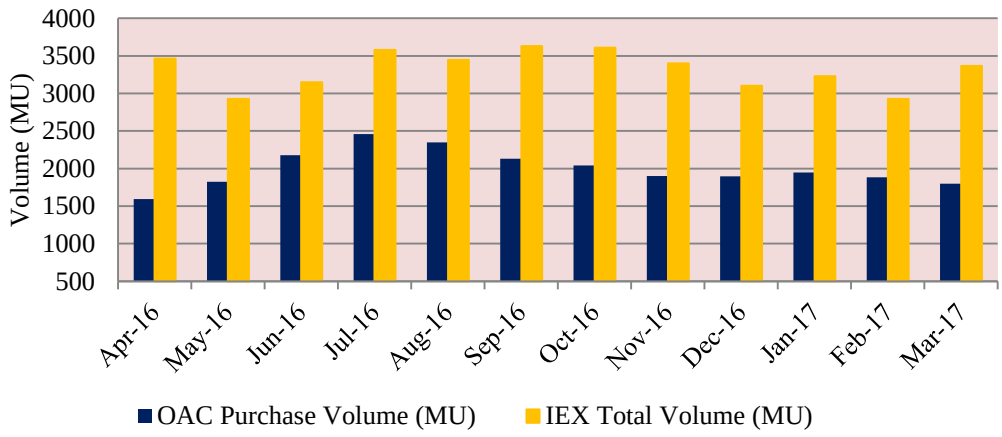


In Table-22 & Figure-35, month-wise comparison is shown between purchase volume of OA consumers and total volume of IEX. During 2016-17, volume of electricity procured by OA consumers as a percentage of total volume transacted in IEX was varying from 46.04% to 69.15%. For the year as a whole, the volume procured by OA consumers as a percentage of total volume transacted in IEX was 60.25%.

Table-22: Volume of Purchase by Open Access Consumers in Day Ahead Market oF IEX, 2016-17

Month	OAC Purchase Volume (MU)	IEX Total Volume (MU)	% OAC Purchase Participation
Apr-16	1595.52	3465.19	46.04%
May-16	1822.61	2928.71	62.23%
Jun-16	2176.27	3146.96	69.15%
Jul-16	2457.84	3580.52	68.64%
Aug-16	2348.28	3445.12	68.16%
Sep-16	2132.68	3630.34	58.75%
Oct-16	2040.12	3609.46	56.52%
Nov-16	1902.12	3401.42	55.92%
Dec-16	1895.69	3101.03	61.13%
Jan-17	1946.32	3230.61	60.25%
Feb-17	1885.3	2926.89	64.41%
Mar-17	1797.02	3364.41	53.41%
Total	**23999.77**	**39830.66**	**60.25%**

Figure-35: Open Access Consumer Purchase Volume and Total Volume in IEX, 2016-17

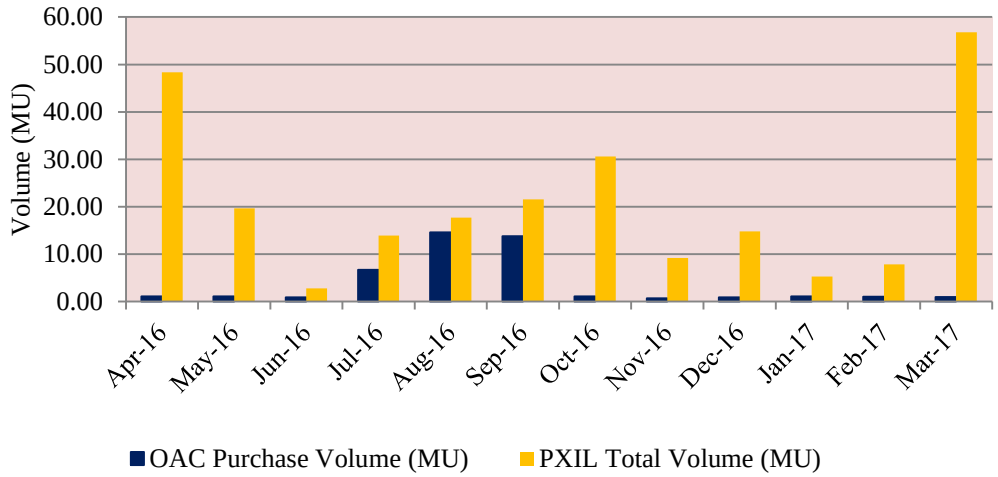


In Table-23 & Figure-36, month-wise comparison is shown between purchase volume of OA consumers and total volume of PXIL. During 2016-17, volume of electricity procured by OA consumers as a percentage of total volume transacted in PXIL was varying between 1.77% and 82.73%. For the year as a whole, the volume procured by OA consumers as a percentage of total volume transacted in PXIL was 17.73%.

Table-23: Volume of Purchase by Open Access Consumers in Day Ahead Market of PXIL, 2016-17

Month	OAC Purchase Volume (MU)	PXIL Total Volume (MU)	% OAC Purchase Participation
Apr-16	1.08	48.37	2.23%
May-16	1.12	19.66	5.68%
Jun-16	0.92	2.81	32.87%
Jul-16	6.72	13.96	48.16%
Aug-16	14.63	17.69	82.73%
Sep-16	13.77	21.57	63.85%
Oct-16	1.11	30.59	3.62%
Nov-16	0.68	9.23	7.39%
Dec-16	0.93	14.78	6.28%
Jan-17	1.07	5.26	20.42%
Feb-17	1.01	7.84	12.86%
Mar-17	1.00	56.76	1.77%
Total	**44.06**	**248.54**	**17.73%**

Figure-36: Open Access Consumer Purchase Volume and Total Volume in PXIL, 2016-17



8. Major Sellers and Buyers of Electricity in the Short-term market

Table-24 and Table-25 show top 10 sellers and buyers of electricity through traders(bilateral trader segment transactions). The same data for IEX is shown in Table-26 and Table-27, and for PXIL in Table-28 and Table-29. It can be seen that the dominant sellers, both at the power exchanges and traders, are a mixed group comprising of independent power producers, distribution companies, and state government agencies. The major buyers from traders and at the power exchanges are mostly state distribution companies and industrial consumers.

Table 24: Major Sellers of Electricity through Traders, 2016-17

S.No.	Seller	State	Volume (MU)	Approximate Percentage of total volume transacted through Traders	Weighted Average Sale Price ₹/kWh
1	Jaypee Nigrie STPP	Madhya Pradesh	2051.57	14.14%	2.87
2	HPSEB	Himachal Pradesh	1778.54	12.26%	4.40
3	Adani Power Ltd	Gujarat	1118.40	7.71%	3.17
4	KWPCL	Chhattisgarh	1011.57	6.97%	2.65

5	Sembcorp Gayatri Power Ltd	Andhra Pradesh	685.97	4.73%	4.10
6	GMR Chhattisgarh Energy Ltd	Chhattisgarh	667.89	4.60%	2.88
7	IL&FS Tamil Nadu Power Company Ltd	Tamil Nadu	498.07	3.43%	4.00
8	Karcham Wangtoo Hydro Electric Plant	Himachal Pradesh	494.63	3.41%	3.54
9	DB Power Ltd	Chhattisgarh	454.15	3.13%	2.82
10	Jindal Power Ltd	Madhya Pradesh	435.56	3.00%	2.95
Note : Volume sold by major sellers and total volume transacted through traders does not include the volume through banking arrangement					

Table 25: Major Buyers of Electricity through Traders, 2016-17

S.No.	Buyer	State	Volume (MU)	Approximate percentage of total volume transacted through traders	Weighted Avearage Purchase Price (₹/kWh)
1	Haryana Power Purchase Centre	Haryana	1613.12	11.12%	4.32
2	Punjab State Power Corporation Limited	Punjab	1268.53	8.74%	3.27
3	WBSEDCL	West Bengal	1126.95	7.77%	2.76
4	TSPCC	Telangana	1021.34	7.04%	4.70
5	Nepal Electricity Authority	Nepal	768.09	5.29%	3.25
6	BSPHCL	Bihar	718.08	4.95%	2.75
7	Chhatisgarh State Power Distribution Co. Ltd.	Chattisgarh	671.81	4.63%	2.67
8	Uttar Pradesh Power Corporation Limited	Uttar Pradesh	660.02	4.55%	3.15
9	Tamil Nadu Generation & Distribution Company	Tamil Nadu	645.60	4.45%	3.89
10	Noida Power Company Limited	Uttar Pradesh	615.71	4.24%	3.71
Note : Volume Bought by major buyers and total volume transacted through traders does not include the volume through banking arrangements					

From Table-25, it can be seen that the weighted average purchase prices of electricity of major buyers such as Haryana Power Purchase Centre, Telangana SPCC, Tamilnadu Generation & Distribution Company and NPCL from traders (bilateral transactions) were higher than the weighted average price for the entire bilateral trader segment (₹3.53/kWh).

Table-26: Major Sellers of Electricity in the Day Ahead Market of IEX, 2016-17

S.No.	Name of Seller	State/ Regional Entity	Sell Volume (MU)	Percentage of the Total Volume Transacted in IEX	Weighted Average Sell Price (₹/KWh)
1	JITPL	Odisha	3142.30	7.89%	2.37
2	MPPMCL	Madhya Pradesh	2621.48	6.58%	2.45
3	GOHP	Himachal Pradesh	2168.01	5.44%	2.54
4	Jindal Power Ltd	Regional Entity	1999.02	5.02%	2.34
5	DB Power Ltd	Regional Entity	1965.04	4.93%	2.40
6	Karcham Wangtoo HEP	Himachal Pradesh	1504.51	3.78%	2.52
7	Adani Power Ltd	Gujarat	1291.00	3.24%	2.40
8	KWPCL	Chattisgarh	1234.69	3.10%	2.29
9	Jaypee Nigrie STPP	Madhya Pradesh	1076.88	2.70%	2.39
10	MCCPL	Chattisgarh	1043.11	2.62%	2.29
Note: Total Volume transacted through Day Ahead Market in IEX was about 39830.67 MU.					

Table-27: Major Buyers of Electricity in the Day Ahead Market of IEX, 2016-17

S.No.	Name of Buyer	State/ Regional Entity	Buy Volume (MU)	Percentage of the Total Volume Transacted in IEX	Weighted Average Buy Price (₹/kWh)
1	BSPHCL	Bihar	1822.00	4.57%	2.55
2	Torrent Power Ltd,	Gujrat	1396.68	3.51%	2.48

3	UPCL	Uttarakhand	1294.61	3.25%	2.76
4	Essar Steel India Ltd	Regional Entity	1107.56	2.78%	2.39
5	CESC	West Bengal	1003.26	2.52%	2.57
6	Reliance Infra Ltd (D)	Maharashtra	868.90	2.18%	2.55
7	APSPDCL	Andhra Pradesh	814.22	2.04%	3.61
8	UPPCL	Uttar Pradesh	804.93	2.02%	2.83
9	WBSEDCL	West Bengal	775.36	1.95%	2.57
10	J&K PDD	J&K	671.98	1.69%	2.85
Note: Total Volume transacted through Day Ahead Market in IEX was about 39830.67 MU.					

From Table-27, it can be seen that the weighted average prices of electricity for major buyers such as BSPHCL, UPCL, CESC, Reliance Infra Ltd, APSPDCL, UPPCL, WBSEDCL and J&K PDD in the day ahead market of IEX were higher than the weighted average price for the entire day ahead market of IEX (₹2.48/kWh).

Table-28: Major Sellers of Electricity in the Day Ahead Market of PXIL, 2016-17

S. No	Name of the Seller	State/ Regional Entity	Sell Volume (MU)	Percentage of total volume transacted in PXIL	Weighted Average Sell Price (₹/kWh)
1	DB Power Ltd	Chhattisgarh	126.85	51.04%	2.78
2	Jindal Power Ltd	Chhattisgarh	35.22	14.17%	2.40
3	JITPL	Orissa	26.70	10.74%	2.70
4	GMR Kamalanga Energy Ltd	Orissa	17.62	7.09%	2.73
5	Karcham Wangtoo HEP	Himachal Pradesh	16.32	6.57%	2.28
6	OPGS Power Gujarat Private Ltd	Gujarat	12.16	4.89%	2.32
7	KSEB	Kerala	3.26	1.31%	2.57
8	GMR Chhattisgarh Energy Ltd	Chhattisgarh	3.09	1.24%	2.77
9	KWPCL	Chhattisgarh	2.40	0.97%	2.70

10	UT Chandigarh	Chandigarh	2.28	0.92%	2.35
Note: Total Volume transacted in the Day Ahead Market in PXIL was about 248.54 MU.					

From Table-29, it can be seen that the weighted average prices of electricity for major buyers such as KSEB, GUVNL, UPCL, TSSPDCL, UT Chandigarh, TNEB and WBSEDCL in the PXIL Day Ahead Market were higher than the weighted average price for the entire day ahead market of PXIL (₹2.56/kWh).

Table-29: Major Buyers of Electricity in Day Ahead Market of PXIL, 2016-17

Sr. No	Name of the Buyer	State/ Regional Entity	Buy Volume (MU)	Percentage of the Total Volume Transacted	Weighted Average Buy Price (₹/kWh)
1	KSEB	Kerala	72.65	29.23%	2.75
2	GUVNL	Gujarat	54.87	22.08%	2.70
3	UPCL	Uttarakhand	43.85	17.64%	2.71
4	Sintex Ind Ltd	Gujarat	15.87	6.38%	2.19
5	HNGIL	Haryana	14.11	5.68%	2.26
6	TSSPDCL-TSPCC	Telangana	12.07	4.86%	2.65
7	IFFCO Plant	Gujarat	11.63	4.68%	2.43
8	UT Chandigarh	Chandigarh	8.78	3.53%	2.63
9	TNEB	Tamilnadu	5.23	2.11%	3.68
10	WBSEDCL	West Bengal	4.80	1.93%	3.21
Note: Total Volume transacted through PXIL was about 248.54 MU.					

9. Effect of Congestion on Volume of Electricity Transacted through Power Exchanges

The volume of electricity transacted through power exchanges is sometimes constrained due to transmission congestion. The details of congestion in both the power exchanges are shown in Table-30 and Table-31.

Annual congestion in power exchanges are shown in Table-30. It can be observed from the table that there is an increasing trend in the unconstrained cleared volume and actual volume transacted. Unconstrained cleared volume and actual volume transacted increased from 8.10BU and 7.09BU respectively in 2009-10 to 41.60BU and 40.08BU respectively in 2016-17. There is an increasing trend in the volume of electricity that could not be cleared (i.e. the difference of unconstrained cleared volume and actual volume transacted) as % to unconstrained cleared volume from 2010-11 to 2012-13 and a declining trend from 2012-13 to 2016-17. Congestion has been reduced since grid integration (integration of NEW Grid and SR Grid) in December 2013, leading to a declining trend in the volume of electricity that could not be cleared as percentage to unconstrained cleared volume in both the power exchanges from 2013-14 onwards.

Table-30: Congestion in Power Exchanges, 2009-10 to 2016-17

Year	Unconstrained Cleared Volume* (BU)	Actual Cleared Volume and hence scheduled (BU)	Volume of electricity that could not be cleared due to congestion (BU)	Volume of electricity that could not be cleared as % to Unconstrained Cleared Volume
1	2	3	4 (2-3)	5 (4/2)
2009-10	8.10	7.09	1.01	12%
2010-11	14.26	13.54	0.72	5%
2011-12	17.08	14.83	2.26	13%
2012-13	27.67	23.02	4.65	17%
2013-14	35.62	30.03	5.59	16%
2014-15	31.61	28.46	3.14	10%
2015-16	36.36	34.20	2.16	6%
2016-17	41.60	40.08	1.52	4%
** This power would have been scheduled had there been no congestion.*				

Source: IEX & PXIL

During 2016-17, in the IEX, the unconstrained cleared volume and the actual volume transacted were 41.31BU and 39.83BU respectively (Table-31). The actual transacted volume was 3.59% lesser than unconstrained volume. During the same year, in PXIL, the unconstrained cleared volume and the actual volume transacted were 0.29BU and 0.25BU respectively. The actual transacted volume was 3.66% lesser than unconstrained volume.

Table-31: Congestion in Power Exchanges, 2016-17

	Items	IEX	PXIL	Total
A	Unconstrained Cleared Volume* (BU)	41.31	0.29	41.60
B	Actual Cleared Volume and hence scheduled (BU)	39.83	0.25	40.08
C	Volume of electricity that could not be cleared and hence not scheduled because of congestion (BU) (A-B)	1.48	0.04	1.52
D	Volume of electricity that could not be cleared as % to Unconstrained Cleared Volume	3.59%	13.91%	3.66%
** This power would have been scheduled had there been no congestion.*				

Source: IEX, PXIL & NLDC

Congestion, consequent market splitting, and the resultant difference in market prices in different regions give rise to congestion charges. The annual congestion charges of both power exchanges for the period from 2008-09 to 2016-17 is provided in Table-32.

Table-32: Congestion Charges of Power Exchanges, 2008-09 to 2016-17

Year	Congestion Charges in IEX (₹ Crore)	Congestion Charges in PXIL (₹ Crore)	Total (₹ Crore)
2008-09	5.27	0.00	5.27
2009-10	255.40	22.39	277.79
2010-11	273.14	86.61	359.75
2011-12	419.13	65.62	484.76
2012-13	417.37	35.93	453.30
2013-14	387.23	5.10	392.33
2014-15	502.41	1.64	504.05
2015-16	214.08	0.14	214.22
2016-17	305.99	0.09	306.08

Source: NLDC

10. Ancillary Services Operations

10.1 Background

Ancillary Services is one of the four essential pillars of Electricity Market design viz., Scheduling and Despatch, Imbalance Settlement, Congestion Management and Ancillary Services. Ancillary Services are support services to maintain power system reliability and support its primary function of delivering energy to customers. These are deployed by the system operator over various time frames to maintain the required instantaneous and continuous balance between aggregate generation and load. Ancillary Services consist of services required for (a) maintaining load-generation balance (frequency control); (b) maintaining voltage and reactive power support; (c) maintaining generation and transmission reserves. Historically, ancillary services were provided by the vertically integrated utilities along with the energy supply services. With the unbundling of vertically integrated utilities, increasing private sector participation and competition introduced in energy markets, there is an increasing need for administering such services, so as to ensure reliable and secure grid operation. Ancillary Services are broadly classified as follows:

(i) **Frequency Control Ancillary Services (FCAS)**: Three levels of Frequency Control are generally used to maintain the balance between generation and load i.e. Primary Frequency Control, Secondary Frequency Control, Tertiary Frequency Control. Three levels differ as per their time of response to a fluctuation and the methodology adopted to realize the fundamental operating philosophy of maintaining reliability and economy.

(ii) **Network Control Ancillary Services (NCAS)**: This can be further subdivided into Voltage Control Ancillary Service and Power Flow Control Ancillary Services.

(iii) **System Restart Ancillary Services (SRAS)**: It is used to restore the system after a full or partial blackout. Black start is vital and inexpensive service. Its costs are primarily the capital cost of the equipment used to start the unit, the cost of the

operators, the routine maintenance and testing of equipment and the cost of fuel when the service is required. At present this is a mandatory service.

10.2 Regulatory Framework of Ancillary Services

Ancillary Services are defined, under Regulation (2)(1)(b) of the CERC (Indian Electricity Grid Code), Regulations, 2010 (IEGC), as follows: *"…in relation to power system (or grid) operation, the services necessary to support the power system (or grid) operation in maintaining power quality, reliability and security of the grid, e.g. active power support for load following, reactive power support, black start, etc;…*"

The Commission notified the CERC (Ancillary Services Operations) Regulationsons on 13th August, 2015. The objective of Reserves Regulation Ancillary Services (RRAS) is to restore the frequency level at desired level and to relieve the congestion in the transmission network. Specifically, these regulations are the first step towards introducing Ancillary Services in the country that will enable the grid operator to ensure reliability and stability in the grid. The RRAS shall support both "Regulation Up" service (that provides capacity by responding to signals or instruction of the Nodal Agency to increase generation) and "Regulation Down" service (that provides capacity by responding to signals or instruction of the Nodal Agency to decrease generation).

CERC, vide order dated 29th February 2016, specified the mark-up for participation in Regulation 'Up' as 50 paisa/kWh. The detailed procedures were laid out on the 08th March 2016 and Ancillary Services were implemented by the Nodal Agency i.e. NLDC in coordination with RLDCs from 12th April, 2016.

Regulation Up Service shall utilize "un-requisitioned surplus" of inter-State generating stations, whose tariff is determined or adopted by the Commission for their full capacity. Un-requisitioned surplus means the reserve capacity in a generating station that has not been requisitioned and is available for dispatch, and is computed as the difference between the declared capacity of the generating station and its total schedule under long-terms, medium-term and short-term transactions, as per the relevant regulations of the Commission. On the other hand, Regulation Down service

may be provided by any eligible generator. Incentives for both the generators and their beneficiaries have been built into the framework.

As per the regulation, all the generators, that are regional entities, and whose tariff for the full capacity is determined or adopted by the CERC have been mandated to provide Ancillary Services as RRAS Providers. NLDC, through the RLDCs, has been designated as the Nodal Agency for Ancillary Services Operations. The Nodal Agency prepares the Merit Order Stack based on the variable cost of generation. Separate stacks are prepared for Up and Down.

Ancillary Services may be triggered because of extreme weather forecast, generating unit or transmission line outages, trend of load met, trend of frequency, any abnormal event such as outage of hydro generating units due to silt, coal supply blockade, etc., excessive loop flows leading to congestion, trend of computed Area Control Error (ACE) at regional level, recall by the original beneficiary, grid voltage profile at important nodes, 'N-1' criteria not being satisfied in a transmission corridor, loading of transmission lines beyond limits specified in CEA Manual on Transmission Planning Criteria.

A virtual regional entity called "Virtual Ancillary Entity (VAE)" has been created in the respective Regional Pool for scheduling and accounting. The quantum of RRAS instruction is incorporated in the schedule of RRAS providers. RRAS instruction may be scheduled to the VAE in any one or more regional grids. The deviation in schedule of the RRAS providers, beyond the revised schedule, is being settled as per the CERC Deviation Settlement Mechanism (DSM) Regulations. The energy dispatched under RRAS is deemed delivered ex-bus.

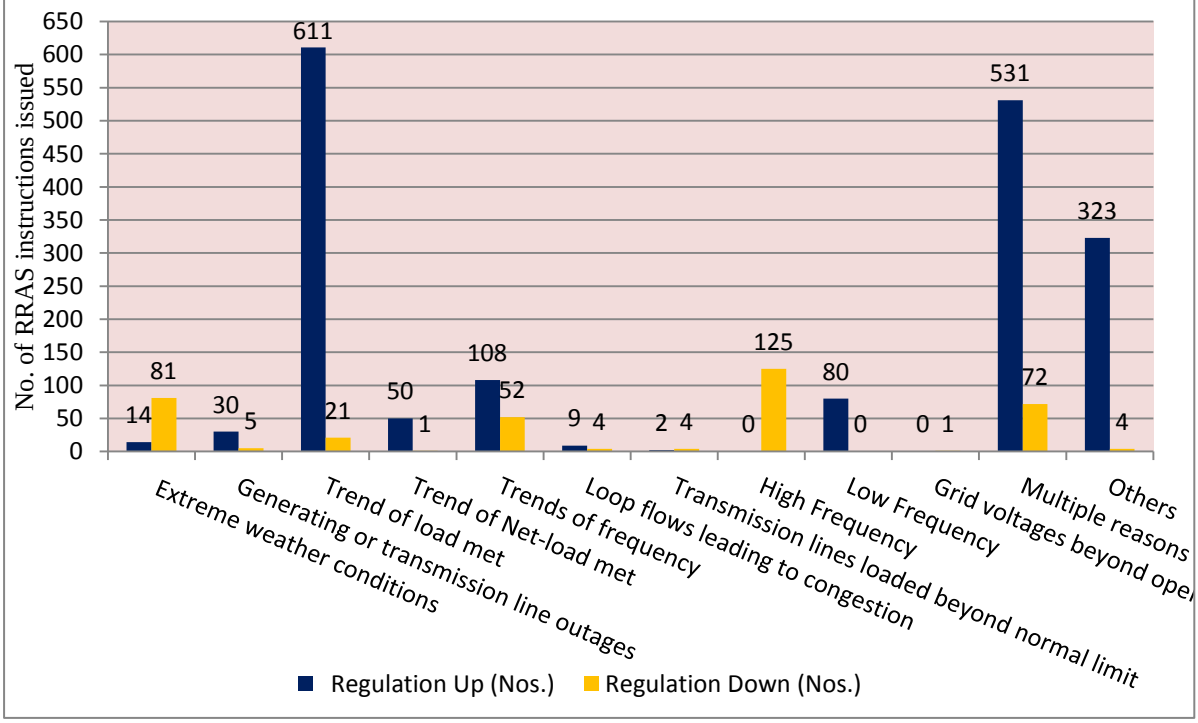
Nodal agency directs the RRAS provider to withdraw RRAS, on being satisfied, that the circumstances leading to triggering of RRAS services have ceased to exist. The RRAS energy accounting is being done by the respective Regional Power Committee (RPC) on weekly basis along with DSM account, based on interface meters data and schedule. A separate RRAS statement is being issued by RPC along with Regional DSM account. Any post-facto revision in rates/charges by RRAS providers is

not permitted. In case of Regulation Up, fixed charges and variable charges along with pre-specified mark-up are payable to the RRAS providers from the pool. In case of Regulation Down, 75 per cent of the variable charges are payable by RRAS providers to the pool. No commitment charges are payable to the RRAS provider.

10.3 RRAS Instructions issued by Nodal Agency

During 2016-17, the Nodal Agency has issued 2128 RRAS Up/Down instructions on account of various triggering criteria. Of the total, there were 1758 RRAS Up instructions and 370 RRAS Down instructions. Majority of the Regulation Up instructions were on account of trend of load met followed by multiple reasons, while majority of the Regulation Down instructions were on account of high frequency followed by extreme weather condition.

Figure-37: Reasons of Ancillary Despatch during 2016-17



At times, the dispatch under Ancillary is not attributable to any single triggering criteria, and the operator has to specify "Others" as triggering criteria. There

is a need to enhance the number of triggering criteria to provide more clarity and to encompass the dynamic behavior of the power system.

Table-33 provides month-wise details on maximum power despatched and maximum power regulated in a time block based on the instructions issued. It can be observed from the table that during the year 2016-17 in a time block, maximum power despatched was 3746 MW in July 2016 while the maximum power regulated was 2249 MW in March 2017.

Table-33: Maximum Power Despatched and Maximum Power Regulated in a Time Block (MW), 2016-17

Month	Max regulation "UP"	Max regulation "DOWN"
Apr-16	470	-
May-16	1050	1590
Jun-16	1662	1105
Jul-16	3746	1504
Aug-16	3214	1946
Sep-16	2351	1200
Oct-16	2098	670
Nov-16	1798	1165
Dec-16	2401	1080
Jan-17	1493	1313
Feb-17	1778	1274
Mar-17	1456	2249

10.4 RRAS Accounting and Settlement

As per Regulation 12 of the CERC (Ancillary Services Operations) Regulations 2015, the Regional Power Committees (RPCs) are required to issue the weekly accounts for RRAS along with the weekly DSM accounts. The RRAS accounts include fixed charges, variable charges, markup, amount of fixed charges to be refunded to the beneficiaries and the payments made from/to the DSM pool.

A Pan-India monthly summary of energy scheduled to/from Virtual Ancillary Entity (VAE) under RRAS has been provided in Figure-38. Payments made towards the ancillary services during 2016-17 has been provided in Figure-39.

Figure-38: Energy Scheduled to/from Virtual Ancillary Entity under RRAS (MU), 2016-17

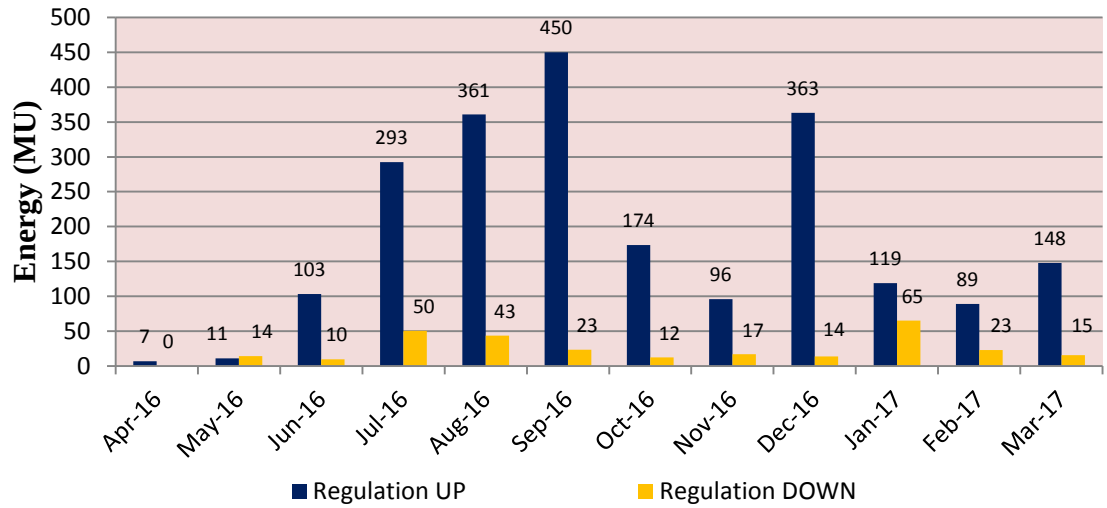
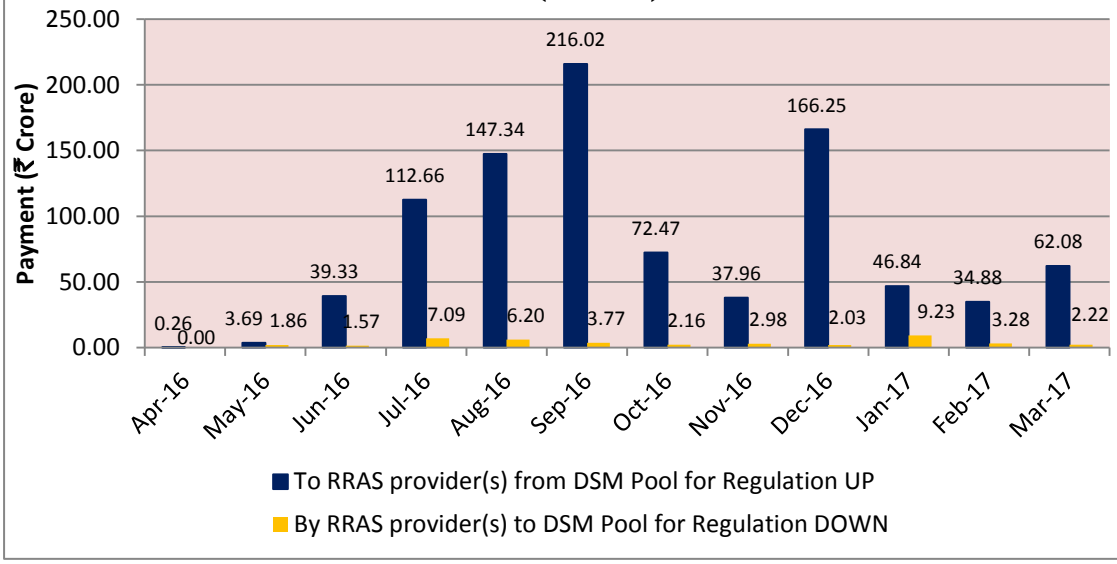


Figure-39: Payments made for Ancillary Services during 2016-17 (₹ Crore)



Presently, the Ancillary Services implementation is load-following and for congestion management. There are other forms of ancillary services which also need to be considered as we move ahead.

Chapter-III

Tariff of Long-term Sources of Power

Section 61 & 62 of the Electricity Act, 2003 provide for tariff regulation and determination of tariff of generation, transmission, wheeling and retail sale of electricity by the Appropriate Commission. The CERC has the responsibility to regulate the tariff of generating companies owned or controlled by the Central Government. The CERC specifies the terms and conditions for the determination of tariff for the generating companies guided by the principles and methodologies specified. The principles of the tariff are based on (a) the factors which would encourage competition, efficiency, economical use of the resources, good performance and optimum investments; (b) safeguarding of consumers' interest and at the same time, recovery of the cost of electricity in a reasonable manner; (c) rewarding efficiency in performance; (d) the tariff progressively reflects the cost of supply of electricity and also, reduces and eliminates cross-subsidies; (e) the promotion of co-generation and generation of electricity from renewable sources of energy; etc.

Section 63 of the Act states that "Notwithstanding anything contained in section 62, the Appropriate Commission shall adopt the tariff if such tariff has been determined through transparent process of bidding in accordance with the guidelines issued by the Central Government" in line with the Ministry of Power notified competitive bidding guidelines in 2005. The guidelines are being issued for procurement of electricity by distribution licensees for (a) long-term procurement of electricity for a period of 7 years and above; and (b) medium-term procurement for a period of upto 7 years but exceeding 1year. The guidelines shall apply for procurement of base-load, peak load and seasonal power requirements through competitive bidding, through the mechanisms: (i) where location, technology, or fuel is not specified by the procurer (Case-1); and (ii) for hydro-power projects, load center projects or other location specific projects with specific fuel allocation such as captive mines available, which the procurer intends to set up under tariff based bidding process (Case-2).

The power procurement through competitive bidding resulted in significant capacity addition in private sector. The details on tariff of inter-state power generating companies (mainly the tariff of central public sector power generating companies), tariff (levelised tariff) of power projects under Case-1 bidding, have been provided below.

1. Tariff of Central Public Sector power generating companies

In 2016-17, the central public sector power generating companies (NTPC, NHPC, NLC, NEEPCO, etc.)/central government owned generating companies accounted for about 36.90% of the total power generation in the country.

The prices paid by distribution companies to procure power from central government owned generating companies in 2016-17 (under long-term Power Purchase Agreements) are shown in Table-34 and 35. It can be seen that, on an average, the distribution companies paid between ₹2.05 and ₹6.48 per kWh for procuring power from coal based stations, between ₹2.65 and ₹7.82 per kWh from gas based power stations, (Table-34), and between ₹1.09 per kWh and ₹8.81 per kWh from hydro stations (Table-35).

Table-34: Tariff of Central Thermal Power Stations, 2016-17

Sl. No.	Name of the Generating Station	Installed Capacity (MW) as on March, 2017	Fixed charges (₹/kWh)	Energy Charges (₹/kWh)	Total Tariff (₹/ kWh)
I: Coal Based thermal generating Stations of NTPC					
A.	**Pit head Generating Stations**				
1	Rihand STPS (St-I)	1000	0.97	1.60	2.57
2	Rihand STPS (St-II)	1000	0.83	1.59	2.42
3	Rihand STPS (St-III)	1000	1.49	1.57	3.06
4	Singrauli STPS	2000	0.61	1.44	2.05
5	Vindhyachal STPS (St-I)	1260	1.11	1.78	2.89
6	Vindhyachal STPS (St-II)	1000	0.89	1.70	2.59
7	Vindhyachal STPS (St-III)	1000	1.20	1.68	2.88
8	Vindhyachal STPS (St-	1000	1.84	1.68	3.51

	IV)				
9	Vindhyachal STPS (St-V)	500	1.65	1.68	3.33
10	Korba STPS (St-I & II)	2100	0.75	1.37	2.13
11	Korba STPS (St-III)	500	1.39	1.37	2.76
12	Ramagundam STPS (St-I&II)	2100	0.68	2.25	2.93
13	Ramagundam STPS (St-III)	500	0.95	2.24	3.19
14	Talcher TPS	460	1.33	1.65	2.97
15	Talcher STPS (St-I)	1000	0.93	1.65	2.57
16	Talcher STPS (St-II)	2000	0.83	1.65	2.48
17	Sipat STPS (St-I)	1980	1.40	1.32	2.72
18	Sipat STPS (St-II)	1000	1.30	1.36	2.66
	Sub-Total (A)	**21400**	**1.05**	**1.75**	**2.80**
B.	**Non-Pit head Generating Stations**				
19	FGUTPP TPS (St-I)	420	1.15	2.94	4.08
20	FGUTPP (St-II)	420	1.00	2.92	3.92
21	FGUTPP (St-III)	210	1.34	2.89	4.23
22	NCTP Dadri (St-I)	840	1.77	3.31	5.08
23	NCTP Dadri (St-II)	980	2.05	3.09	5.14
24	Farrakka STPS (St-I&II)	1600	0.98	2.53	3.51
25	Farrakka STPS (St-III)	500	1.54	2.52	4.06
26	Tanda TPS	440	1.22	2.87	4.09
27	Badarpur TPS	705	1.10	3.69	4.79
28	Kahalgaon STPS (St-I)	840	1.06	2.40	3.46
29	Kahalgaon STPS (St-II)	1500	1.23	2.29	3.52
30	Simhadri (St-I)	1000	1.04	2.75	3.79
31	Simhadri (St-II)	1000	1.67	2.74	4.42
32	Mauda STPS (St-I)	1000	3.98	2.51	6.48
33	Mauda STPS (St-II)	660	2.57	2.60	5.17
34	Barh STPS (St-II)	1320	2.35	2.54	4.89
35	Bongaigaon TPS	250	2.61	3.13	5.73
	Sub-Total (B)	**13685**	**1.82**	**2.85**	**4.67**
	Total Coal (A+B)	**35085**	**1.21**	**1.98**	**3.18**
II: Gas based Power Generating Stations of NTPC					
1	Anta CCGT	419.33	3.09	2.55	5.63
2	Auraiya GPS	663.36	4.52	3.30	7.82
3	Dadri CCGT	829.78	1.41	2.77	4.18
4	Faridabad GPS	431.59	1.97	2.35	4.32
5	Gandhar GPS	657.39	2.20	1.83	4.04

6	Kawas GPS	656.20	2.63	1.86	4.49
	Total	**3658**	**2.26**	**2.31**	**4.57**
III: Gas based Power Generating Stations of NEEPCO					
1	Agartala GPS	135	Tariff is yet to be finalised		
2	Assam GPS	291	1.87	0.78	2.65
	Total NEEPCO	**426**			
IV: Other Inter-state Gas based Power Generating Stations					
1	OTPC Ltd	727	1.84	1.30	3.14
2	RGPPL	1967	1.34	1.82	3.16
3	Torrent Sugen Power Plant	1148	1.21	3.85	5.06
V: Lignite Based thermal generating Stations of NLC					
1	TPS-I	600	0.95	4.54	5.49
2	TPS-II Stage-I	630	0.72	3.16	3.88
3	TPS-II Stage-II	840	0.67	3.16	3.83
4	TPS-I (Expansion)	420	1.01	3.10	4.11
5	TPS-II (Expansion)	500	2.12	2.88	5.00
6	Barsingsar TPS	250	2.32	1.47	3.80
	Total NLC	**3240**			

Table-35: Composite Tariff of Central Hydro Power Stations, 2016-17

Name of Generating Company	Name of the Generating Station	Type	Installed Capacity (MW)	Scheduled Volume (MU)	Annual Fixed Charges (₹/Lakhs)	Composite Tariff (₹/kWh)
NHPC						
1	Baira siul	Pondage	180	641	13355	1.97
2	Loktak	Storage	105	715	14248	3.65
3	Salal	ROR	690	3238	29634	1.10
4	Tanakpur	ROR	123	377	11665	2.96
5	Chamera-I	Pondage	540	2142	31243	2.16
6	Uri-I	ROR	480	2732	35681	1.59
7	Rangit	Pondage	60	326	10416	3.53
8	Chamera-II	Pondage	300	1392	25499	1.96
9	Dhauliganga-I	Pondage	280	920	29509	2.99
10	Dulhasti	ROR	390	2199	93550	5.64
11	Teesta-V	Pondage	510	2678	51717	2.31
12	Sewa-II	Pondage	120	457	19890	4.33
13	Chamera-III	Pondage	231	893	40452	4.25
14	Chutak	ROR	44	217	14613	7.98
15	Uri-II	ROR	240	1439	46923	4.86

16	Nimoo Bazgo	Pondage	45	239	18161	8.81
17	Teesta-LDP-III	Pondage	132	538	36071	6.20
18	Teesta-LDP-IV	Pondage	160	581	16164	2.56
19	Parbati-III	ROR	520	667	33009	5.48
	Total		**5150**	**22393**		
NHDC						
1	Indira Sagar	Storage	1000	3253	60213	3.70
2	Omkareshwar	Storage	520	1417	40917	5.43
	Total		**1520**	**4670**		
THDC						
1	Tehri HPP Stage-I	Storage	1000	3102	134105	5.18
2	Koteshwar HEP	RoR with Pondage	400	1209	39333	3.86
	Total		**1400**	**4311**		
SJVNL						
1	Naptha Jhakri	RoR	1500	6612	165684	2.88
2	Rampur HP	RoR	412	1878	52171	3.23
	Total		**1912**	**8490**		
NEEPCO						
1	Kopili HEP Stage-I	Storage	200	963	10984	1.09
2	Kopili HEP Stage-II	Storage	25	101	1417	1.72
3	Khandong	Storage	50	189	4036	1.93
4	Doyang	Storage	75	246	10156	4.67
5	Ranganadi HEP	Pondage	405	1242	26047	2.18
	Total		**755**	**2742**		
NTPC						
1	Koldam Hydro Power Station-1	RoR with storage	800	3633		3.46*
DVC						
1	Maithon HS	Storage	63	122	3174	2.93
2	Panchet HS	Storage	80	134	2684	1.43
3	Tilayia HS		4	14	870	8.76
	Total		**147**	**270**		

* Tariff is inclusive of other charges of ₹1.86/kWh.

2. Levelised tariff of power projects under Case-I Bidding

Table-35 provides the details on capacity contracted under Case-1 bidding route during the year 2015-16. It is observed from the table that the price of power under Case-1 bidding route was varied in the range of ₹3.99 per kWh to ₹4.83 per kWh.

Table-35: Capacity Contracted under Case-I Bidding Route, 2015-16

S.No.	State	Name of the Developer/Plant	Bid Date	Capacity (MW)	Levelized Tariff (₹/kWh)
1	Kerala	East Coast Energy Ltd	Jun-15	488	4.27
2	Kerala	NCC Power Projects	Jun-15	500	4.35
3	Kerala	Korba West Avantha	Jun-15	540	4.49
4	Andhra Pradesh	MB Power Ltd	Jun-15	374	4.69
5	Andhra Pradesh	Jindal India Thermal Ltd	Jun-15	400	4.83
6	Andhra Pradesh	Essar Power Ltd	Jun-15	500	4.83
7	Andhra Pradesh	Jindal India	Sep-15	200	3.99
8	Andhra Pradesh	Balco-Chhattisgarh	Sep-15	120	4.07
9	Delhi (TPPDDL)	M B Power	Sep-15	374	4.23
10	Delhi (TPPDDL)	Lanco Anpara	Sep-15	100	4.24
11	Delhi (TPPDDL)	Ratan India	Sep-15	400	4.48
Source: Forum of Regulators					

Chapter-IV

Transactions of Renewable Energy Certificates

1. Background of Renewble Energy Certificate Mechanism

The Renewble Energy Certificate (REC) mechanism is a market based instrument, to promote renewable sources of energy and development of market in electricity. The REC mechanism provides an alternative voluntary route to a generator to sell his electricity from renewable sources just like conventional electricity and sell the green attribute separately to obligated entities to fulfill their Renewable Purchase Obligation (RPO). Such a generator can either opt to enter into a Power Purchase Agreement for sale at preferential full cost tariff to a distribution licensee or can opt to take the REC route for such untied capacity. If he opts for the REC route, he can sell his electricity to a distribution licensee such as a conventional source based generation at an average power purchase cost. Or, he can sell to a third party, that is, to an open access consumer at mutually settled prices, or even on power exchanges. On every one megawatt hour of such electricity generated, he is entitled to get one REC from the central registry (which is regulated by the CERC) after getting registered once with this registry. Such registration requires prior accreditation with the state nodal agency for verifying the source of generation, capacity, and grid metering.

There are two categories of RECs, solar and non-solar, to meet the RPO of the corresponding category. This is because the cost of solar-based generation is very high compared to all other sources. An REC can be issued within three months of generation and is valid for one year thereafter. It is to be sold on power exchanges regulated by CERC, which also fixes a price band for exchange of REC (the band of forbearance price and floor price) to protect the interests of obligated entities and generators, respectively. Obligated entities can fulfill RPO by purchasing renewable electricity at full cost preferential tariff or by purchasing REC equivalent to their RPO. Voluntary buyers can also purchase REC. Regulatory charge for shortfall of RPO compliance is at the rate of forbearance price.

The Central Electricity Regulatory Commission (Terms and Conditions for recognition and issuance of Renewable Energy Certificate for Renewable Energy Generation) Regulations, 2010 were issued on 14th January, 2010 for the development of market in power from Non Conventional Energy Sources by issuance of transferable and saleable credit certificates. These Regulations shall apply throughout India except the State of Jammu and Kashmir. The CERC has nominated NLDC as the Implementing Agency (for the Central Registry), which prepares procedures and a web-based platform for the REC mechanism. The REC mechanism was formally launched on 18 November 2010.

2. Trading of Renewble Energy Certificates on Power Exchanges

Trading of RECs is being undertaken on Power Exchanges on the last Wednesday of every month. In the event of a bank holiday on the last Wednesday of any month, trading shall take place on the next bank working day. If there are other exigencies warranting change in the day for trading, the Central Agency can make such change as considered necessary under intimation to all concerned. The bidding window is open on the Power Exchanges designated for dealing in the RECs from 13:00 Hrs to 15:00 Hrs on the day of trading.

One REC is equivalent to 1 MWh of electricity injected into the grid from renewable energy sources. The REC is exchanged only in the power exchanges approved by CERC within the band of a floor price and forbearance (ceiling) price as notified by CERC from time to time. The forbearance price and floor price notified by CERC are as under:

Table-37: Forbearance and Floor Price for REC Transactions w.e.f 1st March 2015

Type of REC	Floor Price (₹/MWh)	Forbearance Price (₹/MWh)
Solar	3500	5800
Non-Solar	1500	3300

The first REC trading session was held on power exchanges in March 2011. Number of RECs transacted on power exchanges increased significantly from 10.15 lakh in 2011-12 to 64.88 lakh in 2016-17. The growth in the RECs transacted on power exchanges has been shown in Table-38.

Table-38: Growth of Renewable Energy Certificates transacted on Power Exchanges, 2011-12 to 2016-17

Financial Year	Number of buyers	Number of sellers	Number of RECs transacted (Lakhs)	% increase in Number of RECs Transacted
2011-12	397	168	10.15	-
2012-13	802	487	25.9	155%
2013-14	1083	703	27.49	6%
2014-15	821	906	30.62	11%
2015-16	1286	737	49.55	62%
2016-17	1698	782	64.88	31%

Source:NLDC

The volume and price of RECs transacted in both power exchanges in 2016-17 has been provided in Table-39 and Table-40. The market clearing volume of Solar RECs transacted in 2016-17 on IEX and PXIL were 404081 and 152933 respectively and the weighted average of market clearing price of these RECs was ₹3500/MWh on both power exchanges. Market clearing volume of Non-Solar RECs transacted in 2016-17 on IEX and PXIL were 4214538 and 1716187 respectively and the weighted average of market clearing price of these RECs was ₹1500/MWh on both power exchanges.

The gap between the volume of buy and sell bids of RECs placed through power exchanges shows that there was less demand for both Solar RECs and Non-Solar RECs. For Solar RECs, the ratio of buy and sell bids was 0.01 in both IEX and PXIL. For Non-Solar RECs, the ratio of buy and sell bids was 0.04 and 0.03 in IEX and PXIL respectively.

Table-39 : Renewable Energy Certificates transacted on Power Exchanges, 2016-17

Sr.No.	Details of REC Transactions	RECs transacted on IEX		RECs transacted on PXIL	
		Solar	Non-Solar	Solar	Non-Solar
A	Volume of Buy Bid	404081	4214538	152933	1716187
B	Volume of Sell Bid	32370492	98150140	14766280	59637425
C	Ratio of Buy Bid to Sell Bid Volume	0.01	0.04	0.01	0.03
D	Market Clearing Volume (MWh)	404081	4214538	152933	1716187
E	Market Clearing Price (₹/MWh)	3500	1500	3500	1500

Month-wise volume and price of RECs transacted through power exchanges are shown in the following table (Table-40).

Table-40 : Volume and Price of Renewable Energy Certificates Transacted on Power Exchanges, 2016-17

Month	IEX		PXIL	
	Volume of REC Transactions (MWh)	Weighted Average Price of REC Transactions (₹/MWh)	Volume of REC Transactions (MWh)	Weighted Average Price of REC Transactions (₹/MWh)
Solar				
Apr-16	22958	3500	2695	3500
May-16	17113	3500	2970	3500
Jun-16	35649	3500	15366	3500
Jul-16	23944	3500	14029	3500
Aug-16	21937	3500	18041	3500
Sep-16	15126	3500	16598	3500
Oct-16	19932	3500	15676	3500
Nov-16	25003	3500	16826	3500
Dec-16	24789	3500	7297	3500
Jan-17	39572	3500	8327	3500
Feb-17	45613	3500	3931	3500
Mar-17	112445	3500	31177	3500
Non-Solar				
Apr-16	238485	1500	51972	1500

May-16	88923	1500	72935	1500
Jun-16	350362	1500	67064	1500
Jul-16	139250	1500	95757	1500
Aug-16	136352	1500	122539	1500
Sep-16	91355	1500	84170	1500
Oct-16	157273	1500	98048	1500
Nov-16	150050	1500	111007	1500
Dec-16	226532	1500	195420	1500
Jan-17	1248242	1500	272051	1500
Feb-17	815357	1500	228878	1500
Mar-17	572357	1500	316346	1500

Annexure-I

List of Transmission Licensees as on 31.03.2017

S.No.	Name of Licensee	Date of grant of licence
1	Powerlinks Transmission Ltd.	13.11.2003
2	Torrent Power Grid Ltd	16.05.2007
3	Jaypee Powergrid Ltd	01.10.2007
4	Essar Power Transmission Company Ltd.	10.04.2008
5	Parbati Koldam Transmission Company Ltd	15.09.2008
6	Western Region Transmission (Maharashtra) (P) Ltd	30.12.2008
7	Western Region Transmission (Gujrat) (P) Ltd	30.12.2008
8	Teestavalley Power Transmission Ltd	14.05.2009
9	North East Transmission Company Ltd	16.06.2009
10	East - North Inter - Connection Company Ltd.	28.10.2010
11	Talcher - II Transmission Company Ltd.	08.11.2010
12	Cross Border Power Transmission Company Ltd	01.12.2010
13	North Karanpura Transmission Company Ltd.	16.12.2010
14	Jindal Power Ltd	09.05.2011
15	Raichur Sholapur Transmission Company Ltd	24.08.2011
16	Jabalpur Transmission Company Ltd	12.10.2011
17	Bhopal Dhule Transmission Company Ltd	12.10.2011
18	Powergrid NM Transmission Ltd	20.06.2013
19	Torrent Energy Ltd	16.07.2013
20	Adani Transmission (India) Ltd	29.07.2013
21	Aravali Power Co. Ltd.	07.11.2013
22	Kudgi Transmission Ltd	07.01.2014
23	Powergrid Vizag Transmission Ltd	08.01.2014
24	Darbhanga - Motihari Transmission Company Ltd	30.05.2014
25	Purulia & Kharagpur Transmission Company Ltd	30.05.2014
26	Patran Transmission Company Ltd	14.07.2014
27	Powergrid Unchahar Transmission Ltd	21.07.2014
28	RAPP Transmission Company Ltd	31.07.2014
29	NRSS XXXI (B) Transmission Ltd	25.08.2014
30	Powergrid Kala Amb Transmission Ltd (NRSS XXXI (A) Transmission Ltd)	04.09.2014
31	NRSS XXIX Transmission Ltd (Sterlite)	14.11.2014
32	Powergrid Jabalpur Transmission Ltd	15.06.2015
33	DGEN Transmission Company Ltd	24.06.2015
34	Powergrid Parli Transmission Ltd (Gadarwara (B) Transmission Ltd)	10.07.2015
35	POWERGRID Warora Transmission Ltd	05.08.2015

36	Maheshwaram Transmission Ltd	23.11.2015
37	Raipur-Rajandgaon-Warora Transmission Ltd	29.02.2016
38	Chhattisgarh-WR Transmission Ltd	29.02.2016
39	Sipat Transmission Ltd	07.03.2016
40	POWERGRID Southern Interconnector Transmission System Ltd	14.03.2016
41	Alipurduar Transmission Ltd	21.03.2016
42	Odisha Generation Phase-II Transmission Ltd	30.06.2016
43	Gurgaon Palwal Transmission Ltd	29.09.2016
44	Warora-Kurnool Transmission Ltd	29.09.2016
45	North Karanpura Transco Ltd	29.09.2016
46	Khargone Transmission Ltd	17.11.2016
47	NRSS XXXVI Transmission Ltd	07.12.2016

Annexure-II

List of Trading Licensee as on 31.3.2017

Sr. No.	Name of Trading Licensee	Date of Issue of License	Present Category of License
1	Tata Power Trading Company Ltd	09.06.2004	I
2	Adani Enterprises Ltd	09.06.2004	I
3	PTC India Ltd	30.06.2004	I
4	NTPC Vidyut Vyapar Nigam Ltd	23.07.2004	I
5	National Energy Trading & Services Ltd	23.07.2004	I
6	JSW Power Trading Company Ltd.	25.04.2006	I
7	GMR Energy Trading Ltd	14.10.2008	I
8	Global Energy (P) Ltd.	28.11.2008	I
9	Knowledge Infrastructure Systems (P) Ltd	18.12.2008	I
10	Shree Cement Ltd	16.03.2010	I
11	Jai Prakash Associates Ltd	23.03.2011	I
12	Statkraft Markets (P) Ltd	21.06.2012	I
13	IL&FS Energy Development Company Ltd	04.09.2014	I
14	Essar Electric Power Development Corporation Ltd	14.12.2005	II
15	RPG Power Trading Company Ltd	23.09.2008	II
16	Mittal Processors (P) Ltd	12.02.2009	II
17	My Home Power (P) Ltd	26.04.2011	II
18	Manikaran Power Ltd	29.06.2012	II
19	Arunachal Pradesh Power Corporation (P) Ltd	11.09.2012	II
20	Solar Energy Corporation of India	01.04.2014	II
21	IPCL Power Trading (P) Ltd	10.02.2015	III
22	Instinct Infra & Power Ltd	07.09.2005	III
23	Gita Power & Infrastructure (P) Ltd	20.10.2015	III
24	Greenko Energies (P) Ltd	22.01.2008	III
25	Shyam Indus Power Solutions (P) Ltd	11.11.2008	III
26	Customised Energy Solutions India (P) Ltd	08.06.2011	III
27	Reliance Energy Trading (P) Ltd	30.06.2004	IV
28	Audhunic Alloys & Power Ltd	26.06.2008	IV
29	Ambitious Power Trading Company Ltd	16.09.2008	IV
30	Vedprakash Power (P) Ltd	19.08.2013	IV
31	Parshavnath Power Projects (P) Ltd	19.05.2014	IV
32	Phillip Commodities India Pvt. Ltd.	21.01.2016	IV
33	Renew Solar Services Pvt. Ltd.	27.01.2017	IV

Historical Volatility Formula:

$$\sigma = \sqrt{\frac{1}{(n-1)} \sum_{y=1}^{n} (\ln \frac{y_i}{y_{i-1}} - \mu)^2}$$

where

$$\mu = \frac{1}{n} \sum_{y=1}^{n} (\ln \frac{y_i}{y_{i-1}})$$

1. Daily prices returns = Ln (y i / yi-1).
2. yi is price for today; y i-1 is price on previous day.
3. Ln is natural logarithm
4. n is the number of observations
5. u is the average daily returns

Herfindahl-Hirschman Index (HHI)

Formula for computing the HHI is as under:

$$HHI = \sum_{i=1}^{N} s_i^2$$

where s_i is the market share of firm *i* in the market, and *N* is the number of firms.

The Herfindahl-Hirschman Index (*HHI*) ranges from 1 / *N* to one, where *N* is the number of firms in the market. Equivalently, if percents are used as whole numbers, as in 75 instead of 0.75, the index can range up to 100^2 or 10,000.

- A HHI index below 0.01 (or 100) indicates a highly competitive index.
- A HHI index below 0.15 (or 1,500) indicates an unconcentrated index.
- A HHI index between 0.15 to 0.25 (or 1,500 to 2,500) indicates moderate concentration.
- A HHI index above 0.25 (above 2,500) indicates high concentration.

There is also a normalized Herfindahl index. Whereas the Herfindahl index ranges from 1/N to one, the normalized Herfindahl index ranges from 0 to 1.