National Electricity Plan

(Volume I)

Generation

[In fulfilment of CEA's obligation under section 3(4) of the Electricity Act 2003]

Government of India
Ministry of Power
Central Electricity Authority

JANUARY, 2018

CONTENTS

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ACRONYMS

ACRONYMS	EXPANSION
AC	Alternating Current
ACQ	Annual Contracted Quantity
AGDSM	Agricultural Demand Side Management
APC	Auxiliary Power Consumption
APDRP	Accelerated Power Development and Reforms Programme
APM	Administered Price Mechanism
AT&C	Aggregate Technical and Commercial
BAU	Business As Usual
Bcum, BCM,Bm^3	Billion cubic metre
BEE	Bureau of Energy Efficiency
BHEL	Bharat Heavy Electricals Ltd.
BIS	Bureau of Indian Standards
BLY	Bachat Lamp Yojna
BoP	Balance of Payment/Balance of Plant
BPL	Below Poverty Line
BT	Billion Tonnes
BU	Billion Units
BWR	Boiling Water Reactor
CAD	Computer-Aided Design
CAGR	Compounded Annual Growth Rate
CBIP	Central Board of Irrigation & Power
CBM	Coal Bed Methane
CCEA	Cabinet Committee on Economic Affairs
CCGT	Combined Cycle Gas Turbine
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CED	Chandigarh Electricity Department
CERC	Central Electricity Regulatory Commission
CFBC	Circulating Fluidized Bed Combustion
CFD	Computational Fluid Dynamics
CFL	Compact Fluorescent Lamp
CFFP	Central Forge & Foundry Plant
CIMFR	Central Institute of Mining and Fuel Research
CII	Confederation of Indian Industry
CIL	Coal India Ltd.
CLA	Central Loan Assistance
COD	Date of Commercial Operation
CO	Carbon mono oxide
CO_2	Carbon di oxide
CPP	Captive Power Plant
CPRI	Central Power Research Institute

ACRONYMS	EXPANSION
CPSU	Central Public Sector Undertaking
Crs	Crores
CRGO	Cold Rolled Grain Oriented
CRNGO	Cold Rolled Non Grain Oriented
CS	Central Sector
CSIR	Council for Scientific and Industrial Research
CSP	Concentrated solar power
CST	Central Sales Tax
CT	Cooling Tower
CTO	Consent To Operate
CUF	Capacity Utilization Factor
DAE	Department of Atomic Energy
DBFOT	Design-Build-Finance-Operate-Transfer
DBFOO	Design, Build, Finance, Own, and Operate
DC	Designated Consumers
DDG	Decentralised Distributed Generation
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DEEP	Discovery of Efficient Electricity Price
DELP	Domestic Efficient Lighting Programme
DGH	Director General Hydro Carbon
DG	Diesel Generating
DISCOM	Distribution Company
DPR	Detailed Project Report
DR	Demand Response
DSM	Demand Side Management
DST	Department of Science & Technology
DVC	Damodar Valley Corporation
DVR	Dynamic Voltage Restorer
EA 2003	Electricity Act 2003
EC	Energy Conservation
EC Act	Energy Conservation Act
ECBC	Energy Conservation Building Code
EE	Energy Efficiency
EEFP	Energy Efficiency Financing Platform
EESL	Energy Efficiency Services Limited
EEZ	Exclusive Economic Zone
EGEAS	Electric Generation Expansion Analysis System
EGoM	Empowered Group of Ministers
ELCOMA	Electric Lamp and Component Manufacturers' Association of India
ENS	Energy Not Served
EPC	Engineering Procurement Contract
EPS	Electric Power Survey
EPSC	Electric Power Survey Committee

ACRONYMS	EXPANSION
ERDA	Electric Research & Development Association
ESCos	Energy Service Company or Energy Savings Company
ESCert	Energy Saving Certificate
ESP	Electro Static Precipitator
EU	European Union
FAUP	Fly Ash Utilisation Programme
FBC	Fluidised Bed Combustion
FEEED	Framework for Energy Efficient Economic Development
FGD	Flue-gas desulfurization
FICCI	Federation of Indian Chambers of Commerce & Industry
FO	Forced Outage
FOR	Forum of Regulators
FRP	Fibre-Reinforced Plastic
FSA	Fuel Supply Agreement
GAIL	Gas Authority of India Limited
GCV	Gross Calorific Value
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHAVP	Gorakpur Haryana Anu Vidyut Pariyojana
GHG	Green House Gas
GIS	Geographic Information System
GPS	Geographic Positioning System
GR	General Review
GSPC	Gujarat State Petroleum Corporation
GT	Gas Turbine
GW	Giga Watt
HBJ	Hazira-Bijapur-Jagdishpur (pipeline)
HFO	Heavy Fuel Oil
HEP	Hydro Electric Project
HELP	Hydrocarbon Exploration and Licensing Policy
HHV	Higher Heating Valve
HRD	Human Resource Development
HSD	High Speed Diesel
HT	High Tension
HVDS	High Voltage Distribution System
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
HVJ	Hazira-Vijaipur-Jagdishpur
IAEA	International Atomic Energy Agency
IC	Installed Capacity
ID	Induced Draft
IEA	International Energy Agency
IEP	Integrated Energy Policy

ACRONYMS	EXPANSION
IEEMA	Indian Electrical and Electronics Manufacturers Association
IGCAR	Indira Gandhi Centre for Atomic Research
IGCC	Integrated Gasification Combined Cycle
IISC	Indian Institute of Science
IIT	Indian Institute of Technology
IMTF	Inter-Ministerial Task Force
INDC	Intended Nationally Determined Contribution
IPDS	Integrated Power Development Scheme
IPP	Independent Power Producer
IRP	Integrated Resource Planning
ITI	Industrial Training Institutes
IS	Indian Standard
ISCC	Integrated Solar Combined Cycle
ISO	International Standard Organisation
IT	Information Technology
JVs	Joint Ventures
KAPP	Kakrapar Atomic Power Plant
kCal	kilo Calorie
kgoe	Kilogram of oil equivalent
KGD6	Krishna Godavari Dhirubhai 6
KKNPP	Kudankulam Nuclear Power Project
kW	kilo Watt
kWh	kilo Watt hour
LE	Life Extension
LEP/LE	Life Extension Programme
LED	Light Emitting Diode
LF	Load Factor
LNG	Liquefied Natural Gas
LOA	Letter of Award
LOLP	Loss of Load Probability
LP	Linear Programming
LSHS	Low Sulphur Heavy Stock
LT	Low Tension
LWR	Light Water Reactor
Mcm	Million cubic metre
MCP	Market Clearing Price
MMTPA	Million Metric Tonnes Per Annum
MMSCMD	Million Metric Standard Cubic Metre per Day
MNRE	Ministry of New & Renewable Energy
MNP	Minimum Need Programme
MoEF&CC	Ministry of Environment ,Forest & Climate Change
MoP	Ministry of Power
MoP&NG	Ministry of Petroleum and Natural Gas

ACRONYMS	EXPANSION
MoRTH	Ministry of Road Transport and Highways
MoU	Memorandum of Understanding
MuDSM	Municipality Demand Side Management
MT	Million Tonne
MTEE	Market Transformation for Energy Efficiency
MToe	Million Tonnes Oil equivalent
MU	Million Units
M&V	Monitoring & Verification
MW	Mega Watt
NAPCC	National Action Plan on Climate Change
NAPS	Narora Atomic Power Station
NCDP	New Coal Distribution Policy
NDT	Non Dispatchable Technologies
NECA	National Energy Conservation Awards
NEF	National Electricity Fund
NEP	National Electricity Plan
NELP	New Exploration Licensing Policy
NETRA	NTPC Energy Technology Research Alliance
NHPC	National Hydroelectric Power Corporation
NIWE	National Institute of Wind Energy
NLC	Neyveli Lignite Corporation Limited
NMDC	National Mineral Development Corporation
NMEEE	National Mission for Enhanced Energy Efficiency
NML	National Metallurgical Laboratory
NO_X	Oxides of Nitrogen
NPP	National Perspective Plan
NPCIL	Nuclear Power Corporation of India Ltd.
NPTI	National Power Training Institute
NPMU	National Smart Grid Mission Project Management Unit
NSGM	National Smart Grid Mission
NSM	National Solar Mission
NTPC	National Thermal Power Corporation
OCGT	Open Cycle Gas Turbine
O&M	Operation & Maintenance
ODC	Over Dimension Consignment/ Over Dimension Cargo
PAP	Project Affected People
PAT	Perform Achieve & Trade
PC	Pulverized Coal
PCRA	Petroleum Conservation Research Association
PFA	Power For All
PFBC	Pressurised Fluidized Bed Combustion
PFC	Power Finance Corporation
PGCIL	Power Grid Corporation of India Limited

ACRONYMS	EXPANSION
PHWR	Pressurised Heavy Water Reactor
PIE	Partnership In Excellence
PIB	Public Investment Board
PLF	Plant Load Factor
PLL	Phase-locked loop
PMGY	Pradhan Mantri Gramodaya Yojna
PMP	Phased Manufacturing Programme
PPMP	Power Project Monitoring Panel
PPP	Public Private partnership
PRGF	Partial Risk Guarantee Fund
POSOCO	Power System Operation Corporation
PPA	Power Purchase Agreement
PPM	Parts Per Million
PRGFEE	Partial Risk Guarantee Fund for Energy Efficiency
PS	Private Sector
PSA	Power Supply Agreement
PSC	Production Sharing Contract
PSDF	Power System Development Fund
PSP	Pump Storage Plant
PV	Photovoltaic
PSS	Pumped Storage Schemes
PSU	Public Sector Undertaking.
R&D	Research & Development
R&M	Renovation & Modernisation
R-APDRP	Restructured Accelerated Power Development and Reforms Programme
RAPS	Rajasthan Atomic Power Station
REB	Regional Electricity Board
REC	Rural Electrification Corporation
RECTPCL	REC Transmission Projects Limited
RES	Renewable Energy Sources
RFP	Request for Proposal
RFQ	Request for Quotation
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RGTIL	Reliance Gas Transportation Infrastructure Ltd
RHE	Rural Household Electrification
RLA	Residual Life Assesment
RLDC	Regional Load Dispatch Centre
RLNG	Regasified Liquefied Natural Gas
RM	Reserve Margin
ROM	Run Of Mines
ROR	Run Of River
ROW	Right Of Way
RPCs	Regional Power Committees

ACRONYMS	EXPANSION
RPO	Renewable Purchase Obligation
RSOP	Research Schemes on Power
R&M	Renovation & Modernisation
R&R	Rehabilitation & Resettlement
SAARC	South Asian Association for Regional Corporation
SBDs	Standard Bidding Documents
SCADA	Supervisory Control and Data Acquisition
SCR	Selective Control Reduction
SDAs	State Designated Agencies
SDL	State Development Loan
SEAD	Super-Efficient Appliance Development
SEB	State Electricity Board
SEC	Specific Energy Consumption
SECI	Solar Energy Corporation of India
SEEP	Super-Efficient Equipment Program
SERC	State Electricity Regulatory Commission
SJVNL	Satluj Jal Vidyut Nigam Limited
SLDC	State Load Dispatch Centre
SDL	Statutory Liquidity Ratio
S&L	Standard & Labelling
SMEs	Small & Medium Enterprises
SOG	Sanctioned & Ongoing
SO_x	Oxides of Sulphur
SPM	Suspended Particulate Matter
SS	State Sector
SSTS	Solid State Transfer Switches
STPP	Super Thermal Power Plant
STPS	Super Thermal Power Station
STUs	State Transmission Utilities
SWHS	Solar Water Heater System
T&D	Transmission & Distribution
TERI	The Energy Research Institute
TIFAC	Technology Information Forecasting & Assessment Council
TOD	Time Of The Day
TOR	Terms of Reference
TOU	Time of Use
TPES	Total Primary Energy Supply
TPP	Thermal Power Plant
TPS	Thermal Power Station
UAVs	Unmanned Aerial Vehicles
UDAY	Ujwal DISCOM Assurance Yojana
ULB	Urban Local Bodies
UJALA	Unnat Jyoti by Affordable LED for All

ACRONYMS	EXPANSION
UMPP	Ultra Mega Power Project
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USC	Ultra Super Critical
UT	Union Territory
VAT	Value Added Tax
VCFEE	Venture Capital Fund for Energy Efficiency
VRE	Variable Renewable Energy

PREAMBLE FOR NATIONAL ELECTRICITY PLAN, 2015

Section 3(4) of Electricity Act, 2003 stipulates that, the Central Electricity Authority (CEA) shall prepare a National Electricity Plan in accordance with the National Electricity Policy and notify such plan once in five years.

Provided that the Authority while preparing the National Electricity Plan shall publish the draft National Electricity Plan and invite suggestions and objections thereon from licensees, generating companies and the public within such time as may be prescribed:

Provided further that the Authority shall –

a) Notify the plan after obtaining the approval of the Central Government;
b) Revise the plan incorporating therein the directions, if any, given by the Central Government while granting approval under clause (a).

Further Section 3(5) of said act stipulates that, the Authority may review or revise the National Electricity Plan in accordance with the National Electricity Policy.

Para 3 of National Electricity Policy, 2005 stipulates that, assessment of demand is an important pre-requisite for planning capacity addition. Also, section 73 (a) of the Electricity Act provides that formulation of short-term and perspective plans for development of the electricity system and coordinating the activities of various planning agencies for the optimal utilization of resources to sub serve the interests of the national economy shall be one of the functions of the CEA. The Plan prepared by CEA and approved by the Central Government can be used by prospective generating companies, transmission utilities and transmission/distribution licensees as reference document.

Accordingly, CEA shall prepare the National Electricity Plan that would be for a short-term framework of five years while giving a 15-year perspective and would include:

- Short-term and long term demand forecast for different regions;
- Suggested areas/locations for capacity additions in generation and transmission keeping in view the economics of generation and transmission, losses in the system, load centre requirements, grid stability, security of supply, quality of power including voltage profile etc. and environmental considerations including rehabilitation and resettlement;
- Integration of such possible locations with transmission system and development of national grid including type of transmission systems and requirement of redundancies; and
- Different technologies available for efficient generation, transmission and distribution.
- Fuel choices based on economy, energy security and environmental considerations.

While evolving the National Electricity Plan, CEA will consult all the stakeholders including State Governments and the State Governments would, at state level, undertake this exercise in coordination with stakeholders including distribution licensees and State Transmission Utilities (STUs). While conducting studies periodically to assess short-term and long-term demand, projections made by distribution utilities would be given due weightage. CEA will also interact with institutions and agencies having economic expertise, particularly in the field of demand forecasting. Projected growth rates for different sectors of the economy will also be taken into account in the exercise of demand forecasting.

Accordingly, the first National Electricity Plan covering the review of 10th plan, detailed plan for 11th plan and perspective Plan for 12th Plan was notified in the Gazette in August, 2007.

The Second National Electricity Plan covering the review of 11th plan, detailed plan for 12th plan and perspective Plan for 13th plan was notified in the Gazette in December, 2013 in two volumes **(Volume-I, Generation and Volume-II, Transmission).**

Inputs from report of Working Group on Power set up by erstwhile Planning Commission headed by Secretary (Power), MOP were used during the formulation of National Electricity Plan. Planning Commission has been replaced with NITI

AYOG, therefore Chairperson CEA vide letter no. DO No. CEA/PLG/IRP/2/10/2015/439 dated 09.07.2015 had requested MoP for their advice on constituting a Committee for National Electricity Plan. MoP vide letter DO No.38-7/1/2015-PNP dated 27.07.2015 advised CEA to constitute a Committee under Chairmanship of Chairperson, CEA with members from stakeholder's organizations. Accordingly, Chairperson CEA vide Order No. CEA/PLG/IRP/2/10 dated 28.08.2015 constituted a Committee for National Electricity Plan 2015 for the preparation of the National Electricity Plan with following composition & Terms of Reference(TOR).

COMMITTEE FOR PREPARATION OF NATIONAL ELECTRICITY PLAN 2015

A. CONSTITUTION:

- **i.** Chairperson, CEA - **Chairman**
- **ii.** Chief Engineer(IRP), CEA - **Member Secretary**

MEMBERS

- i. All Members of CEA
- ii. Economic Advisor, MOP
- iii. Joint Secretary, (MNRE)
- iv. Director General, BEE
- v. Advisor(Energy), NITI Aayog
- vi. Director General, CPRI
- vii. Chairman cum Managing Director, NTPC
- viii. Chairman cum Managing Director, NHPC
- ix. Chairman cum Managing Director, PGCIL
- x. Chairman cum Managing Director, PFC
- xi. Chief Executive Officer, (POSOCO)
- xii. Chairman cum Managing Director, NPCIL
- xiii. Chairman cum Managing Director, REC

B. TERMS OF REFERENCE OF THE COMMITTEE FOR NEP, 2015

- i. To review the likely achievements vis-à-vis targets set for the twelfth plan period towards generation from conventional sources along with reasons for shortfalls, if any.
- ii. To assess the peak load and energy requirement for the period 2017-22 and perspective forecast for 2022-27.
- iii. To assess the incremental capacity requirement to meet the projected load and energy requirement after considering R & M schemes, renewable and captive injection and suggest the feasible break up in terms of thermal, hydro, nuclear etc.
- iv. To make an assessment of the resource requirement like fuel, land, water, indigenous manufacturing capabilities, infrastructural, human resource for meeting the capacity addition requirements.
- **v.** To assess investment requirement for generation and transmission capacity **addition during 2017-22.**
- vi. To suggest energy conservation measures through Demand Side Management and suggest a strategy for low carbon growth.
- vii. Review of latest technological development and R & D in the power sector and to assess its suitability for Indian conditions.
- viii. Development of integrated Transmission Plan for the period from 2017-22 and perspective plan for 2022-27 including Grid Security, evacuation of Renewable Energy Sources and exploring SAARC integration.

C. 1. The NEP committee may co-opt any expert as may be considered necessary.

2. NEP committee may constitute separate sub-Committees on any aspect. The report of the Sub-Committee(s) shall be submitted to NEP Committee for consideration.

The first meeting of the Committee for National Electricity Plan, 2015 was held on 01.09.2015 under the chairmanship of Chairperson, CEA wherein, it was decided to constitute 11 nos. of Sub-Committees to look into different aspects of power sector and provides inputs to committee for NEP. Thereafter NEP Committee had met on 26.11.2015, 07.01.2016, 09.03.2016, and 26.04.2016. The constitution and TOR of the Sub-Committees are given as:

CONSTITUTION AND TERMS OF REFERENCE OF 11 SUB COMMITTEES CONSTITUTED UNDER COMMITTEE FOR NEP, 2015

1. SUB-COMMITTEE- 1- POWER FOR ALL

CONSTITUTION:
- Member, (GO&D), CEA – Chairman
- Chief Engineer (PFA), CEA - Member Secretary

MEMBERS:
- CEA-CE(DP&D), CE(PSLF)
- Representatives from REC, MNRE, BEE, PFC, FICCI

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Assessment in terms of increase in demand (MW&MU) due to "Power for all" schemes
- Measures for making available reliable and quality power to consumers at affordable rates
- Review effectiveness of 12th Plan Schemes like R-APDRP and to suggest modifications and/or give recommendations

2. SUB-COMMITTEE 2: DEMAND SIDE MANAGEMENT, ENERGY EFFICIENCY & CONSERVATION

CONSTITUTION:
- DG (BEE)- Chairman
- Chief Engineer, (TPE&CC), CEA - Member Secretary

MEMBERS:
- Representatives from EESL, PCRA, CII, IEEMA, ELCOMA, MNRE, NITI Aayog, FICCI
- CEA-CE(DP&D)

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Assess Energy Conservation measures implemented and review achievements till 12th Plan.
- Assessment of reduction of energy demand and peak demand through Demand Side Management (DSM) and Energy Efficiency Targets for 2017-22 and measures to be adopted
- Achievements and Plans with respect to Missions of Climate Change

3. SUB-COMMITTEE 3: DEMAND PROJECTION

CONSTITUTION:
- Member, (Planning), CEA – Chairman
- Chief Engineer, (PSLF), CEA - Member Secretary

MEMBERS:
- CEA- CE(PFA), Member Secretary(RPCs)
- Representatives of BEE, NITI Aayog, POSOCO, MNRE

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Demand Assessment in terms of peak and energy requirements for the period from 2017-22 and 2022-2027 considering impact of PFA, DSM and Energy Conservation Measures.

4. SUB-COMMITTEE 4- REVIEW OF 12TH PLAN AND GENERATION PLANNING

CONSTITUTION:
- Member, (Planning), CEA – Chairman
- Chief Engineer (IRP), CEA - Member Secretary

MEMBERS:
- CEA- Director (IRP), Director (RE), Director (TPM), Director (HPM), Director (OM), Director (TPI), Director (HPI), Director(PSLF), Director(GM)
- POSOCO, NPCIL, MNRE

TERMS OF REFERENCE OF SUB-COMMITTEE:
- To review the likely achievement vis-a-vis targets during 12th Plan period towards generation including non-conventional sources and R&M/LE. Reasons for shortfalls, if any.

- Assessment of generation capacity addition during 2017-22 from grid connected Renewable Energy Sources
- Recommend optimal mix of additional Generation Capacity for 2017-22 – Listing of Projects & their phasing and advance action for 2022-27 including broad identification of projects
- Assess potential for R&M/LE and formulate plans to maximize benefit (efficiency & capacity utilization)

5. SUB-COMMITTEE 5- INTEGRATION OF RENEWABLE ENERGY SOURCES

CONSTITUTION:
- Member, (PS), CEA- Chairman
- Chief Engineer, (PSP&A-II), CEA- Member Secretary

MEMBERS:
- CEA- CE(RE), CE(GM), CE(IRP), CE(RA), CE(PSLF), NITI Aayog
- Representatives from POSOCO, RPCs, MNRE, PGCIL

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Issues relating to seamless integration of Renewable Energy Sources into Power System
- Balancing requirement for Renewable
- Flexible Generation

6. SUB-COMMITTEE 6- TECHNOLOGICAL ADVANCEMENT AND RESEARCH & DEVELOPMENT

CONSTITUTION:
- Director General, CPRI -Chairman
- Executive Director (NETRA), NTPC - Member Secretary

MEMBERS:
- Representatives from IEEMA, IIT- Kanpur, PGCIL, DST, BHEL, MNRE
- CEA-CE(R&D), CE(TETD), CE(HETD), CE(SETD)

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Review of Existing R&D Facilities & Programmes in Power Sector
- Recommendations regarding Science & Technology programmes to be implemented during 2017-22, including identification, transfer and diffusion of technology in various areas of the Power Sector.

7. SUB-COMMITTEE 7: FUEL REQUIREMENT

CONSTITUTION:
- Member, (Planning), CEA- Chairman
- Chief Engineer, (FM), CEA - Member Secretary

MEMBERS:
- Representatives from MoP&NG, MoC, NPCIL, NLC, MNRE
- CEA- CE(IRP) and CE(TPI)

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Identify and quantify the different types of fuel required to meet the capacity addition, source-wise fuel availability etc.

8. SUB-COMMITTEE 8- FUND REQUIREMENT

CONSTITUTION:
- Member, (E&C), CEA - Chairman
- Chief Engineer (F&CA), CEA- Member Secretary

MEMBERS:
- Representatives from MOP, PFC, REC, NTPC, NHPC, PGCIL, NITI Aayog, NPCIL, MNRE
- CEA- CE(TPI), CE(HPI), CE(PSP&A)

TERMS OF REFERENCE OF SUB-COMMITTEE
- Review of financial issues relevant to Power System.

- Identify the investment required to meet the capacity addition and associated transmission system, possible sources of funds etc.

9. SUB-COMMITTEE 9- KEY INPUTS FOR POWER SECTOR

CONSTITUTION:
- Director, (Projects), NTPC - Chairman
- Chief Engineer, (TETD), CEA - Member Secretary

MEMBERS:
- CEA-CE(TPI), CE(PSP&A), CE(SETD), MNRE, FICCI
- Representatives of BHEL, Ministry of Railways, Steel, MoP&NG, Shipping, Surface transport, Cement, Private equipment Manufacturers, CII

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Identify the key inputs required for meeting the capacity addition requirement.
- To assess infrastructural support required for Power capacity addition during 2017-22 & 2022-27.
- Land and Water requirement.
- Transport (Railways, Roads, Waterways, pipeline, LNG terminals).
- Port Facilities
- Construction & Manufacturing Capabilities specifically erection machinery & erection agencies including Civil & BOP contractors.
- Steel, Cement, Aluminium and other materials.

10. SUB-COMMITTEE-10: TRANSMISSION PLANNING

CONSTITUTION:
- Member, (PS), CEA - Chairman
- Chief Engineer (PSP&A-II), CEA - Member Secretary

MEMBERS:
- CEA- CE(PSP&A-I), CE(PSPM), CE(SETD), RPCs
- Representative of PGCIL, POSOCO, MNRE, Haryana, Orissa, Gujarat, Tamil Nadu, one of the North Eastern State

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Review of achievement of 12th Plan targets for transmission and reasons of shortfall
- Development of integrated Transmission Plan for the period from 2017-22 and perspective plan for 2022-27
- Explore SAARC integration
- Green Corridor
- Technological development in Transmission

11. SUB-COMMITTEE-11: HUMAN RESOURCE REQUIREMENT

CONSTITUTION:
- Director General (NPTI)-Chairman
- Chief Engineer(HRD), CEA- Member Secretary

MEMBERS:
- Representative of PGCIL, NTPC, NHPC, MNRE, Two State Gencos
- Representative from National Skill Development Corporation

TERMS OF REFERENCE OF SUB-COMMITTEE:
- Assess the human resource requirement
- Human Resource Development plan

In view of the stipulations of the Act as mentioned above, exercise for preparation of the NEP was undertaken by CEA. This Plan is outcome of the inputs provided by various Sub Committees of the NEP. The Draft NEP was published on the CEA and MoP website for views/suggestions/objections from the stakeholders and general public. A summary of relevant comments received from various stakeholders, along with the action taken thereof, is given in **Table I** below.

Summary of Comments received on Draft Report of National Electricity Plan (Generation)

Table I

S.NO.	SUMMARY OF THE COMMENTS	ACTION TAKEN	MODIFICATION IN NEP
1	**POSOCO**		
1.1	**Demand projections** The following two issues have been left out in arriving at projected demand. (i) Impact of space cooling requirements on power demand; (ii) Impact of electric vehicle mobility on power demand.	The Final NEP is based on projections of 19th EPS.	No
1.2	It is suggested that NEP may be reviewed at least once in two years.	It has been recommended in NEP for mid-term review of EPS. Based on the review, NEP would be revised, if required.	No
1.3	It is suggested that the list of the power plants planned for retirement, which is of the order of 5200 MW, may be given in annexure.	List of power plants considered for retirement is given as Annexure in NEP.	Yes
1.4	Various outputs from EGEAS Software may be given as an Annexure to the NEP.	EGEAS outputs are voluminous. Inclusion of these as a part of NEP would unnecessarily increase the volume.	No
1.5	It might be worthwhile to consider studying a lower growth rate of say 5%.	Will be done, if required, after mid-term review of EPS.	No
1.6	There is an inherent assumption that coal plants would not face water scarcity in case of failure of monsoon.	Percentage of coal-based plants affected due to water scarcity is quite low when compared with the total installed capacity of the coal-based plants in the country. With the integration of renewable energy sources in the grid, coal based plants are expected to run at a low PLF which will also reduce their water requirement.	No
1.7	Some power plants have very poor levels of fly ash utilization.	As suggested, this is now included in NEP	Yes.
1.8	NREL Report concludes that there is hardly any impact on emissions due to frequent cycling and ramping of the power plants.	Further detailed studies may be needed to establish the correlation between emission and cycling.	No
1.9	There is a need to include system planners and system operators also in the capacity building and training programmes.	The manpower projections and training requirement for the period 2017-22 and 2022-27 include the requirement of system planners and operators. The microscopic categorization	No

		is taken care in the Skill Development Plan of the MoP	
1.10	A separate chapter on storage technologies could also be added.	Storage technology is in nascent stage and it would be premature to discuss in detail in NEP about its implementation impact in load management vis-a-vis cost-effectiveness.	No
1.11	Minor typographical errors in draft NEP.	Taken care of.	Yes.
2	**MAHAVITRAN- MAHARASHTRA**		
2.1	A realistic Demand projection for next five years (FY2017-18 to FY 2021-22) is required.	The Final NEP is based on projections of 19th EPS.	No
2.2	Overstated demand would result in stranded capacity and corresponding Transmission Capacity requirement, which results in increase in consumer tariff.		
2.3	Distribution Licensee wise projected demand needs to be provided in NEP	The details are available in 19th EPS.	No
2.4	No mention of peak load management for each Distribution Licensee in the NEP	Not within the scope of NEP	No
2.5	How the State wise targets of DSM have been arrived?	The state-wise target were worked out by BEE and the figures were furnished by DSM Sub-Committee-02, which is headed by DG, BEE.	No
2.6	• The cost of renewable energy purchases has severely affected MSEDCL finances in recent years. Therefore, the concerns of Distribution Licensee cannot be ignored while promotion of renewable energy. • Construction of transmission infrastructure like "Green Corridor" would significantly impact transmission tariff • The investment requirement for RE Capacity addition and grid interaction of RE Capacity will have large-scale implications on consumer tariffs. • 175 GW of Renewable Energy Capacity has been envisaged to be commissioned by the end of FY 2021-22. The aforementioned capacity has to be integrated with the grid which is a critical task and comes with a cost.	The cost of RES should be seen from the perspective of the overall sustainability. Analysis should not be focussed only on short-term tangible cost-benefit analysis. Long-term societal cost-benefit should also be factored. Capacity addition from RES is as per the target set by GOI.	No
2.7	MEDA is the nodal agency for development of renewable energy in the State. The renewable energy potential may be considered as per MEDA data	The RES figures projected in the Draft NEP is as per MNRE data.	No
2.8	In Annexure 6.3, the target to be achieved by 2022 (solar – 11926 and wind 7600) seems to be on higher side		
2.9	Considering the large capacity addition from RE Generation Sources along with coal based capacity addition, it is expected that the	This has already been highlighted in NEP	No

	thermal power plants would be left stranded or run at lower PLF.		
2.10	It is suggested that a separate chapter on investment is required	A separate chapter on Fund Requirement is already there in NEP.	No
3	**HARYANA POWER PURCHASE CENTRE**		
3.1	As on today up to 25 MW Hydro plants are covered under renewable power category. This range should be enhanced upto 100 MW to promote higher range capacity plants. The cost of smaller plants is more than the large plants in term of cost per MW.	It is as per MNRE. However, the suggestion given is being included in the recommendations of NEP	Yes
3.2	Solar power is available only during off peak hours which will further increase the gap between Peak and off peak. The government should promote off grid solar power system as it is more beneficial.	The NEP is concerned with meeting the demand of the grid connected loads.	No
3.3	Transmission system strengthening should be done optimizing the source to be consumed in the same region and inter region should be planned in future to reduce the impact in POC charges.	It is dealt in Volume 2- Transmission of NEP.	
3.4	The availability of gas based plants during peak hours shall help in reducing the gap between the off peak and peak hours. As such, the availability of natural gas to the gas based power plants may be increased.	It has already been recommended in NEP.	No
4	**GRIDCO**		
4.1	i) Region-wise demand forecast may be brought out in NEP. ii) Area-wise and location-wise capacity additions from different energy sources may be given in Plan.	i) Region-wise demand forecast has been brought out in the 19th EPS. ii) State-wise locations for capacity additions from different energy sources are given in the NEP.	No
4.2	----the planning period in which 50,025 MW under construction **coal-based generating units** for capacity addition has been envisaged. The details of locations /capacity and commercial operation dates may also be given.	The coal based capacity under construction for likely benefit during 2017-22 have been revised to 47,855 MW. The details of locations /capacity and year-wise commissioning dates are given in annexure.	Yes
4.3	It is requested to identify the planning period during which the UMPPs have been scheduled for commissioning.	At the time of preparation of NEP, details were not available.	No
4.4	**Retirement of old units** – i) Name of the units being retired during 2017-22 may be given.	List of power plants considered for retirement is given in NEP.	Yes

	ii) -----whether it would be prudent to retire best performing units because of its age and capacity		
4.5	GCV issue may be focused in the NEP as “despatch GCV” of coal should be approximately equal to the “as received GCV”.	Third party sampling for ascertaining the GCV of coal is already in place.	No
4.6	----planning study should suggest replenishing the coal bearing States from the renewable energy equivalent to that sacrificed from coal-based generating plants ----	Not within the scope of Planning.	No
4.7	i) Region-wise demand forecast may be brought out in NEP. ii) Area-wise and location-wise capacity additions from different energy sources may be given in Plan.	i) Region-wise demand forecast has been brought out in the 19th EPS. ii) State-wise locations for capacity additions from different energy sources are given in the NEP.	No
5	**GOVERNMENT OF TELANGANA**		
5.1	Spinning reserve requirements may be stipulated keeping in view the key risks the system is likely to face, including falls in solar insolation (given the high RE capacity planned in the grid) and technical failure of generating stations.	5% Spinning Reserve is taken as per National Electricity Policy,2005.	No
5.2	Assumption of 40% of Solar energy from solar rooftops is highly optimistic and government /DISCOMs need to proactively take steps to increase penetration of solar roof tops.	Data regarding capacity addition from Solar Rooftop aggregating 40 GW is as per MNRE.	No
5.3	In order to be able to achieve PFA by 2019, it is imperative for Central Government to ease funding to the DISCOMs especially Telangana Discoms.	It is outside the purview of NEP.	No
5.4	A roadmap for capacity building in these areas be also included in the NEP. The roadmap could plan for creation of Centre of Excellence in RE integration and management in each state/DISCOM Recent initiatives by states include a dedicated load management centre for renewables. Efforts are required to strengthen such initiatives and ensure capable manpower for their operations	A Separate chapter 14 is provided for Human Resource Development in Power Sector in NEP wherein the capacity building in Renewable sector is mentioned.	No
5.5	Penetration of 800 MW of Solar Water Heating system may be optimistic and may be moderated.	800 MW of Solar Water Heating system is as per MNRE projection.	No
5.6	To assess the efficacy of the TOD/TOU programmes, discoms may undertake studies after a year of implementing the TOD/TOU scheme. Suitable adjustments may be made on the TOD/TOU time slots as well as incentive	Not within the scope of NEP	

	to achieve the desired objective of reducing the peak load on the system.		
5.7	Government should increase awareness among consumers about the programme. A strong monitoring and verification mechanism needs to be implemented and benefits case needs to be established on the savings.	This needs to be done at the DISCOM's end.	No
5.8	Computation of Peak demand by using load factor might not give realistic picture considering changes in demand drivers. The plans of state discoms on load management need to be factored. simple load factor multiplication for energy saving from Energy efficiency measures to arrive peak demand reduction would not be reflective of the true system conditions	The Final NEP is based on projections of 19th EPS.	No
5.9	As seen in the sensitivity analysis, PLF of coal based thermal plants is highly dependent on RES and hydro capacity additions. And also variation in load during 24 hours of day would result in backing down of thermal plants beyond their technical minimum. Hence, it is advisable to encourage state and central Gencos in reducing technical minimum of coal based thermal plants for grid stability and to provide reliable power to the consumers Countries such as Germany, which have high RE have made significant progress in increasing the flexibility of their thermal plants and making them more responsive to demand.	It has already been mentioned in the Recommendation chapter 15 of NEP.	No
5.10	Potential of Wind-solar hybrid plant across India needs to be established and hybrid plants needs to be encouraged to be set up at those locations.	It is in the scope of MNRE.	No
5.11	The state of Telangana has a potential of 4244 MW of wind as per the latest NIWE estimates. In addition, potential also exists for Hydro, biomass and waste to energy power generation.	The figures projected in NEP is as per MNRE.	No
5.12	The installed capacity of RE Technologies in Telangana as on 31.03.2016 is as follows – Biomass………………………… 58.00 MW Bagasse………………………. 124.15 MW Small Hydro…………………. 25.56 MW Municipal Solid Waste …….18.6 MW Industrial Waste ……………..18.5 MW Wind………………………………..77.7 MW Solar…………………………...527.84 MW		No
5.13	While hydro power is a flexible solution, control over release of water does not always stay with the SLDC. This might possibly limit the hydro plants to be used as peak load plants.	The crucial role of hydro and gas based plants in meeting the balancing requirements of RES	No

	Going forward, due to massive RES capacity addition, it is prudent to have peak load energy sources for grid balancing. Hence, there should be options to secure gas for gas-based power projects. Pricing and production clarity on domestic gas and adequate sources of R-LNG are important to ensure operations of gas-based plants	has been elaborately highlighted in NEP.	
5.14	View on likely off-take of electric vehicles and its impact on the grid can be discussed.	19th EPS has factored this.	No
5.15	Managing deficit is crucial but managing surplus would also be another key issue to be addressed in future. This would necessitate more robust and dynamic short term market. NEP should discuss about complexities in short term market and bottlenecks that need to be addressed by SLDC/ DISCOMs.	Host of regulatory issues are involved. Regulators may have to address this.	No
5.16	Going forward, it is prudent to widen the scope of IT intervention and automation in G-T-D to manage the grid stability and to optimize the costs. Hence, elaborate the same.	Outside the scope of NEP.	No
5.17	Spinning reserve requirements may be stipulated keeping in view the key risks the system is likely to face, including falls in solar insolation (given the high RE capacity planned in the grid) and technical failure of generating stations.	5% Spinning Reserve is taken as per National Electricity Policy,2005.	No
6	**POWER COMPANY KARNATAKA LIMITED(PCKL)**		
6.1	The target of Renewable capacity of 175 GW by 2022 has to be reviewed.	Capacity addition from RES is as per the target set by GOI.	No
6.2	Repowering of existing wind power projects under the existing "Policy for repowering of wind power projects" may be encouraged along with going for new wind power projects.	The suggestion is incorporated in the recommendation of Final NEP.	Yes
6.3	Hydro and gas based power plants shall be reserved for peaking support and for balancing the grid by providing suitable tariff mechanism	The NEP has been formulated based on this philosophy only. Regulators have to address the tariff design issue.	No
6.4	Review committee at national level and regional level may be considered under NEP to monitor the progress of the projects.	Recommendations of the review in already included in the NEP.	No
6.5	List of the coal based projects of 50,025 MW under construction may be provided in the NEP.	This is being added in the NEP	Yes
6.6	Suitable mechanism may be evolved for avoiding building up of the stranded capacities and for utilization of any such existing stranded capacities.	Setting up of power plants is largely delicensed as per Electricity Act 2003. NEP is a reference document which helps the prospective investor in facilitating the decision making process.	No
6.7	Some typographical errors have been mentioned.	Necessary corrections has been done in final NEP.	Yes
7	**BRPL**		

7.1	Consider Hydro projects as Renewable sources.	This is being added in the recommendation	Yes
7.2	DSM should be encouraged to reduce Peak load.	This has already been incorporated in the NEP.	No
7.3	The resultant tariff of RES after balancing adjustment could be uncompetitive with prevailing coal prices.	The cost of RES should be seen from the perspective of the overall sustainability. Analysis should not be focussed only on short-term tangible cost-benefit analysis. Long-term societal cost-benefit should also be factored.	No
7.4	RE capacity has been highly exaggerated and impractical.	Capacity addition from RES is as per the target set by GOI.	No
7.5	Pumped storage plants are commercially unviable.	Pumped storage plants are expected to play a crucial role in meeting the balancing and ramping requirement of the grid. Regulators need to design necessary Tariff for this	No
7.6	Old and inefficient plants should be phased out rather than increasing the Capex. DISCOMs are highly affected by increasing cost by installing necessary equipment.	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	Yes.
8	**NITI AAYOG**		
8.1	It is suggested that cost implications of all the three scenarios need to be compared for planning purpose.	Government of India has set up the target of 175 GW for renewable energy sources. The major focus is to arrest adverse climate change. Further, RES technology is evolving compared to the mature technology of conventional plants. Hence, cost comparison would be highly subjective.	No
8.2	It is suggested that the National Electricity Plan should not keep capacity addition static for coal-based generation, but should lower capacity augmentation, which could work at higher PLF.	Setting up of coal based plants is delicenced. Decision of setting up of power plants is dependent on the individual wisdom of investor.	No
8.3	It has been stated that presently, existing gas-based power plants are operating at very low PLF (23%) and few gas-based power plants are lying idle due to non-availability of natural gas. As per electrical demand projects by CEA, the gas based project projects are likely to operate at 23% PLF. This is matter for serious consideration.	In NEP, the role of gas based plants have been highlighted and the minimum requirement of gas for RES integration has also been specified.	No
8.4	Considering the electricity demand projections and capacity addition Plan of CEA, the Hydro Generating are likely to operating at 36% of total capacity. This will also result in sub optimal operation of hydro projects.	Utilisation of Hydro Plants depends on the available hydro energy. For study purpose, Design Energy has been taken into consideration. There is no question of Sub optimal Utilization of Hydro Power.	No

8.5	It is proposed that CEA may take up an exercise to estimate balancing capacity	Balancing Capacity will be covered in Volume. II- Transmission of NEP.	No
8.6	Cost norms considered for calculating the fund requirement for the generation sector has been taken on higher side of coal (Rs. 7 crore per MW) and hydro (Rs. 10 Crore per MW) sector. Opening up of competitive bidding route for generation sector should have brought down the cost per MW of installation cost. This needs to be reconciled.	The Cost/MW norms considered are as per actual trend of expenditure plus additional costs due to new environmental norms.	No
8.7	Moving form super critical technology to ultra/advanced super critical technology is the key for substantial improvement in efficient utilisation of natural resource (coal)	It has already been taken in NEP.	No
8.8	As regards the RE Integration, no estimates have been done in respect of back up storage solution required when no power generates from RE.	It has already been mentioned in Volume. II- Transmission of NEP.	No
8.9	The NE plan has identified different types of costs to be incurred during integration of RE in the main grid but has not provided cost estimates of such costs.	It is in the nascent state. Therefore, estimation of cost at this stage is very subjective.	
8.10	For R&D projects, new technology like quantum dots, Organic coatings, Multi-junction cells, and third generation technology like solar panels which utilizes UV and infrared-spectrum which ultimately increases the efficiencies of cells, needs to be also factored in the report.	As suggested, this is now included in NEP.	Yes
8.11	Planning of RE based power must factor in the requirement of land, which is very crucial for the country. The report has not made any such assessment.	MNRE was requested for working out the same separately.	No
8.12	Table 10.8 – 10.9 provides key material assessment for conventional power generation. The same assessment should also be done for RE based power generation.	Included in NEP.	No
8.13	Skill identification for RE to be made separately as this has been merged with thermal (upto 2022). However, for 2022-27, there has been separate assessment, which provides technical and non-technical manpower requirement.	Skill identification for RE was not given separately as the RE manpower at the beginning of 2017-22 was not available.	Yes
8.14	In the chapter-5, the battery storage system needs to be included.	Storage technology is in nascent stage and at present it would be premature to discuss its operational as well as cost implication in details in NEP	No
9	**BHEL**		
9.1	The basis and factors considered for the demand projection have not been covered in entirety.	The Final NEP is based on projections of 19th EPS.	No
9.2	The draft NEP seems to be skewed towards environmental sustainability alone	Capacity addition from RES is as per the target set by GOI.	No

9.3	The draft NEP has considered a meagre capacity of 5.2 GW for retirement against 55 GW capacity which shall be exceeding a life of 25 years by 2027.	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	No
9.4	To make the planning process more comprehensive and realistic, solar achievable solar capacity addition should be considered.	Capacity addition from RES is as per the target set by GOI.	No
10	**GOVERNMENT OF MADHYA PRADESH**		
10.1	Has given elaborate comments on the achievement made by MP Govt. towards Reforms in Power Sector, infrastructure growth, Generation and transmission, AT&C loss reduction and Feeder separation scheme.		No
11	**M.P. GENERATING COMPANY LIMITED**		
11.1	In some power plants in M.P., some portion of the land within the power stations can be utilized for installation of solar PV power generation projects.	This is now added as a recommendation in NEP	Yes
11.2	For MP, solar potential has been indicated as 61660 MW whereas the tentative target of 5675 MW installation up to year 2022 has been indicated. The details of such estimation may be given by CEA.	The potential and target for MP given in NEP is as per the data furnished by MNRE	No
11.3	Coal based capacity addition of super-critical/ultra-super-critical units in place of decommissioning of old/inefficient thermal plants may be appropriately brought out in the concluding part of NEP.	It is already mentioned in NEP.	No
12	**GOVERNMENT OF PUNJAB**		
12.1	• Punjab is a power surplus state. To achieve the RES capacity addition target, conventional power projects have to be backed down and other cheaper power surrendered • Power generation from RES is infirm and unreliable. Grid stability will be difficult to achieve. • It would not be possible to frequently ramp up and down the thermal plants • Further addition of RES should be as per RPO target only	Capacity addition from RES is as per the target set by GOI. Issues related to capacity addition has been dealt in details in NEP.	No
13	**GOVERNMENT OF WEST BENGAL**		
13.1	No Comment		No
14	**NLC**		
14.1	There should be protection available to the existing players in thermal generation segment by way of lowering of norms for recovery of fixed charges.	This is a regulatory issue.	No
14.2	Lower PLF of TPPs is foreseen due to growing of RES. There should be proper balance in this regard for the recovery of additional investment.	Setting up of thermal electric plants is delicensed. The objective of NEP is to provide a reference document to the prospective investors.	No

14.3	There should be protection available to the existing players in thermal generation segment by way of lowering of norms for recovery of fixed charges.	This is a regulatory issue.	No
15	**NPCIL**		
15.1	Likely capacity Addition from Nuclear in the 12th plan is expected to be 2000 MW instead of 2500 MW given in the review.	The review was carried out as on 31.03.2016 based on the inputs from NPCIL.However actual capacity addition has been considered in final NEP.	No
15.2	Include a Capacity of 500 MW from PFBR by BHAVINI in the list.	This is the unit which is slipping from the 12th plan and has been considered in the Generational Planning study.	No
15.3	NPCIL has furnished a list of additional projects which may also come during 2022-27.	Based on the past achievement a conservative capacity addition of 6800 MW has been considered. Any addition in excess of this from Nuclear sources can be accommodated in the grid.	No
15.4	Revised cost estimate per MW for Nuclear plants have been submitted.	These are being considered in the final NEP.	Yes.
15.5	For projects likely to be launched beyond 2027,some advanced actions are required for which funds may be required during 2022-27.	These are being considered in the final NEP.	Yes.
15.6	NPCIL has furnished percentage details of Auxiliary Power Consumption in respect of different types of Nuclear Power Stations.	These are being considered in the final NEP.	Yes.
16	**NEEPCO**		
16.1	To be included: NEEPCO has a view that the model test should be conducted for all the hydro projects having unit sizes above 25 MW.	Included in final NEP	Yes
17	**NHPC**		
17.1	The status of unit-3 and unit-4 of Tessta Low Dam –IV HEP at sl.No 66 and 67 are mentioned as “ÜC” whereas these units are commissioned in July,2016 and August’2016 respectively.	The review was carried as on 31.03.2016 accordingly the status of the projects as on 31.03.2016 is given in Annexure 2. Review has been revised as on 31.03.2017 in the final NEP.	No
17.2	Silt Erosion: Hard Coating(HP-HVOF) on under water parts due to high silt and to increase the life of underwater parts due to high silt and to increase the life of underwater parts.	Included in Final NEP	Yes
17.3	The following to be included in the current issues and challenges in Hydro Chapter: • Non-availability of grid power during initial stage • Safety and security problem	Included in Final NEP	Yes

18	**FICCI**		
18.1	It would be logical if National Electricity Policy is finalized ahead of National Electricity Plan.	As per Sec.3 (4) of EA,2003, CEA has to prepare NEP every 5 years in accordance with the National Electricity Policy, the Policy existing at the time has been taken into account for the preparation of NEP.	No
18.2	Proposes revision of free power in favour of the State Government in case of Hydro projects since it interferes with project economics.	This is as per the extant Hydro Power Policy. Revision of hydro policy is not within the purview of NEP. Hydro policy is formulated taking into account various factors into consideration including the project economics.	No
18.3	An empowered National Body overseeing and monitoring the implementation with participation of States is proposed to enable accelerated execution of hydel projects.	In the recommendation part of the NEP, proposal for removal of bottlenecks in execution of hydel projects has already been mentioned.	No
18.4	NEP may suggest policy measures to be examined that would be necessary to promote use of gas as feedstock for power generation.	In the NEP, vital role of gas based TPPs has been highlighted.	No
18.5	With PLF of coal based TPPs projected to be 47.9% in 2021-22 under RES capacity addition of 175 GW, policy and regulatory guidelines will be necessary to deal with the redundancy of base load generation capacities and provide the cost recovery principles through adequate market mechanism and tariff design.	This is a regulatory issue.	No
18.6	The new capacity likely to accrue during 2017-22 will be significantly higher than 50,025 MW taken in the Plan. Directional guidance is necessary to decide whether to progress with projects corresponding to additional capacity not considered in the draft Plan or treat them as redundant.	As per CEA's assessment, a capacity addition during 2017-22 may be 47,855 MW. After the enactment of EA 2003, electricity generation has been delicensed.	No
18.7	Review is also suggested of the capacity of 5200 MW contemplated for retirement by the end of 2021-22.	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	No
19	**IEEMA**		
19.1	NEP has considered retirement of only 5200 MW of old and inefficient subcritical units with life exceeding 40 years	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	Yes
19.2	The draft NEP shows that non-fossil fuel will contribute more than 60% of the Installed Capacity which is much higher than INDC target	Capacity addition from RES is as per the target set by GOI.	No
19.3	Various domestic equipment manufacturers made huge investment in setting up of supercritical facilities which are now at a	RES is not going to contribute significantly to meet the peak demand. Hence requirement of	No

	serious risk due to draft NEP projections. Keeping in view the huge imports from China in setting up RES capacity, both the purpose are likely to be defeated.	coal based capacity is not highly co-related with RES capacity addition.	
19.4	The lower per capita electricity consumption in India suggests the potential latent demand yet to be tapped in the country	Demand taken in the Final NEP is as per the projection of 19th EPS.	No
19.5	The draft NEP assumes greater importance due to long gestation period in setting up of thermal power plants. A scenario of power shortage may be faced in case of any shortfalls in the draft NEP projections.		
20	**WORLD ENERGY COUNCIL**		
20.1	Realistic assessment of growth of demand is needed	The Final NEP is based on projections of 19th EPS.	No
20.2	• Report brings out that no coal based capacity addition is required under any scenario irrespective of RE capacity addition. Though true in this respect, larger the capacity addition through the Renewables, larger will be the cycling stress on the coal based power plants and lower will be the power factor. Moreover, peak demand will have to be met by the conventional power plants. • RE addition will only add additional cost and investment requirement and would lower the thermal PLF. Therefore, addition of RE capacity without storage will not make any sense • Cycling for coal based stations would lead to excessive stress and should be avoided.	Government of India has set up the target of 175 GW for renewable energy sources. The major focus is to arrest adverse climate change. NEP has already highlighted that thermal power plants will run at low PLF due to the addition of capacity from renewable energy sources. Storage technology is in nascent stage and it would be premature to discuss in detail in NEP about its implementation impact in load management vis-a-vis cost-effectiveness.	No
20.3	The retirements of old, inefficient capacity needs to be captured in a more robust manner which would invariably lead to construction of more efficient units.	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	No
21	**L&T**		
21.1	Underestimation of old thermal units considered for retirement.	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	Yes.
21.2	In view of resource (land and solar PV module capacity) constraints, the actual scenario of solar power capacity addition till 2022 can be lower than scenario III (41,237 MW) of draft NEP.	Solar is not going to contribute in meeting peak demand. Therefore, slipping in respect of solar capacity addition is not going to increase the thermal capacity addition.	No
21.3	Instead of halting installation of new coal power plants, emphasis should be laid on replacing across 58 GW of sub-critical units,	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	No

	likely to be older than 25 years by 2027, with efficient super-critical units in the final NEP.		
22	**SIEMENS**		
22.1	In the draft NEP, 5.2 GW of capacity only has been considered for retirement. This seems to be under estimated.	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	No
22.2	Under "the phased manufacturing program", various boiler and Turbine suppliers added manufacturing facilities in India. This was followed by Sub-suppliers like BOP, steel, civil contractors etc. ramping up their investment and their capabilities. Drastic changes would lead to financial losses to these investors and slowdown the heavy industries manufacturing set up in India. Utilising manufacturing capabilities of thermal power plant equipment strengthens "make in India" compared to renewable which has high import factor	Capacity addition from RES is as per the target set by GOI. RES is not going to contribute significantly to meet the peak demand. Hence requirement of coal based capacity is not highly co-related with RES capacity addition.	No
22.3	Thermal plants are economically viable. Plants with improved flexibility can also act as peaking plants. With new technology, environmental norms can also be achieved.		No
22.4	Make in India, Smart Cities, 24X7- Power Supply to All, UDAY etc. may affect the demand projection	Already taken in the 19th EPS	No
23	**GE /ALSTOM**		
23.1	Estimates are extremely conservative with respect to conventional electricity sources especially coal. Even reports from international agencies consider greater role for coal in long term Indian energy mix.	The estimates in the NEP for conventional electricity sources have been made based on the detailed estimation of demand by the 19th EPS and followed by generation expansion studies carried out in CEA.	No
23.2	Capacity addition estimates of hydro and renewables for 2017-22 period as well as for 2022-27 period is extremely high.	Realistic assessment of hydro capacity addition has been considered in final NEP.	No
23.3	Retirement plan considers only those units which are >40 years old and/or are <100MW unit size. This is extremely conservative.	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered. This consists of normal retirements of 5927 MW + retirement of 16,789 MW due to inadequate space for FGD.	Yes
23.4	Basis of selecting ENS figure?	In the NEP, ENS was selected based on the study of ENS of different countries.	No
23.5	Hydro imports from Bhutan considered for 2022 is 5.1 GW.	The details of hydro import from Bhutan has been incorporated in the final NEP.	Yes.
23.6	Hydro Projects considered for likely benefits for 2017-22 period are debatable.	Realistic assessment of hydro capacity addition for the period	No

		2017-22 has been considered in final NEP.	
23.7	As a prudent measure, in view of lack of precedent for RES growth, the forecasting model should consider moderate growth rate as input parameters. More realistic assessment of potential of renewables in Indian market needs to be done.	Capacity addition from RES is as per the target set by GOI.	No
23.8	The actual electricity demand, i.e. unconstrained demand for electricity, in India is far more than the figures projected in the draft report.	The demand has been taken as per 19th EPS .	No
24	**WRI**		
24.1	DSM measures: DSM measures can be broadly classified into energy efficiency and DR. It would be useful to separately highlight these	DSM figures are only by energy efficiency. DR in India is in primary stage. This has to be implemented through regulatory mechanism	No
24.2	Clarify what is the “proposed capacity addition” of States/UTs for scaling of hourly renewable generation. Are these the ones proposed by MNRE or adopted by States?	RES capacity addition w.r.t. the states have been provided by MNRE	No
24.3	Hydro Power capacity addition has always slipped over historical time periods. To build conclusions, more weightage should be given to scenarios with slippages.	Realistic assessment of hydro capacity addition during 2017-22 have been considered in final NEP.	No
24.4	The mechanisms to foster the growth of ramp up power market needs to be explained in the document.	Regulators have to address this issue.	No
25	**ENZEN GLOBAL SOLUTIONS PVT. LTD.**		
25.1	The Captive power and co-generation plant installed capacity 47,200 MW and its balance not reflecting in the overall installed capacity of 310 GW of the country. Similarly, the 162 BU generated from the CPP and co-gen plants are not reflected.	Installed capacity given in the NEP corresponds to be installed capacity of utilities only, this does not include the CPPs.	No
25.2	**DSM -** 5. Demand Response (DR) should be covered as an additional DSM measure.	DR in India is in primary stage. This has to be implemented through regulatory mechanism	No
	6. A regulatory framework for both Voluntary DR & Automated DR is required to be made.	Already included in recommendations in the DSM chapter.	No
	7. Creation of Energy Efficiency standards for Industries/Equipment. The existing Standard & labelling programme needs to be extended to cover all industrial equipment	BEE is already working labelling programme for industrial appliance	No

	8. ISO 50001 implementation should be promoted/mandated across Industries, Large buildings and Commercial establishments.	ISO 50001 is voluntary standard and not in purview of EC Act.	No
	9. Promotion of industrial internet and ICT based energy management systems and making it mandatory for industries to report energy conservation achievements.	PAT scheme is promoting energy conservation reporting	No
25.3	2. Indigenous technologies (renewable as well as energy efficient technologies) should be given preference in procurement. 4. Preparation of biomass atlas is required. the micro wind source atlas should be further disseminated.	Included in recommendations in the RES chapter.	Yes.
25.4	**Hydro Power in India** 2. Energy storage as a Chapter to be included in the NEP.	Storage technology is in nascent stage and at present it would be premature to discuss its operational as well as cost implication in details in NEP	No
25.5	**R&D –** 1. Develop design principles and guidance document for setting up micro grids. 3. Data analytics and tools can be used for monitoring and improving the performance of utilities. 4. **Section 13.5** : There are 11 R&D activities identified in the field of New & Renewable Energy, this needs to include: • Low wind speed turbine development (India has very few locations with high wind speeds) • Development of low cost material for small wind turbine blades and tower. 6. **Section 13.12** Need for preparation of a well-defined Policy to provide incentives for the commercialization of products developed through indigenous R&D efforts and by Start-up Organizations based in India. This should be aimed at easing the Market entry for newly/indigenously developed power products and solutions. Incentives could be excise duty exemption for a period of at least five years from the date of commercialization and QR relaxation (prior experience, financials).	Included in recommendations in the R&D chapter.	Yes
26	**GMR**		

26.1	Gas Based Power Plants can explore possibilities to utilize the Gas produced from HELP regime.	Included in the Final NEP	Yes
26.2	Request for re-drafting para I, Line I as follows: 'Out of the total installed capacity of 3,02,088 MW as on 31st March 2016, a capacity of 27,123 MW (about 8.97%) is from gas based power plants'.	Considered in the final NEP.	Yes
26.3	Request for addition in para I, last line as follows: '…..gas-based power share in India only 8.7% against the world average around 22%.'	Included in the final NEP.	Yes
26.4	Gas based power plant capacity addition shall be reviewed considering the skewed proportion towards coal compared to other countries.	First priority is to ensure adequate fuel for existing gas based stations so as to achieve full utilization of the existing plants.	No
26.5	In order to utilize the Stranded Gas Based Power plants as well as plants receiving the Domestic Gas, Ministry of Power (MoP) has come out with Scheme for utilization of Gas Based Generation Capacity, which should be further continued beyond March 2017 on long term basis to facilitate, meet the peaking and balancing power requirements going forward.	Outside the scope of NEP.	No
26.6	Recommendation 3 of Chapter 8 may suitably be amended as follows: "where the gas sold or purchased and transported through a common carrier pipeline or any other common transport or distribution system becomes comingled and fungible with other gas in the pipeline or system and such gas is introduced in the pipeline or system in one State and is taken out from the pipeline in another State, such sale or purchase of gas shall be deemed to be a moment of good from one State to another." With this there is a free flow of RLNG from West to East coast of India.	Not feasible due to technical difficulties	No
26.7	One of the key aspects on the regulatory front will be to declare the Gas based power plants as clean and green energy plants.	Outside the scope of NEP	No
27	**OTPC**		
27.1	If the adequate quantum of gas is not available, then the entire objective of low carbon growth may get jeopardized in absence of balancing mechanism.	This has already been highlighted in NEP.	No

27.2	Incentives and subsidies should be provided for setting up of combined cycle gas based power plants.	Outside the scope of NEP	No
27.3	With the deployment of 175 GW of renewable energy, there is a possibility of creation of Non- Performing Assets both for the power producers and the banks.	NEP has already highlighted that thermal power plants will run at low PLF due to the addition of capacity from renewable energy sources.	No
27.4	1.A nationwide study catering to regional requirements may be required to assess the intermittence of RES plants. 2. Based on this and international experience like that in Europe, capacity market may be designed and implemented as soon as possible.	1.The same is taken care of in the Vol-II : Transmission of NEP. 2. This is a regulatory issue.	No
27.5	Incentives provided to plants based on renewable energy should also be extended to CCPP.	Outside the scope of NEP.	No
27.6	Gas based generation should be promoted and planned under the Renewable Purchase Obligation regulations.	Outside the scope of NEP.	No
27.7	The subsidy being extended to the beneficiaries of the gas supplies under Administered Price Mechanism may also be extended to Non-APM gas supplies in the North Eastern region for future supply agreements being envisaged in the region.	Outside the scope of NEP.	No
28	**JINDAL POWER**		
28.1	Requested for review of the Hydro Policy, 2008 taken into account the impact of reduced saleable energy due to the provision of free power, withdrawal of provision of mega power benefits, etc.	Outside the scope of NEP.	No
28.2	Long term funding with low interest rates for hydro power plants.	Included in final NEP.	Yes
28.3	Declare Hydro as renewables and introduce Hydropower Purchase obligation.	Declaring hydro as Renewable is included as recommendation of NEP	Yes
28.4	Increase investor interest by giving incentive for Hydro Power Developers.	Outside the scope of NEP.	No
28.5	Funding of infrastructure cost by Government of India (from National Clean Energy Fund), another could be infrastructure cost to be recovered from 12% free Power being given to State.	Outside the scope of NEP.	No
28.6	Proposal of single window clearance for Hydropower projects.	Outside the scope of NEP.	No
28.7	For the purpose of Flood Moderation Benefits, the developers do not accrue any tangible benefits for the exclusive increase in the dam	Regulatory issue.	No

	heights, this additional cost should be borne by the Government in national interest.		
28.8	i) A detailed recommendation on the policy for encouraging pumped storage schemes should be mentioned in the NEP. ii) Table 7.5 & Table 7.2 needs correction/updation.	i)Already recommended in NEP ii) Correction/ updation done in the NEP.	Yes
29	**WARTSILA INDIA PVT. LTD.**		
29.1	Retirement of old and inefficient units and replacing them either with more efficient super critical units or with gas based flexible generation based on the demand pattern of the State to which the old units were catering to. In case the PLF of existing base load plants is below optimum level then adding further base load capacity even if super critical will only lead to increase in system level cost of generation and burden the end consumers even more.	NEP has highlighted the vital role of hydro, gas plants etc. in meeting the ramping requirement associated with the variability and uncertainty of RES	No
29.2	2.----it may be more prudent to consider a combination of coal plants topped up by gas engine plants for peakier load to meet the load not only more economically but also more efficiently. 3.Gas based plants should also include internal Combustion Gas Engine plants where peaking availability for both OCGE as well as CCGE can be considered as 90%. 5. ….gas engine based plants should be considered for capacity expansion for the purpose of renewable integration as well as meeting efficiently the peakier load.	The immediate priority is to ensure adequate fuel for existing gas based stations so as to achieve full utilization of the existing plants.	No
29.3	4. While evaluating various technologies, the document covers CCGE heat rates however it has not considered OCGE heat rate which is 2300 kcal/kwh and hence much more efficient in handling load variations. 6. OCGE can support the peaking and renewable integration qualitative parameters of start-up shut down and ramp up/ramp down very efficiently and hence need to be analysed on an equal platform.	Suitable heat rates for open and closed cycle gas power plants have been considered.	No
30	**GREENPEACE**		
30.1	Large hydro and nuclear energy have significant impact on the environment. Therefore, it would make sense to avoid these technologies in favour of more nimble, decentralized, cheaper options such as wind and solar power.	A judicious mix of conventional and renewable capacity is required to take into account the variability and uncertainty associated with generation available from RES.	No
31	**IWPA**		

31.1	To consider additional gas stations in generation plant for better RE (Renewable Energy) integration.	First priority is to ensure adequate supply of fuel for existing gas based stations so as to achieve full utilization of the existing plants.	No
31.2	----"must run" for RE power must be made as a primary law by including the same in the RE Act to make this plan successful.	The draft NEP has been prepared by incorporating RE as a must run. However, making law in this regard is outside the scope of NEP.	No
31.3	Retro fit the existing conventional plants to make it as factual power plants. This will help better integration of RE power.	This has already been highlighted in the NEP.	No
31.4	Responsibility for balancing renewables to be entrusted with RLDCs instead of RE rich States.	Included in NEP.	Yes.
32	**PETROLEUM FEDERATION OF INDIA**		
32.1	The gas requirement in the power sector has been projected to the tune of 54 MMSCMD which seems to be on a lower side and it hampers the plan for increasing the share of natural gas in the primary energy mix.	The minimum requirement of gas to the tune of 45 MMSCMD has been projected in the NEP. Ideal availability of gas should be corresponding to the 70%-80% of PLF.	No
33	**YAMUNA JIYE ABHIYAN /SHANKAR SHARMA/MITRAMADHYAMA**		
33.1	Because of the huge inefficiency prevailing in the country's power sector, the highest priority is needed to take the overall efficiency to the international best practice levels; this approach is known to cost least amongst various options to meet the legitimate demand for electricity of all sections of our society; it will also have the shortest gestation periods and many associated benefits.	By adopting super-critical technology (and ultra-super-critical technology which is in the process of development) and by establishing UMPPs, the efficiency of coal-based plants are going to improve significantly.	No
33.2	Realistic Demand Projection	The demand taken in the final NEP is as per the projections of 19th EPS.	No
33.3	Power sector may not need a lot of additional capacity if the existing infrastructure is put to use optimally	Studies have been carried out to find out the optimal capacity addition requirement.	No
33.4	CEA's draft plan has focused on solar, wind, biomass and small hydropower sources, the potential for ocean energy in India with over 6,000 km of coastline should not be ignored. Similarly, geothermal potential requires scrutiny.	Capacity addition from RES is as per the target set by GOI.	No
33.5	RES should be vigorously promoted.	Government of India is already doing it.	No
34	**CAG (CITIZEN CONSUMER AND CIVIC ACTION GROUP)**		
34.1	No plan for States – It would help if the Plan contain chapters on showing State-level electricity recommendations.	Details of the state level plans are not covered in NEP.	No
34.2	Waste to energy – It is submitted that waste to energy plants are not renewable energy sources. They have same environmental	Sources of RES generation have been considered as per the program finalized by MNRE.	No

	effects of thermal power plants and cannot be treated as renewable energy sources.		
34.3	Construction of certain coal based plants may be put on hold as market will be glutted with excess power effectively turning into a buyer's market. This will put downward pressure on per unit cost of power and so will make operations of such sources unviable leading to stranded assets---	After the enactment of Electricity Act 2003, electricity generation has been delicensed. Developers set up the plants based on their own wisdom. Govt. cannot force anybody to set up/not to set up power plant. Government only issue advisory in this regard.	No
34.4	EIA - -----a separate section should be added on EIA process and give adequate planning directions to projects proponents to reinforce their adherence the same.	This is not in the purview of NEP.	No
34.5	Electricity storage - ---it is submitted that the NEP take cognizance of the importance of energy storage and incorporate the same as a section in NEP.	Storage technology is in nascent stage and it would be premature and subjective to discuss in detail in NEP regarding its operational impact vis-à-vis cost.	No
35	**DUETSCHE BANK AG, HONG KONG**		
35.1	36 GW capacity addition from RES in 2017 is highly ambitious.	Capacity addition figures given in NEP is as per the projections given by MNRE	No
35.2	There is no mention of the retirements 36 GW of old projects	In the final NEP, retirement of 22,716 MW of coal based capacity has been considered.	No
35.3	CEA estimates seem highly ambitious in relation to the ability of RES to be absorbed	Capacity addition from RES is as per the target set by GOI.	No
35.4	CEA assumes all hydro(15GW), Nuclear(2.8GW) and RES(175 GW) as committed capacity. It looks aggressive.	Revised likely hydro and nuclear Capacity has been considered in final NEP. Capacity addition from RES is as per the target set by GOI.	No

36	**ASSAM POWER GENERATION CORPORATION LIMITED**		
36.1	No Comment		No
37	**ANTHIKA ENGINEERING**		
37.1	The following should be included in NEP: • Details of slippage of R&M/LE works from 12th Five-year Plan • Details of R&M works proposed to be undertaken during 2017-22. • Year-wise R&M budget	Due to MoEF&CC new environmental norms, the R&M works proposed is yet to be finalized.	No
38	**ZAL COWASJI**		
38.1	Adequate incentive mechanism may be provided for the SPV installation both for the new houses as well as old houses/buildings	This is included in the final NEP	Yes
39	**TORISHIMA PUMPS INDIA PVT. LTD.**		
39.1	List of coal based capacity addition of 50025 MW may be given in the NEP	This is included in the final NEP	Yes
40	**SHRI VIVEK GUPTA, IIM LUCKNOW**		
40.1	Key Inputs should focus more on inputs required for installing Solar Power Projects.	Inputs for the same would be made available by MNRE separately.	No

40.2	As per Table 14.15, there is no requirement of management graduates in power sector. Given the competitive environment in the power sector and the number of solar power companies marketing their Roof top solar products, this needs to be rethought.	The requirement of management graduate is included in the Graduate Engineer category	No
41	**DR. ANINDYA BHATTACHARYA, ENERGY EXPERT**		
41.1	Chapter 13 on new technologies could be little bit elaborated with a technology development pathway (Time Vs technology) covering the initiatives taken in the country towards newer and efficient technologies of power generation	Appropriately incorporated in the Final NEP	Yes
41.2	Demand projection is ok but its methodologies are not very robust.	The Final NEP is based on projections of 19^{th} EPS.	No
41.3	Chapter 10 on key inputs for power generation is an interesting chapter but is very important in the context of sustainability of the sector. Given the facts of rapidly changing environment and society and availability of resources, the chapter should have delved with more detail and clarity. Especially the Water-Energy-land nexus could have been a separate sub-section here should the information is already available.	The details regarding land and water requirements and key issues associated with land acquisition are already included under para 10.10.1 & 10.10.2 respectively of the chapter.	No
41.4	Conclusions & Recommendation section is well written but given the purpose of the NEP, it should have contained more detailed guidance and benefits of doing so.	Providing detailed guidance for implementation is outside the purview of NEP	No

MAJOR HIGHLIGHTS

1. The actual capacity addition during 12th Plan from conventional sources as on 31st March,2017 is 99,209.6 MW (Coal 83,560 MW, Lignite 1,290 MW, Gas 6,880.5 MW, Hydro 5,479 MW, Nuclear 2,000 MW) against a target of 88,537 MW. This is about 112% of the target.
2. 56 % of total capacity addition during 12th plan has come from private sector.
3. There has been considerable slippage against the capacity addition target in respect of Hydro (5,451 MW) and Nuclear (3,300 MW) during the 12th Plan period.
4. During 12th plan, capacity addition from supercritical technology based coal power plants is around 42% of the total capacity addition from coal based plants.
5. R&M/LE works in respect of 37 Nos. thermal units with aggregate capacity of 7,202.6 MW have been completed during 12th Plan up to 31st March,2017. Also about 4014.6 MW of Hydro capacity has been achieved through uprating, life extension and restoration activities for a total of 20 hydro R&M schemes up to 31st March,2017.
6. As on 31st March,2017, India has achieved a total installed capacity of 57,244.24 MW from Renewable Energy Sources.
7. By 2021-22, the Renewable Energy capacity target has been set to 175 GW.
8. A capacity addition of 32,741 MW from Renewable Energy Sources has been achieved during 12th Plan.
9. Total energy savings due to implementation of various energy saving measures during the years 2021-22 and 2026-27 are estimated to be 249 BU and 337 BU respectively.
10. As per the 19th Electric Power Survey, the projected Peak Demand is 226 GW and Energy requirement is 1,566 BU at the end of year 2021-22.
11. As per the 19th EPS report, the projected Peak Demand is 299 GW and Energy requirement is 2047 BU at the end of year 2026-27.
12. Considering the demand projections for the year 2021-22 as per the 19th EPS (where CAGR works out to be 6.18%), committed capacity addition from Gas 406 MW, Hydro 6,823 MW, Nuclear 3,300 MW, RES 1,17,756 MW and likely retirement of 22,716 MW (5,927 MW-old and inefficient units + 16,789 MW-completing 25 years by 2022 and without FGD space) of coal based capacity during 2017-22, the study result reveals that coal based capacity addition of 6,445 MW is required during the period 2017-22. However, a total capacity of 47,855 MW coal based power projects are currently under different stages of construction and are likely to yield benefits during the period 2017-22. Thereby, the total capacity addition during 2017-22 is likely to be 1,76,140 MW.
13. An alternate scenario has also been constructed, considering demand CAGR of 7.18% during the years 2017-22 and keeping other parameters unchanged. It was found that 19,700 MW coal based capacity addition would then be required during the years 2017-22, in case of increased demand scenario. However, coal based capacity of 47,855 MW are at different stages of construction and are likely to yield benefit during 2017-22. The PLF % of coal based power stations will therefore increase substantially. However all the requirements mentioned in the highlights are based on the demand projections as per 19th EPS.
14. Considering the demand projections for the year 2026-27, as per the 19th EPS, coal based capacity addition of 47,855 MW already under construction for benefits during 2017-22, committed capacity addition of Nuclear 6,800 MW, Hydro 12,000 MW, RES 1,00,000 MW and likely retirement of 25,572 MW of coal based capacity (which will be completing more than 25 years of age by 2027) during 2022-27, the study results reveal that capacity addition of 46,420 MW is required during the period 2022-27. This capacity addition required during 2022-27, as shown in the results is, in fact, the peaking capacity requirement to be met in the grid. This capacity requirement can be met from any conventional source of energy but preferably from peaking power plants like Hydro, Gas or Energy Storage Devices.
15. Considering the generation capacity addition mentioned in 13 and 14 above, the share of non-fossil based installed capacity (Nuclear + Hydro + Renewable Sources) will increase to 49.3 % by the end of 2021-22 and will further increase to 57.4% by the end of 2026-27.
16. The Renewable Energy Generation will contribute about 20.1 % and 24.4 % of the total energy in 2021-22 and 2026-27 respectively.
17. The total coal requirement in the year 2021-22 and 2026-27 has been estimated as 735 MT and 877 MT respectively including imported coal of 50 MT. The coal requirement for the year 2021-22 and 2026-27 have been worked out considering 30% reduction in Hydro generation due to failure of monsoon and being supplemented by coal based generation.

18. Against a total domestic natural gas allocated to power projects of 87.05 MMSCMD, the total gas supplied to these gas based power plants during the year 2016-17 was only 29.59 MMSCMD.
19. It has been estimated that the gas based stations shall need at least 45.27 MMSCMD of gas to meet the balancing and peaking requirement of the grid arising due to RES integration. If the storage devices become economically viable in future, then they can also be used for the balancing.
20. Adequate manufacturing facilities exist in India for main plant equipment. However, lack of orders is a concern of all equipment manufacturers.
21. The total fund requirement for the period 2017-2022 is estimated to be ₹ 11,55,652 Crores, which also includes the likely expenditure **during this period** for the projects coming up in the year 2022-2027.
22. The total fund requirement for the period 2022-27 is estimated to be 9,56,214 crores but **does not include advance action for projects coming up during the period 2027-2032**.
23. The total CO_2 emissions for the year 2021-22 and 2026-27 is estimated at 1026 Million Tonnes and 1173 Million Tonnes respectively.
24. The average CO_2 emission factor is estimated at 0.721 kg CO_2/kWh during 2015-16 (including renewables). It is expected that this average CO_2 emission factor may reduce to 0.604 kg CO_2/kWh by the end of year 2021-22 and to 0.524 kg CO_2/kWh by the end of 2026-27, considering the projected addition of RES capacity.
25. Emission intensity kgCO2/GDP (₹) from grid connected power stations is likely to reduce by 40.51% at the end of 2021-22 and 53.65 % at the end of 2026-27 from the year 2005 level.
26. It is estimated that 20.69 Million Tonnes of CO_2 emissions has been avoided by 31st March,2017 due to commissioning of Super-critical technology based coal power plants vis-à-vis the scenario of only subcritical units had been commissioned.
27. It is estimated that about 268 Million Tonnes of CO_2 emission will be avoided annually by the end of the year 2021-22 due to the addition of renewable energy sources.
28. Country has achieved 60.97 % of fly ash utilisation in the years 2015-16. In terms of absolute value, the same stands at 107.77 Million Tonnes.
29. Sufficient number of Engineers, Managers and Diploma holders are available in the country. However, there is a gap in respect of lower level skills like that of ITI.

CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

Growth of Power sector is key to the economic development of the country as it facilitates development across various sectors of the economy, such as manufacturing, agriculture, commercial enterprises and railways. Since independence the power sector in India has grown considerably. However, the enactment of Electricity Act, 2003, has brought in revolutionary changes in almost all the areas of the sector. Through this Act a conducive environment has been created to promote private sector participation and competition in the sector by providing a level playing field. This has led to significant investment in generation, transmission and distribution areas. Over the years the installed capacity of Power Plants (Utilities) has increased to 3,26,833 MW as on 31.3.2017 from a meagre 1,713 MW in 1950. Similarly, the electricity generation increased from about 5.1 Billion units in 1950 to 1,242 BU (including imports) in the year 2016-17. The per capita consumption of electricity in the country has also increased from 15 kWh in 1950 to about 1,122 kWh in the year 2016-17. Out of 5,97,464 census villages, 5,92,135 villages (99.25%) have been electrified as on 31.03.2017. Regional grids have been integrated into a single national grid with effect from 31.12.2013 thereby providing free flow of power from one corner of the country to another through strong inter regional AC and HVDC links. As a result, the all India peak demand (MW) not met as well as energy (MU) not supplied have registered steady decline. The peak not met and energy not supplied were 1.6 % and 0.7 % respectively during the year 2016-17.

1.1 ELECTRICITY ACT 2003, NATIONAL ELECTRICITY POLICY 2005 AND TARIFF POLICY 2016

1.1.1 Electricity Act 2003 and Stipulations Regarding National Electricity Plan

The Electricity Act, 2003 provides an enabling legislation conducive to development of the Power Sector in transparent and competitive environment, keeping in view the interest of the consumers.

As per Section 3(4) of the Electricity Act 2003, Central Electricity Authority (CEA) is required to prepare a National Electricity Plan in accordance with the National Electricity Policy and notify such Plan once in five years. The draft plan has to be published and suggestions and objections invited thereon from licensees, generating companies and the public within the prescribed time. The Plan has to be notified after obtaining the approval of the Central Government. The National Electricity Policy stipulates that the Plan prepared by CEA and approved by the Central Government can be used by prospective generating companies, transmission utilities and transmission/distribution licensees as a reference document.

1.1.2 National Electricity Policy 2005 and Stipulations Regarding National Electricity Plan

The Aims and Objectives of the National Electricity Policy are as follows:

- Access to Electricity - Available for all households in next five years.
- Availability of Power - Demand to be fully met by 2012. Energy and peaking shortages to be overcome and adequate spinning reserve to be available.
- Supply of Reliable and Quality Power of specified standards in an efficient manner and at reasonable rates.
- Per capita availability of electricity to be increased to over 1000 units by 2012.
- Minimum lifeline consumption of 1 unit/household/day as a merit good by year 2012.
- Financial Turnaround and Commercial Viability of the Electricity Sector.
- Protection of consumers' interests.

National Electricity Policy stipulates that the National Electricity Plan would be for a short-term framework of five years while giving a 15-year perspective and would include:

- Short-term and long term demand forecast for different regions;
- Suggested areas/locations for capacity additions in generation and transmission keeping in view of the economics of generation and transmission, losses in the system, load centre requirements, grid stability, security of supply,

quality of power including voltage profile, etc.; and environmental considerations including rehabilitation and resettlement;
- Integration of such possible locations with transmission system and development of national grid including type of transmission systems and requirement of redundancies;
- Different technologies available for efficient generation, transmission and distribution.
- Fuel choices based on economy, energy security and environmental considerations.

The Policy also stipulates that while evolving the National Electricity Plan, CEA will consult all the stakeholders including State Governments and the State Governments would, at State level, undertake this exercise in coordination with stakeholders including distribution licensees and State Transmission Utilities (STUs). While conducting studies periodically to assess short-term and long-term demand, projections made by distribution utilities would be given due weightage. CEA will also interact with institutions and agencies having economic expertise, particularly in the field of demand forecasting. Projected growth rates for different sectors of the economy will also be taken into account in the exercise of demand forecasting.

The Policy stipulates that in addition to enhancing the overall availability of installed capacity to 85%, a spinning reserve of at least 5% at national level would be needed to be created to ensure grid security, quality and reliability of power supply.

The Policy states that efficient technologies, like super-critical technology, Integrated Gasification Combined Cycle (IGCC) etc. and large size units would be gradually introduced for generation of electricity as their cost effectiveness gets established.

The present National Electricity Policy was enunciated in 2005 and since then it's various Aims and Objectives have achieved different levels of implementation. Keeping in view of these and to cater to the further challenges of the sector, the National Electricity Policy is under revision.

1.1.3 Tariff Policy 2016

The Central Government has notified the revised Tariff Policy vide Gazette notification dated 28.01.2016 in exercises of powers conferred under section 3(3) of Electricity Act, 2003. The Tariff Policy has been evolved in consultation with the State Governments, the Central Electricity Authority (CEA), the Central Electricity Regulatory Commission and various stakeholders.

The objectives of this Tariff Policy are to:

1) Ensure availability of electricity to consumers at reasonable and competitive rates;
2) Ensure financial viability of the sector and attract investments;
3) Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimize perceptions of regulatory risks;
4) Promote competition, efficiency in operations and improvement in quality of supply;
5) Promote generation of electricity from renewable sources;
6) Promote hydroelectric power generation including Pumped Storage Projects (PSP) to provide adequate peaking reserves, reliable grid operation and integration of variable renewable energy sources;
7) Evolve a dynamic and robust electricity infrastructure for better consumer services;
8) Facilitate supply of adequate and uninterrupted power to all categories of consumers;
9) Ensure creation of adequate capacity including reserves in generation, transmission and distribution in advance, for reliability of supply of electricity to consumers.

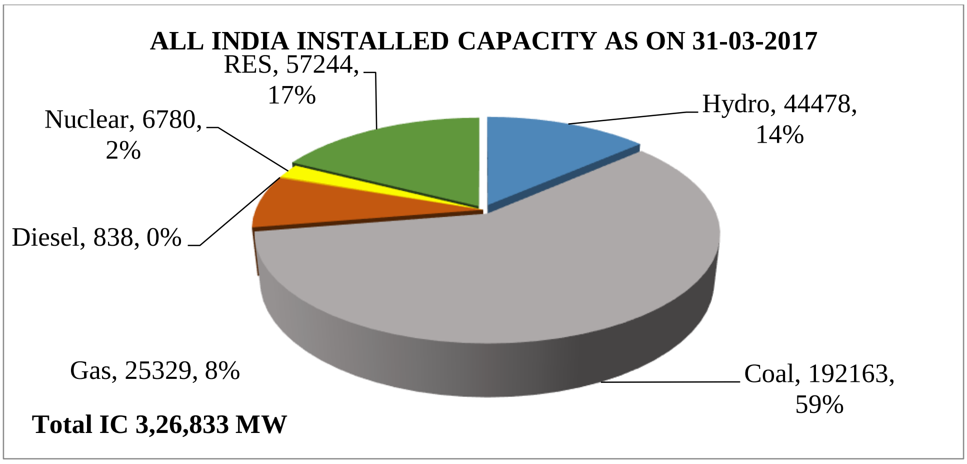
1.2 POWER SCENARIO IN THE COUNTRY

1.2.1 Installed Capacity

The Installed Capacity of the country as on 31.3.2017 was 3,26,833 MW comprising of 2,18,330 MW thermal, 6,780 MW Nuclear, 44,478 MW hydro and 57,244 MW renewables and is depicted in the **Exhibit 1.1**.

Exhibit 1.1.

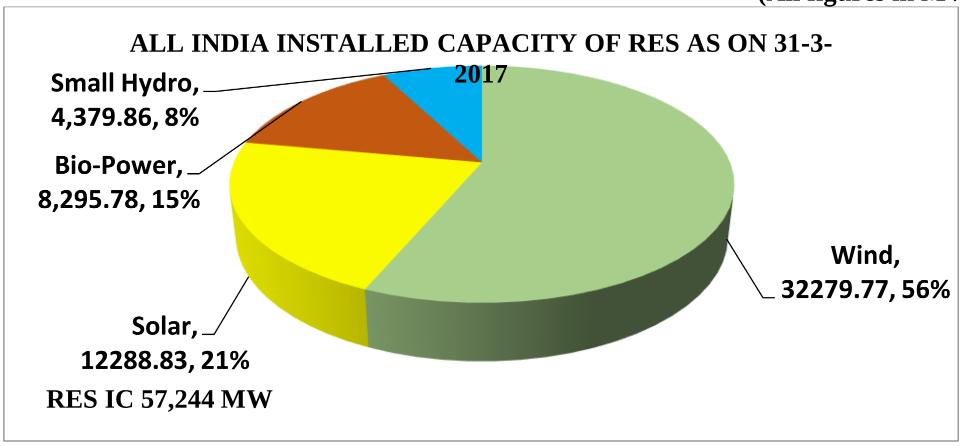
(All figures in MW)



The country has significant potential of generation from renewable energy sources. All efforts are being made by Government of India to harness this potential. The Installed capacity as on 31st March, 2017 from renewable energy sources is 57,244.23 MW. The total renewable installed capacity comprises of 32,279.77 MW of wind, 12288.83 MW of solar, 8,295.78 MW of bio-Power & waste power and 4,379.86 MW of small hydro plants as shown in **Exhibit 1.2**. India ranks fourth in the world in terms of installed capacity of wind turbine power plants.

Exhibit 1.2

(All figures in MW)



The growth of Installed Capacity and Electricity Generation in India from various sources is shown in **Table 1.1, Exhibit 1.3 and 1.4.**

Table 1.1

Growth of Installed Capacity & Electricity Generation

Plan/Year	Installed Capacity (MW)	Generation (BU)*	Generation Growth rate in (%)	Compound Generation Growth (%)
		10th Plan		
2002-03	107877	530.61	3.2	**5.16**
2003-04	112684	558.34	5.0	
2004-05	118426	587.42	5.2	
2005-06	124287	617.51	5.1	
2006-07	132329	662.52	7.3	
		11th Plan		
2007-08	143061	704.47	6.3	**5.77**
2008-09	147965	723.79	2.7	
2009-10	159398	771.60	**6.6**	
2010-11	173626	811.10	**5.1**	
2011-12	199877	877.00	**8.1**	
		12th Plan		
2012-13	223,344	912.05	**4.0**	**5.74**
2013-14	248,554	967.15	**6.0**	
2014-15	274,904	1048.67	**8.4**	
2015-16	305,163	1107.82	**5.6**	
2016-17	326,833	1160.14	**4.7**	

- Generation from conventional sources only

Exhibit 1.3

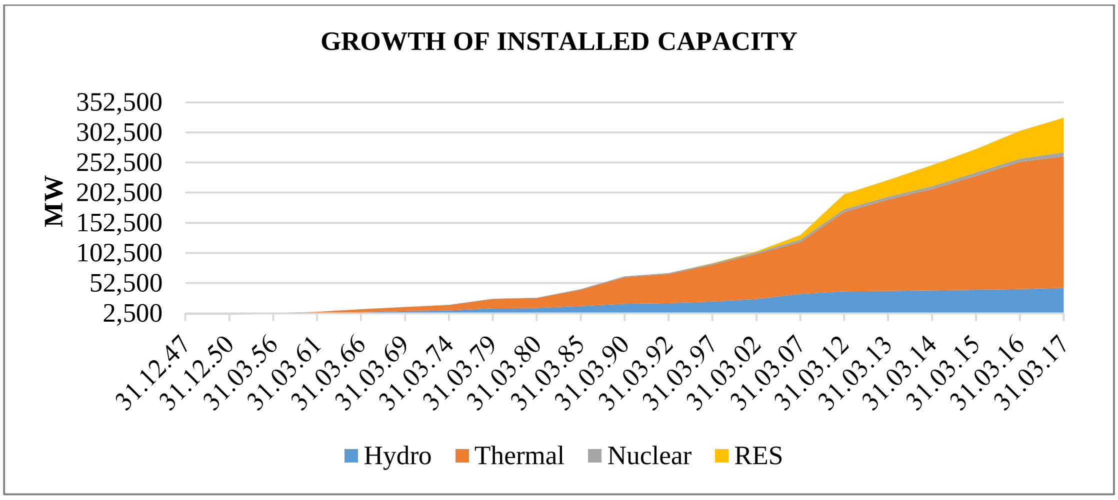
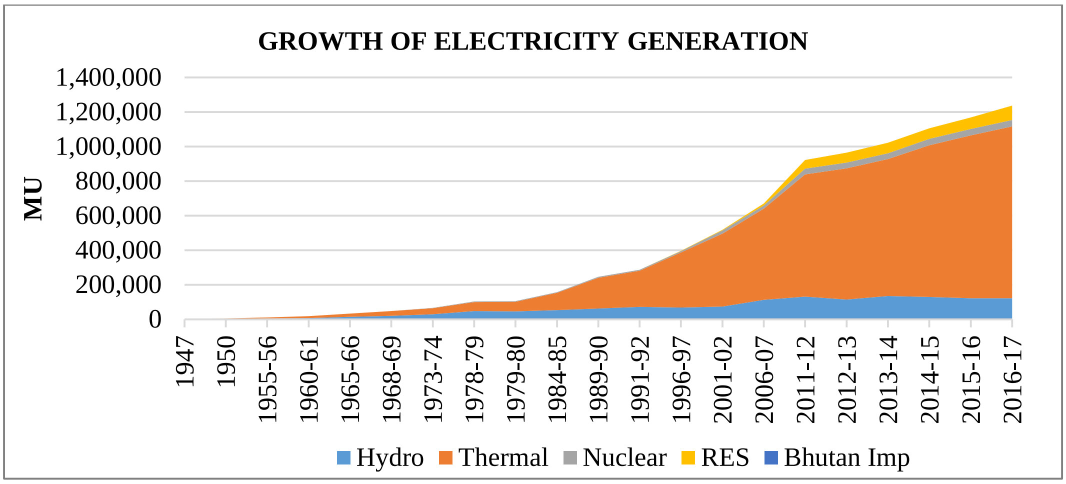


Exhibit 1.4



1.2.2 Per Capita Electricity Consumption

The per capita electricity consumption was 883.64 kWh at the beginning of the 12th five-year plan i.e. 01.04.2012 and as on 31.03.2017 the per capita electricity consumption has increased to 1122 kWh. The per capita electricity consumption during 12th Plan is summarized in **Table 1.2.**

Table 1.2

Per Capita Electricity Consumption

YEAR	PER CAPITA CONSUMPTION (kWh)
2012-13	**914.41**
2013-14	**956.64**
2014-15	**1010.00**
2015-16	**1075.00**
2016-17	**1122.00**

1.2.3 Actual Power Supply Position

The peak demand not met was about 12,159 MW (9.0%) and the average energy not supplied in the country was about 87 Billion kWh (8.7%) during the 1st year of 12th plan i.e. 2012-13. The peak not met and energy not supplied of the country has substantially declined to 2,608 MW (1.6%) and 7.6 Billion Units (0.7%) respectively by the end of 12th Plan (2016-17). The power supply position in the country during 12th Plan is summarized in **Table 1.3**.

Table 1.3

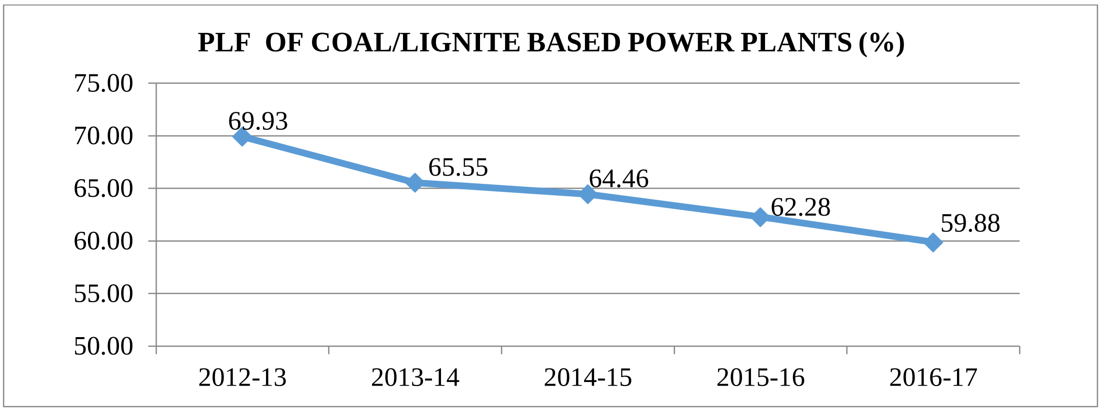
All-India Actual Power Supply Position (2012-17)

PERIOD	PEAK DEMAND (MW)	PEAK MET (MW)	PEAK NOT MET/ SURPLUS (MW) (- / +)	PEAK NOT MET/ SURPLUS (%) (- / +)	ENERGY REQUI-REMENT (MU)	ENERGY AVAIL-ABILITY (MU)	ENERGY NOT SUPPLIED/ SURPLUS (MU) (- / +)	ENERGY NOT SUPPLIED/ SURPLUS (%) (- / +)
2012-13	135,453	123,294	-12,159	-9.0	998,114	911,209	-86,905	-8.7
2013-14	135,918	129,815	-6,103	-4.5	1,002,257	959,829	-42,428	-4.2
2014-15	148,166	141,160	-7,006	-4.7	1,068,943	1,030,800	-38,143	-3.6
2015-16	153,366	148,463	-4,903	-3.2	1,114,408	1,090,850	-23,558	-2.1
2016-17	159,542	156,934	-2,608	-1.6	1,142,928	1,135,332	-7.596	-0.7

1.2.4 Plant Load Factor of Coal/Lignite Based Power Plant

The national average Plant Load Factor (PLF) of Coal/Lignite based power generating stations has been steadily decreasing during 12th plan period from 69.93% during 2012-13, to 59.88% during 2016-17. The year wise PLF is shown in **Exhibit 1.5**

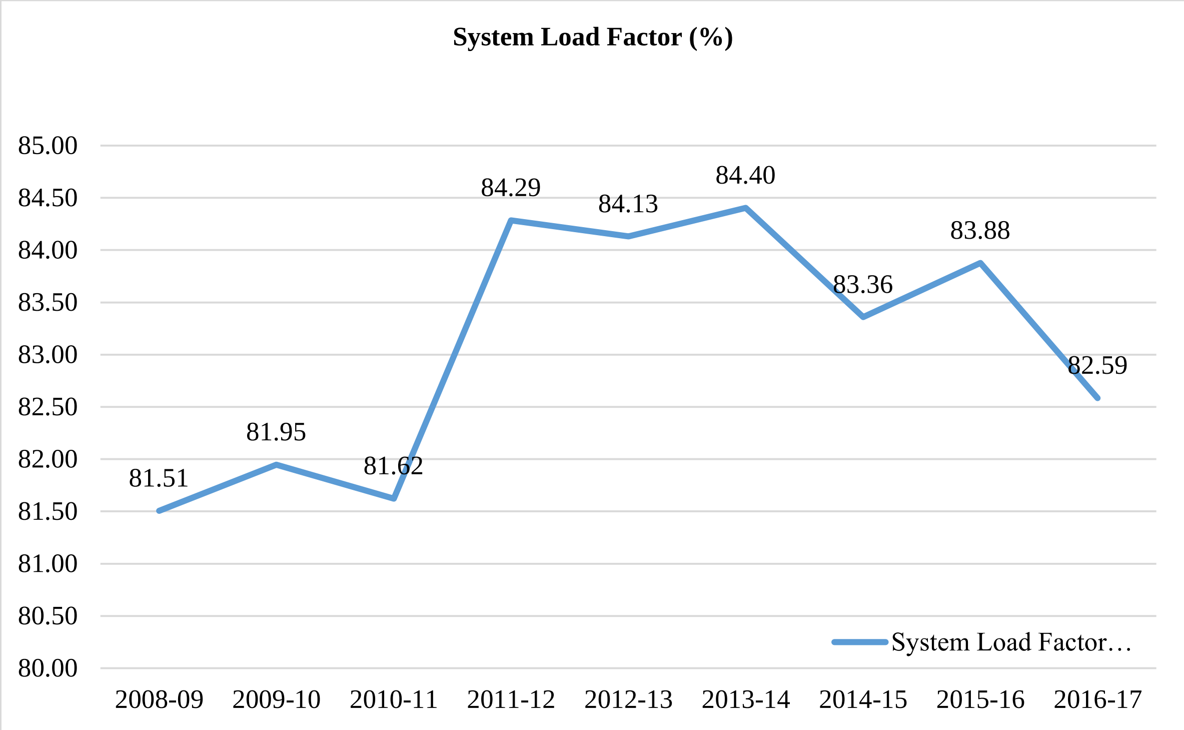
Exhibit 1.5



1.2.5 Annual System Load Factor

The Annual System Load Factor is the ratio of the energy availability in the system to the energy that would have been required during the year if the annual peak load met was incident on the system throughout the year. This factor depends on the pattern of utilization of different categories of load. The Annual System Load factor has remained close to 84% since 2011-12 till 2015-16, primarily because of prevailing energy shortages in the system and the load staggering measures adopted in the various States particularly in agriculture sector. System Load factor has come down to 82.6% during 2016-17. Annual System Load Factor is as depicted in the **Exhibit 1.6.**

Exhibit 1.6



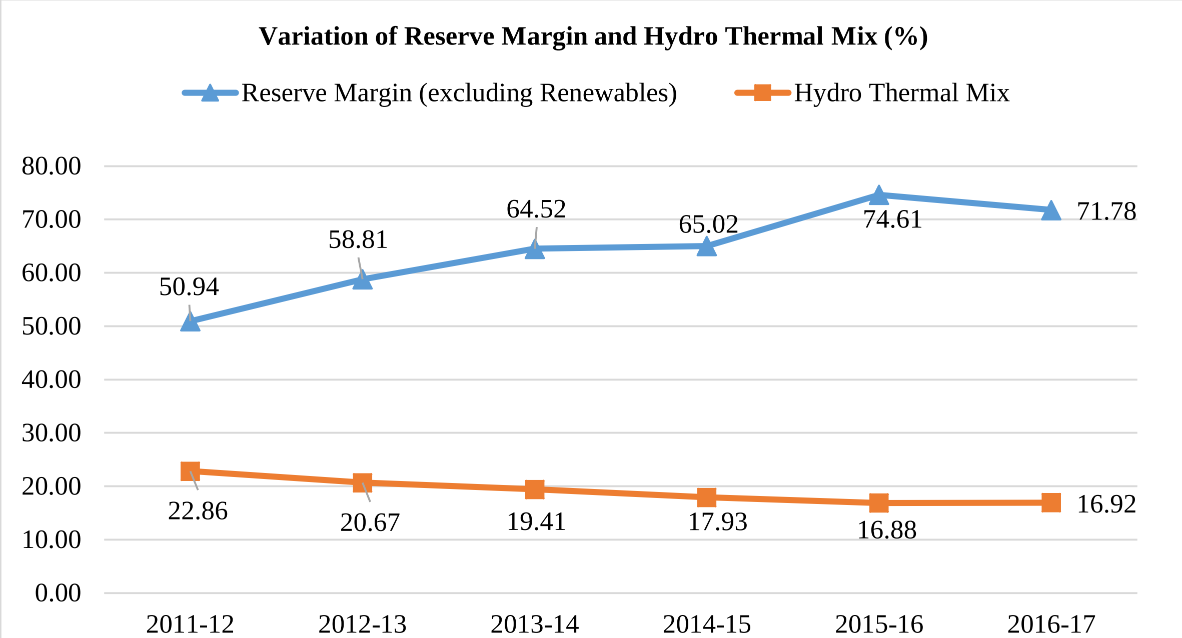
1.2.6 Reserve Margin and Hydro Thermal Mix

Reserve margin of a system is defined as the difference between the Installed Capacity and the peak load met as a percentage of the peak load met. This factor depends on a number of parameters, major ones being the mode of power generation i.e. hydro, thermal, renewable and the availability of the generating stations which primarily is a function of forced and planned shutdown of the generating units, capacity of the Discoms to procure power. The Reserve Margin has increased from 50.94% in 2011-12 to 71.78% in March, 2017.

The Hydro-Thermal mix has been decreasing from 22.86% as on 31st March, 2012 to 16.92% in March, 2017 mainly due to reduced hydro capacity addition vis –a –vis thermal capacity addition during successive years. Pattern of reserve margin and hydro thermal mix is illustrated in the **Exhibit 1.7.**

This increase in Reserve Margin is on account of decrease in thermal PLF from 73.32 % in 2011-12 to 59.88 % in 2016-17.

Exhibit 1.7



1.3 VARIOUS INITIATIVES OF THE GOVERNMENT

1.3.1 Development of Power Projects On Tariff Based Bidding

Promotion of competition in the electricity industry in India is one of the key objectives of the Electricity Act, 2003 (the Act). Competitive procurement of electricity by the distribution licensees is expected to reduce the overall cost of procurement of power and facilitate development of power markets.

Section 61 & 62 of the Act provide for tariff regulation and determination of tariff of generation, transmission, wheeling and retail sale of electricity by the Appropriate Commission. 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."

Tariff Policy was revised on 28th January, 2016 to facilitate procurement of power on tariff based bidding. As per the revised Tariff Policy "All future requirement of power should continue to be procured competitively by distribution licensees except in case of expansion of existing projects or where there is a company owned or controlled by the State Government as an identified developer and where regulator will need to restore to tariff determination based on norms provided that expansion of generation capacity by private developers for this purpose would be restricted to one time addition of not more than 100% of the existing capacity". Power projects can be developed by States under Case I and Case II bidding as follows:

(i) Where the location, technology or fuel is not specified by the procurer (**Case 1**);
(ii) For hydro-power projects, load centre 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 Standard Bidding Documents (SBDs) for Case-2/UMPPs were reviewed and the Model Bidding Documents for construction and operation of power generation projects/Ultra Mega Power Projects(UMPPs) on Design, Build, Finance, Operate and Transfer (DBFOT) basis were issued on 20th Sept, 2013. Further, Ministry of Power has appointed an Expert Committee to review the Standard / Model Bidding Documents for UMPPs and other location specific projects under Case-2 route. The Expert Committee, after exhaustive deliberations/discussions with various stakeholders, has prepared revised SBDs and Guidelines for UMPPs based on allocated Domestic Coal Blocks and submitted the same to the Ministry of Power and the same is under the process of Inter-Ministerial consultations. The Expert Committee has also submitted its recommendation for comments from various stakeholders and guidelines for determination of tariff through UMPPs on imported coal.

Ministry of Power had issued SBDs for Case-1 power projects on 27th March,2009. The revised SBDs containing Model RFQ, Model RFP, Model Power Sale Agreement as well as Guidelines to be adopted by distribution licensees for procurement of electricity on Design, Build, Finance, Own and Operate (DBFOO) basis were issued on 8th November,2013 and 9th November,2013 respectively. Further, in order to ensure that the benefits of coal block auction are passed on to the consumers, amendments to these Guidelines have been issued vide Resolution No. 23/09/2015-R&R dated 16th April, 2015.

1.3.2 Development of Ultra Mega Power Projects

For the development of coal based Ultra Mega Power Projects (UMPPs) of about 4,000 MW capacity each under tariff based competitive bidding route using Supercritical Technology on build, own and operate basis was launched by the Central Government in 2005-06. The UMPPs will be located either at pit head based on domestic coal or at coastal locations based on imported coal. For UMPPs based on domestic coal, coal block will also be allocated to the project developer.

The objective is to achieve faster capacity addition and to minimize the cost of power to consumers due to economy of scale. Four UMPPs were awarded to the developers selected through tariff based competitive bidding which are Mundra UMPP in Gujarat, Sasan UMPP in MP, Krishnapatnam UMPP in AP and Tilaiya UMPP in Jharkhand. All units of Mundra UMPP (5X800 MW) and Sasan UMPP (6X660 MW) have been commissioned. The developer of Krishnapatnam Ultra Mega Power Project, namely M/s Coastal Andhra Power Ltd (CAPL), had started the construction work but has stopped the construction work citing new regulation of the Government of Indonesia as the reason which prohibits sale of coal, including sale to affiliate companies, below bench mark price. Andhra Pradesh Southern Power Distribution Company Limited (APSPDCL), who is the lead procurer from Krishnapatnam Project has issued termination notice to Coastal Andhra Power Limited (CAPL). CAPL had approached the High Court of Delhi. The Delhi High Court has dismissed the petition of CAPL on 2nd July,2012. CAPL has approached Division Bench, Delhi High Court as well as Indian Arbitrator Council for arbitration. The matter is subjudice.
For Tilaiya UMPP, the developer (Jharkhand Integrated Power Ltd, a subsidiary of RPL) has issued notice of termination of Power Purchase Agreement on 28th April,2015 citing non transfer of land to the developer by the Jharkhand Government. Procurers have accepted the termination notice in November,2015 and after transfer of SPV (Special Purpose Vehicle), necessary development activities for re-bidding would be started as per revised standard bidding documents(SBDs).

Four more UMPPs (Bedabahal in Odisha, Cheyyur in Tamil Nadu, Kakwara in Bihar, Husainabad in Jharkhand) have been identified for bidding process.

In addition, five other UMPPs, one in Uttar Pradesh, two additional UMPPs in Orissa, second UMPP in Gujarat and second UMPP in Tamil Nadu are in various stages of planning. The selection/investigation of sites for the above mentioned additional UMPPs are in process of consultation with the concerned State Governments.

Broad status of UMPPs is placed at **Annexure 1.1.**

1.3.3 Allocation of Captive Coal Blocks/Mines

The coal production in the country had not been keeping pace with the increasing demand of the power sector due to various reasons, major one being delay in development of coal mines in the country. This had necessitated the need to import coal. Therefore, it has been decided to allocate coal blocks to project developers for captive use. All UMPPs at pithead have been allocated coal blocks.

The Hon'ble Supreme Court of India in its judgment dated 25th August,2014 and Order dated 24th September,2014 had declared allocations of 204 Coal Blocks out of 218 Coal Blocks made since 1993 as illegal. In compliance to the above Supreme Court Order dated 24th September,2014, 9 coal mines in power sector for the linked end use power plant have been allotted through e-Auction to the winning bidders (Developers). In addition to above, 38 coal mines for linked end use power plant have also been allotted through e-Allotment to Central/state sector utilities.

1.3.4 Hydro Policy - 2008

With a view to ensure accelerated development of hydro power, Hydro Power Policy- 2008 has been notified by Government of India on 31st March,2008. The salient features of the policy are given below:

1) Transparent selection criteria for awarding sites to private developers.
2) As notified in Revised Tariff Policy, 2016, Cost plus tariff regime (in which tariff is to be determined by the regulator under section 62 of Electricity Act, 2003) has been extended for public & private sector hydro power projects up to 15th August,2022.
3) Enables developer to recover his additional costs through merchant sale of upto a maximum of 40% of the saleable energy.
4) Developer to provide 100 units of electricity per month to each Project Affected Family - in cash or kind or a combination of both for 10 years from the COD.
5) Developer to assist in implementing rural electrification in the vicinity of the project area & contribute 10% share of the State Government under the RGGVY scheme.
6) Additional 1% free power from the project (over and above 12% free power earmarked for the host State) for Local Area Development Fund - regular revenue stream for welfare schemes, creation of additional infrastructure and common facilities.
7) The State Governments to contribute a matching 1% from their share of 12% free power.

1.3.5 Augmentation of Indigenous Equipment Manufacturing Capacity

Indigenous manufacturing capacity for supercritical equipment has been created by BHEL and several Joint Ventures (JV) set up by the international equipment manufacturers in partnership with Indian companies. BHEL has entered into technology collaboration agreements with M/s. Alstom for supercritical boilers and M/s. Siemens for supercritical turbine generators. BHEL has achieved manufacturing capacity for power equipment of 20,000 MW/ year (includes thermal, hydro and nuclear). Indigenous manufacturing capacity set up by JVs for supercritical boilers is 9,200 MW and supercritical turbine generators is 11,000 MW as given in **Table 1.4** below.

Table 1.4
Planned Manufacturing capacity MW per annum

Joint Venture	Boilers	Turbine-generator
L&T-MHI	4000 MW	4000 MW
Alstom -Bharat Forge	-	4000 MW
Toshiba- JSW	-	3000 MW
Thermax-Babcock & Wilcox	3000 MW	-
Doosan Chennai Works Pvt. Ltd.	2200 MW (both subcritical and supercritical)	-
Total	**9200 MW**	**11000 MW**

With a view to encourage the domestic suppliers and provide orders to them, bulk orders for 11 nos. 660 MW supercritical units for NTPC and DVC and 9 nos. 800 MW supercritical units for NTPC were approved by the Government and undertaken by NTPC. These bulk orders are with mandatory requirement of indigenization of manufacturing of supercritical units by the successful bidders as per a pre-agreed Phased Manufacturing Programme (PMP). The roadmap for PMP has also been defined indicating milestones for setting up manufacturing facilities for boilers and turbine generators and the same are being monitored by a committee under Central Electricity Authority.

It was decided by MoP that an advisory may be issued to all the Central sector and State sector thermal power generating companies for sourcing of supercritical units from indigenous manufacturers. Accordingly, an advisory was issued by CEA vide its letter dated 27th January, 2017 suggesting incorporation of condition for phased indigenous manufacturing facilities in the bids to be invited for boilers and turbine generators of supercritical projects on similar lines as bulk orders approved by the Government.

1.3.6 Renewable Energy Sources

The Government of India has presently set an installed capacity target of 1,75,000 MW from renewable energy sources by 2022. This includes 1,00,000 MW from solar, 60,000 MW from wind, 10,000 MW from biomass and 5000 MW from small hydro power. Within the target of 1,00,000 MW for solar energy, 40,000 MW would be from solar roof tops and the balance 60,000 MW would be from off the ground large and medium scale projects involving both the State Governments and also other institutes like Central Public Sector Undertakings (CPSUs), Independent Power Producers (IPPs), Solar Energy Corporation of India (SECI) etc.

1.3.7 Nuclear Power

The Government has recently taken several initiatives to facilitate expansion of nuclear power in the country like creation of the Indian Nuclear Insurance Pool (INIP), Amendment of the Atomic Energy Act to enable Joint Venture companies of Public Sector Enterprises to set up nuclear power plants. In the 2016-17 budget speech, the Finance Minister has also announced that the Government is drawing up a comprehensive plan, spanning next 15 to 20 years, to augment the investment in nuclear power generation and provision for Budgetary allocation. The announcement has given an impetus for accelerating the nuclear capacity addition in the country. A road map in respect of indigenous Pressurised Heavy Water Reactors (PHWR) is being drawn up as a part of the comprehensive plan on nuclear capacity addition. The Government had already accorded “in principle” approval for various new sites/expansion of existing site for setting up indigenous Pressurised Heavy Water Reactor (PHWR), imported Light Water Reactors (LWRs) and PFBRs.

1.3.8 Power for All

Government of India has taken a joint initiative with respective State Governments for preparation of State specific documents for providing 24x7 Power for All (PFA) to all households/homes, industrial & commercial consumers and adequate supply of power to agricultural consumer as per State Policy. This initiative aims at ensuring uninterrupted supply of quality power to existing consumers and providing electricity access to all unconnected consumers by 2019 in a phased manner.

In these PFA documents, an assessment of energy required to provide 24x7 Power for All connected and unconnected consumers, adequacy of availability of power to the State from various generating sources, Inter State Transmission System, Intra State Transmission System and distribution system to ensure 24x7 power supply is being made. The development of Renewable Energy (RE) plan and Energy Efficiency (EE) potential in the States are also being included in this document.

This joint initiative of Government of India and State Governments aims to enhance the satisfaction levels of the consumers, improve the quality of life of people, and increase the economic activities resulting into inclusive development of the States.

State Specific Documents for the all the States/UTs have been approved by the respective State Governments and signed by State & Central Government for implementation.

The Central and State Governments are meeting regularly to review the progress of the Roll Out Plan & related milestones envisaged in the documents and respective Governments would strive to achieve the objectives by taking the necessary steps.

1.3.9 Initiatives Taken by Government of India in Distribution Sector

Distribution is the most important link in the entire power sector value chain. As the only interface between utilities and consumers, it is the cash register for the entire sector. Under the Indian Constitution, power is a concurrent subject and the responsibility for distribution and supply of power to rural and urban consumers rests with the States. However, Government of India provides assistance to states through various Central sector / Centrally sponsored schemes for improving the distribution sector.

1.3.9.1 Integrated Power Development Scheme (IPDS)

Government of India launched Restructured-Accelerated Power Development and Reforms Programme (R-APDRP) in 2008 during 11th Plan period as a Central sector scheme to encourage energy audit and accounting through IT intervention and to reduce the Aggregate Technical and Commercial (AT&C) losses up to 15%. The size of the R-APDRP scheme was ₹ 51,577 crores. The focus of R-APDRP Scheme was on actual demonstrable performance by utilities in terms of sustained AT&C loss reduction. The programme was continued till December, 2014.

For providing 24x7 power supply in the urban areas, Central Government launched "Integrated Power Development Scheme" (IPDS) on 3rd December, 2014 for:

(i) Strengthening of sub-transmission and distribution networks in the urban areas.
(ii) Metering of distribution transformer/feeders/consumers in the urban areas.
(iii) IT enablement of distribution sector and strengthening of distribution network, for completion of the targets laid down under R-APDRP for the period 2012-17 and 2017-22 by carrying forward the approved outlay for R-APDRP to IPDS.

The components at (i) and (ii) above have an estimated outlay of ₹ 32,612 crores including a budgetary support of ₹ 25,354 crores from Government of India during the entire implementation period.

The scheme of R-APDRP as approved by Government for continuation during the period 2012-17 and 2017-22 has been subsumed in the newly launched Integrated Power Development Scheme (IPDS) on 3rd December,2014, as a separate component relating to IT enablement of distribution sector and strengthening of distribution network for urban areas [component (iii) above] for which Government has already approved the scheme cost of ₹ 44,011 crores including a budgetary support of ₹ 22,727 crores. This outlay will be carried forward to the new scheme of IPDS in addition to the outlay indicated above.

Power Finance Corporation (PFC) is the nodal agency for the operationalization of IPDS in the country.

1.3.9.2 Deen Dayal Upadhyaya Gram Jyoti Yojna" (DDUGJY)

Government of India has approved Deen Dayal Upadhyaya Gram Jyoti Yojna" (DDUGJY) on 3rd December, 2014 for

(i) Separation of agriculture and non-agriculture feeders facilitating judicious rostering of supply to agricultural & non-agriculture consumers in the rural areas; and
(ii) Strengthening and augmentation of sub-transmission & distribution infrastructure in rural areas, including metering of distribution transformers/feeders/consumers.
(iii) Rural electrification for completion of the targets laid down under RGGVY for 12th and 13th Plans by carrying forward the approved outlay for RGGVY to DDUGJY.

The components at (i) and (ii) of the above scheme have an estimated outlay of ₹ 43,033 crores including a budgetary support of ₹ 33,453 crores from Government of India during the entire implementation period.

The scheme of RGGVY as approved by Government for continuation for years 2012-17 and 2017-2022 has been subsumed in this scheme as a separate rural electrification component for which Government has already approved the scheme cost of ₹ 39,275 crores including a budgetary support of ₹ 35,447 crores. This outlay will be carried forward to the new scheme of DDUGJY in addition to the outlay of ₹ 43,033 crores. Rural Electrification Cooperation Limited (REC) is the nodal agency for the operationalization of DDUGJY in the Country.

Under DDUGJY, a total of 6159 projects at an estimated cost of ₹ 1,29,274 crores covering feeder segregation, metering, augmentation of distribution system and electrification of un-electrified/ partially electrified villages & electricity connections to Below Poverty Line (BPL) households have been approved as on 31st March,2017.

Under the scheme, electrification of 1,28,387 un-electrified villages, intensification of 7,39,986 partially electrified villages and electricity connections to 4.27 crore households has been approved. Out of which electrification of 1,22,159 un-electrified villages (94%), intensification of 4,14,563 partially electrified villages (54%) and electricity connections to 2,54,68,200 households (59%) has been achieved.

1.3.9.3 UDAY (Ujwal Discom Assurance Yojana) Scheme for Operational and Financial Turnaround of Power Distribution Companies.

Ministry of Power vide Office Memorandum dated 20th November 2015, announced **UDAY (Ujwal DISCOM Assurance Yojana),** a Scheme for the Financial Turnaround of Power Distribution Companies (DISCOMs). The scheme has been approved by the Government of India with an objective to improve the operational and financial efficiency of the State DISCOMs. The focus of UDAY Scheme is on States taking over the debt of State owned Discoms. Under the scheme, States were to take over 75% of DISCOM debt as on 30 September 2015 over two years - 50% in 2015-16 and 25% in 2016-17. States were to issue non-SLR (non- statutory liquidity ratio) including SDL (State Development Loans) bonds in the market or directly to the respective banks / Financial Institutions (Fls) holding the DISCOM debt to the appropriate extent. Non-SLR bonds issued by the State will have a maturity period of 10-15 years with a moratorium on repayment of principal up to 5 years, as required by the State.

DISCOM debt to be taken over by the State includes DISCOM bonds which are committed to be taken over by the State as part of Financial Restructuring Plan (FRP) 2012. FRP Scheme was approved and notified by the Central Government in October 2012, to enable financial turnaround of State Discoms. Bonds already taken over in the year 2015-16 are covered as part of the scheme. Jharkhand and Jammu & Kashmir are given special dispensation to borrow ₹ 7,431 crore and ₹ 2,140 crore respectively to clear the provisional outstanding dues of various CPSUs as on 30th Sept, 2015 in the financial year 2015-16 itself. Debt taken over by the State and borrowings by Jharkhand and J&K under this scheme would not be counted against the fiscal deficit limit of respective State in the financial years 2015-16 and 2016-17.

As per the UDAY scheme, for improving operational efficiencies, the participating States and utilities would have to follow the specified timeline of the targeted activities e.g. Compulsory feeder and Distribution Transformer (DT) metering by States, Consumer Indexing & GIS Mapping of losses, Upgrade or change transformers, meters etc. Smart metering of all consumers consuming above 200 units / month, Demand Side Management (DSM), Quarterly tariff revision, campaign to check power theft, Assure increased power supply in areas where the AT&C losses reduce.

In addition, the outcomes of operational improvements is measured through following indicators:

a) Reduction of AT&C loss to 15% in 2018-19 as per the loss reduction trajectory to be finalized by Ministry of Power (MoP) and States, and
b) Reduction in gap between Average Cost of Supply (ACS) & Average Revenue Realized (ARR) to zero by 2018-19 as finalized by MoP and States.

States accepting the scheme and performing as per operational milestones are given additional / priority funding through DDUGJY, IPDS, Power Sector Development Fund (PSDF) or other such schemes of MoP and MNRE. Such States are supported with additional coal at notified prices and, in case of availability through higher capacity utilization, low cost power from NTPC and other Central Public Sector Undertakings (CPSUs). States not meeting operational milestones are liable to forfeit their claims on DDUGJY & IPDS grants.

Ministry of Power subsequently issued the Office Memorandum dated 13.01.2016 regarding (i) Participation by State Power Departments (those involved in distribution of electricity as unbundled State Electricity Boards and; (ii) Participation by States where DISCOMs are not financially stressed, for improvement in operational efficiency. It is mentioned in this OM that in case of State Power Departments, the issue of State takeover of debts does not arise and in case of States where DISCOMs are not financially distressed, there is no need for State to take over DISCOM debts. In regard to these cases, it is further stated in this Office Memorandum that States may also enter into bipartite/tripartite

MOUs, as applicable, along with their DISCOMs and the Ministry of Power for implementation of the Scheme for improvement of operational parameters as per the MoP's Office Memorandum dated 20th November 2015 for UDAY.

A Committee has been constituted by MoP vide OM dated 19.01.2016, under the Chairmanship of Secretary MoP to ensure close monitoring of performance under UDAY to prevent any slippage.

According to the notified scheme, the cut-off date for the States to take over 50% of DISCOM debt and issue of non-SLR including SDL bonds in the market or directly to the respective banks/Fls holding the DISCOM debt to the appropriate extent, was 31st March, 2016. However, many States who had shown willingness to join UDAY, could not join the Scheme by 31.03.2016 as they were in the process of obtaining necessary approvals at their end. In order to facilitate the States to avail the benefits of UDAY Scheme, the Government of India had extended the time lines of scheme to allow such States to join the UDAY by 31.03.2017.

The timelines for taking over 50% of the DISCOM debts, as existing on 30.09.2015, through issuance of Bonds by participating States under UDAY was also extended to 31.03.2017.

Further, the timelines for taking over outstanding CPSU dues of the State of Jammu & Kashmir as on 30.09.2015, was extended to 31.03.2017.

Twenty six States and one UT namely Assam, Andhra Pradesh, Goa, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Puducherry, Rajasthan, Tamil Nadu, Uttar Pradesh, Jharkhand, Chhattisgarh, Gujarat, Bihar, Punjab, Jammu & Kashmir, Haryana Uttarakhand, Tripura, Sikkim, Arunachal Pradesh, Kerala, Meghalaya and Mizoram have already signed the Memorandum of Understanding (MoUs) with Ministry of Power under UDAY.

The States of Gujarat, Uttarakhand, Goa, Karnataka, Manipur, Puducherry(UT), Kerala, Tripura, Sikkim, Arunachal Pradesh & Mizoram have signed MOU for Operational turnaround only.

1.3.9.4 National Smart Grid Mission (NSGM)

To promote the development of Smart Grid in the country, Government of India has launched 'National Smart Grid Mission (NSGM)' on 27th March,2015 for planning, monitoring and implementation of policies & programs related to development of Smart Grid in India.
The total estimated cost for NSGM activities for 12th plan is ₹ 980 crores including a budgetary support of ₹ 338 crores. Under NSGM, 30% funding will be provided for the development of Smart Grid in selected Smart Cities in the country along with development of micro grid in the country. 100% funding is also proposed for training & capacity building and consumer engagement etc.
Smart Grid Projects at Chandigarh worth ₹ 28.58 crores, at Amravati (Maharashtra) worth ₹ 90.05 crores, at Congress Nagar (Nagpur) worth ₹ 139.15 crores and at Kanpur worth ₹ 319.57 crores have been sanctioned under NSGM. The National Smart Grid Mission Project Management Unit (NPMU) is handholding States for speeding up development of Smart Grid Network in the country.

1.3.9.5 Creation of National Electricity Fund (NEF) for Distribution Scheme

Investment in Sub-transmission and distribution has been lacking due to resource crunch being experienced by the State transmission and distribution utilities. The break-up of the generation and transmission & distribution schemes shall normally be 50:50. However, more investment is taking place in generation and investment in intra-state transmission system and distribution system has been much less than the desired proportion.
Government of India has approved the NEF (Interest Subsidy) scheme to promote the capital investment in the distribution sector by providing interest subsidy, linked with reform measures, on the loans taken by public and private power utilities for various capital works under distribution projects. This scheme shall be applicable in the entire country and all distribution projects shall be considered. The works covered under RGGVY & R-APDRP projects shall not be eligible so as to ensure non-duplication and non-overlapping of grant/subsidy towards investment.

1.3.10 Energy Efficiency

Government of India has undertaken a two pronged approach to cater to the energy demand of its citizens while ensuring minimum growth in CO_2 emissions, so that the global emissions do not lead to an irreversible damage to the earth system. On one hand, the Government is promoting greater use of renewables in the energy mix mainly through solar and wind and at the same time shifting towards supercritical technologies for coal based power plants. On the other hand, efforts are being made to efficiently use the energy in the demand side through various innovative policy measures under the overall ambit of Energy Conservation Act, 2001.

Ministry of Power, through Bureau of Energy Efficiency (BEE), has initiated a number of energy efficiency initiatives in the areas of household lighting, commercial buildings, standards and labelling of appliances, demand side management in agriculture/municipalities, SME's and large industries including the initiation of the process for development of energy consumption norms for industrial sub sectors, capacity building of State Designated Agency (SDA), etc. These initiatives have resulted in an avoided capacity generation of 36,323 MW during the period 2006-2014.

1.3.11 The National Mission on Enhanced Energy Efficiency

The National Mission for Enhanced Energy Efficiency (NMEEE) is one of the eight missions under the National Action Plan on Climate Change (NAPCC). NMEEE aims to strengthen the market for energy efficiency by creating conducive regulatory and policy regime and has envisaged fostering innovative and sustainable business models to the energy efficiency sector.

The NMEEE spelt out four initiatives to enhance energy efficiency in energy intensive industries which are as follows:

1) Perform, Achieve and Trade Scheme (PAT), a regulatory instrument to reduce specific energy consumption in energy intensive industries, with an associated market based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.
2) Market Transformation for Energy Efficiency (MTEE), for accelerating the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable.
3) Energy Efficiency Financing Platform (EEFP), for creation of mechanisms that would help finance Demand Side Management(DSM) programmes in all sectors by capturing future energy savings.
4) Framework for Energy Efficient Economic Development (FEEED), for development of fiscal instruments to promote energy efficiency.

The Mission seeks to upscale the efforts to unlock the market for energy efficiency which is estimated to be around ₹ 74,000 crores and help achieve total avoided capacity addition of 19,598 MW, fuel savings of around 23 million tonnes per year and greenhouse gas emission reductions of 98.55 million tonnes per year at its full implementation stage. Continuation of NMEEE was approved by Cabinet on 6th August, 2014 with a total outlay of ₹ 775 crores.

1.3.12 Domestic Efficient Lighting Programme

Domestic Efficient Lighting Programme (DELP) was launched by Government of India, replacing the Bachat Lamp Yojana (BLY). The scheme provides LED bulbs at a subsidized rate for replacing incandescent lamps or Compact Fluorescent Lamps(CFL) to households. More than 9 crore LED bulbs were distributed in 2015-16 registering a 150 times growth against 6 lakhs in 2013-14. Procurement price of LED bulbs reduced from ₹310 for a 7 W bulb in January 2014 to ₹ 38.00 for a 9 W bulb in the last bidding carried out in 2016. As on 20.09.2017 26,37,24,970 LED bulbs have been distributed.

1.3.13 Human Resource Development – Adopt an ITI Scheme

Power industry is highly capital intensive industry where human element is the most vital input. The power sector provides wide range of opportunities across different levels of skill and aptitude. Power industry requires technically trained manpower for various roles such as project planning, implementation, erection, commissioning, testing, O&M for generation transmission and distribution of power, which includes renewable energy sector and manufacturing segment. Due to the technology intensive nature of the business, technical and managerial competency is crucial in ensuring timely implementation of projects and optimum performance upon commissioning.

The labour intensity of energy production, i.e. the labour required per unit of energy produced, is much higher in renewable energy sources than in conventional energy production primarily due to the distributed nature of the projects. These distributed renewable sources of power not only provide clean, green and sustainable form of energy but also have enormous potential to generate employment in the rural communities. Small hydro, solar and biomass based energy can go a long way in powering rural communities. Government of India has set a target for renewable capacity of 175 GW by 2022, it is important to ensure that the manpower be trained and equipped in these emerging areas.

Driven by the imperative to mitigate climate change, there is an increasing focus on renewable energy, energy efficiency, conservation measures so as to reduce carbon footprint from the power sector. This inter-alia, includes implementation of energy efficient systems, monitoring & auditing. Other key focus areas include loss reduction in distribution utilities and improving Demand Side Management (DSM). Monitoring systems for detecting losses as well as DSM techniques require usage of advanced IT and communication systems which call for a large number of personnel to be trained in these specialised areas.

With the emergence of competitive markets and power trading systems, a large number of highly skilled professionals with commercial and technical knowledge are required in this area. Other key decision makers and managers also need to develop a good understanding of the trading systems in order to make commercial decisions.

With the increase in the stakeholders in the industry, the role of regulators is also very important. Training of regulators at regular intervals is an important issue that would promote institutional capability and provide the regulators with the necessary skill sets. Apart from the regulators, the respective State Governments should also initiate steps to provide training to the staff of regulatory commissions since it has been observed that the in-house capacity of most of the regulatory commissions is inadequate.

1.3.14 Scheme for Utilisation of Gas Based Capacity

Government of India has sanctioned a scheme for utilization of gas based power generation capacity for the years 2015-16 and 2016-17. The scheme envisages supply of imported spot Re-gasified Liquefied Natural Gas (RLNG) to the stranded gas based plants as well as plants receiving domestic gas, selected through a reverse e-bidding process. The scheme also envisages sacrifices to be made collectively by all stakeholders and support from PSDF (Power System Development Fund). The outlay for the support from PSDF has been fixed at ₹ 7500 crores (₹ 3500 crores and ₹ 4000 crores for the year 2015-16 and 2016-17 respectively).

The following interventions/ sacrifices are envisaged in the scheme, to be made by the Central Government, State Governments, power developers and gas transporters collectively:

a) Streamlining the procedure for availing customs duty waiver on imported LNG for the gas based power plants
b) Waiver of Value Added Tax (VAT) on the e-bid RLNG
c) Waiver of Central Sales Tax (CST), Octroi and Entry Tax on the e-bid RLNG
d) Waiver of Service Tax on regasification and transportation of the e-bid RLNG
e) Reduction in pipeline tariff charges by 50%, reduction in marketing margin by 75% on incremental volumes by GAIL / other transporters on the e-bid RLNG
f) Capping of fixed cost to be recovered by the promoters: Power developers to forgo return on their equity.
g) Provision for co-mingling and swapping of gas
h) Exemption from transmission charges and losses for such stranded gas based power projects on lines of solar power on generation from the e-bid RLNG
i) Support from Power System Development Fund (PSDF)

1.4 DIGITAL INITIATIVES

1.4.1 TARANG

With the perspective of Good Governance and keeping in line with the "Digital India" initiative of Government of India, REC Transmission Projects Limited(RECTPCL), a wholly owned Subsidiary of Rural Electrification Corporation Limited has developed "TARANG"- Transmission App for Real Time Monitoring and Growth – as a mobile app and web interface. Tarang shall track ongoing transmission projects as well as provide wider participation in bidding process for upcoming projects. Another web portal "e-trans" for e-bidding and e-reverse auction for Tariff Based Competitive Bidding (TBCB) in transmission projects has also been introduced .This portal shall bring more transparency ,efficiency and competition in transmission sector.

1.4.2 URJA(Urban Jyoti Abhiyaan)

This scheme is aimed to empower citizens to bring transparency in performance of their town, DISCOMs, and state. The App is a platform for user to get information on the power supply services in their region as well as pan India. User can keep check on how their town, DISCOM, State is performing compared to other regions for different months and dates.

1.4.3 DEEP (Discovery of Efficient Electricity Price)

DEEP is a 'e-Bidding' portal for medium term (1-5 years) purchase of power. The portal will provide a common e-bidding platform with e-reverse auction facility to facilitate nation-wide power procurement through a wider network so as to bring uniformity and transparency in the process of power procurement.

1.4.4 Vidyut Pravah

This mobile application provides highlights of the power availability in the country on real time basis. The mobile application will empower the common people to demand 24x7 power from the States. Vidyut Pravah mobile application provides data pertaining to market price of power from power exchange, value of current all India demand in GW and all India and State shortage including peak hour and total energy shortage. The real time data and comparison with previous day/year data is also available. Data from multiple sources, including the States and power exchanges, has been made available through a single portal for the convenience of all.

1.4.5 'E-TRANS' WEB PLATFORM:

This will provide e-bidding and e-reverse auction for Tariff Based Competitive Bidding (TBCB) in transmission projects.

1.4.6 UJALA (Unnat Jyoti by Affordable LED for All):

UJALA scheme aims to promote efficient use of energy at the residential level; enhance the awareness of consumers about the efficacy of using energy efficient appliances and aggregating demand to reduce the high initial costs thus facilitating higher uptake of LED lights by residential users. It may be noted that the scheme was initially labelled as DELP (Domestic Efficient Lighting Program) and was relaunched as UJALA**.** UJALA mobile App has also been launched which reflects the status of the energy efficient devices distributed to the consumers on State-wise and all-India basis and the corresponding energy savings achieved.

1.4.7 GARV-II

To ensure transparency in implementation of rural electrification programme, a new mobile app, GARV-II has been launched to provide real time data of all six lakh villages of the country. Under this facility, village-wise, habitation-wise base line data on household electrification for all States provided by them has been incorporated. Further, village-wise works sanctioned under Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) have also been mapped to monitor progress of works in each village.

1.4.8 FLEXIBILITY OF COAL

The Cabinet on 04.05.2016 approved the proposal for allowing flexibility in utilization of domestic coal amongst power generating stations with a aim to reduce cost of generation.
Flexibility allows using domestic coal amongst power plants of State, Central Generating Stations and Independent Power Producers (IPPs).
MoP issued the methodology for using coal in State/Central generating stations in June, 2016 and methodology for utilization of coal by States in IPPs in Feb,2017.

1.4.9 SHAKTI - Scheme for Harnessing and Allocating Koyala (Coal) Transparently in India.

- Thermal plants holding letters of assurance (LoAs) will be eligible to sign fuel supply pacts under the new policy after ensuring that all the conditions are met. The plants have to be commissioned by March 2022.
- Coal linkages on notified price for Central Government and State Government Generating Companies (GENCOs) on recommendations made by Ministry of Power.
- Coal linkages on auction basis on discount on the tariff for IPPs having long term PPAs.
- Future coal linkages on auction basis on premium above the notified price of the coal company for IPPs without PPAs.
- Linkage allocation to State Discoms against PPA on Tariff based bidding.
- Linkage allocation to group of States against PPA on Tariff based bidding.
- Linkage auction to power plants based on Imported Coal.

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Annexure 1.1

STATUS OF ULTRA MEGA POWER PROJECTS

Sl. No.	Name of UMPP	Location	Levelised tariff (₹/kwh)	Status
1	Mundra UMPP (5x800 MW)	Mundra in village Tundawand in District Kutch Gujarat	2.263	Project awarded and transferred to M/s.Tata Power Ltd. on 24.04.2007. Project is fully commissioned.
2	Sasan UMPP (6x660 MW)	Sasan in District Singrauli. Madhya Pradesh	1.196	Project awarded and transferred to M/s. Reliance Power Ltd. On 07.08.2007. Project is fully commissioned.
3	Krishnapatnam UMPP (6x660 MW)	Krishnapatnam in District Nellore, Andhra Pradesh	2.330	The project was handed over to Reliance Power Ltd. on 29.01. 2008.The developer has stopped work at site, citing new regulation of coal pricing in Indonesia. Lead Procurer namely Andhra Pradesh Southern Power Distribution Company (APSPDCL) has issued termination notice to Coastal Andhra Power Ltd (CAPL). The case is subjudice in division bench, Delhi High Court.
4	Tilaiya UMPP (6x660 MW)	Near Tilaiya village in Hazaribagh and Koderma Districts, Jharkhand	1.770	Project awarded and transferred on 7th August, 2009 to M/s Reliance Power Ltd. The developer (Jharkhand Integrated Power Ltd, a subsidiary of RPL) has issued notice of termination of Power Purchase Agreement on 28.4.2015 citing reasons as non transfer of land to the developer by Jharkhand Government. Procurers have accepted the termination notice in November,2015 and after transfer of SPV, necessary development activities for re-bidding would be started as per revised standard bidding documents(SBDs).

Projects identified for Bidding:

SI	Name of UMPP	Location	Status
1	Bedabahal	Bedabahal in Sundergarh District, Odisha	The site for this UMPP is in village Bedabahal in Sundergarh district. Request for Qualification (RfQ) and Request for proposal (RfP) were issued in 2013 as per revised Standard bidding Document (SBD) for UMPPs. The Bidders had withdrawn from the bidding process due to reason that the revised SBD does not fully address their concerns. The main areas of concern were DBFOT structure, coal cost for being fully passed through, stricter norms than CERC/CEA and grid code, onerous termination clauses and intrusive role of Independent Engineer. Accordingly, MoP vide letter dated 29.12.2014 terminated the bidding process. Fresh RFQ and RFP are to be issued

			after approval of revised standard bidding document by Govt.of .india.
2	Tamil Nadu	Village Cheyyur, District Kancheepuram	The site at Cheyyur in Kanchipuram district in Tamil Nadu has been identified at Panaiyur village. (RFQ) and (RFP) were issued in 2013 as per revised Standard Bidding Documents (SBD) for UMPPs. The bidders had withdrawn from the bidding process due to the reason that the revised SBD does not fully address their concern. The main areas of concern were DBFOT structure, coal cost not being fully passed through, stricter norms than CERC/CEA and grid code, onerous termination clauses and intrusive role of independent Engineer. Accordingly, MoP vide letter dated 29.12.2014 terminated the bidding process. Fresh RFQ and RFP are to be issued after approval of revised Standard Bidding Document by Govt.of India.
3	Bihar	Kakwara in Banka Districtt	A site at Kakwara in Banka District has been identified for setting up of UMPP in Bihar. Operating SPV namely Bihar Mega Power Limited (BMPL) and infrastructure SPV namely Bihar Infrapower Limited has been incorporated on 09.07.2015 and 30.06.2015 respectively. Ministry of coal vide O.M dated 08.04.3015 tentatively recommended Pirpainti / Barahat coal blocks to this UMPP. ToR accorded by MoEF&CC on 07.006.2016 The work on technical studies etc. has already commenced. Rapid EIA Report would be available by January 2017.
4	2nd Jharkhand UMPP	Husainabad, Deoghar District	A site at Husainabad, Deoghar District has been identified for setting up of 2nd UMPP in Jharkhand. Operating SPV namely Deoghar Mega Power Ltd and Infrastructure SPV namely Deoghar Infra Limited has been incorporated on 26.4.2012 and 30.06.2015 respectively. In the Review meeting held on 16.12.2016, Ministry of power has requested Govt. of Jharkhand to provided suitable site with availability of adequate water for setting up of Deoghar UMPP. It was decided that Govt. of Jharkhand would identify the source from which adequate water would be available for Deoghar UMPP and communicate the same to Ministry of Power.

Other Ultra Mega Power Projects in various stages of planning:

Sl. No	Name of UMPP	Location	Status
1.	1st additional UMPP in Orissa	Bijoypatna in Chandbali Tehsil of Bhadrak district for coastal location	Based on the site visit report submitted by CEA in March 2012, site near village Bijoypatana in Chandbali Tehsil of Bhadrak district was finalised . Consent from Government of Odisha is awaited.

2.	2nd additional UMPP in Orissa	Narla&Kasinga sub division of Kalahandi District for inland location	Based on the site visit report submitted by CEA in May 2012, the site near Narla and Kesinga subdivision of Kalahandi district was finalised. Consent from Government of Odisha is awaited.
3.	Uttar Pradesh	Etah in Uttar Pradesh	The sites for UMPP in Uttar Pradesh are being examined by CEA/PFC. For UMPP in UP, proposed at Etah, major portion of land is agricultural land and very far from coal fields. The proposed site at Etah not being a coastal or Pithead Site; specific approval of MoP is required.
4.	2nd Tamil Nadu UMPP	Site not finalized.	Government of Tamil Nadu had requested MOP/CEA to reconsider Nagapattinam site for second UMPP in TN. However ,this site was not found suitable by CEA for the UMPP. TANGEDCO vide letter dated 10.10.2012 has informed that "alternate site for the proposed second UMPP of Tamil Nadu is still being identified through District Collector, Nagapattinam. It is further stated by TANGEDCO that all the Collectors have also been requested to identify suitable land for the proposed Ultra Mega power Project in their respective areas.
5.	2nd Gujarat UMPP	Site Not Finalized	On 12.01.2016, CEA & PFCCL team has visited the site in Chikali-Kob Villages in Gir Somnath District, Gujarat identified by Government of Gujarat to explore the possibilities for setting up of UMPP. As the land identified is not sufficient to set up an UMPP, Govt. of Gujarat has been requested to propose suitable alternate site for 2nd UMPP in Gujarat.

CHAPTER 2

REVIEW OF CAPACITY ADDITION DURING 12TH FIVE YEAR PLAN (2012-17)

2.0 INTRODUCTION

The capacity addition target set for the 12th Five Year Plan is 88,537 MW from conventional sources of energy. This chapter includes details of capacity addition during 12th plan (2012-17) and also the constraints faced in timely execution of the power projects.

2.1 12TH PLAN CAPACITY ADDITION TARGET FROM CONVENTIONAL SOURCES

One of the major objectives of the National Electricity Policy,2005 is to fully meet the electricity demand by the year 2012, thus mitigating all peaking and energy shortages. Now this objective is aimed to be achieved by the year 2017. Accordingly**,** a capacity addition target for the 12th Plan was finalised at 88,537 MW. Details of sector wise and mode wise capacity addition target is given in **Table 2.1** and subsequently in **Exhibits 2.1** and **2.2**.

Table 2.1

12th Plan Capacity Addition Target

(Figures in MW)

Source	Central	State	Private	Total
Hydro	6,004	1,608	3,285	10,897
Thermal	14,878	13,922	43,540	72,340
Nuclear	5,300	0	0	5,300
Total	26,182	15,530	46,825	88,537

Exhibit 2.1

(Figures in MW)

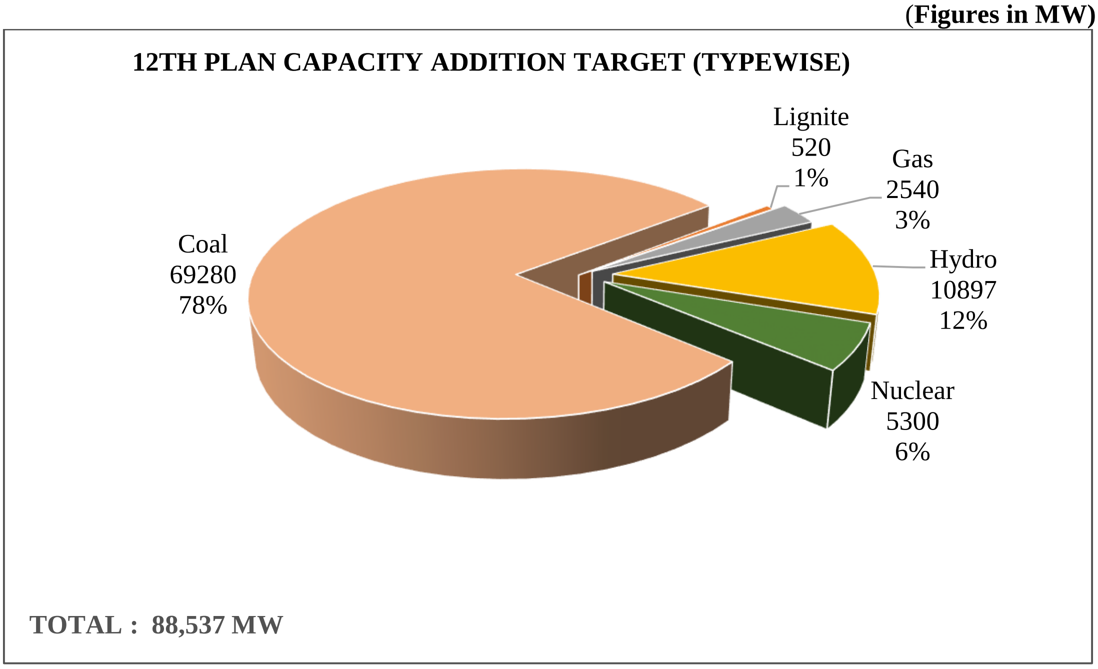
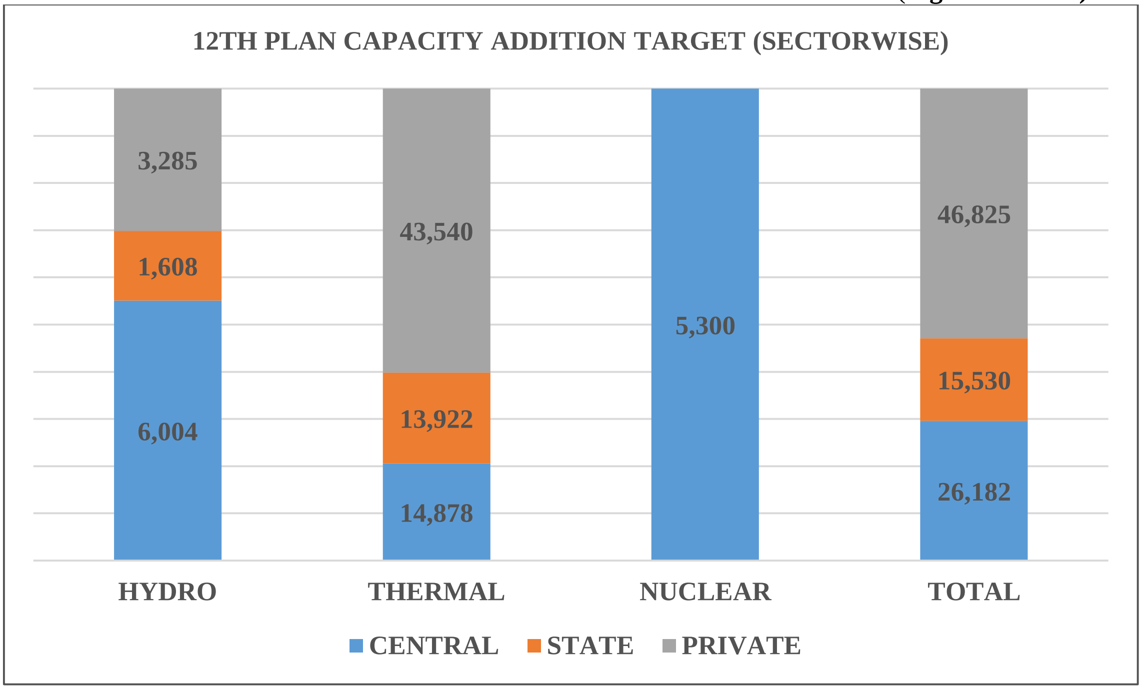


Exhibit 2.2

(Figures in MW)



2.2 CAPACITY ADDITION FROM CONVENTIONAL SOURCES DURING 12TH PLAN

The target set for capacity addition during the 12th Plan was 88,537 MW from conventional sources. As on 31st March, 2017, capacity of 99,209.5 MW has been added during 12th five Year Plan comprising of 5,479 MW of Hydro, 91,730.5 MW of Thermal and 2,000 MW of Nuclear.

Out of planned capacity addition target of 88,537 MW to be achieved by the end of 12th plan, a capacity addition of 63,912.9 MW has been achieved as per target and projects totalling to 24,614 MW have slipped from 12th Plan target on account of various reasons viz. delay in placement of order for main plant, slow progress of civil works, poor geology etc. Further, additional projects totalling to 35,296.6 MW which were at various stages of construction and originally not included in the 12th Plan capacity addition target have also been commissioned during 12th Plan period. A summary of the total capacity addition during 12th Plan is given in **Table 2.2.**

Table 2.2

Summary of capacity addition achieved during 12th Plan

(Figures in MW)

A	**12th Plan Capacity Addition Target**	**88,537**
B	**Capacity addition as per target (88,537 MW) of 12th Plan as on 31.03.2017**	**63,912.9**
C	**Capacity slipped from the capacity addition target of 12th Plan**	**24,613.8**
D	**Additional Capacity commissioned during 12th Plan as on 31.03.2017 outside the capacity addition target**	**35,296.6**
Total Capacity addition achieved during 12th Plan (B+D)		**99,209.5**

*excludes 10 MW downward capacity revision in respect of Hinduja TPP

During the 12th Plan period, the year wise capacity addition achieved from conventional sources is shown in **Table 2.3**. Capacity addition achieved during 2015-16 was 23,976 MW, which is the highest capacity addition ever achieved in a single year in the country. State wise capacity addition target and total capacity addition achievement (as per target and additional) during 12th plan is placed at **Annexure 2.1.** List of power projects commissioned during 12th Plan period is placed at **Annexure 2.2.**

Table 2.3
Year wise capacity addition achieved during 12th Plan

(Figures in MW)

Year	Sector	Central	State	Private	Total
2012-13	Hydro	374	66	70	**510**
	Thermal	5023.3	3911	11187.5	**20121.8**
	Nuclear	0	0	0	**0**
	Total	**5397.3**	**3977**	**11257.5**	**20631.8**
2013-14	Hydro	914	45	99	**1058**
	Thermal	1660	3322	11785	**16767**
	Nuclear	0	0	0	**0**
	Total	**2574**	**3367**	**11884**	**17825**
2014-15	Hydro	736	0	0	**736**
	Thermal	2659.2	4886.1	13285	**20830.3**
	Nuclear	1000	0	0	**1000**
	Total	**4395.2**	**4886.1**	**13285**	**22566.3**
2015-16	Hydro	480	610	426	**1516**
	Thermal	3295.6	6460	12705	**22460.6**
	Nuclear	0	0	0	**0**
	Total	**3775.6**	**7070**	**13131**	**23976.6**
2016-17	Hydro	80	355	1224	**1659**
	Thermal	3230.5	3622.25	4698	**11550.8**
	Nuclear	1000	0	0	**1000**
	Total	**4310.5**	**3977.25**	**5922**	**14209.8**

The sector wise, mode wise capacity addition achieved during 12th Plan from conventional sources, is shown in **Table 2.4**.

Table 2.4
Capacity addition achieved during 12th Plan

(Figures in MW)

Sector	Hydro	Thermal			Nuclear	Total
		Coal+Lignite	Gas	Total		
State	1076	20130	2071.4	22201.4	0	**23,277.4**
Private	1819	49730	3930.5	53660.5	0	**55,479.5**
Central	2584	14990	878.6	15868.6	2000	**20,452.6**
Total	**5,479**	**84,850**	**6,880.5**	**91,730.5**	**2000**	**99,209.5**

Exhibit 2.3

(Figures in MW)

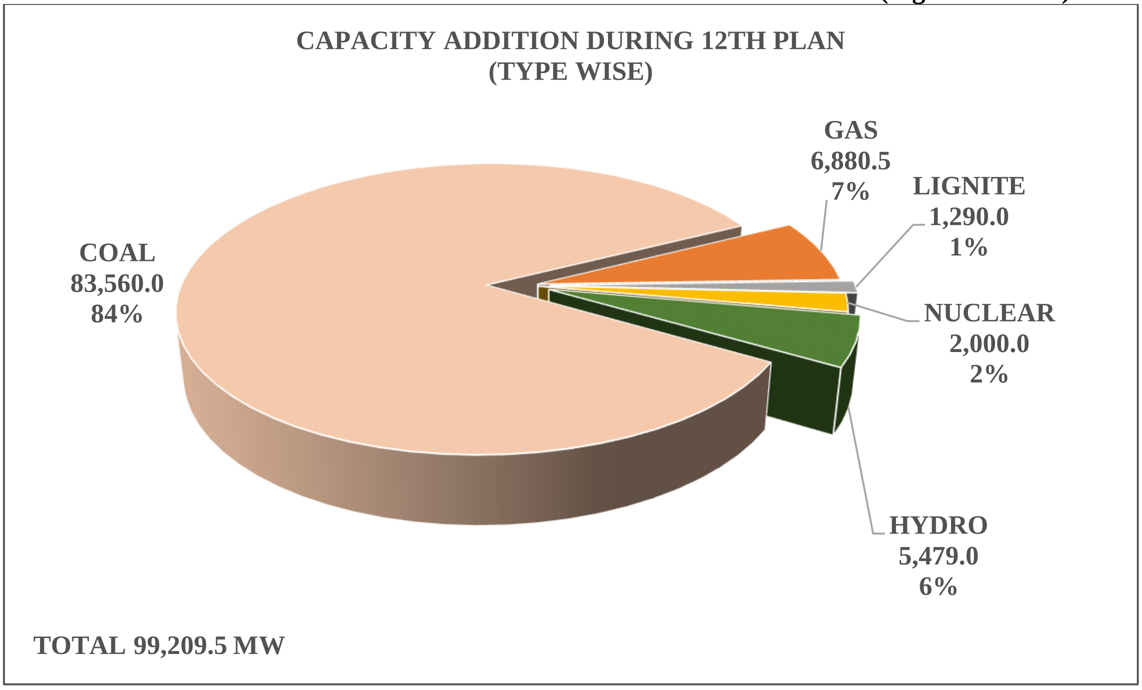


Exhibit 2.4

(Figures in MW)

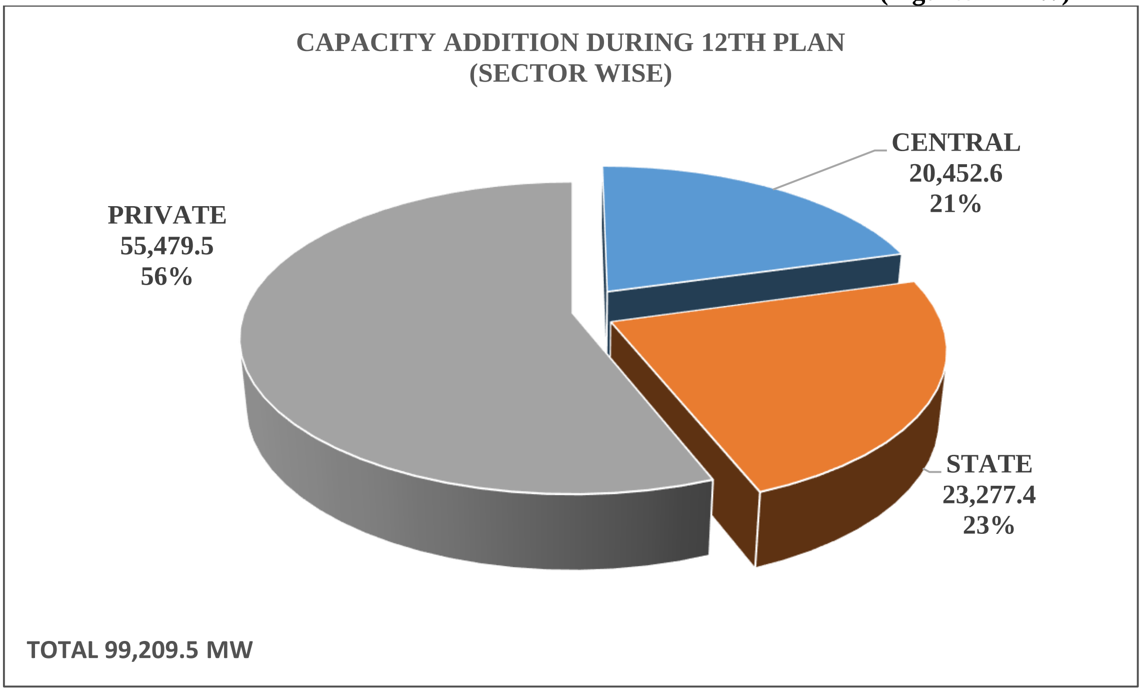
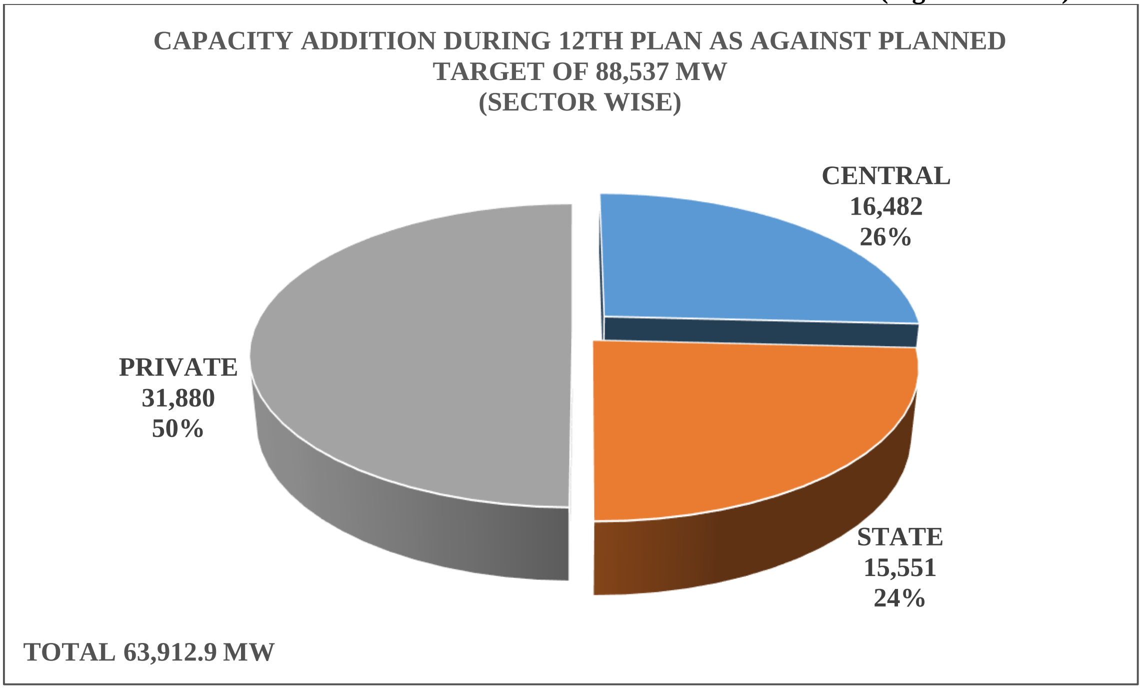


Exhibit 2.5

(Figures in MW)



2.3 ADDITIONAL CAPACITY ADDITION ACHIEVED DURING 12TH PLAN (NOT INCLUDED IN THE TARGETED CAPACITY OF 88,537 MW)

As per Electricity Act,2003, thermal generation has been delicensed which encouraged setting up of thermal power projects. As a result, a capacity of 35,296.6 MW not included in the 12th Plan target has yielded benefits during 12th Plan. The sector wise and mode wise details are shown in **Table 2.5** and **Exhibit 2.6**. This includes private sector contribution of 22,399.5 MW, amounting to around 63.5% of the total capacity addition which is outside the target.

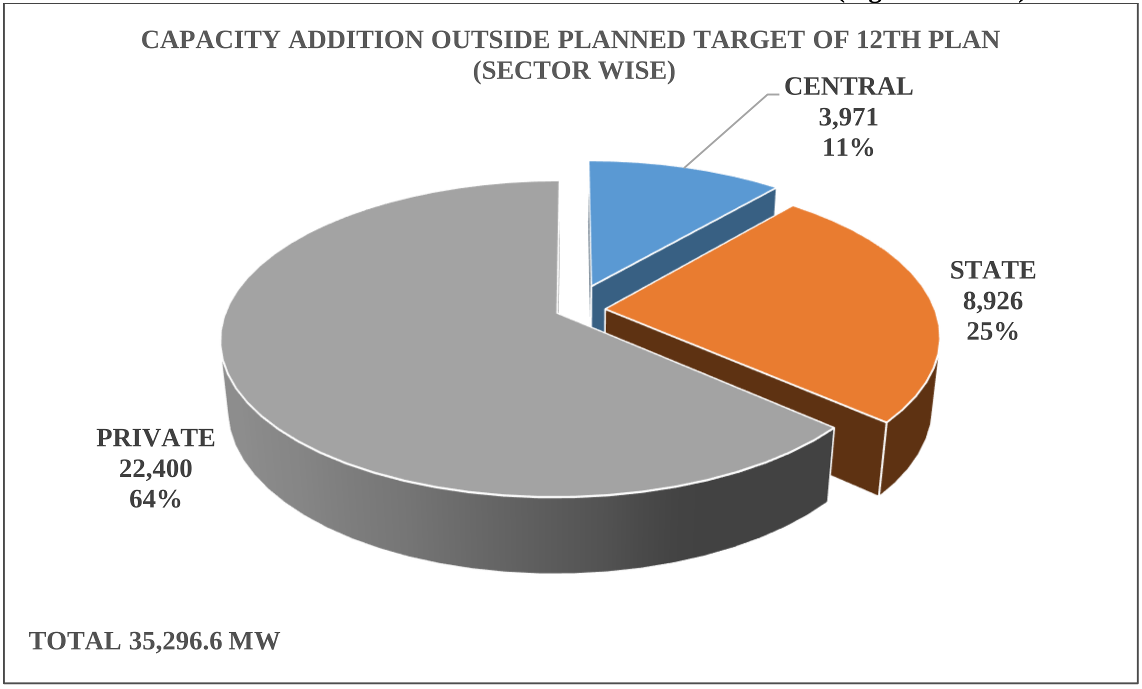
Table 2.5
Additional Capacity Addition achieved during 12th Plan

(Figures in MW)

Sector	Hydro	Thermal			Nuclear	Total
		Coal	Gas/LNG	Total		
Central	0.0	3,920.0	51	3,971	0.0	3,971.0
State	9.0	8,520.0	397.1	8,917.1	0.0	8,926.1
Private	24.0	18,445.0	3,930.5	22,375.5	0.0	22,399.5
Total	33.0	30,885.0	4,378.6	35,263.6	0.0	35,296.6

Exhibit 2.6

(Figures in MW)



Majority of additional projects commissioned during 12th Plan were listed in the previous National Electricity Plan. However, projects to the tune of 88,537 MW were identified based on the assessment of their likely commissioning during 12th Plan period.

2.4 A COMPARISON OF 12TH PLAN WITH PREVIOUS FIVE YEAR PLANS

The capacity addition target vs achievement during the previous few five year Plans is given in **Table 2.6.**

As can be seen from **Table 2.6**, capacity addition achievement for previous five year Plans was short of the target whereas during 12th Plan, the capacity addition achieved is 112% of the target.

Table 2.6

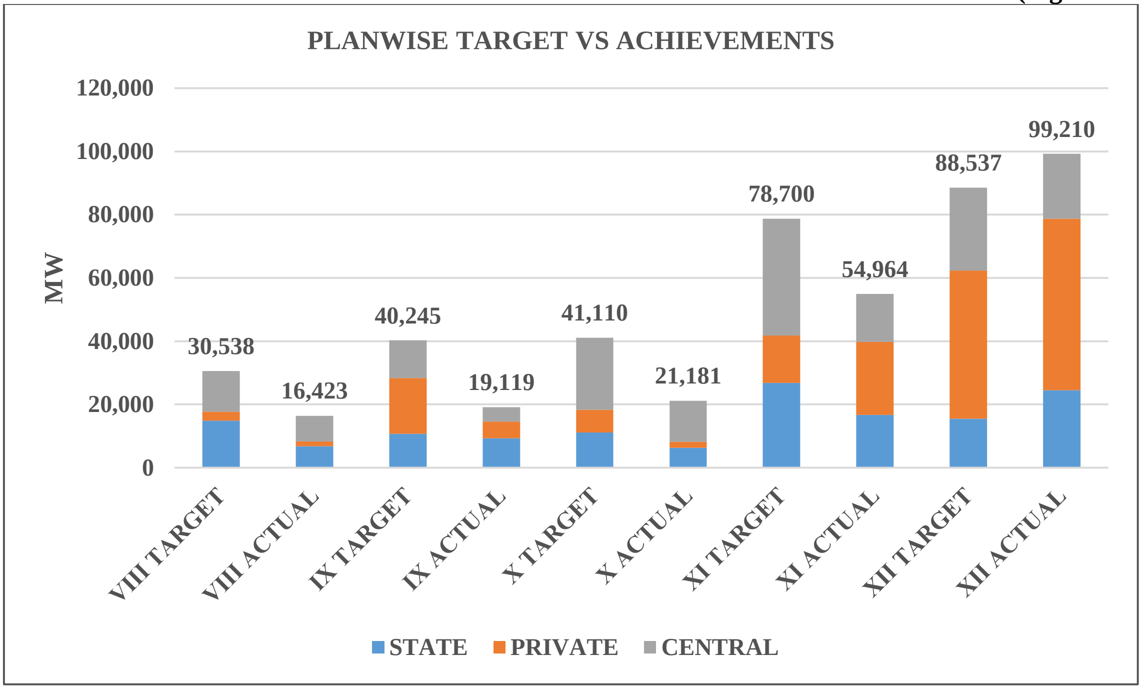
Capacity Addition Target vis-a-vis Achievement in previous five year Plans

(Figures in MW)

Plan/ Sector	8th Plan		9th Plan		10th Plan		11th Plan		12th Plan	
	Target	Actual	Target	Actual	Target	Actual	Target	Actual	Target	Actual
State	14,870	6,835	10,748	9,353	11,157	6,245	26,783	16,732	15,530	23,277.4
Private	2,810	1,430	17,589	5,262	7,121	1,930	15,043	23,012	46,825	55,479.5
Central	12,858	8,157	11,909	4,504	22,832	13,005	36,874	15,220	26,182	20,452.6
Total	**30,538**	**16,423**	**40,245**	**19,119**	**41,110**	**21,180**	**78,700**	**54,964**	**88,537**	**99,209.5**
% Achievement		**53.7**		**47.5**		**51.5**		**69.84**		**112.1**

Exhibit 2.7(a)

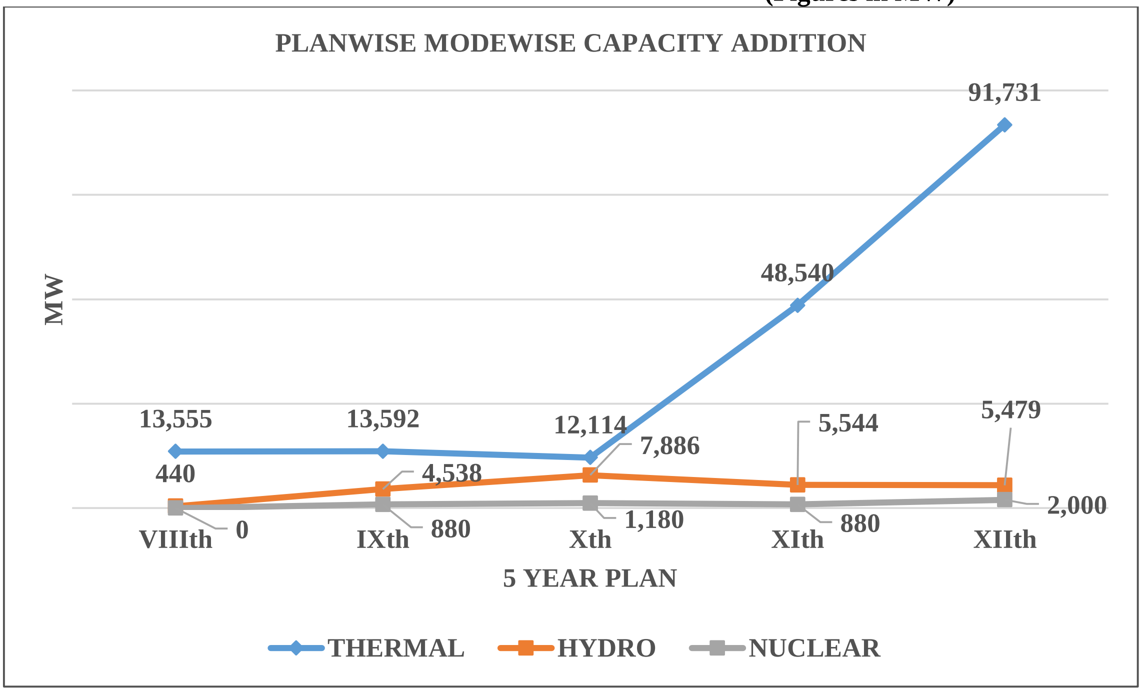
(Figures in MW)



From the **Exhibit 2.7(a),** it can be seen that private sector contribution towards capacity addition has significantly increased during the 11th Plan period onwards contributing around 42% of the total capacity added during 11th Plan and about 55% of the total capacity addition during 12th Plan.
Mode wise capacity addition from 8th Plan to 12th Plan is shown in **Exhibit 2.7(b).**

Exhibit 2.7(b)

(Figures in MW)



It can be seen from **Exhibit 2.7(b)** that thermal capacity addition after 10th Plan has increased significantly but capacity addition from Hydro and Nuclear has not been able to keep pace with that of thermal capacity addition.

2.5 COAL BASED THERMAL CAPACITY ADDITION

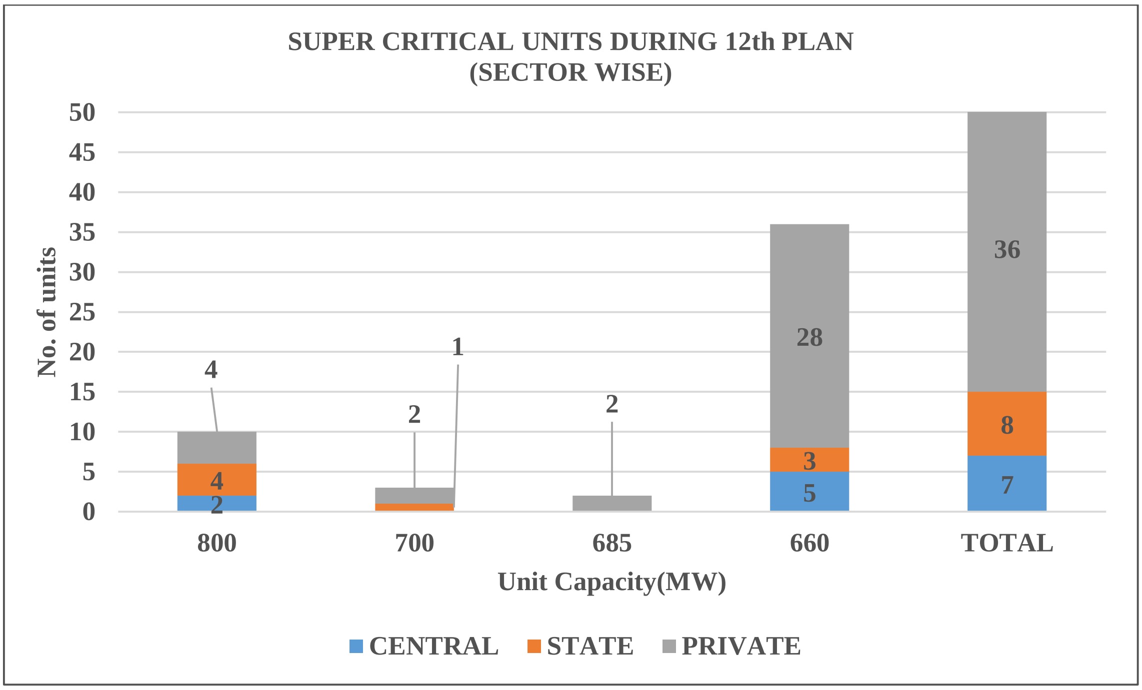
To follow low carbon growth strategy, Government of India is promoting supercritical technology for coal based power plants, which has higher efficiency than conventional sub critical technology, thereby ensuring less CO_2 emissions. **Table 2.7** shows that around 35,230 MW (42%) of the total capacity addition from coal units (84,850 MW) are based on supercritical technology (660MW and above) during the 12th Plan period. It is observed that 36 no. of coal based units on supercritical technology have been commissioned in private sector out of the total of 51 no of supercritical technology based units commissioned during 12th Plan.

Table: 2.7

Supercritical technology based capacity addition

Unit Size(MW)	No. Of Units				Total Capacity (MW)	% of Total Coal Based Capacity
	Central	State	Private	Total		
800	2	4	4	10	**8,000**	**9.4**
700	0	1	2	3	**2,100**	**2.5**
685	0	0	2	2	**1,370**	**1.6**
660	5	3	28	36	**23,760**	**28.0**
Sub-total (Supercritical)	**7**	**8**	**36**	**51**	**35,230**	**41.5**
Less than 660 (Sub-critical)	**23**	**33**	**74**	**130**	**49,620**	**58.5**
Total	**30**	**41**	**110**	**181**	**84,850**	**100.00**

Exhibit: 2.8



2.6 PROJECTS SLIPPING FROM 12TH PLAN CAPACITY ADDITION TARGET

Out of targeted capacity addition of 88,537 MW, a capacity of 24,613.8 MW (29% of the target) has slipped from 12th Plan. Sector wise and mode wise details of capacity slipped are shown in **Table 2.8 and Exhibit 2.9.**

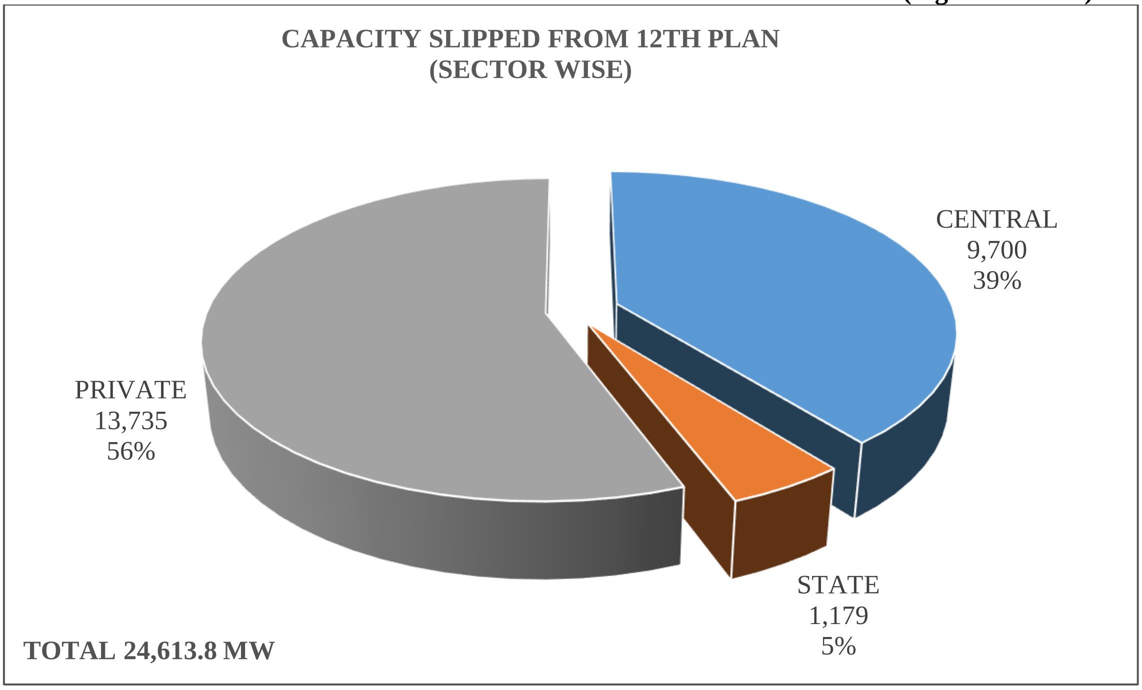
Table 2.8
Capacity Slipped from capacity target of 88,537 MW during 12th Plan
(Figures in MW)

Sector	Hydro	Thermal			Nuclear	Total
		Coal	Gas/LNG	Total		
Central	3,420.0	2,980.0	0.0	2,980.0	3,300.0	**9,700.0**
State	541.0	600.0	37.8	637.8	0.0	**1,178.8**
Private	1,490.0	12,245.0	0.0	12,245.0	0.0	**13,735.0**
Total	**5,451.0**	**15,825.0**	**37.8**	**15,862.8**	**3,300.0**	**24,613.8**

*excludes 10 MW downward capacity revision in respect of Hinduja TPP

Exhibit 2.9

(Figures in MW)



State-wise list of capacity slipped from 12th Plan is placed at **Annexure 2.1**. List of power projects slipped from 12th Plan capacity addition target is placed at **Annexure 2.3**.

2.7 MAJOR REASONS FOR SLIPPAGE OF PROJECTS FROM 12TH PLAN

2.7.1 Hydro Projects

- Slow progress of civil works
- Poor geology
- Unfavorable weather conditions like heavy monsoons, floods, cyclones, cloud burst, etc.
- Law and order issues

- Funds Constraints
- Contractual issues
- Environmental issues
- Local issues
- Resettlement and Rehabilitation issues

2.7.2 Thermal Projects

- Problems in acquisition of land for construction of power plant, ash dyke, raw water reservoir, corridor for pipelines, Railway siding etc. and Right of Way /Right of Use for raw water pipe line, ash slurry disposal pipelines and transmission lines etc.
- Local agitations including aspects such as R&R issues, labor disputes and law and order problems. Further, ethnic violence in some specific regions has also resulted in long interruptions at work site.
- Delay in timely availability of railway transport system and healthiness/load carrying capacity of road transport system for smooth transportation of equipment and fuel to the plant site.
- Change in State policies viz. in respect of sand mining, extraction of ground water etc. during plant construction period.
- Issues in timely availability of startup power at site.
- Issues in timely completion of power evacuation system and capacity of transmission system to evacuate full power generated at the plant.
- Shortage of Natural Gas
- Cost overruns on account of delay in timely completion of power projects
- Issues in availability of adequate finances from banks and financial institutions for completion of projects leading to cost overruns/increased cost of the plant.
- Poor performance of main contractor and sub-vendors including BoP sub-vendors for various reasons/issues involved.
- Contractual disputes resulting in termination of contract and re-tendering etc. resulting in project delays and cost overrun.
- Natural calamities and extreme weather conditions including heavy rains, cyclones etc., specifically in coastal areas.
- Non signing of long term PPA with DISCOMs and non-fulfillment of PPA conditions by the project developers. In some cases, even no PPA is available for sale of power from the power plant.
- Delay in availability of Consent to Establish, Consent to Operate (CTO) from respective State Governments.

2.8 RENOVATION & MODERNIZATION PROGRAMME

R & M has been recognized as one of the cost effective options for obtaining the additional generation and better outputs from the existing old power units. R&M of such units is very essential for bringing in improvement in the performance of the units as well as for system upgradation to comply with the stricter environmental conditions or stipulations in case of thermal units. However, the Life Extension (LE) of the old power units is carried out with an aim to extend their useful life from 15 to 20 years beyond the original designed economical life.

2.8.1 Thermal

LE/R&M works which were to be taken up during 12th Plan are given in **Table 2.9.** R&M/LE works in respect of 37 nos. thermal units with aggregate capacity of 7,202.26 MW have been completed during 12th Plan. Details of the achievement of R&M and LE projects completed during 12th Plan are shown in **Table 2.10.**

Table 2.9

LE / R&M Programme during 12th Plan (2012 - 17)

Category	LE/R&M works identified during 12th Plan No. of units & capacity (MW)		Total (State Sector + Central Sector) No. of units & capacity (MW)
	State Sector	Central Sector	
LE	38 (6,820)	32 (5,246)	70 (12,066)
R&M	20 (4,150)	45 (13,151)	65 (17,301)
Total	58 (10,970)	77 (18,397)	135 (29,367)

Table 2.10

Achievements of R&M and LE Projects during 12th Plan (up to 31st March,2017)

Sl. No.	Particulars	LE/R&M works completed during 12th Plan No. of units & capacity (MW)		Total (State Sector + Central Sector) No. of units & capacity (MW)
		State Sector	Central Sector	
1	**LE**	10(1380)	11(1,261.76)	21(2,641.76)
2	**R&M**	5(850)	11(3,710.5)	16(4,560.5)
Total		**15(2,230)**	**22(4,972.26)**	**37(7,202.26)**

Details of Achievements of LE and R&M Programme during 12th Plan up to 31st March,2017 are placed at **Annexure 2.4**

2.8.2 Hydro

During 12th Plan, a total of 22 hydro R&M schemes (2 in Central Sector and 20 in State Sector) having an installed capacity of about 7,105.35 MW were expected to be completed at an estimated cost of about 1,353 crores. Details of the same are given in **Table 2.11**.

Table 2.11

Programme and Achievements of R&M and LE Projects during 12th Plan (up to 31.03.2017)

Status	No of Hydro LE/R&M works		Total No. of schemes	Total Capacity (MW)
	Central Sector	State Sector		
Programme to be completed during 12th Plan	2	20	22	7,105.35
Completed as on 31.3.2017	2	18	20	4,014.60

2.9 CAPTIVE POWER PLANTS

Large number of captive plants including co-generation power plants of varied types and sizes exist in the country, which are utilized in process industry and in-house power consumption. Number of industries set up their captive plants to ensure reliable and quality power. Some plants are also installed as stand-by units for operation only during emergencies when the grid supply is not available. Surplus power, if any, from captive power plants could be fed into the grid as the Electricity Act, 2003 provides for non-discriminatory open access.

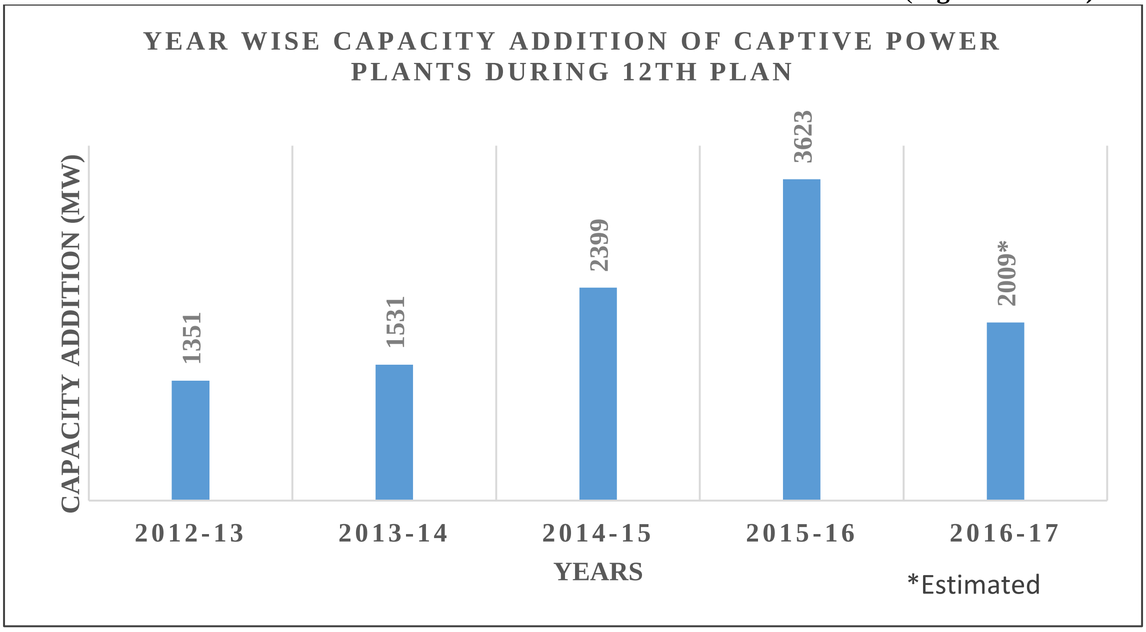
The installed capacity of captive power plants (1 MW and above) is about 50,288.67* MW as on 31st March,2017 registering a growth of 4.16 % over the year 2015-16. The total installed captive power plant capacity was 48,279.48 MW on 31st March,2016.

The energy generation from captive power plants during the year 2015-16 was about 168.4 BU registering a growth of about 3.95%. The generation from captive power plants was 162 BU during 2014-15.

The year wise capacity addition from captive power plants during 12th plan period is furnished at **Exhibit 2.10.**

Exhibit 2.10

(Figures in MW)



2.10 CAPACITY ADDITION DURING 12th PLAN FROM RENEWABLE ENERGY SOURCES

The installed capacity of renewable energy sources in the country at the end of 11th Plan (2007-12) was 24,503 MW. During 11th Plan, a capacity addition of 16,744 MW was achieved from renewable energy sources.

A capacity addition target of 30,000 MW was set for the 12th Plan from renewable energy sources as per the details shown in **Table 2.12**.

Table 2.12
Capacity addition target for Renewable Energy Sources during 12th Plan
(Figures in MW)

Source	Capacity
Solar	10,000
Wind	15,000
Other RES	5,000
Total	**30,000**

However, the target of installed capacity of RES by 2021-22 has been revised to 1,75,000 MW.
The installed capacity from renewable energy sources in the country is 57,244.23 MW as on 31.03.2017. Source wise installed capacity of renewable energy sources is shown in **Table 2.13** and **Exhibit 2.11**.

*Estimated figure

Table 2.13

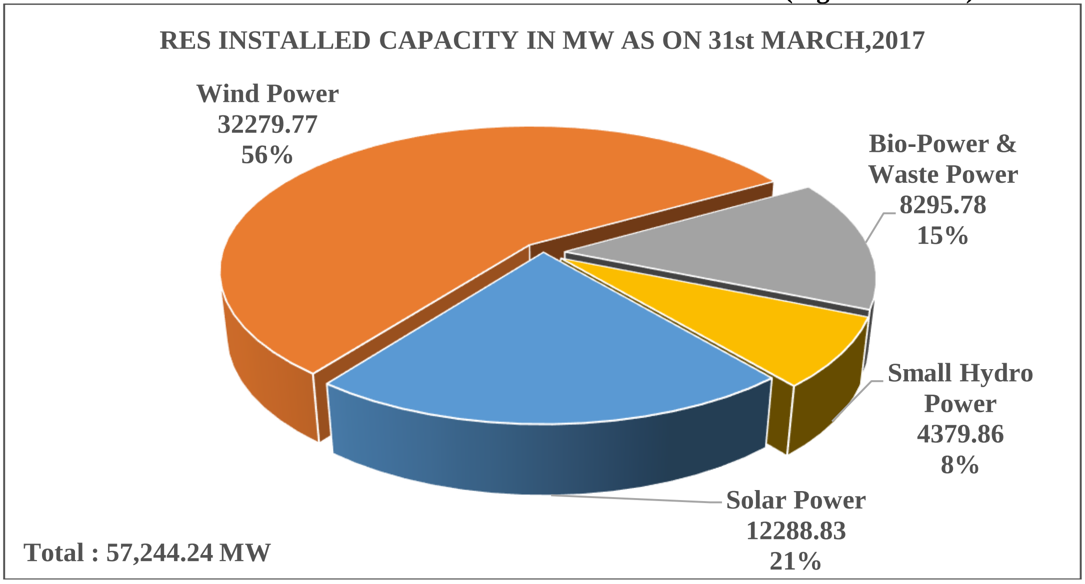
Installed capacity of Renewable energy sources as on 31st March,2017

(Figures in MW)

Source	Capacity
Solar	12,288.83
Wind	32,279.77
Bio-Power and waste power	8,295.78
Small Hydro	4,379.86
Total	**57,244.24**

Exhibit 2.11

(Figures in MW)



As on 31st March,2017, a capacity addition of 32,740.84 MW from renewable energy sources has been achieved during 12th Plan. The details of capacity added source wise during 12th Plan is given in **Table 2.14**.

Table 2.14

Capacity addition achieved from Renewable Energy Sources during 12th Plan as on 31st March,2017

(Figures in MW)

Source	Capacity*
Solar	11,347.53
Wind	15,383.17
Bio-Power and waste power	5,040.78
Small Hydro	969.36
Total	**32,740.84**

Note: As reported by MNRE

2.11 CONCLUSIONS

- In the 12th Plan, the target of capacity addition from conventional sources was 88,537 MW. However, the capacity addition achieved from conventional sources during 12th Plan period is 99,209.5 MW which is about 112% of the target.

- As envisaged in Electricity Act, 2003, private players have started playing dominant role in capacity addition in power sector, with 55 % of total capacity addition from conventional sources during 12th Plan.

- There has been considerable slippage in the Hydro and Nuclear capacity addition envisaged in the 12th Plan. The factors affecting capacity addition in Hydro and Nuclear sectors need to be addressed urgently to arrest the further decline in the generation mix.

- Capacity addition from supercritical technology based coal power plants have contributed around 42% of the total capacity addition from coal based plants commissioned during 12th Plan.

Annexure 2.1

STATE-WISE SECTOR-WISE CAPACITY COMMISSIONED/ SLIPPED DURING 12th PLAN AS ON 31.03.2017 (2012-17)

		TARGET -88,537 MW				Total Achievement as on 31.3.2017				Slipped from 12th Plan (As per the Target of 88,537 MW)			
S No	STATE/ UTs	C S	S S	P S	TOTAL	C S	S S	P S	TOTAL	C S	S S	P S	TOTAL
1	DELHI	0	750	0	750	0	750	0	750	0	0	0	0
2	HARYANA	500	0	660	1160	500	0	660	1160	0	0	0	0
3	HIMACHAL PRADESH	2763	506	314	3583	1963	195	94	2252	800	311	244	1355
4	JAMMU & KASHMIR	659	450	0	1109	329	450	0	779	330	0	0	330
5	PUNJAB	0	0	3920	3920	0	0	3920	3920	0	0	0	0
6	RAJASTHAN	1400	1260	270	2930	0	1860	1860	3720	1400	0	0	1400
7	UTTAR PRADESH	1000	1750	1980	4730	1500	1750	3300	6550	0	0	660	660
8	UTTARAKH-AND	520	0	505	1025	0	0	780	780	520	0	175	695
9	CHANDIGA-RH	0	0	0	0	0	0	0	0	0	0	0	0
SUB TOTAL NORTHERN		**6842**	**4716**	**7649**	**19207**	**4292**	**5005**	**10614**	**19911**	**3050**	**311**	**1079**	**4440**
10	CHHATTISG-ARH	660	1500	10680	12840	660	1500	9115	11275	0	0	4215	4215
11	GUJARAT	1400	1452	1400	4252	0	2578	5383	7961	1400	0	0	1400
12	MAHARASH-TRA	1000	1410	7890	10300	2320	3230	7768	13318	0	0	2130	2130
13	MADHYA PRADESH	1000	1700	4680	7380	1500	1700	8225	11425	0	0	1060	1060
14	GOA	0	0	0	0	0	0	0	0	0	0	0	0
15	DAMAN & DIU	0	0	0	0	0	0	0	0	0	0	0	0
16	DADRA & NAGAR HAVELI	0	0	0	0	0	0	0	0	0	0	0	0
SUB TOTAL WESTERN		**4060**	**6062**	**24650**	**34772**	**4480**	**9008**	**30491**	**43979**	**1400**	**0**	**7405**	**8805**
17	ANDHRA PRADESH	0	2250	6160	8410	0	1650	5940	7590	0	600	2020	2620
18	TELANGA-NA	0	360	0	360	0	2070	0	2070	0	90	0	90
19	KARNATA-KA	0	0	0	0	1600	2300	0	3900	0	0	0	0
20	KERALA	0	100	0	100	0	0	0	0	0	100	0	100
21	TAMIL NADU	4750	1860	660	7270	4250	1860	2700	8810	500	0	660	1160
22	PUDUCHE-RRY	0	0	0	0	0	0	0	0	0	0	0	0
SUB TOTAL SOUTHERN		**4750**	**4570**	**6820**	**16140**	**5850**	**7880**	**8640**	**22370**	**500**	**790**	**2680**	**3970**
23	BIHAR	4690	0	0	4690	1960	0	0	1960	2730	0	0	2730
24	JHARKHAN-D	1000	0	1080	2080	1000	0	540	1540	0	0	540	540
25	ORISSA	0	0	3960	3960	0	0	3200	3200	0	0	1360	1360
26	SIKKIM	0	0	2066	2066	0	0	1395	1395	0	0	671	671
27	WEST BENGAL	1492	0	600	2092	1492	1259	600	3351	0	0	0	0
SUB TOTAL EASTERN		**7182**	**0**	**7706**	**14888**	**4452**	**1259**	**5735**	**11446**	**2730**	**0**	**2571**	**5301**

		TARGET -88,537 MW				Total Achievement as on 31.3.2017				Slipped from 12th Plan (As per the Target of 88,537 MW)			
S No	STATE/ UTs	C S	S S	P S	TOTAL	C S	S S	P S	TOTAL	C S	S S	P S	TOTAL
28	ARUNACHA-L PRADESH	1710	0	0	1710	0	0	0	0	1710	0	0	1710
29	ASSAM	750	100	0	850	500	62	0	562	250	38	0	288
30	MANIPUR	0	0	0	0	0	0	0	0	0	0	0	0
31	MIZORAM	60	0	0	60	0	0	0	0	60	0	0	60
32	MEGHALYA	0	82	0	82	0	42	0	42	0	40	0	40
33	NAGALAND	0	0	0	0	0	0	0	0	0	0	0	0
34	TRIPURA	828	0	0	828	879	21	0	900	0	0	0	0
SUB TOTAL N.EASTERN		**3348**	**182**	**0**	**3530**	**1379**	**125**	**0**	**1504**	**2020**	**78**	**0**	**2098**
35	A &N ISLANDS	0	0	0	0	0	0	0	0	0	0	0	0
36	LAKSHDWE-EP	0	0	0	0	0	0	0	0	0	0	0	0
		26182	**15530**	**46825**	**88537**	**20453**	**23277**	**55480**	**99210**	**9700**	**1179**	**13735**	**24614**

CS: Central Sector; SS: State Sector; PS: Private Sector

Annexure 2.2

LIST OF PROJECTS COMMISSIONED DURING 12TH PLAN AS ON 31.03.2017

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITIONAL
	CENTRAL SECTOR					
1	Indira Gandhi TPP (Jhajjar) JV U3	Coal	HARYANA	NTPC	500	Target
2	Rihand TPP-III U5	Coal	UTTAR PRADESH	NTPC	500	Target
3	Rihand TPP-III U6	Coal	UTTAR PRADESH	NTPC	500	Additional
4	unchahar TPS ST-iv U-6	Coal	UTTAR PRADESH	NTPC	68.67	Target
5	Rampur HEP U1	Hydro	HIMACHAL PRADESH	SJVNL	68.67	Target
6	Rampur HEP U2	Hydro	HIMACHAL PRADESH	SJVNL	68.67	Target
7	Rampur HEP U3	Hydro	HIMACHAL PRADESH	SJVNL	68.67	Target
8	Rampur HEP U4	Hydro	HIMACHAL PRADESH	SJVNL	68.67	Target
9	Rampur HEP U5	Hydro	HIMACHAL PRADESH	SJVNL	68.67	Target
10	Rampur HEP U6	Hydro	HIMACHAL PRADESH	SJVNL	200	Target
11	Kol Dam HEP U1	Hydro	HIMACHAL PRADESH	NTPC	200	Target
12	Kol Dam HEP U2	Hydro	HIMACHAL PRADESH	NTPC	200	Target
13	Kol Dam HEP U3	Hydro	HIMACHAL PRADESH	NTPC	200	Target
14	Kol Dam HEP U4	Hydro	HIMACHAL PRADESH	NTPC	77	Target
15	Chamera-III HEP U1	Hydro	HIMACHAL PRADESH	NHPC	77	Target
16	Chamera-III HEP U2	Hydro	HIMACHAL PRADESH	NHPC	77	Target
17	Chamera-III HEP U3	Hydro	HIMACHAL PRADESH	NHPC	130	Target
18	Parbati - III HEP U1	Hydro	HIMACHAL PRADESH	NHPC	130	Target
19	Parbati - III HEP U2	Hydro	HIMACHAL PRADESH	NHPC	130	Target
20	Parbati - III HEP U3	Hydro	HIMACHAL PRADESH	NHPC	130	Target
21	Parbati - III HEP U4	Hydro	HIMACHAL PRADESH	NHPC	60	Target
22	Uri-II HEP U1	Hydro	JAMMU & KASHMIR	NHPC	60	Target
23	Uri-II HEP U2	Hydro	JAMMU & KASHMIR	NHPC	60	Target
24	Uri-II HEP U3	Hydro	JAMMU & KASHMIR	NHPC	60	Target
25	Uri-II HEP U4	Hydro	JAMMU & KASHMIR	NHPC	15	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITION AL
26	Nimoo Bazgo HEP U1	Hydro	JAMMU & KASHMIR	NHPC	15	Target
27	Nimoo Bazgo HEP U2	Hydro	JAMMU & KASHMIR	NHPC	15	Target
28	Nimoo Bazgo HEP U3	Hydro	JAMMU & KASHMIR	NHPC	11	Target
29	Chutak HEP U1	Hydro	JAMMU & KASHMIR	NHPC	11	Target
30	Chutak HEP U2	Hydro	JAMMU & KASHMIR	NHPC	11	Target
31	Chutak HEP U3	Hydro	JAMMU & KASHMIR	NHPC	11	Target
32	Chutak HEP U4	Hydro	JAMMU & KASHMIR	NHPC	660	Target
33	Sipat-I TPP U 3	Coal	CHHATTISGARH	NTPC	500	Target
34	Mauda TPP U1	Coal	MAHARASHTRA	NTPC	500	Target
35	Mauda TPP U2	Coal	MAHARASHTRA	NTPC	660	Additional
36	Mouda STPP Ph-II U-3	Coal	MAHARASHTRA	NTPC	660	Additional
37	Mouda STPP Ph-II U4	Coal	MAHARASHTRA	NTPC	500	Target
38	Vindhyachal TPP St-IV U11	Coal	MADHYA PRADESH	NTPC	500	Target
39	Vindhyachal TPP St-IV U12	Coal	MADHYA PRADESH	NTPC	500	Additional
40	Vindhyachal STPP St-V U13	Coal	MADHYA PRADESH	NTPC	500	Target
41	Vallur (Ennore) TPP U2	Coal	TAMIL NADU	NTPC/ TNEB JV	500	Target
42	Vallur (Ennore) TPP U3	Coal	TAMIL NADU	NTPC/ TNEB JV	500	Target
43	Tuticorin TPP JV U1	Coal	TAMIL NADU	NPTL (NLC JV)	500	Target
44	Tuticorin TPP JV U2	Coal	TAMIL NADU	NPTL (NLC JV)	250	Target
45	Neyveli II TPP U2	Lignite	TAMIL NADU	NLC	1000	target
46	Kudankulam U 1	Nuclea r	TAMIL NADU	NPC	1000	target
47	Kudankulam U 2	Nuclea r	TAMIL NADU	NPC	800	Additional
48	Kudgi STPP Ph-I , U-1	Coal	KARNATAKA	NTPC	800	Additional
49	Kudgi STPP Ph-I , U-2	Coal	KARNATAKA	NTPC	195	Target
50	Muzaffarpur (Kanti) TPP U3	Coal	BIHAR	NTPC JV	195	Target
51	Muzaffarpur (Kanti) TPP U4	Coal	BIHAR	NTPC JV	660	Target
52	Barh STPP-II U1	Coal	BIHAR	NTPC	660	Target
53	Barh STPP-II U2	Coal	BIHAR	NTPC	250	Target
54	Nabinagar TPP U1	Coal	BIHAR	NTPC JV	500	Target
55	Bokaro TPP A Exp U1	Coal	JHARKHAND	DVC	500	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITIONAL
56	Koderma TPP U2	Coal	JHARKHAND	DVC	600	Target
57	Raghunathpur TPP U1	Coal	WEST BENGAL	DVC	600	Target
58	Raghunathpur TPP U2	Coal	WEST BENGAL	DVC	33	Target
59	Teesta Low Dam-III HEP U1	Hydro	WEST BENGAL	NHPC	33	Target
60	Teesta Low Dam-III HEP U2	Hydro	WEST BENGAL	NHPC	33	Target
61	Teesta Low Dam-III HEP U3	Hydro	WEST BENGAL	NHPC	33	Target
62	Teesta Low Dam-III HEP U4	Hydro	WEST BENGAL	NHPC	40	Target
63	Teesta Low Dam-IV HEP U1	Hydro	WEST BENGAL	NHPC	40	Target
64	Teesta Low Dam-IV HEP U2	Hydro	WEST BENGAL	NHPC	40	Target
65	Teesta Low Dam-IV HEP U3	Hydro	WEST BENGAL	NHPC	40	Target
66	Teesta Low Dam-IV HEP U4	Hydro	WEST BENGAL	NHPC	250	Target
67	Bongaigaon TPP U1	Coal	ASSAM	NTPC	250	Target
68	Bongaigaon TPP U2	Coal	ASSAM	NTPC	363.3	Target
69	Tripura CCGT Block-1	Gas	TRIPURA	ONGC JV	363.3	Target
70	Tripura CCGT Block-2	Gas	TRIPURA	ONGC JV	65.4	Target
71	Monarchak CCGT GT	Gas	TRIPURA	NEEPCO	35.6	Target
72	Monarchak CCGT	Gas	TRIPURA	NEEPCO	500	Additional
73	Agartala CCPP ST-I	Gas	TRIPURA	NEEPCO	25.5	Additional
74	Agartala CCPP ST-1	Gas	TRIPURA	NEEPCO	25.5	Target
	SUB TOTAL (CENTRAL SECTOR)				**20,452.6**	
	STATE SECTOR					
1	Pragati -III (BAWANA) CCGT (GT-3)	Gas	DELHI	PPCL	250	Target
2	Pragati -III (BAWANA) CCGT (GT-4)	Gas	DELHI	PPCL	250	Target
3	Pragati -III (BAWANA) CCGT (ST-2)	Gas	DELHI	PPCL	250	Target
4	Kalisindh TPP U1	Coal	RAJASTHAN	RRVUNL	600	Target
5	Chhabra TPP Ext U3	Coal	RAJASTHAN	RRVUNL	250	Target
6	Chhabra TPP Ext U4	Coal	RAJASTHAN	RRVUNL	250	Target
7	Ramgarh CCGT (GT)	Gas	RAJASTHAN	RRVUNL	110	Target
8	Ramgarh CCGT (ST)	Gas	RAJASTHAN	RRVUNL	50	Target
9	Kalisindh TPP U2	Coal	RAJASTHAN	RRVUNL	600	Additional
10	Anpara-D TPP U1	Coal	UTTAR PRADESH	UPRVUNL	500	Target
11	Anpara-D TPP U2	Coal	UTTAR PRADESH	UPRVUNL	500	Target
12	Parichha TPP EXT U5	Coal	UTTAR PRADESH	UPRVUNL	250	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITION AL
13	Parichha TPP EXT U6	Coal	UTTAR PRADESH	UPRVUNL	250	Target
14	Harduaganj TPP EXT U9	Coal	UTTAR PRADESH	UPRVUNL	250	Target
15	Kashang - I HEP	Hydro	HIMACHAL PRADESH	HPPCL	65	Target
16	Kashang II HEP	Hydro	HIMACHAL PRADESH	HPPCL	65	Target
17	Kashang III HEP	Hydro	HIMACHAL PRADESH	HPPCL	65	Target
18	Baglihar-II HEP U1	Hydro	JAMMU & KASHMIR	J&K State Power Develop-ment Corp. Ltd.	150	Target
19	Baglihar-II HEP U2	Hydro	JAMMU & KASHMIR	J&K State Power Develop-ment Corp. Ltd.	150	Target
20	Baglihar-II HEP U3	Hydro	JAMMU & KASHMIR	J&K State Power Develop-ment Corp. Ltd.	150	Target
21	Korba West St.III TPP U5	Coal	CHHATTISGARH	CSEB	500	Target
22	Marwah TPP U1	Coal	CHHATTISGARH	CSEB	500	Target
23	Marwah TPP U2	Coal	CHHATTISGARH	CSEB	500	Target
24	Sikka TPP Ext. U3	Coal	GUJARAT	GSECL	250	Target
25	Ukai TPP EXT U6	Coal	GUJARAT	GSECL	500	Target
26	Pipavav JV CCGT Block-1	Gas	GUJARAT	GSECL	351	Target
27	Pipavav JV CCGT Block-2	Gas	GUJARAT	GSECL	351	Target
28	Dhuvaran CCPP-III	Gas	GUJARAT	GSECL	376.1	Additional
29	Bhavnagar CFBC TPP, U-1	Lignite	GUJARAT	Bhavnagar Energy	250	Additional
30	Bhavnagar CFBC TPP, U-2	Lignite	GUJARAT	Bhavnagar Energy	250	Additional
31	Sikka TPS Extn., U-4	Coal	GUJARAT	GSECL	250	Additional
32	Chandrapur TPP Ext. U8	Coal	MAHARASHTRA	MAHGE-NCO	500	Target
33	Koradi TPP Ext U8	Coal	MAHARASHTRA	MAHGE-NCO	660	Target
34	Parli TPP U3	Coal	MAHARASHTRA	MAHGE-NCO	250	Target
35	Chandrapur TPS, U-9	Coal	MAHARASHTRA	MSPGCL	500	Additional
36	Koradi TPS Expn., U-9	Coal	MAHARASHTRA	MSPGCL	660	Additional
37	Koradi TPS Expn., U-10	Coal	MAHARASHTRA	MSPGCL	660	Additional
38	Satpura TPP EXT U10	Coal	MADHYA PRADESH	MPGENCO	250	Target
39	Satpura TPP EXT U11	Coal	MADHYA PRADESH	MPGENCO	250	Target
40	Shree Singhaji TPP U1	Coal	MADHYA PRADESH	MPGENCO	600	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITIONAL
41	Shree Singhaji TPP U2	Coal	MADHYA PRADESH	MPGENCO	600	Target
42	Sri Damodaram Sanjeevaiah TPP (Krishnapattnam TPP) U1	Coal	ANDHRA PRADESH	APGENCO	800	Target
43	Sri Damodaram Sanjeevaiah TPP (Krishnapattnam TPP) U2	Coal	ANDHRA PRADESH	APGENCO	800	Target
44	Nagarjuna Sagar TR HEP U1	Hydro	ANDHRA PRADESH	APGENCO	25	Target
45	Nagarjuna Sagar TR HEP U2	Hydro	ANDHRA PRADESH	APGENCO	25	Target
46	Mettur TPP EXT U1	Coal	TAMIL NADU	TNEB	600	Target
47	North Chennai TPP Ext U1	Coal	TAMIL NADU	TNEB	600	Target
48	North Chennai TPP Ext U2	Coal	TAMIL NADU	TNEB	600	Target
49	Bhawani Barrage HEP II U1	Hydro	TAMIL NADU	TNEB	15	Target
50	Bhawani Barrage HEP II U2	Hydro	TAMIL NADU	TNEB	15	Target
51	Bhawani Barrage HEP III U1	Hydro	TAMIL NADU	TNEB	15	Target
52	Bhawani Barrage HEP III U2	Hydro	TAMIL NADU	TNEB	15	Target
53	Lower Jurala HEP U1	Hydro	TELANGANA	TSGENCO	40	Target
54	Lower Jurala HEP U2	Hydro	TELANGANA	TSGENCO	40	Target
55	Lower Jurala HEP U3	Hydro	TELANGANA	TSGENCO	40	Target
56	Lower Jurala HEP U4	Hydro	TELANGANA	TSGENCO	40	Target
57	Lower Jurala HEP U5	Hydro	TELANGANA	TSGENCO	40	Target
58	Lower Jurala HEP U6	Hydro	TELANGANA	TSGENCO	40	Target
59	Pulichintala HEP U1	Hydro	TELANGANA	TSGENCO	30	Target
60	Kakatiya TPS Extn., U-1	Coal	TELANGANA	TSGENCO	600	Additional
61	Singareni TPP, U-1	Coal	TELANGANA	Singareni Collieries Co. Ltd	600	Additional
62	Singareni TPP, U-2	Coal	TELANGANA	Singareni Collieries Co. Ltd	600	Additional
63	Bellary TPP St-III, U-3	Coal	KARNATAKA	KPCL	700	Additional
64	Yermarus TPP, U-1	Coal	KARNATAKA	KPCL	800	Additional
65	Yermarus TPP, U-2	Coal	KARNATAKA	KPCL	800	Additional
66	Durgapur TPP Ext.	Coal	WEST BENGAL	Durgapur Projects Ltd	250	Additional
67	Sagardighi TPS-II, U-3	Coal	WEST BENGAL	WBPDCL	500	Additional
68	Sagardighi TPS-II, U-4	Coal	WEST BENGAL	WBPDCL	500	Additional
69	Jaldakha HEP	Hydro	WEST BENGAL	WBSEDCL	9	Additional

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITION AL
70	Namrup CCGT	Gas	ASSAM	APGCL	62.25	Target
71	Myntdu St-I HEP ADDL UNIT	Hydro	MEGHALYA	MeSEB	42	Target
72	Rokhia GT	Gas	TRIPURA	Govt of Tripura	21	Additional
	SUB TOTAL (STATE SECTOR)				**23,277.35**	
	PRIVATE SECTOR					
1	Mahatma Gandhi Jhajjar TPP U2	Coal	HARYANA	China Light Power	660	Target
2	Talwandi Sabo TPP U1	Coal	PUNJAB	Vedanta	660	Target
3	Talwandi Sabo TPP U2	Coal	PUNJAB	Vedanta	660	Target
4	Talwandi Sabo TPP U3	Coal	PUNJAB	Vedanta	660	Target
5	Goindwal Sahib TPP U1	Coal	PUNJAB	GVK Industries	270	Target
6	Goindwal Sahib TPP U2	Coal	PUNJAB	GVK Industries	270	Target
7	Nabha TPP U1	Coal	PUNJAB	L&T Power Developme-nt Ltd	700	Target
8	Nabha TPP U2	Coal	PUNJAB	L&T Power Developme-nt Ltd	700	Target
9	Jallipa Kapurdi TPP U5	Lignite	RAJASTHAN	Raj West Power Ltd	135	Target
10	Jallipa Kapurdi TPP U6	Lignite	RAJASTHAN	Raj West Power Ltd	135	Target
11	Jallipa Kapurdi TPP U 7-8	Lignite	RAJASTHAN	Raj West Power Ltd	270	Additional
12	Kawai TPP U1	Coal	RAJASTHAN	Adani Power Ltd	660	Additional
13	Kawai TPP U2	Coal	RAJASTHAN	Adani Power Ltd	660	Additional
14	Bara TPP U1	Coal	UTTAR PRADESH	Prayagraj Power Gen. Co. Ltd (Jaypee Group)	660	Target
15	Bara TPP U2	Coal	UTTAR PRADESH	Prayagraj Power Gen. Co. Ltd (Jaypee Group)	660	Target
16	Lalitpur TPP, U-1	Coal	UTTAR PRADESH	Lalitpur power Generation Co. Ltd	660	Additional
17	Lalitpur TPP, U-2	Coal	UTTAR PRADESH	Lalitpur power Generation Co. Ltd	660	Additional

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITIONAL
18	Lalitpur TPP, U-3	Coal	UTTAR PRADESH	Lalitpur power Generation Co. Ltd	660	Additional
19	Budhil HEP U1	Hydro	HIMACHAL PRADESH	LANCO Green Power Pvt Ltd	35	Target
20	Budhil HEP U2	Hydro	HIMACHAL PRADESH	LANCO Green Power Pvt Ltd	35	Target
21	Chanju-I HEP U1	Hydro	HIMACHAL PRADESH	IA Energy	12	Additional
22	Chanju-I HEP U2	Hydro	HIMACHAL PRADESH	IA Energy	12	Additional
23	Srinagar HEP U1	Hydro	UTTARAKHAND	AHPCo. Ltd.	82.5	Target
24	Srinagar HEP U2	Hydro	UTTARAKHAND	AHPCo. Ltd.	82.5	Target
25	Srinagar HEP U3	Hydro	UTTARAKHAND	AHPCo. Ltd.	82.5	Target
26	Srinagar HEP U4	Hydro	UTTARAKHAND	AHPCo. Ltd.	82.5	Target
27	Gama CCPP,block-I	Gas	UTTARAKHAND	M/S GAMA INFRAPROP PVT. LTD.	225	Additional
28	Kashipur CCPP Block-1	Gas	UTTARAKHAND	Sravanthi Energy Pvt.	225	Additional
29	Avantha Bhandar TPP U1	Coal	CHHATTISGARH	Korba West Power Company Ltd.	600	Target
30	Maruti Clean Coal & Power Ltd.TPP U1	Coal	CHHATTISGARH	Maruti Clean Coal & Power Ltd.	300	Target
31	Uchpinda TPP U1	Coal	CHHATTISGARH	R.K.M. PowerGen Pvt Ltd	360	Target
32	Uchpinda TPP U2	Coal	CHHATTISGARH	R.K.M. PowerGen Pvt Ltd	360	Target
33	Akaltara (Nariyara) TPP U1	Coal	CHHATTISGARH	KSK Mahanadi Power Company Limited	600	Target
34	Akaltara (Nariyara) TPP U2	Coal	CHHATTISGARH	KSK Mahanadi Power Company Limited	600	Target
35	Kasaipalli TPP U 2	Coal	CHHATTISGARH	ACB India	135	Target
36	Swastik Korba TPP U1	Coal	CHHATTISGARH	ACB India	25	Target
37	Vandana Vidyut TPP U1	Coal	CHHATTISGARH	Vandana Vidyut	135	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITION AL
38	Balco TPP U1	Coal	CHHATTISGARH	Bharat Aluminium Co. Ltd	300	Target
39	Balco TPP U2	Coal	CHHATTISGARH	Bharat Aluminium Co. Ltd	300	Target
40	Baradhra (D B Power) TPP U1	Coal	CHHATTISGARH	DB Power Ltd	600	Target
41	Baradhra (D B Power) TPP U2	Coal	CHHATTISGARH	DB Power Ltd	600	Target
42	Newpara (TRN Energy) TPP U1	Coal	CHHATTISGARH	TRN Energy	300	Target
43	Ratija TPP	Coal	CHHATTISGARH	ACB India	50	Target
44	Tamnar TPP U1	Coal	CHHATTISGARH	Jindal Power Ltd	600	Target
45	Tamnar TPP U2	Coal	CHHATTISGARH	Jindal Power Ltd	600	Target
46	Chakabura TPP	Coal	CHHATTISGARH	ACB India Ltd.	30	Additional
47	Tamnar TPP U3	Coal	CHHATTISGARH	Jindal Power Ltd	600	Additional
48	Raikheda TPP U1	Coal	CHHATTISGARH	GMR	685	Additional
49	Tamnar TPP U4	Coal	CHHATTISGARH	Jindal Power Ltd	600	Additional
50	Raikheda TPP, U-2	Coal	CHHATTISGARH	GMR	685	Additional
51	Ratija TPP U-2	Coal	CHHATTISGARH	Spectrum Coal & Power Ltd.	50	Additional
52	Mundra UMPP, U 2	Coal	GUJARAT	Tata Power Company Ltd	800	Target
53	Salaya TPP U 2	Coal	GUJARAT	Essar Power Salaya Ltd	600	Target
54	Mundra UMPP U 3,4,5	Coal	GUJARAT	Tata Power Company Ltd	2400	Additional
55	Uno Sugen CCGT	Gas	GUJARAT	Torrent Power	382.5	Additional
56	DGEN Mega CCPP Module 1	Gas	GUJARAT	Torrent Power	400	Additional
57	DGEN Mega CCPP Module 2	Gas	GUJARAT	Torrent Power	400	Additional
58	DGEN Mega CCPP Module 3	Gas	GUJARAT	Torrent Power	400	Additional
59	India Bulls- Amravati TPP Ph-I, U1	Coal	MAHARASHTRA	India Bulls Power Limited	270	Target
60	India Bulls- Amravati TPP Ph-I, U2	Coal	MAHARASHTRA	India Bulls Power Limited	270	Target
61	India Bulls- Amravati TPP Ph-I, U3	Coal	MAHARASHTRA	India Bulls Power Limited	270	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITION AL
62	India Bulls- Amravati TPP Ph-I, U4	Coal	MAHARASHTRA	India Bulls Power Limited	270	Target
63	India Bulls- Amravati TPP Ph-I, U5	Coal	MAHARASHTRA	India Bulls Power Limited	270	Target
64	India Bulls - Nasik TPP Ph-I, U1	Coal	MAHARASHTRA	India Bulls Realtech Limited	270	Target
65	India Bulls - Nasik TPP Ph-I, U2	Coal	MAHARASHTRA	India Bulls Realtech Limited	270	Target
66	Dhariwal Infrastructure (P) Ltd TPP U1	Coal	MAHARASHTRA	Dhariwal Infrastruct-ure (P) LTD	300	Target
67	Dhariwal Infrastructure (P) Ltd TPP U2	Coal	MAHARASHTRA	Dhariwal Infrastruct-ure (P) LTD	300	Target
68	EMCO Warora TPP U1	Coal	MAHARASHTRA	GMR EMCO Energy Ltd	300	Target
69	EMCO Warora TPP U2	Coal	MAHARASHTRA	GMR EMCO Energy Ltd	300	Target
70	Butibori TPP Ph -II U 1	Coal	MAHARASHTRA	Vidarbha Industries Power Ltd	300	Target
71	Tiroda TPP PH-I U1	Coal	MAHARASHTRA	Adani Power Ltd	660	Target
72	Tiroda TPP PH-I U2	Coal	MAHARASHTRA	Adani Power Ltd	660	Target
73	Tiroda TPP Ph-II U1	Coal	MAHARASHTRA	Adani Power Ltd	660	Target
74	GEPL TPP U1	Coal	MAHARASHTRA	Gupta Energy Pvt Ltd	60	Target
75	GEPL TPP U2	Coal	MAHARASHTRA	Gupta Energy Pvt Ltd	60	Target
76	Bela TPP U 1	Coal	MAHARASHTRA	Ideal Energy Projects Ltd	270	Target
77	Tiroda TPP Ph-II U2	Coal	MAHARASHTRA	Adani Power Ltd	660	Additional
78	Butibori TPP Ph -II U2	Coal	MAHARASHTRA	Vidarbha Industries Power Ltd	300	Additional
79	Tiroda TPP Ph-II U3	Coal	MAHARASHTRA	Adani Power Ltd	660	Additional
80	Mangaon CCPP	Gas	MAHARASHTRA	PGPL	388	Additional
81	Annupur TPP Ph-I U1	Coal	MADHYA PRADESH	MB Power (Madhya Pradesh) Ltd.	600	Target
82	Annupur TPP Ph-I U2	Coal	MADHYA PRADESH	MB Power (Madhya Pradesh) Ltd.	600	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITION AL
83	Bina TPP U1	Coal	MADHYA PRADESH	Bina Power Supply Comp. Ltd (Jaypee Group)	250	Target
84	Bina TPP U2	Coal	MADHYA PRADESH	Bina Power Supply Comp. Ltd (Jaypee Group)	250	Target
85	Sasan UMPP U1	Coal	MADHYA PRADESH	Reliance Power Ltd.	660	Target
86	Sasan UMPP U2	Coal	MADHYA PRADESH	Reliance Power Ltd.	660	Target
87	Seioni (Jhabua) TPP U1	Coal	MADHYA PRADESH	Jhabua Power Ltd	600	Target
88	Mahan TPP U1	Coal	MADHYA PRADESH	Essar Power	600	Additional
89	Niwari TPP U1	Coal	MADHYA PRADESH	M/s BLA Pvt Ltd	45	Additional
90	Sasan UMPP U4	Coal	MADHYA PRADESH	Reliance Power Ltd.	660	Additional
91	Sasan UMPP U3	Coal	MADHYA PRADESH	Reliance Power Ltd.	660	Additional
92	Sasan UMPP U5	Coal	MADHYA PRADESH	Reliance Power Ltd.	660	Additional
93	Nigri TPP U1	Coal	MADHYA PRADESH	JP Power Ventures Ltd.	660	Additional
94	Nigri TPP U2	Coal	MADHYA PRADESH	JP Power Ventures Ltd.	660	Additional
95	Sasan UMPP U6	Coal	MADHYA PRADESH	Reliance Power Ltd.	660	Additional
96	Nagarjuna Construction Company Ltd Ph-I U1	Coal	ANDHRA PRADESH	Nagarjuna Constructi-on Company Ltd	660	Target
97	Nagarjuna Construction Company Ltd Ph-I U2	Coal	ANDHRA PRADESH		660	Target
98	Painampuram TPP U1	Coal	ANDHRA PRADESH	Thermal Powertech Corporation Ltd.	660	Target
99	Painampuram TPP U2	Coal	ANDHRA PRADESH	Thermal Powertech Corporation Ltd.	660	Target
100	Thamminapatnam TPP U1	Coal	ANDHRA PRADESH	Meenakshi Energy Pvt. Ltd.,	150	Target
101	Thamminapatnam TPP U2	Coal	ANDHRA PRADESH	Meenakshi Energy Pvt. Ltd.,	150	Target
102	Simhapuri TPP Ph-I, U 2	Coal	ANDHRA PRADESH	Simhapuri Energy Pvt. Ltd.,	150	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITIONAL
103	Hinduja TPP, U1	Coal	ANDHRA PRADESH	Hinduja	520	Target
104	Hinduja TPP, U2	Coal	ANDHRA PRADESH	Hinduja	520	Target
105	Simhapuri TPP Ph-II, U1	Coal	ANDHRA PRADESH	Simhapuri Energy Pvt. Ltd.,	150	Additional
106	Simhapuri TPP Ph-II, U2	Coal	ANDHRA PRADESH	Simhapuri Energy Pvt. Ltd.,	150	Additional
107	Kondapalli CCGT St-III A	Gas	ANDHRA PRADESH	Lanco	371	Additional
108	Kondapalli CCGT St-III B	Gas	ANDHRA PRADESH	Lanco	371	Additional
109	Vemagiri CCPP-II Block-I	Gas	ANDHRA PRADESH	GMR Rajahmundry energy Ltd	384	Additional
110	Vemagiri CCPP-II Block-II	Gas	ANDHRA PRADESH	GMR Rajahmundry energy Ltd	384	Additional
111	Ind Barath (Tuticorin) TPP U1	Coal	TAMIL NADU	Ind. Barath Power Ltd.	150	Additional
112	Ind Barath (Tuticorin) TPP U2	Coal	TAMIL NADU	Ind. Barath Power Ltd.	150	Additional
113	Mutiara (Melamurthur) TPP U1	Coal	TAMIL NADU	Coastal Energaen	600	Additional
114	Melamaruthur TPP, U-2	Coal	TAMIL NADU	Coastal Energen	600	Additional
115	ITPCL TPP U-1 (Cuddalore)	Coal	TAMIL NADU	IL & FS Power Ltd	600	Additional
116	ITPCL TPP U-2 (Cuddalore)	Coal	TAMIL NADU	IL & FS Power Ltd	600	Additional
117	Jorethang Loop HEP U1	Hydro	SIKKIM	DANS Pvt. Ltd	48	Target
118	Jorethang Loop HEP U2	Hydro	SIKKIM	DANS Pvt. Ltd	48	Target
119	Chujachen HEP U1	Hydro	SIKKIM	Gati Infrastructure Ltd.	49.5	Target
120	Chujachen HEP U2	Hydro	SIKKIM	Gati Infrastructure Ltd.	49.5	Target
121	Teesta-III HEP U1	Hydro	SIKKIM	Teesta Urja Ltd	200	Target
122	Teesta-III HEP U2	Hydro	SIKKIM	Teesta Urja Ltd	200	Target
123	Teesta-III HEP U3	Hydro	SIKKIM	Teesta Urja Ltd	200	Target
124	Teesta-III HEP U4	Hydro	SIKKIM	Teesta Urja Ltd	200	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY	TARGET/ ADDITIONAL
125	Teesta-III HEP U5	Hydro	SIKKIM	Teesta Urja Ltd	200	Target
126	Teesta-III HEP U6	Hydro	SIKKIM	Teesta Urja Ltd	200	Target
127	Adhunik Power & Natural Resources Ltd TPP U1	Coal	JHARKHAND	Adhunik Power & Natural Resources Ltd.	270	Target
128	Adhunik Power & Natural Resources Ltd TPP U2	Coal	JHARKHAND	Adhunik Power & Natural Resources Ltd.	270	Target
129	Derang TPP U1	Coal	ORISSA	Jindal India Thermal Power Ltd	600	Target
130	Utkal (Ind Barath Energy Pvt. Ltd.) TPP U1	Coal	ORISSA	Ind. Barath power (Utkal) Ltd.	350	Target
131	Kamalanga TPP U1	Coal	ORISSA	GMR Energy	350	Target
132	Kamalanga TPP U2	Coal	ORISSA	GMR Energy	350	Target
133	Kamalanga TPP U3	Coal	ORISSA	GMR Energy	350	Target
134	Sterlite TPP U4	Coal	ORISSA	Sterlite Energy	600	Target
135	Derang TPP U2	Coal	ORISSA	Jindal India Thermal Power Ltd	600	Additional
136	Haldia TPP U1	Coal	WEST BENGAL	CESC	300	Target
137	Haldia TPP U2	Coal	WEST BENGAL	CESC	300	Target
	SUB TOTAL (PRIVATE SECTOR)				**55,479.5**	
	TOTAL 12TH PLAN				**99,209.45**	

Annexure 2.3

LIST OF PROJECTS SLIPPED FROM 12TH PLAN CAPACITY ADDITION TARGET AS ON 31.03.2017

(All figures in MW)

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
	CENTRAL SECTOR				
1	RAPP U 7 & 8	Nuclear	RAJASTHAN	NPC	1400
2	Parbati-II HEP U1	Hydro	HIMACHAL PRADESH	NHPC	200
3	Parbati-II HEP U2	Hydro	HIMACHAL PRADESH	NHPC	200
4	Parbati-II HEP U3	Hydro	HIMACHAL PRADESH	NHPC	200
5	Parbati-II HEP U4	Hydro	HIMACHAL PRADESH	NHPC	200
6	Kishan Ganga HEP U1	Hydro	JAMMU & KASHMIR	NHPC	110
7	Kishan Ganga HEP U2	Hydro	JAMMU & KASHMIR	NHPC	110
8	Kishan Ganga HEP U3	Hydro	JAMMU & KASHMIR	NHPC	110
9	Tapovan Vishnugad HEP U1	Hydro	UTTARAKHAND	NTPC	130
10	Tapovan Vishnugad HEP U2	Hydro	UTTARAKHAND	NTPC	130
11	Tapovan Vishnugad HEP U3	Hydro	UTTARAKHAND	NTPC	130
12	Tapovan Vishnugad HEP U4	Hydro	UTTARAKHAND	NTPC	130
13	KAPP U-3,4	Nuclear	GUJARAT	NPC	1400
14	PFBR (Kalpakkam)	Nuclear	TAMIL NADU	NPC	500
15	Barh STPP-I U1	Coal	BIHAR	NTPC	660
16	Barh STPP-I U2	Coal	BIHAR	NTPC	660
17	Barh STPP-I U3	Coal	BIHAR	NTPC	660
18	Nabinagar TPP U2	Coal	BIHAR	NTPC JV	250
19	Nabinagar TPP U3	Coal	BIHAR	NTPC JV	250
20	Nabinagar TPP U4	Coal	BIHAR	NTPC JV	250
21	Bongaigaon TPP U3	Coal	ASSAM	NTPC	250
22	Pare HEP U1	Hydro	ARUNACHAL PRADESH	NEEPCO	55
23	Pare HEP U2	Hydro	ARUNACHAL PRADESH	NEEPCO	55
24	Kameng HEP U1	Hydro	ARUNACHAL PRADESH	NEEPCO	150
25	Kameng HEP U2	Hydro	ARUNACHAL PRADESH	NEEPCO	150
26	Kameng HEP U3	Hydro	ARUNACHAL PRADESH	NEEPCO	150
27	Kameng HEP U4	Hydro	ARUNACHAL PRADESH	NEEPCO	150
28	Subansiri Lower HEP U1	Hydro	ARUNACHAL PRADESH	NHPC	250
29	Subansiri Lower HEP U2	Hydro	ARUNACHAL PRADESH	NHPC	250
30	Subansiri Lower HEP U3	Hydro	ARUNACHAL PRADESH	NHPC	250

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
31	Subansiri Lower HEP U4	Hydro	ARUNACHAL PRADESH	NHPC	250
32	Tuirial HEP U1	Hydro	MIZORAM	NEEPCO	30
33	Tuirial HEP U2	Hydro	MIZORAM	NEEPCO	30
	SUB TOTAL (CENTRAL SECTOR)				**9700**
	STATE SECTOR				
1	Uhl-III HEP U1	Hydro	HIMACHAL PRADESH	BVPC	33.34
2	Uhl-III HEP U2	Hydro	HIMACHAL PRADESH	BVPC	33.34
3	Uhl-III HEP U3	Hydro	HIMACHAL PRADESH	BVPC	33.34
4	Sawara Kuddu HEP	Hydro	HIMACHAL PRADESH	HPPCL	111
5	Sainj HEP U1	Hydro	HIMACHAL PRADESH	HPPCL	50
6	Sainj HEP U2	Hydro	HIMACHAL PRADESH	HPPCL	50
7	Rayal seema TPP U6	Coal	ANDHRA PRADESH	APGENCO	600
8	Thottiar HEP U1	Hydro	KERALA	KSEB	30
9	Thottiar HEP U2	Hydro	KERALA	KSEB	10
10	Pallivasal HEP U1	Hydro	KERALA	KSEB	30
11	Pallivasal HEP U2	Hydro	KERALA	KSEB	30
12	Pulichintala HEP U2	Hydro	TELANGANA	TSGENCO	30
13	Pulichintala HEP U3	Hydro	TELANGANA	TSGENCO	30
14	Pulichintala HEP U4	Hydro	TELANGANA	TSGENCO	30
15	Namrup CCGT	Gas	ASSAM	APGCL	37.75
16	New Umtru HEP U1	Hydro	MEGHALYA	MeECL	20
17	New Umtru HEP U2	Hydro	MEGHALYA	MeECL	20
	SUB TOTAL(STATE SECTOR)				**1178.75**
	PRIVATE SECTOR				
1	Bara TPP U3	Coal	UTTAR PRADESH	Prayagraj Power Gen. Co. Ltd (Jaypee Group)	660
2	Tidong-I HEP U1	Hydro	HIMACHAL PRADESH	N S L Tidong Power Generation Ltd	50
3	Tidong-I HEP U2	Hydro	HIMACHAL PRADESH	N S L Tidong Power Generation Ltd	50
4	Sorang HEP U1	Hydro	HIMACHAL PRADESH	Himachal Sorang Power Pvt. Ltd	50

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
5	Sorang HEP U2	Hydro	HIMACHAL PRADESH	Himachal Sorang Power Pvt. Ltd	50
6	Tangnu Romai-I HEP U1	Hydro	HIMACHAL PRADESH	Tangnu Romai Power Generation Ltd	22
7	Tangnu Romai-I HEP U2	Hydro	HIMACHAL PRADESH	Tangnu Romai Power Generation Ltd	22
8	Singoli Bhatwari HEP U1	Hydro	UTTARAKHAND	L&T Uttaranchal Hydro Power Ltd	33
9	Singoli Bhatwari HEP U2	Hydro	UTTARAKHAND	L&T Uttaranchal Hydro Power Ltd	33
10	Singoli Bhatwari HEP U3	Hydro	UTTARAKHAND	L&T Uttaranchal Hydro Power Ltd	33
11	Phata Byung HEP U1	Hydro	UTTARAKHAND	Lanco Energy Pvt. Ltd.	38
12	Phata Byung HEP U2	Hydro	UTTARAKHAND	Lanco Energy Pvt. Ltd.	38
13	Lanco Amarkantak TPP U3	Coal	CHHATTISGARH	LANCO Amarkantak Pvt Ltd	660
14	Lanco Amarkantak TPP U4	Coal	CHHATTISGARH	LANCO Amarkantak Pvt Ltd	660
15	Uchpinda TPP U3	Coal	CHHATTISGARH	R.K.M. PowerGen Pvt Ltd	360
16	Vinjkote (Darrampura) TPP U1	Coal	CHHATTISGARH	SKS Ispat and Power Ltd.	300
17	Vinjkote (Darrampura) TPP U2	Coal	CHHATTISGARH	SKS Ispat and Power Ltd.	300
18	Vinjkote (Darrampura) TPP U3	Coal	CHHATTISGARH	SKS Ispat and Power Ltd.	300
19	Akaltara (Nariyara) TPP U3	Coal	CHHATTISGARH	KSK Mahanadi Power Company Limited	600
20	Vandana Vidyut TPP U2	Coal	CHHATTISGARH	Vandana Vidyut	135
21	Athena Singhtarai TPP U1	Coal	CHHATTISGARH	Athena Chhattisgarh Power Ltd.	600
22	Newpara (TRN Energy) TPP U2	Coal	CHHATTISGARH	TRN Energy	300
23	India Bulls - Nasik TPP Ph-I, U3	Coal	MAHARASHTRA	India Bulls Realtech Limited	270

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
24	India Bulls - Nasik TPP Ph-I, U4	Coal	MAHARASHTRA	India Bulls Realtech Limited	270
25	India Bulls - Nasik TPP Ph-I, U5	Coal	MAHARASHTRA	India Bulls Realtech Limited	270
26	Lanco Mahanadi, Vidarbha TPP U1	Coal	MAHARASHTRA	Lanco Mahanadi Power Pvt Ltd	660
27	Lanco Mahanadi, Vidarbha TPP U2	Coal	MAHARASHTRA	Lanco Mahanadi Power Pvt Ltd	660
28	D B Power TPP, Sidhi U-1	Coal	MADHYA PRADESH	DB Power (Madhya Pradesh) Ltd	660
29	Maheshwar HEP U1	Hydro	MADHYA PRADESH	SMHPCL	40
30	Maheshwar HEP U2	Hydro	MADHYA PRADESH	SMHPCL	40
31	Maheshwar HEP U3	Hydro	MADHYA PRADESH	SMHPCL	40
32	Maheshwar HEP U4	Hydro	MADHYA PRADESH	SMHPCL	40
33	Maheshwar HEP U5	Hydro	MADHYA PRADESH	SMHPCL	40
34	Maheshwar HEP U6	Hydro	MADHYA PRADESH	SMHPCL	40
35	Maheshwar HEP U7	Hydro	MADHYA PRADESH	SMHPCL	40
36	Maheshwar HEP U8	Hydro	MADHYA PRADESH	SMHPCL	40
37	Maheshwar HEP U9	Hydro	MADHYA PRADESH	SMHPCL	40
38	Maheshwar HEP U10	Hydro	MADHYA PRADESH	SMHPCL	40
39	Thamminapatnam TPP U3	Coal	ANDHRA PRADESH	Meenakshi Energy Pvt. Ltd.,	350
40	Thamminapatnam TPP U4	Coal	ANDHRA PRADESH	Meenakshi Energy Pvt. Ltd.,	350
41	Bhavanapaddu TPP U1	Coal	ANDHRA PRADESH	East Coast Energy	660
42	Bhavanapaddu TPP U2	Coal	ANDHRA PRADESH	East Coast Energy	660
43	Ind Barath TPP U1	Coal	TAMIL NADU	Ind Barath Power (Madras) Ltd	660
44	Bhasmey HEP U1	Hydro	SIKKIM	Gati Infrastructure Ltd.	17
45	Bhasmey HEP U2	Hydro	SIKKIM	Gati Infrastructure Ltd.	17
46	Bhasmey HEP U3	Hydro	SIKKIM	Gati Infrastructure Ltd.	17
47	Rangit-IV HEP U1	Hydro	SIKKIM	Jal Power Corp. Ltd.	40
48	Rangit-IV HEP U2	Hydro	SIKKIM	Jal Power Corp. Ltd.	40

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
49	Rangit-IV HEP U3	Hydro	SIKKIM	Jal Power Corp. Ltd.	40
50	Teesta-VI HEP U1	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125
51	Teesta-VI HEP U2	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125
52	Teesta-VI HEP U3	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125
53	Teesta-VI HEP U4	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125
54	Mata Shri Usha TPP Ph-I U1	Coal	JHARKHAND	Corporate Power Ltd.	270
55	Mata Shri Usha TPP Ph-I U2	Coal	JHARKHAND	Corporate Power Ltd.	270
56	Utkal (Ind Barath Energy Pvt. Ltd.) TPP U2	Coal	ORISSA	Ind. Barath power (Utkal) Ltd.	350
57	Lanco Babandh Dhenkanal TPP U1	Coal	ORISSA	Lanco Babandh	660
58	K.V.K. Nilanchal TPP U1	Coal	ORISSA	K.V.K. Nilachal Power Pvt. Ltd.	350
	SUB TOTAL(STATE SECTOR)				**13735**
	TOTAL(12TH PLAN)				**24613.75**

Annexure 2.4

DETAILS OF ACHIEVEMENTS OF LE AND R&M PROGRAMME DURING 12TH PLAN UP TO 31.03.2017

YEAR	Name of the TPS	Unit No.	Capacity (MW)	Utility	Sector	Date of Achievement
1. 2012-2013						
LE	Bathinda	3	110	PSPCL	State	05.08.2012
	Kawas	GT-1A	106	NTPC	Central	21.01.2013
R&M	DPL	6	110	DPL	State	07.05.2012
	Patratu	10	110	NTPC	State	24.05.2012
	Anpara'A	1 to 3	3x210	UPRVUNL	State	21.03.2013
	Tanda	2	110	NTPC	Centre	15.09.2012
	Sub Total	**8 (units)**	**1176**			
2. 2013-2014						
LE	Parichha	2	110		State	05.05.2013
	Muzafarpur	1	110		State	05.07.2013
	Kawas	GT-1B	106	NTPC	Central	28.08. 2013
	Gandhar	GT – 3	131	NTPC	Central	29.09.2013
	Kawas	GT-2B	106	NTPC	Central	31.03.2014
R&M	Kathalguri	GT-3	33.5	NEEPCO	Central	31.03.2014
	Kathalguri	GT-4	33.5	NEEPCO	Central	31.03.2014
	Kathalguri	GT-5	33.5	NEEPCO	Central	31.03.2014
	Sub Total	**8(units)**	**663.5**			
3. 2014-2015						
LE	Bathinda	4	110	PSPCL	State	10.07.2014
	Muzafarpur	2	110	BSPGCL	State	30.09.2014
	Auraiya	GT-1	111.19	NTPC	Central	22.06. 2014
	Gandhar	GT-1	131	NTPC	Central	06.07.2014
	Kawas	GT-2A	106	NTPC	Central	22.08.2014
	Auraiya	GT-2	111.19	NTPC	Central	28.10.2014
	Auraiya	GT-3	111.19	NTPC	Central	25.12.2014
	Auraiya	GT-4	111.19	NTPC	Central	02.03.2015
R&M	NIL	-	-	-	-	-
	Sub Total	**8 (units)**	**901.76**			
4. 2015-2016						
LE	Harduaganj	7	110	UPRVUNL	State	01.05.2015
	Bandel	5	210	WBPDCL	State	21.09.2015
	Gandhar	GT-2	131	NTPC	Central	15.04.2015
R&M	Simhadri	1	500	NTPC	Central	31.03.2016
	Simhadri	2	500	NTPC	Central	31.03.2016
	Sub Total	**5 (units)**	**1451**			
5. 2016-17						
LE	Obra	10	200	UPRVUNL	State	08.04.2016
	Barauni	7	110	BSPGCL	State	03.08.2016
	Obra	11	200	UPRVUNL	State	31.12.2016
R&M	Ramagundam	4	500	NTPC	Central	March 2017
	Ramagundam	5	500	NTPC	Central	March 2017
	Ramagundam	6	500	NTPC	Central	March 2017
	Rihand STPS	1	500	NTPC	Central	March 2017
	Rihand STPS	2	500	NTPC	Central	March 2017
Sub Total		**8(units)**	**3010**			
Grand Total		**37 (units)**	**7202.26**			

Summary

Scheme	No. of units (Capacity in MW)	Central	State
Total LE	21 (2641.76)	11 (1261.76)	10 (1380)
Total R&M	16 (4560.50)	11 (3710.5)	05 (850)
Grand Total	37 (7202.26)	22 (4972.26)	15 (2230)

CHAPTER 3

DEMAND SIDE MANAGEMENT, ENERGY EFFICIENCY & CONSERVATION

3.0 BACKGROUND

Demand-Side Management (DSM) is applied to energy efficiency measures that would modify or reduce end-user's energy demand. It is basically the selection, planning, and implementation of measures intended to have an influence on the demand either caused directly or indirectly by the utility's programs. DSM has been traditionally considered as a means of reducing peak electricity demand. In the short term, DSM program facilitates reduction in energy cost as well as the need for adding new distribution networks, thereby enhancing reliability for utilities and in the long term, can help to limit the need for utilities to build new power plants, and transmission lines. As a customer strategy, DSM programs encourage the installation and use of end-use technologies that consume less energy, thereby reducing the customers' overall electric bill. Energy Efficient technologies also have higher efficiency operating characteristics, they tend to last longer and thus reducing the operation and maintenance cost. This is especially true for programs that encourage the use of high efficiency heating, cooling, and ventilation equipment (HVAC), energy efficient lighting, fans and motors. For some utilities, DSM programs can help them reduce their peak/costly power purchases from the wholesale market thereby lowering their overall cost of operations. Reduced or shifted energy usage can directly translate into less air pollution, less carbon emissions, and thereby reducing the potential environmental threats associated with global warming.

3.1 ENERGY CONSERVATION ACT AND FORMATION OF BUREAU OF ENERGY EFFICIENCY

Considering vast energy saving potential and in order to bring a movement in energy conservation and energy efficiency in different end-uses in the country, the Government of India enacted the Energy Conservation (EC)Act, 2001 for providing sustainable and more efficient management of our energy resources. The Act came into force in March, 2002. The broad objectives of E C Act, 2001 are:

a) Promote faster adoption of energy efficiency and conservation through regulation, participation and cost-effective measures
b) Involve States and other stakeholders in the energy efficiency initiatives

c) Create a sustainable environment for demand of energy efficient products, technologies and professionals

It is universally acknowledged that the business case for Energy Efficiency is compelling, good return on investment, reduction of input cost, delinking economic growth and energy dependency. It also yields significant co-benefits, which include economic growth and job creation. Despite such apparently straightforward advantages, the rate of adoption of Energy Efficiency (EE) historically lagged behind the opportunities. To address the adoption bottleneck through regulatory and promotional activities, Bureau of Energy Efficiency (BEE) was created in 2002 with the mission to *"assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the E C Act, 2001 with the primary objective of reducing energy intensity of the Indian economy"*.

3.2. ASSESSMENT OF ENERGY EFFICENCY MEASURES AND ACHIEVEMENTS TILL 12TH PLAN.

India's energy intensity in 2001 was 0.175 kgoe/₹ (kg of oil equivalent/₹) and it came down to 0.0131 kgoe/₹ in 2013. This is equivalent to a saving of about 258 mtoe (Million tonnes of oil equivalent) of Total Primary Energy Supply (TPES) during this period based on a year-to-year basis estimation. The year-to-year energy saving (in TPES term) has seen an increasing trend during 2001 to 2013 which have been mainly due to couple of factors i.e.

- Energy Efficiency initiatives
- Structural shift in economic activities, product & energy mix etc.

In 2010, BEE under the aegis of Ministry of Power, was also entrusted with the task of implementing the National Mission for Enhanced Energy Efficiency (NMEEE). The various Energy Efficiency initiatives taken by BEE under the four major intervention areas are given in **Table 3.1.**

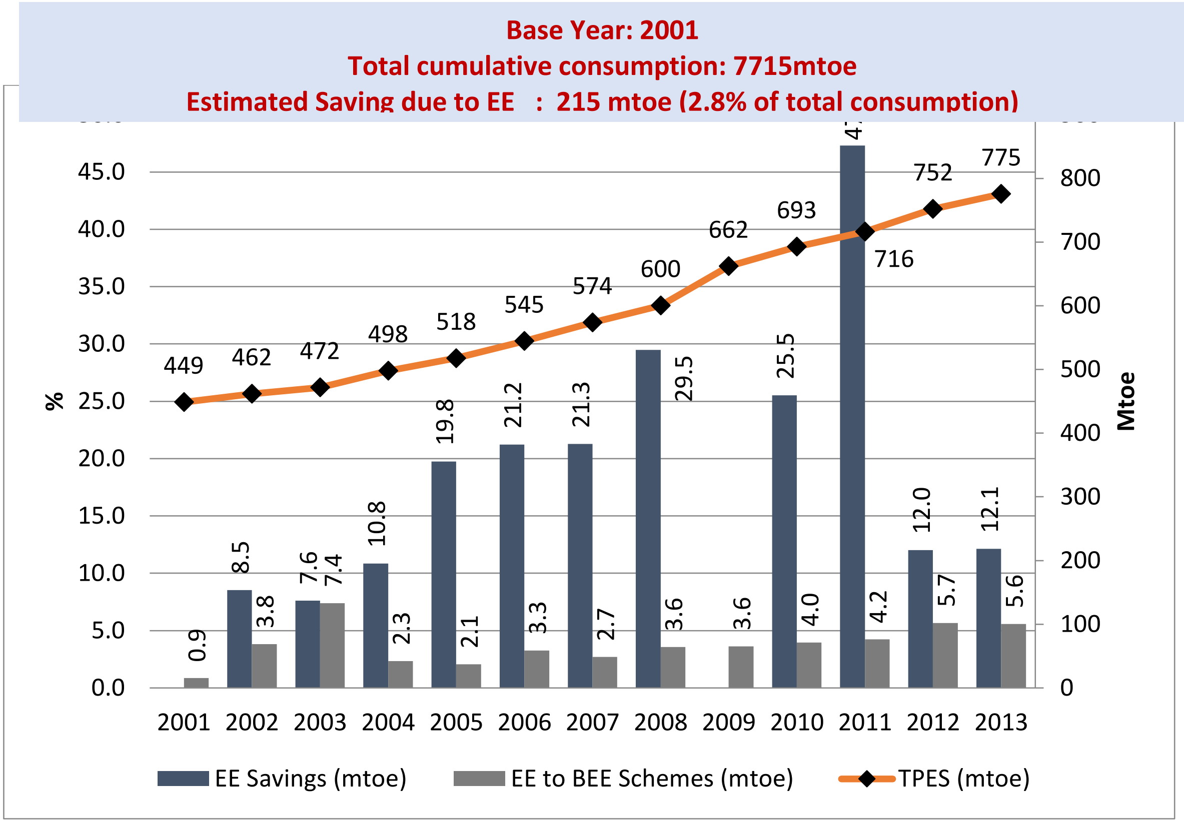
Table 3.1
Energy Efficiency Initiatives by BEE

Regulatory	Market Transformation
• Mandatory Standards and Labelling (S&L) for selective appliances and equipment • Energy Conservation Building Code (ECBC) • Energy usage norms for large industries through Perform-Achieve-Trade (PAT) scheme • Certification of Energy Efficiency professionals (Energy Auditors and Energy Managers) • Fuel efficiency norms for passenger cars • Mandatory Energy Audit of large industries • State level regulations (appliances, buildings & industry sector)	• Promotion of energy efficiency in Agriculture and Municipality sectors to reduce peak demand: Identification of options in AgDSM, MuDSM and SME programs • Formulate and Promote EE and new technologies: CFL, LED, Waste Heat Recovery, Tri-generation etc. • Promote and facilitate usage of energy efficient appliances: Public Procurement • Market transformation of large industries in adopting EE technologies: Energy Saving certificates in PAT scheme • Capacity Building of DISCOMs for implementation of DSM measures • Create awareness and disseminate information on energy efficiency and conservation: Consumer awareness program • Promote use of CFLs through innovative financing i.e. Bachat Lamp Yojana through CDM route • Promote use of LEDs through innovative financing i.e. Domestic Efficient Lighting Program • Promote Super-Efficient Appliance Deployment (SEAD) in colour TVs by international recognition: SEAD program under Clean Energy Ministerial • International co-operation
Fiscal Measures	**Financial Incentives**
• Creation of Partial Risk Guarantee Fund (PRGF) and Venture Capital Fund (VCF) • Creation of State Energy Conservation Funds (SECF)	• Formulate and facilitate implementation of pilot projects and demonstration projects: AgDSM, WHR projects in States, LED street lighting, LED village campaign • Enhancement of laboratory facilities for testing of energy efficient appliances: Laboratory capacity building program • Provision of incentives to manufactures in Super-Efficient Equipment Program (SEEP)

The cumulative energy consumption of the country was 7715 mtoe during 2001-2013 at the user-ends. It is estimated that 215mtoe (i.e. 2.8% of the total consumption) energy was saved due to energy efficiency measures from the year 2001 to 2013. Out of this, about 23% savings is due to direct result of BEE's interventions. The overall energy saving due to BEE's schemes/programs is about 49.1mtoe during 2001-2013. As per BEE calculations, an avoided capacity of 36,323MW during the years 2006 to 2014 has been achieved. The National Energy Conservation Award (NECA) scheme which was launched by Ministry of Power in 1999 has also resulted energy savings in participating industries.

The total energy consumption and energy savings due to energy efficiency measures are shown in **Exhibit 3.1.**

Exhibit: 3.1



It is quite evident from the **Exhibit 3.1** that the saving realization due to BEE schemes has been appreciable after 2007 when many schemes were operationalized. In terms of avoided capacity, BEE has always exceeded the yearly targets assigned to it by Central Government. Although the scheme wise targeted saving has not been achieved by all schemes, the overall saving has been remarkable. It is found that BEE schemes have the maximum direct impact on residential sector as 77% of the savings are result of Standards & Labelling program which mainly covers household appliances. However, BEE efforts have led to much bigger impact on account of customers taking voluntary initiatives due to increased awareness.

3.2.1 Achievements of demand reduction by Energy Efficiency measure

It is observed that the benefits reported by BEE, have been mainly concentrated in one or two schemes i.e. appliance and industry programs (as shown in **Table 3.2**). Therefore, there is lot of scope in other schemes and larger penetration opportunities of energy efficiency in different stages and types of end users.

Table 3.2

Scheme-wise saving during 2006 – 2014

SL	Scheme	Avoided Generation (MW)
1	Standard & Labeling	29,771
2	Building (ECBC)	14.2
3	Bachat Lamp Yojana	427
4	Strengthening of State Designated Agency	1,065
5	Designated Consumers and Small & Medium Enterprises	2.1
6	Agricultural DSM(AgDSM) and Municipality DSM (MuDSM)	0.70
7	National Energy Conservation Award	5,043
	TOTAL	**36,323**

3.3 PROJECTIONS OF ENERGY SAVINGS AND PEAK AVOIDED

The breakup of projections of energy savings and Peak avoided for Utility and non-utility for the years 2017-22 and 2022-27 have been estimated and are shown **in Table 3.3(a) to Table 3.3(d)**

Table3.3(a)

Projections of energy savings during 2017-22

Details	2017-18	2018-19	2019-20	2020-21	2021-22
Savings Utility (BU)	123	156	176	190	206
Savings Non-Utility (BU)	17	25	31	38	43
Total (Billion Units)	**140**	**181**	**207**	**228**	**249**

Table3.3(b)

Projections of Peak avoided during 2017-22

Details	2017-18	2018-19	2019-20	2020-21	2021-22
Savings Utility(MW)	7333	7936	8319	8864	9436
Savings Non-Utility(MW)	361	474	519	568	619
Peak Avoided (MW)	**7693**	**8411**	**8838**	**9432**	**10055**

Table 3.3(c)

Projections of energy savings during 2022-27

Details	2022-23	2023-24	2024-25	2025-26	2026-27
Savings Utility (BU)	217	230	244	257	273
Savings Non-Utility (BU)	47	51	55	60	64
Total (Billion Units)	**264**	**281**	**299**	**317**	**337**

Table3.3(d)

Projections of Peak avoided during 2022-27

Details	2022-23	2023-24	2024-25	2025-26	2026-27
Savings Utility(MW)	9900	10450	11037	11659	12324
Savings Non-Utility(MW)	668	720	774	835	900
Peak Avoided (MW)	**10569**	**11169**	**11811**	**12494**	**13225**

3.4. DEMAND SIDE MANAGEMENT AND ENERGY EFFICIENCY TARGETS FOR 2017-2022 AND 2022-27

The BEE has categorically taken following approach for widespread adoption of energy efficiency programs by various sectors of economy:

- Widening of scope in on-going programs
- Launch of new programs & missions
- Faster market transformation
- Cost-effectiveness of energy efficient products, services and knowledge
- Mandatory programs and enforcement
- Inclusive participation in EE programs by all sections of the society

The projections of reduction of energy demand through implementation of various programmes of Demand side management for 2017-2022 are given in **Table 3.4**.

Table 3.4

Projections of reduction of energy demand for the years 2017-22

Program	2017-18	2018-19	2019-20	2020-21	2021-22
S&L (BU)	56.49	60.33	64.43	8.81	73.49
Buildings (BU)	6.52	8.04	9.64	6.25	6.56
Agriculture(BU)	0	2.7	3.6	4.59	5.63
Industries (PAT Scheme)(BU)	29.7	49.17	61.33	78.11	90.37
National Energy Conservation Awards (NECA)(BU)	13.8	14.2	15.2	16.3	17.4
LED Domestic Lighting(BU)	28.87	39.375	42.5	43.6	45.3
LED Street Lighting(BU)	5.2	7.6	9.7	9.9	10.3
Total (Billion Units)	**140.5**	**181.4**	**206.4**	**227.5**	**249.0**
Savings (million toe)	35.14	45.36	51.61	56.89	62.27
Peak Avoided (MW)	7,693	8,411	8,838	9,432	10,055
Peak Avoided (MW) due to installation of SWHS*	800	800	800	800	800
GDP (Billion ₹)	81,138	86,798	92,852	99,328	1,06,256
Savings/GDP (kgoe/ ₹ GDP)	0.00043	0.00052	0.00056	0.00057	0.00059
Energy Intensity (BAU) - kgtoe/₹ GDP	0.012	0.011	0.011	0.011	0.011
Energy Intensity Reduction (%)	**3.58%**	**4.73%**	**5.09%**	**5.18%**	**5.36%**

* Solar Water Heater System (SWHS) projections furnished by MNRE

The projections of reduction of energy demand through implementation of various programmes of Demand side management for 2022-2027 are given in **Table 3.5**.

Table 3.5
Projections of reduction of energy demand for the years 2022-27

Program	2022-23	2023-24	2024-25	2025-26	2026-27
S&L(BU)	78.49	83.82	89.52	95.61	102.11
Buildings(BU)	6.89	7.23	7.59	7.97	8.36
Agriculture(BU)	2.93	2.03	1.04	0	0
Industries (PAT Scheme) (BU)	98.9	107.7	116.7	126.0	136.1
National Energy Conservation Awards (NECA) (BU)	18.6	19.9	21.3	22.8	24.4
LED Domestic Lighting(BU)	47.4	49.3	51.0	52.6	54.1
LED Street Lighting(BU)	10.8	11.2	11.5	11.8	12.0
Total (Billion Units)	**263.92**	**281.16**	**298.74**	**316.74**	**337.12**
Savings (million toe)	65.98	70.29	74.68	79.19	84.28
Peak Avoided (MW)	10569	11169	11811	12494	13225
GDP (Billion ₹)	113667	121595	130076	139149	148854
Savings/GDP (kgoe/ ₹ GDP)	0.00058	0.00058	0.00057	0.00057	0.00057
Energy Intensity (BAU) - kgtoe/₹ GDP	0.010	0.010	0.010	0.010	0.009
Energy Intensity Reduction (%)	**5.80%**	**5.80%**	**5.70%**	**5.70%**	**6.33%**

State-wise Energy Savings (BU) targets for the years 2017-18 to 2026-27 are placed at **Annexure 3.1.**

3.5 MEASURES TO BE ADOPTED TO ACHIEVE THE TARGET

3.5.1 Standards & Labelling for Appliances, Buildings Codes & Energy Efficiency Research Centre

3.5.1.1 Standard and Labelling (S&L) Program

(i) Ensure More Participation by Manufacturers in Mandatory & Voluntary Programs

- Create Market Demand for Star labelled Products through consumer awareness and linking to procurement policy.
- Facilitation of application process by BEE through up-gradation of web portal and strengthening the helpdesk.

(ii) Widen the Program

- 28 appliances are to be covered by 2017. However, 7 will be mandatory out of these 28 appliances.

(iii) Deepen the Program

- Transition from voluntary to mandatory zone for at least three products
- Up gradation/tightening of norms of Room Air Conditioner, Refrigerator, Distribution Transformers, Induction cooker, color television etc.

(iv) S&L for Transport Sector

There are total 13.3 million passenger cars (2010 – 11) in India which consume about 9 mtoe. The average annual sales of new passenger cars in the country are about 1.1 million. Energy consumption standard have been notified for passenger cars and would be applicable from 2017-18 for the 1st phase & 2022-23 for the 2nd phase. The targeted energy saving by 2025 is 22.97 mtoe.

3.5.1.2 Energy Conservation Building Code

(i) 75% of all new commercial buildings to be ECBC compliant and 20% of the existing commercial buildings to reduce their energy consumption through retrofits**.**

(ii) To meet the targets, several activities have been proposed like adoption & facilitation for ECBC implementation, development of test standards for building components, support for creation of building material testing laboratories, capacity building and creating a cadre of ECBC professionals through a testing & certification programme, training & capacity building programmes for various stakeholders.

(iii) Design Guidelines for 'Energy-Efficient Multi-Story Residential Buildings' are developed with the objective to provide comprehensive information on how to design energy-efficient multi-story residential buildings. Additionally, to improve energy efficiency in existing buildings retrofitting & Star labelling of commercial building would be continued.

3.5.2 Demand Side Management (Agriculture, Municipality, SME and DISCOMs and Solar Water Heating Systems)

3.5.2.1 Agriculture DSM (AgDSM)

(i) Regulatory mechanism to mandate the use of BEE star labelled pump sets for new connections by DISCOMs.
(ii) Facilitate Implementation of DPRs prepared during 11thPlan period and setting up Monitoring & Verification protocol.
(iii) Technical assistance and capacity development of all stakeholders.
(iv) Demo projects in pumping efficiency in Rural Public Health & Drinking water systems.
(v) Selection of beneficiary States as per the selection criteria for providing financial assistance to farmers for promotion of Energy Efficient Pump sets and for implementation of demonstration projects on efficiency improvement of Rural Drinking Water Pumping systems.

3.5.2.2 Municipality DSM (MuDSM)

(i) Build the technical & managerial capacity of the energy conservation cell of Urban Local Bodies
(ii) Realize the energy saving through implementation of selective DPRs prepared during 11th plan period in few ULBs.
(iii) Facilitate other ULBs to replicate implementation through knowledge transfer.
(iv) Involve various stakeholders to create a market transformation in energy efficiency.
(v) Facilitate State Urban Development Departments to create institutional arrangements through which projects can be implemented.
(vi) One-day interaction meeting cum workshops in different States with participation from various stakeholders like Urban Development Department, ULBs, SDAs, ESCOs & energy auditing agencies. These States have also started activities to form the State Level Steering Committee and selection of ULBs for implementation of demonstration projects.

3.5.2.3 Small, Medium Enterprises (SMEs)

The SME sector is an important constituent of the Indian economy, contributing significantly in GDP, manufacturing output and export. Similarly, this sector also plays a significant role in energy consumption which is about 25% of the total energy consumption by industrial sector. BEE is targeting the SME sector for reduction in energy consumption by 6% of the energy used in the energy intensive manufacturing SMEs which is equivalent to 1.75 mtoe. Due to demand side management activities, demand from SME will be reduced and their profit margins will increase and will lead to better management in the sector. The targeted goal would be achieved by introducing innovative business models and financial instruments (like Venture Capital Fund/Revolving Fund, Partial Risk Guarantee Fund) as given below:

(i) Sector specific approach for energy efficiency and technology up gradation through facilitation of implementation of DPRs
(ii) Energy mapping of the targeted SME Sector on all India basis
(iii) Undertaking of Innovative Financial Schemes for adoption of EE Technologies in the SMEs
(iv) Technical assistance and capacity building
(v) SMEs Product Labelling Promotion Scheme

3.5.2.4 Capacity Building of DISCOMs

Bureau of Energy Efficiency has launched a programme for capacity building of DISCOMs. This programme will help in integration of EE activities with the activities managed by Distribution Companies (DISCOMs) for Demand Side Management. Further, this programme will help in capacity building of DISCOMs and development of various mechanisms to promote DSM in their respective States. 34 nos. DISCOMs have been selected to participate in this programme. The following activities would be carried out by BEE and DISCOMs under this programme.

(i) Establishment of DSM Cell by selected DISCOMs.
(ii) Creation of about 500 Master Trainers from officials of DISCOMs under Training of Trainers (ToT).
(iii) Training of 4000-5000 circle level officials of DISCOMs under Capacity building workshops.
(iv) Providing Manpower Support to DISCOMs for facilitating DISCOMs for implementation of DSM measures in their areas.
(v) Providing Consultancy support to DISCOMs for load survey, load research, load strategies etc. and preparation of DSM action plans.
(vi) Adoption of DSM regulations by the Regulator.
(vii) Incorporation of DSM plan along-with Multi-Year Tariff (MYT).
(viii) Implementation of DSM Action Plan.
(ix) Monitoring and Verification and reporting to the SERC.

3.5.2.5 Installation of Solar Water Heating Systems (SWHS)

Solar water Heating is now a mature technology. Wide spread utilization of solar water heaters can reduce consumption of conventional energy being used for heating water in homes, industries and commercial & institutional establishments. Solar water heaters of 100-300 litres capacity are suited for domestic applications and larger capacity heating systems can be used for restaurants, guest-houses, hotels, hospitals, industries etc. A solar heating system of $2m^2$ area can replace electric geyser of 2 kW load. MNRE has informed the projections of installation of SWHS having total area of 800,000 m^2 /year in the country during 2016-17 to 2020-21. These SWHS would have the potential to reduce the annual peak load of the country by 800 MW.

3.5.3 Institutional Mechanism: Strengthening of State Designated Agencies (SDA)

It is well recognized that State Designated Agencies (SDAs) in different States need to play a very important role in terms of carrying forward various energy efficiency initiatives at the State level. The thrust of the SDA program is based on strengthening the 35 SDAs which would enable them to implement various EE and EC programs and activities initiated by BEE or SDAs themselves.

The activities include sector specific interventions in areas like municipality (drinking water and sewage treatment), agriculture sector (pumping), street lighting, commercial buildings, Government buildings and waste heat recovery in SMEs including demonstration projects. Following initiatives of SDAs are proposed to be supported that would help in strengthening the capacities of SDAs and undertaking of various projects and programmes to promote energy efficiency in their respective States:

(i) Support for implementing State-wise sector specific energy saving plan by the SDAs
(ii) Continued engagement of SDAs with energy efficiency professionals like energy auditors, energy managers and ESCOs

(iii) Implement various EE demonstration projects in the States to showcase the effectiveness of the most advanced energy efficient technology and pursue State Governments to replicate the project in other parts of the States.
(iv) LED village campaign in the villages and pursue State Governments to replicate the project in other parts of the States.
(v) Providing technical support to the SDAs
(vi) Publicity /awareness on EE in the States
(vii) Workshops/ training programmes for all the stakeholders
(viii) Capacity building programmes for the SDAs

3.5.4 Regulatory Instruments

3.5.4.1 ToD (Time of Day) Metering / ToU (Time of Use) Pricing

ToD/ToU metering is a billing method in which depending on the expected load on the grid, a billing day is divided into several time zones. The duration of each time zone is programmable and the user can define the time zones as per his requirements. The meter records the energy consumed in different time zones in separate registers and exhibits accordingly. Consumption in each of the time zone is charged at different rates. The tariff rates for different time zones are fixed in such a way that a consumer pays more for energy used during peak hours than for off-peak hours. It becomes the responsibility of the consumer to either restrict his energy usage or pay accordingly. This encourages consumers to shift load during cheaper time periods of the day. TOD metering helps consumers to manage their consumption which in turn helps the utility in managing the peak demand.

TOD metering helps in shifting the loads mostly to off- peak hours, resulting in reduction in the peak demand requirement of the utilities by flattening their load curve. It would also improve the financial health of the utilities as the utilities would not have to buy costly power during peak hours.

Hence, TOD Metering system is very useful for utilizing the available electrical energy in an optimum way. This also helps the utilities to plan their distribution infrastructure appropriately. This can be implemented in all consumer categories be it domestic, commercial, industrial or even BPL consumers.

Presently, most of the States have implemented this type of metering for industrial and commercial consumers. However, it is very difficult to assess the reduction in Peak Demand achieved through the use of TOD metering unless specific inputs are received from the States in this regard.

3.5.4.2 Demand Response (DR)

Ability to reduce electricity demand from appliance to manage peak demand would reduce the need for costly investments in energy supply, manage shortages, and improve the reliability of the electricity grid. DR primarily takes the form of: (a) involuntary load shedding by utilities, and (b) time of use pricing. More nuanced equipment based auto DR can be used to avoid blanket load shedding in the short run and avoid investment in expensive peak plants in the long run. Demand Response (DR) can, therefore, be considered a valuable resource for managing the electricity grid. It can effectively mitigate peak demand and also reduce the costs associated with integrating intermittent renewable electricity generation.

3.5.5 Reduction in AT&C losses:

To address the issues related to the high AT&C losses and reforms in the distribution sector of the States, the Government of India launched Accelerated Power Development and Reforms Programme (APDRP) for 10th Plan and Restructured Accelerated Power Development and Reforms Programme (R-APDRP) for 11thPlan. In the 11th Plan, the scheme has been restructured with emphasis on actual demonstrable performance in terms of sustained loss reduction. The programme was of ₹ 51,577 crores.
Ministry of Power has further sanctioned "Integrated Power Development Scheme" (IPDS) in December, 2014 with the following components:

(i) Strengthening of sub-transmission and distribution networks in the urban areas.
(ii) Metering of distribution transformer/feeders/consumers in the urban areas.

(iii) IT enablement of distribution sector and strengthening of distribution network, for completion of the targets laid down under R-APDRP for 12th and 13th Plans by carrying forward the approved outlay for R-APDRP to IPDS.

The components at (i) and (ii) above have an estimated outlay of ₹ 32,612 crores, including a budgetary support of ₹ 25,354 crores from Government of India during the entire implementation period.

The scheme of R-APDRP as approved by Govt. for continuation in 12th and 13th Plans has been subsumed in this scheme as a separate component relating to IT enablement of distribution sector and strengthening of distribution network [component (iii) above] for which Govt. has already approved the scheme cost of ₹ 44,011 crores including a budgetary support of ₹ 22,727 crores. This outlay will be carried forward to the new scheme of IPDS in addition to the outlay indicated above. **(Source: MoP order No. 26/1/2014-APDRP dated 03-12-2014)**

Ministry of Power has also laid down a State-wise AT&C loss reduction trajectory till the year 2019-20 to be followed by various States across the country.

3.5.6 Affordable Energy Efficient Lighting Solution

(i) The Lighting Industry has seen a strong growth of more than 67% from ₹ 8500 Crores in 2010 to ₹ 16200 Crores in 2014. This has been driven largely from Incandescent Lamps (GLS) to Compact Fluorescent Lamps (CFL) and recently with Light Emitting Diodes (LEDs) Several Government initiatives have supported this transition, including Government regulations and directives to use CFL in Government buildings, and large installations. Government being largest buyer of lighting products, impacts the industry business by various actions. Recent initiatives by Government to promote and procure LED Lighting products, has suddenly changed the scenario for which the lighting industry was not prepared.

The chart below gives a fair idea of total population of Light points in domestic sector, Street Light population in year 2005, possible growth by 2020 and likely business available that needs to be tapped in India.

Table 3.6

	2005	2014	Est 2020
Light Points	1.3 billion	>2 billion	> 2.5 billion
Incandescent sold	1 billion	800 million	200 million
CFL Sold	67 million	> 450 million	20 million
LED Lamps sold	-	23 million	1 Billion
CFL Manufacturing Capacity in India	4 million	> 1 billion	Conversion to LED manufacturing
Unelectrified area	40%	20%	10%
Street Lights population in India	22 million	30.5 million	47 million
LED Street Light Sale	-	2.5 million	10 million *

*Street Light sale between 2015-2020 will be around 41 million

(ii) Initiatives by Government to Promote LED Lighting in India

Making BIS standards mandatory, establishment of Energy Efficiency Services Limited (EESL), making star labelling for LED Lamps by BEE and later for LED down lights and launching Demand side management schemes to promote LED lamps are the initiatives that the Government has taken to push use of LED Lighting in all segments. Under Electronic System Design & Manufacturing, DeitY has initiated several schemes to provide relief and funding for land, equipment and tax holiday etc., to promote electronic manufacturing in India including LED Lighting.

3.6 ACHIEVEMENTS AND PLANS WITH RESPECT TO MISSIONS OF CLIMATE CHANGE

The National Mission on Enhanced Energy Efficiency (NMEEE) is one of the eight missions under the National Action Plan on Climate Change (NAPCC). NMEEE aims to strengthen the market for energy efficiency by creating conducive regulatory and policy regime and has envisaged fostering innovative and sustainable business models for the energy efficiency sector.

The NMEEE spelt out four initiatives to enhance energy efficiency in energy intensive industries which are as follows:

- Perform, Achieve and Trade Scheme (PAT), a regulatory instrument to reduce specific energy consumption in energy intensive industries, with an associated market based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.
- Market Transformation for Energy Efficiency (MTEE), for accelerating the shift to energy efficient appliances in designated sectors through innovative measures to make the products more affordable.
- Energy Efficiency Financing Platform (EEFP), for creation of mechanisms that would help finance demand side management programmes in all sectors by capturing future energy savings.
- Framework for Energy Efficient Economic Development (FEEED), for development of fiscal instruments to promote energy efficiency.

The Mission seeks to upscale the efforts to unlock the market for energy efficiency which is estimated to be around ₹ 74,000 crore and help achieve total avoided capacity addition of 19,598 MW, fuel savings of around 23 million tonnes per year and greenhouse gas emissions reductions of 98.55 million tonnes per year at its full implementation stage. Continuation of NMEEE was approved by Cabinet on 6th August, 2014 with a total outlay of ₹ 775 crores.

3.6.1 Perform, Achieve and Trade (PAT)

On 30th March, 2012 energy saving targets for 478 designated consumers belonging to 8 sectors were notified. In the first cycle of PAT (ending in year 2014-15), 478 industrial units in 8 sectors (Aluminium, Cement, Chlor- Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power, Textile) have been mandated to reduce their specific energy consumption (SEC) i.e. energy used per unit of production by March,2015. Overall, the SEC reduction targets aim to secure 4.05% reduction in the SEC in these industries totalling an energy saving of 6.686 million tonne of oil equivalent which would account for mitigation of about 24 million tons of CO2.

Sector Specific proforma along with Sector Specific Normalization Factors to streamline the monitoring and verification (M&V) process has been prepared. The sector/ sub-sector specific Normalization Factors were developed to neutralize the effects on specific energy consumption (SEC) in the assessment year as well as baseline year so that undue advantages or disadvantages could not be imposed on any Discoms while assessing the targets. To facilitate the M&V process, M&V guidelines for all the 8 sectors have been developed. BEE has put in place a process of accreditation of Energy Auditors who will be engaged to execute the M&V process of DCs to assess their performances. Development of Energy Saving Certificates (EScerts) trading infrastructure is in process in collaboration with Central Electricity Regulatory Commission (CERC).

Documents on “Pro-forma and Normalization Equation” and “Normalization Document and Monitoring and Verification Guidelines” have been prepared to facilitate the effective implementation of the scheme and copies of same have been provided to all Designated Consumers, Accredited Energy Auditors and State Designated Agencies.

The Draft Rules/Regulations for trading of energy savings certificate has been finalized and submitted for getting concurrence of CERC for finalization and Notification. For Development of Repository of trading platform, POSOCO has been identified as repository of ESCerts Trading. PATNET, an online platform for data reporting, trading of ESCerts, etc. is operational.

PAT “Deepening” process has already been initiated to include more DCs while keeping the same threshold and in some sectors such as Iron and Steel and Pulp and Paper by reducing the threshold so that more and more industrial units participate in the energy enhancement scheme. Similarly, “Widening” of the PAT i.e. inclusion of more sector in the

PAT fold has also been initiated. Presently, refinery, Electricity DISCOMs, and Railways are under consideration for including in the PAT cycle II. PAT is visualized as a multi-cycle scheme aimed towards raising the efficiency of economy to a higher level.

PAT cycle I was completed on 31stMarch, 2015. From 1st April, 2015 to 14thAugust, 2015 was the M&V phase. The verification of the performance of DCs was carried out by Accredited Energy Auditing Firms. Currently scrutiny of performance assessment documents (PADs) is under process by State Designated Agencies (SDAs) and by Bureau of Energy Efficiency (BEE). After the scrutiny by BEE and on the recommendation of BEE, the Central Government will issue ESCerts which can be traded at Power Exchanges.

When compared to the baseline energy consumption at the beginning of PAT scheme, the energy efficiency measures have resulted in a savings of around 6% till 2010.

Table 3.7

Sector	Specific Energy Consumption (ToE /MT)		
	2005	2010 (% saving over 2005)	2017 (projected % saving over 2005)
Cement	0.08	0.075 (6%)	0.07 (9.63%)
Pulp and Paper	0.78	0.72 (7%)	0.67 (29.49%)
Iron and Steel	0.70	0.66 (6%)	0.63 (10.29%)
Fertilizers	0.63	0.59 (6%)	0.57 (11.11%)

In next three years (2016-17,2017-18 and 2018-19), the industrial energy savings are targeted to reach 10% through widening of PAT scheme to new sectors as well as increasing the penetration within the current sectors. In addition, guidelines for mandatory disclosures on energy consumption by companies, under the Companies Act will help in achieving the 10% targets.

As per Guidelines on Energy and Energy Conservation Reporting in Annual Reports of companies, all firms, registered under the Companies Act, are mandated to disclose their annual energy consumption and energy conservation initiatives through the company's annual report. With the appropriate guidelines in place, the scope and nature of data provided, including energy and energy conservation data, will be more streamlined and robust. This will also encourage companies to undertake energy audits, identify energy intensive areas within the firm as well as formulate energy efficiency measures to improve energy savings.

Outreach activities to consult with designated consumers and technology providers including knowledge exchange platform to share experiences within and between sectors.

3.6.2 Market Transformation for Energy Efficiency (MTEE)

Under MTEE, two programmes have been developed i.e. Bachat Lamp Yojana (BLY) and Super-Efficient Equipment Programme (SEEP).

i) Bachat Lamp Yojana (BLY): It is a public-private partnership program comprising of BEE, Distribution Companies (DISCOMs) and private investors to accelerate market transformation in energy efficient lighting. Under this program, over 29 million incandescent bulbs have been replaced by CFLs

In the next phase of BLY, BEE will promote use of LED lights using the institutional structure of BLY Programme. BEE provides support to Rural Electrification Corporation (REC) for framing technical specification and monitoring and verification of the energy savings from the LED bulbs distributed under RGVVY scheme to BPL households. BEE will also undertake outreach activities to promote large scale adoption of LEDs.

(ii) Domestic Efficient Lighting Programme (DELP): Energy Efficiency Services Limited (EESL) has evolved a service model where it works with electricity distribution companies (DISCOMs) through a benefit sharing approach.

The Domestic Efficient Lighting Programme (DELP) obviates the need for DISCOMs to invest in the upfront cost of LED bulbs; EESL procures the LEDs bulbs and provides to consumers at a rate of ₹ 10 each as against their market price of ₹ 350-600.

A) DELP scheme -Key features:

DELP will leverage the Demand Side Management (DSM) regulatory framework that SERCs have created to set up a robust payment security mechanism. EESL, on its own or in collaboration with partners, will undertake project implementation and take the investment risk. The methodology has been uniquely developed with strong focus on the monitoring and verification aspects. Following are some of the key features of DELP.

- Distribution of LEDs to households at cost of ₹ 10 as against a market price of ₹ 350 to 600
- At least three years' free replacement warrantee
- No impact on tariff
- Payment to EESL from DISCOM spread over 5 years from energy savings achieved
- Benefits sharing approach

The upfront investment made by EESL is paid back in two different ways as indicated under as case studies:

Table 3.8

Case study 1: DELP implementation at Puducherry

No of household consumers targeted	**2.45 lakh**
No of inefficient ICLs (60 watt) to be replaced	7.35 lakh (three per household)
Wattage of LED	7 watt
Reduction of wattage per household	159 watt
Total reduction of connected load in the State	38.9 MW
Energy consumption reduction per household	166.95 kWh per annum (based on 3.5 hours of usage for 300 days a year)
Total energy consumption reduction in the DISCOM	40.9 million kWh
Cost reduction for households per annum	₹ 500-600
Approximate cost reduction for DISCOMS per annum	₹ 16.9 crore
Upfront investment by State/ DISCOM	Nil
Investment by EESL	₹ 22.785 crore

B) Service Model–Street Light

EESL has been designated as the implementing agency for Street Light programmes. EESL has evolved a service model to enable Municipalities to replace conventional lights with LEDs at no upfront cost. The balance cost is recovered through the municipalities by monetising the energy savings.

Case Study 2-Vizag Street Light Project

EESL has implemented about 92,000 street light retrofit projects in Vizag. This project will reduce the energy consumption by 50%. The entire upfront capital of ₹ 64 crores has been invested by EESL and will be recovered over a 7 years' period. The municipality will pay EESL a sum of ₹ 18.5 crore every year whereas its overall costs savings would be ₹ 31 crores annually. This service model is replicable as it obviates the need for upfront capital as well as reduces the recurring expenditure of municipalities. This model could help scale up energy efficient street light replacement in the country. A brief on Vizag efficient street light project is as follows:

Table 3.9

Case Study 2-Vizag Street Light Project

No of street lights being replaced in Vizag	**91,997**
Expected annual energy savings	24 million KWh
Expected reduction of installed street light load	3.90 MW
Actual capital investment	₹ 64 crore
Estimated cost savings to municipalities every year	₹ 31 crore
Annual payments to EESL for 7 years (inclusive of O&M Costs)	₹ 18.5 crore
Actual reduction of electricity bill in 1st quarter of this calendar year as compared to similar period last year	55%

LED deployment: 4.5 million LED lights to domestic consumers and 90,000 LED street lights have been deployed by Energy Efficiency Services Limited (EESL) with an estimated saving of about 274 million units of electricity.

(iii) Super-Efficient Equipment Programme (SEEP): The other component under MTEE is a new programme called Super-Efficient Equipment Programme (SEEP). SEEP is a program designed to bring accelerated market transformation for super-efficient appliances by providing financial stimulus innovatively at critical point/s of intervention. Under this program, ceiling fan has been identified as the first appliance to be adopted. SEEP for ceiling fans aims to leapfrog to an efficiency level which will be about 50% more efficient than market average by providing a time bound incentive to fan manufacturers to manufacture super-efficient (SE) fans and sell the same at a discounted price. The goal is to support the introduction and deployment of super-efficient 35W ceiling fans, as against the current average ceiling fan sold in Indian market with about 70W rating. For the 12th Plan, it is targeted for deployment of 2 million fans during the Plan period with an outlay of ₹ 100 crores. Under this program, maximum of ₹ 500 per fan incentive will be given to fan manufactures for manufacture and sale of fans meeting SEEP specifications.

Consultations with main stakeholders of the program such as fan manufactures technology providers, R&D institutions, academia and civil society organizations have been completed. Main technical specifications have been finalized. Assessment of testing capacity and development of testing protocols have been completed. Independent agency for monitoring and verification has already been engaged. A panel of 5 Super-Efficient fan manufacturers has been selected through an open competitive bidding process.

3.6.3 Energy Efficiency Financing Platform (EEFP)

Energy Efficiency Financing Platform (EEFP) is one of the initiatives under NMEEE to provide a platform to interact with financial institutions and project developers for implementation of energy efficiency projects. Under EEFP, MoUs have been signed with financial institutions to work together for the development of energy efficiency market and capacity building of FIs. In May 2015, BEE has signed a MoU with Indian Banks' Association regarding Training Programme for scheduled commercial banks (except cooperative banks) on Energy Efficiency Financing. This Training Programme has been launched on 1st June 2015 in Mumbai, and two training of trainers workshops have been conducted so far. Under EEFP, BEE has also released the booklet on "Success stories of Energy Efficiency Projects Financed in India" and "Training Manual on energy efficiency financing"

3.6.4 Framework of Energy Efficiency Economic Development (FEEED):

Framework for Energy Efficient Economic Development (FEEED) is targeted to provide appropriate fiscal instruments that may supplement the efforts of the Government for creation of energy efficiency market. Under FEEED, BEE has constituted two funds namely Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) and Venture Capital Fund for Energy Efficiency (VCFEE). PRGFEE is a risk sharing mechanism to provide financial institutions (banks/NBFCs) with a partial coverage of risk involved in extending loans for energy efficiency projects. Under PRGFEE, the support has been provided to Government buildings, private buildings (commercial or multi-story residential buildings), municipalities, SMEs and industries. The guarantee will not exceed ₹ 3 crores (has been proposed to increase to ₹ 15 crores) per project or 50% of loan amount, whichever is less. BEE has constituted the Supervisory Committee for PRGFEE and selected the consortium of RECPDCL-REC-EESL as the Implementing Agency for PRGFEE, which is in process of operationalizing the fund. The notification of PRGFEE rules is also under process.

VCFEE is a fund to provide equity capital for energy efficiency projects. A single investment by the fund shall not exceed ₹ 2 crores. The Fund shall provide last mile equity support to specific energy efficiency projects, limited to a maximum of 15% of total equity required, through Special Purpose Vehicles or ₹ 2 crores, whichever is less. The support has been provided to only Government buildings, private buildings (commercial or multi-storied residential buildings) and municipalities.

3.6.5 Other initiatives of Government for enhancing energy efficiency in Generation sector

i) Adoption of super-critical technology in thermal generation

Supercritical units are designed with higher steam parameters of 247kg/cm2, 565/593 °C. With the higher steam parameters of supercritical units, the efficiency of these supercritical units would be about 2-3% higher than the efficiency of present 500 MW sub-critical units. This would lead to corresponding savings in coal consumption and reduction in GHG emissions. The thermal units in the country so far have largest size unit capacity of 800 MW. 60 Nos. supercritical units of sizes 660/800 MW with a total capacity of 41,310 MW have been commissioned. In the period 2017-22, coal based capacity addition was mainly through supercritical units.

Coal fired thermal generation units based on Ultra-super-critical technology having steam pressure of 257-300 kg/cm2 and temperature of 600/610°C are also being introduced in the country.

The national average thermal efficiency of coal/lignite based power plants has increased from 32.53% in 2009-10 to about 34% in 2013-14. It is expected that the efficiency of coal based generation would further improve in the period 2017-22 due to commissioning of large size super critical units

ii) Automatic transfer of LOA/Coal Linkage in case of Scrapping old thermal units

Min. of Coal, Government of India has formulated a policy on automatic transfer of LOA/coal linkage (granted to old plants) to new plants in case of scrapping of old units and replacing them with new higher efficiency super-critical units. (Illustration: for setting up of new supercritical plant of 1000 MW capacity, at least 500 MW of old capacity has to go be retired. Old plants can be clubbed together to achieve this). The additional coal required shall be accorded priority in allocation subject to availability on best efforts basis from CIL.

iii) Retirement of old & in-efficient thermal units

The retirement of old and inefficient units of thermal generating stations and replacing them with new and more efficient units is one of the major initiatives taken by Government of India. The identified units are to be retired in a phased manner along with the matching capacity addition in the respective State, so as to have no impact of retirement on the power supply position in the States/country. A capacity of 2398 MW has been retired in 11th Plan period. In 12th Plan, capacity of 5,082 MW was retired.

iv) Renovation and Modernization (R&M) & Life Extension (LE) of existing old power stations

With an objective of improving efficiency and availability of old units, R&M and LE works of total capacity of 16,146 MW have been completed in 11th Plan period. In 12th Plan R&M and LE works for total capacity 7,202.26 MW was completed.

v) R&D for Advance Ultra Supercritical technology

Under the National Mission for development of clean coal technologies, an R&D project has been taken up to indigenously develop Advance Ultra Supercritical (A-USC) technology with steam temperature of around 700 ^{0}C. Typically an A-USC power plant having steam parameters of 300 kg/cm2 pressure and 700°C steam temperature may have plant efficiencies of around 46% (HHV higher heat value basis).

NTPC, Indira Gandhi Centre for Atomic Research (IGCAR) and BHEL have signed a MOU for development of the A-USC technology. It is proposed to execute an 800 MW A-USC indigenous demonstration plant (with main steam pressure of around 300 kg/ cm2 and temperature of 700 ^{0}C) in a 7-year period from the date of financial sanction by the

Govt. of India. The 7-year period comprises of two and half years of design and development work (R&D phase) and four and half years of power project construction phase.

3.7 CONCLUSION AND RECOMMENDATIONS

- Regulators to notify their DSM regulations and direct the DISCOMs to prepare their DSM action Plans. Regulators may direct Distribution Companies to take up energy efficiency measures in their areas. The DISCOMs may be suitably incentivized to implement DSM projects like lighting, air-conditioning, agricultural pumps, refrigerators and ceiling fans etc. for reduction in their peak demand.

- Encourage implementation of ToD Tariffs for industries and commercial consumers in phased manner and include domestic consumers subsequently.

- DISCOMs may be advised to carry out annual audits of energy flow of their distribution system.

- Retirement of old and inefficient units and replacing them with more efficient supercritical units.

- Joint Committee may be constituted under chairmanship of Secretary (Power) with official from BEE, CEA, EESL, SERC, DISCOMs and other stakeholders to monitor and recommend improvements in DSM measure.

Annexure 3.1

STATE-WISE ENERGY SAVINGS TARGETS FOR THE YEARS 2017-18 TO 2026-27

(All figures in BU)

NORTHERN REGION	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2026-27
Haryana	4.89	6.40	7.31	8.07	8.86	9.32	9.91	10.51	11.12	11.84
Himachal Pradesh	1.79	2.40	2.79	3.18	3.52	3.79	4.07	4.36	4.65	4.97
Jammu & Kashmir	1.31	1.63	1.83	1.94	2.07	2.20	2.33	2.46	2.60	2.74
Punjab	6.33	8.15	9.21	10.15	11.11	11.70	12.43	13.18	13.95	14.84
Rajasthan	6.10	7.99	9.11	9.93	10.84	11.24	11.86	12.49	13.12	13.92
Uttar Pradesh	11.46	14.49	16.30	17.80	19.34	20.48	21.77	23.09	24.44	25.95
Uttarakhand	2.26	2.96	3.40	3.84	4.24	4.55	4.89	5.23	5.58	5.96
Chandigarh	0.39	0.47	0.51	0.53	0.56	0.60	0.63	0.67	0.71	0.75
Delhi	6.58	7.78	8.49	8.57	9.06	9.59	10.13	10.69	11.26	11.86
Sub-Total (NR)	41.12	52.26	58.96	64.01	69.59	73.46	78.03	82.68	87.42	92.83
WESTERN REGION										
Gujarat	10.28	13.89	16.13	18.46	20.50	21.79	23.31	24.86	26.46	28.27
Madhay Pradesh	5.55	7.27	8.29	9.13	9.97	10.42	11.04	11.66	12.29	13.05
Chhattisgarh	2.92	3.79	4.33	4.84	5.33	5.67	6.06	6.46	6.87	7.33
Maharashtra	18.54	23.87	27.11	29.64	32.41	34.27	36.47	38.72	41.01	43.64
Goa	0.74	0.98	1.13	1.28	1.41	1.52	1.63	1.75	1.86	1.99
Daman & Diu	0.35	0.50	0.60	0.73	0.82	0.90	0.97	1.05	1.13	1.21
D & N Haveli	1.04	1.51	1.82	2.24	2.55	2.78	3.02	3.26	3.52	3.79
Sub-Total (WR)	39.44	51.81	59.42	66.32	72.99	77.36	82.51	87.76	93.14	99.28
SOUTHERN REGION										
Andhra Pradesh	12.21	15.95	18.18	20.15	22.13	23.30	24.78	26.28	27.83	29.65
Karnataka	8.99	11.90	13.70	15.08	16.55	17.37	18.44	19.53	20.63	21.94
Kerala	4.74	5.79	6.42	6.83	7.35	7.84	8.34	8.86	9.39	9.95
Tamil Nadu	13.93	17.85	20.25	22.19	24.23	25.71	27.38	29.09	30.84	32.80
Puducherry	0.54	0.71	0.82	0.93	1.03	1.11	1.19	1.28	1.37	1.46
Lakshadweep	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sub-Total (SR)	40.41	52.20	59.38	65.20	71.31	75.35	80.16	85.06	90.08	95.83
EASTERN REGION										
Bihar(Projected)	1.69	2.08	2.31	2.49	2.69	2.87	3.05	3.24	3.44	3.65
Jharkhand(Estimated) $	3.83	5.16	6.01	7.02	7.85	8.48	9.15	9.83	10.53	11.29
Orissa	3.25	4.19	4.77	5.36	5.90	6.35	6.81	7.28	7.77	8.29
West Bengal $	8.63	11.04	12.55	13.88	15.21	16.31	17.46	18.64	19.85	21.16
A & N Islands	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.10
Sikkim	0.07	0.09	0.09	0.09	0.10	0.11	0.11	0.12	0.12	0.13
Sub-Total (ER)	17.54	22.63	25.81	28.92	31.82	34.19	36.66	39.19	41.81	44.62
NORTH EASTERN REGION										
Assam	1.20	1.49	1.67	1.80	1.96	2.09	2.23	2.38	2.52	2.68
Manipur	0.09	0.11	0.12	0.12	0.13	0.14	0.15	0.15	0.16	0.17
Meghalaya	0.31	0.39	0.45	0.50	0.55	0.59	0.63	0.68	0.72	0.77
Nagaland	0.10	0.11	0.12	0.13	0.13	0.14	0.15	0.16	0.17	0.18

$ -Estimated

CHAPTER 4
DEMAND PROJECTIONS

4.0 INTRODUCTION

Demand assessment is an essential prerequisite for planning of generation capacity addition and commensurate transmission and distribution system required to meet the future electricity requirement of various sectors of the economy. The type and location of power plants is largely dependent on the magnitude, spatial distribution as well as the variation of electricity demand during the day, seasons and on yearly basis. Reliable planning of capacity addition for future is largely dependent on accurate assessment of future electricity demand.

4.1 DEMAND ASSESSMENT BY CENTRAL ELECTRICITY AUTHORITY- ELECTRIC POWER SURVEY COMMITTEE

Electricity demand of the country is periodically assessed by the Electric Power Survey Committee (EPSC), taking into account the actual electricity demand incident on the system in the past years, planned and under implementation policies and programmes of the Government, various developmental activities projected in future, impact of energy conservation measures, etc. The last exercise to assess the demand was the 18th Electric Power Survey (EPS) and the report of 18th EPS was brought out in December, 2011. The 18th EPS Report covered year-wise electricity demand for States/ UTs, Regions and for the country till the year 2021-22 and perspective electricity demand for the years 2026-27 and 2031-32. The 19th Electric Power Survey Committee (EPSC) was constituted by CEA in June, 2015. The terms of reference of the Committee were as under:

i. To forecast the year- wise electricity demand for each State/ UT, Region and for the country for the years 2016-17 to 2026-27.

ii. To project the perspective electricity demand for each State/ UT, Region and for the country the year 2031-32 and 2036-37.

The Electric Power Survey Committee had wide representation from the stake holders in the power sector with representatives from Niti Aayog, Ministry of Power, Bureau of Energy Efficiency, NTPC, NHPC, REC, BBMB, State Transmission Companies, State Distribution companies, Electricity Departments, TERI, FICCI, CII, NCAER, etc. The 19th EPS report has been brought out in January,2017.

4.2 METHODOLOGY ADOPTED

Partial End Use Method (PEUM) has been adopted to project electricity demand for 19th EPS. Partial End Use Method is a “bottom-up” approach focusing on end-uses or final energy needs of different categories of consumers like domestic, commercial, irrigation, industries, railway traction, etc. Various initiatives of Government of India/State Governments like Power for All (PFA), DSM, energy conservation and efficiency improvement measures, Make in India, etc. have been broadly factored in the electricity demand projection.

4.2.1 Data for Carrying Out Electricity Demand Projection

For carrying out electricity demand projection, the annual electricity data covering category-wise consumption of electrical energy, category-wise connected electric load, T&D losses, mid-year population, number of consumers, number of energized irrigation pump sets, aggregate capacity of irrigation pump sets, etc. from the year 2003-04 had been furnished by the Discoms/Utilities/ Electricity Departments of the States / UTs. Additional information such as programme of reduction in T&D losses, electrification of un-electrified households, irrigation pump sets energisation programme, details of lift irrigation schemes, LT & HT public water works, bulk power supply etc. were also provided by the Discoms/Utilities/ Electricity Departments of the States / Union Territories. Some of the states indicated that the tariff structure for various categories of consumption adopted by their State(s) is different from categories included in the EPS and therefore they have clubbed these under the broad categories while furnishing information to CEA.

State/UT wise annual statements of power supply position brought out by CEA indicating actual electrical energy requirement and availability, peak electricity demand and peak met and the inter-regional and all-India diversity factors were also studied and considered for the demand projection. State/UT wise data of electricity demand for railway traction was provided by Ministry of Railways/Railway Board based on their programme of railway track electrification and expansion plans.

Year-wise electricity demand projection has been carried out for the years 2016-17 to 2026-27 with the year 2015-16 being taken as the base year. Perspective electricity demand projection has been done for the years 2031-32 and 2036-37. The medium/long term projection of electricity demand has been done for 66 Discoms, 36 States/UT's, 5 Regions and for the country. Since some distribution licensees (eg. KESCO, JUSCO etc.) did not furnish the data separately, they have been considered as point load by the main Distribution Licensee.

4.3 POLICY INITIATIVES OF GOVERNMENT AFFECTING ELECTRICITY DEMAND

4.3.1 Reduction of AT&C losses

Programmes for reduction of AT&C losses like Ujjwal Discom Assurance Yojana (UDAY), IPDS, DDUGJY etc. are under implementation by the Government. The target is to reduce AT&C losses to about 13 % by the year 2021-22 on all-India basis. Reduction of AT&C losses would lead to reduction in electricity demand. The losses for Discoms have been taken as per the trajectory of loss reduction given by the respective Discoms.

4.3.2 DSM, Energy Conservation & Efficiency improvement programs

Ministry of Power, Government of India and the State Governments have introduced various programmes for vigorous Demand Side Management (DSM), improvement of energy efficiency and energy conservation measures like S&L (Standards & Labelling), Perform-Achieve-Trade (PAT) scheme in industries, Energy Efficient Lighting solutions, Super-Efficient Equipment Programme etc. There would be reduction in electrical energy requirement and peak electricity demand through implementation of these programs. These initiatives have been factored in the electricity demand projection exercise.

4.3.3 Power for All (PFA) Initiative

Government of India had taken a joint initiative with respective State Governments/UT's for preparation of State/UT specific documents for providing 24X7 Power to all households/homes, industrial and commercial consumers and adequate supply of power to agricultural consumers as per their policy. This initiative aims at ensuring uninterrupted supply of quality power to existing consumers and providing access to electricity to all un-connected consumers by 2019 in a phased manner. This initiative would result in higher growth of electrical energy requirement in the initial years of the forecast period.

4.3.4 Dedicated Freight Corridor

Electricity demand on account of dedicated freight corridor has been factored in the electricity demand of Railways as per information provided by Ministry of Railways/Railway Board based on their programme of railway track electrification and expansion plans.

4.3.5 Make in India

Make in India is an initiative launched by the Government of India to encourage multi-national, as well as national companies to manufacture their products in India. This initiative would lead to growth in electricity demand. The state utilities/Discoms were requested to include the electricity demand due to this programme in their demand projections.

4.3.6 Electric Vehicles

As per the National Electric Mobility Mission Plan 2012 of Department of Heavy Industries, Government of India, the number of electric vehicles in India is likely to be 6 millions by the year 2020 (4 million two wheelers & 2 million four wheelers). The electric vehicles are likely to charge their batteries during day time i.e. during periods of high solar power, when thermal power stations would be running at part load and during off-peak hours in the night after getting back home. This therefore would not lead to any increase in the peak electricity demand.

4.3.7 Roof top solar programme

India has set its renewable energy capacity addition targets to 175 GW by 2022 in view of the significant Renewable Energy potential in the country. This includes 100 GW from solar, 60 GW from wind, 10 GW from biomass and 5 GW from small hydro power. The 100 GW of solar includes 40 GW from solar rooftop. Some of the electricity demand will be met locally through these rooftop solar installations, leading to less requirement from the grid.

The likely impact on electricity demand due to implementation of various initiatives, policies/programmes of Government of India and the States has been suitably incorporated in the electricity demand projection. The State Authorities have indicated that data submitted to CEA for the 19th EPS Exercise have been arrived at by considering the impact of such policies/programmes on the electricity demand of respective Discoms/States/UTs.

4.4 OVERVIEW OF ELECTRICITY DEMAND PROJECTION

4.4.1 Electricity demand projections from 2016-17 to 2026-27 on all-India basis

The electricity consumption on all-India basis during the year 2016-17, 2021-22 and 2026-27 has been assessed as 921 BU, 1300 BU and 1743 BU respectively. The electrical energy requirement on all-India basis during the year 2016-17, 2021-22 and 2026-27 has been assessed as 1160 BU, 1566 BU and 2047 BU respectively. The peak electricity demand has been estimated as 162 GW during the year 2016-17; 226 GW during 2021-22 and 299 GW during the year 2026-27. The electrical energy consumption, T&D losses, electrical energy requirement, peak electricity demand and derived load factor for the years 2016-17, 2021-22 and 2026-27 is summarized in **Table 4.1**.

Table 4.1

Electrical energy consumption, T&D losses, electrical energy requirement and peak electricity demand for the years 2016-17, 2021-22 & 2026-27 on all-India basis as per 19th EPS Report

	Year			CAGR (%)	
	2016-17	2021-22	2026-27	2016-17 to 2021-22	2021-22 to 2026-27
Electrical energy consumption (MU)	920,837	1,300,486	1743,086	7.15	6.03
T&D losses (MU)	239,592	265,537	304,348		
T&D losses (%)	20.65	16.96	14.87		
Electrical energy requirement (MU)	1160,429	1566,023	2047,434	6.18	5.51
Peak Electricity Demand (MW)	161,834	225,751	298,774	6.88	5.77
Derived Load factor (%)	81.85	79.19	78.23		

As evident from **Table 4.1**, CAGR of electrical energy requirement from 2016-17 to 2021-22 works out to 6.18 % and the CAGR of electrical energy requirement from 2021-22 to 2026-27 works out to 5.51 %. The CAGR of electrical energy requirement in the country from the year 2010-11 to 2015-16 has been 5.28 %.

CAGR of electrical energy consumption from 2016-17 to 2021-22 works out to 7.15 % and the CAGR of electrical energy consumption from 2021-22 to 2026-27 works out to 6.03 %. The percentage increase in electrical energy requirement is less than the increase in electricity consumption on account of reduction in T&D losses.

4.4.2 Region-wise electricity demand projection for the years 2016-17, 2021-22 & 2026-27

The region-wise summary of electrical energy requirement and peak electricity demand for the years 2016-17, 2021-22 and 2026-27 is given in **Table 4.2**.

Table 4.2

Region-wise electrical energy requirement & peak electricity demand for the years 2016-17, 2021-22 & 2026-27 as per 19th EPS Report

Region	Electrical Energy Requirement (MU)			Peak Electricity Demand (MW)		
	2016-17	2021-22	2026-27	2016-17	2021-22	2026-27
Northern	356,521	468,196	616,345	55,596	73,770	97,182
Western	352,304	481,501	627,624	50,141	71,020	94,825
Southern	307,047	420,753	550,992	44,782	62,975	83,652
Eastern	128,300	171,228	217,468	20,883	28,046	35,674
North - Eastern	15,876	23,809	34,301	2,810	4,499	6,710
Sub-total (Regions)	1160,048	1565,487	2046,730	161,757	225,643	298,632
A&N Islands	329	475	632	67	97	129
Lakshadweep	52	62	73	10	11	13
All-India	1160,429	1566,023	2047,434	161,834	225,751	298,774

State/UT-wise details of electrical energy requirement (ex-bus) and peak electricity demand for the years 2016-17, 2021-22 and 2026-27 is given at **Annexure-4.1** and **Annexure-4.2** respectively.

The electricity demand projection carried out by the Electric Power Survey Committee, covers electricity demand only for the utility system. The projections do not include the portion of electricity demand of Industries and other consumers that would be met from captive power plants.

4.5 CAPTIVE POWER PLANTS (CPP)

Large number of captive power plants including co-generation power plants of varied type and sizes exist in the country which is either utilized in process industry or for in-house consumption. Some plants are also installed as standby units for operation only during emergencies when the grid supply is not available. Captive power plants including co-generation power plants, therefore play a supplementary role in meeting the country's electricity demand.

4.5.1 Installed Capacity and Electricity Generation from Captive Power Plants

Captive plants over the years have been evolved from plants owned by single promoter to group captive to the medium of maximizing the benefit by selling its surplus power. The Installed Capacity of Captive Power plants (1 MW and above) was 44,657 MW as of 31st March, 2015. The gross electricity generation from captive power plants during the year 2014-15 was 162 BU. Details of the same are given in **Table 4.3**.

Table 4.3

Mode wise installed capacity and electricity generation from Captive Power Plants (1 MW and above as on 31st March, 2015)

Sl. No.	Mode	Installed Capacity (1 MW & above) (MW)	Electricity Generation (MU) in the year 2014-15
1	Hydro	65.09	144.69
2	Steam	26,088.59	1,28,401.06
3	Diesel	13,309.73	12,376.00
4	Gas	5,193.44	21,135.25
	Total	44,656.85	1,62,057.00

4.5.2 Status of Captive Generation- Self Use by the Industry and Electrical Energy exported to the Grid

In view of the thrust being given to captive plants and also due to the liberal provisions of the Electricity Act, 2003, encouraging feeding of surplus electricity into the grid, the captive power plants have also been feeding electricity into the grid. Details of the same are given in **Table 4.4**.

Table 4.4

Installed Capacity of Captive Power Plants, electricity generation and electricity fed into the Grid

	Installed Capacity of Captive Power Plants (MW)	Net Electricity Generation from Captive Power Plants (MU)	Electricity used by industry having CPP for self- use (MU)	Electricity exported to utilities (MU)
2009-10	31,516.87	97,444.67	88,412.33	9,032.34
2010-11	34,444.12	1,10,326.40	96,098.37	14,228.03
2011-12	39,375.37	1,22,524.78	1,12,261.61	10,263.17
2012-13	40,726.39	1,31,511.93	1,15,457.79	16,054.14
2013-14	42,257.87	1,36,301.05	1,22,300.32	14,000.73
2014-15	44,656.85	1,47,468.49	1,34,271.80	13,196.69

With improvement in grid supply, a scenario of grid supply partially replacing the supply from captive power plants has been worked out. **Table 4.5** and **4.6** shows the scenario of forecast of self-use energy which will be met out of CPP generation (MU) from 2016-17 to 2026-27 without any transfer of industrial consumption to the utility grid and the forecast of self-use energy which will be met out of captive generation with transfer of 15% electrical energy from CPP to utility grid in the year 2021-22 and transfer of 25 % electrical energy from CPP to utility grid in the year 2026-27.

Table 4.5
Forecast of energy consumption (self-use) from CPP generation

Year	CPP generation for self-use (MU)	Reduction of Electricity consumed from CPP by transfer to grid supply (%)	Net electricity consumed by industries from CPP after partial transfer to grid supply (MU)
2016-17	1,59,675	0	1,59,675
2021-22	2,34,627	15	1,99,433
2026-27	3,39,382	25	2,54,987

Table 4.6
Forecast of electrical energy requirement considering transfer of electricity consumed by industries from captive power plants to grid supply

Year	Electrical Energy Requirement (Utilities-grid supply) (MU)	Increase of energy requirement by industries from utility grid due to partial transfer of energy consumed from CPP to the utility grid (includes T&D losses) (MU)	Revised electrical energy requirement on all-India basis considering partial transfer of energy consumed by industries from captive power plants to grid supply (MU)
2016-17	11,60,429	**0**	11,60,429
2021-22	15,66,023	**41,163**	16,07,186
2026-27	20,47,434	**97,634**	21,45,068

If 15% and 25% of the electricity consumed by industries from captive power plants is transferred to the utility grid in the years 2021-22 and 2026-27 respectively, it is estimated that additional electrical energy of about 41 BU in the year 2021-22 and 97 BU in the year 2026-27 would be required by industries from the utility grid.

However, since the electricity tariff for industrial and commercial consumers are high at present as these are cross-subsidizing small consumers, it may be cheaper for industrial and commercial consumers to take power from their own captive power plants. Indeed, there has been increasing interest to set up or take equity in captive power plants, signifying a shift away from grid supply. Therefore, the above is not considered as a likely scenario in electricity demand projections.

4.6 CONCLUSIONS

The electrical energy requirement and peak electricity demand on all-India basis has been taken as per the 19th EPS Report to work out the generation capacity addition requirement. The EPS exercise involves all stakeholders and an extensive exercise has been done. Distribution company wise electricity demand projection has been carried out to arrive at the State, region and the all- India electricity demand projection. Electrical energy requirement and peak electricity demand on all-India basis adopted for generation expansion planning exercise is as under:

Year	Electrical Energy Requirement (MU)	Peak Electricity Demand (MW)
2021-22	1566,023	2,25,751
2026-27	2047,434	2,98,774

Annexure- 4.1

STATE-WISE/UT-WISE ELECTRICAL ENERGY REQUIREMENT (UTILITIES) (EX-BUS) (MU)

State/UTs	2016-17	2021-22	2026-27
Delhi	31937	37778	44267
Haryana	48991	63618	85743
Himachal Pradesh	9726	11866	14576
Jammu & Kashmir	14871	18819	25254
Punjab	54118	72392	95658
Rajasthan	73222	91216	126290
Uttar Pradesh	108070	150797	195323
Uttarakhand	13712	19406	26480
Chandigarh	1876	2304	2756
Northern Region	**356521**	**468196**	**616345**
Goa	4236	5593	6932
Gujarat	98376	136159	178693
Chhattisgarh	27167	37840	51088
Madhya Pradesh	68588	99871	125394
Maharashtra	145396	189983	249628
D. & N. Haveli	6550	9343	12373
Daman & Diu	1991	2712	3517
Western Region	**352304**	**481501**	**627624**
Andhra Pradesh	54673	78540	111485
Telangana	52695	84603	104345
Karnataka	66146	85932	110368
Kerala	24622	31371	39357
Tamil Nadu	105923	136643	180989
Puducherry	2990	3664	4448
Southern Region	**307047**	**420753**	**550992**
Bihar	21599	38416	54363
Jharkhand	22847	30649	39252
Odisha	26028	32164	37453
West Bengal	57342	69361	85590
Sikkim	484	638	810
Eastern Region	**128300**	**171228**	**217468**
Assam	8997	14051	20462
Manipur	1240	2103	3300
Meghalaya	2094	2566	3177
Nagaland	815	1129	1524
Tripura	1265	1595	1930
Arunachal Pradesh	886	1498	2601
Mizoram	580	866	1307
North- Eastern Region	**15876**	**23809**	**34301**
Andaman & Nicobar Islands	329	475	632
Lakshadweep	52	62	73
All- India (Electrical Energy Requirement)	**1160,429**	**1566,023**	**2047,434**

Annexure-4.2

STATE-WISE/UT-WISE PEAK ELECTRICITY DEMAND (UTILITIES) (MW)

State/UTs	2016-17	2021-22	2026-27
Delhi	6318	7471	8751
Haryana	9428	12222	16451
Himachal Pradesh	1555	1898	2331
Jammu & Kashmir	2278	3095	4482
Punjab	11551	14886	18809
Rajasthan	11535	14435	20131
Uttar Pradesh	16067	23664	31064
Uttarakhand	2153	3180	4538
Chandigarh	400	491	587
Northern Region	**55596**	**73770**	**97182**
Goa	624	858	1096
Gujarat	15373	21429	28387
Chhattisgarh	4348	6208	8518
Madhya Pradesh	10766	15676	19682
Maharashtra	20446	28866	39828
D. & N. Haveli	861	1291	1798
Daman & Diu	313	426	553
Western Region	**50141**	**71020**	**94825**
Andhra Pradesh	8245	11843	16820
Telangana	8300	14499	18653
Karnataka	10895	14271	18481
Kerala	4131	5263	6603
Tamil Nadu	15412	20273	27392
Puducherry	476	583	708
Southern Region	**44782**	**62975**	**83652**
Bihar	3607	6576	9308
Jharkhand	3905	5193	6626
Odisha	4306	5340	6273
West Bengal	10383	12688	15680
Sikkim	129	170	216
Eastern Region	**20883**	**28046**	**35674**
Assam	1550	2713	4166
Manipur	232	410	667
Meghalaya	399	488	605
Nagaland	166	234	322
Tripura	297	391	495
Arunachal Pradesh	164	278	482
Mizoram	118	171	252
North Eastern Region	**2810**	**4499**	**6710**
Andaman & Nicobar Islands	67	97	129
Lakshadweep	10	11	13
All - India (Peak Electricity Demand)	**161,834**	**225,751**	**298,774**

CHAPTER 5

GENERATION PLANNING

5.0 INTRODUCTION

Electricity is one of the key enablers for achieving socio-economic development of the country. Amongst various modes adopted for meeting the ever increasing demand of power to achieve the targeted growth rate, Generation capacity augmentation is the most vital component. The economic growth leads to growth in demand of power. To meet this demand, in view of the limited available fuel resources for generation, capacity addition has to be planned very optimally.

During the 12th Plan (2012-17), a capacity addition of 99,209 MW was commissioned against target of 88,537 MW from conventional sources. It is for the first time in the history of the Indian power sector that such a large capacity addition during a single plan period was achieved which is 112 % of the target. During 11th plan the achievement in capacity addition was 69.84% of the target.

This chapter highlights the Principles and Methodology of Generation Planning adopted to assess the capacity addition required from conventional energy sources by the end of year 2021-22 and 2026-27. Capacity addition target from non-conventional energy resources has also been considered.

5.1 OPTIONS FOR POWER GENERATION IN INDIA

Coal is the major source for power generation in our country and since Low Carbon Growth Strategy has to be followed, other generation options need to be harnessed in the most optimum manner.

Fuel Options available for Power Generation are:

- Conventional Sources – Coal and lignite, Hydro, Nuclear, Natural gas
- Non-Conventional Renewable Energy Sources- Solar, Wind, Biomass, small hydro, tidal, Geothermal, Waste to energy, Hydrogen/ fuel cells, etc.

5.2 GENERATION FROM CONVENTIONAL SOURCES IN INDIA

5.2.1 Hydro

Total Hydro Electric Power potential in the country was assessed as 84,044 MW (at 60% load factor) from a total of 845 number of identified Hydro Electric Schemes, which when fully developed would result in an installed capacity of about 1,48,701 MW on the basis of probable average load factor. The total energy potential is assessed as 600 billion units per year. Hydropower is used to its maximum potential for meeting peak loads and all new projects must be designed with this objective in mind. However, the full development of India's hydro-electric potential, while technically feasible, faces various issues including issues of water rights, resettlement of project affected people and environmental concerns etc. and all these issues need to be resolved to exploit full potential. As on 31.03.2017, the installed capacity of hydroelectric power plants in the country was 44,478 MW which is 13.6% of the total installed capacity of the country.

5.2.2 Nuclear

Presently, Nuclear Power Corporation India Limited is operating 21 reactors with an installed capacity of 6,680 MW. Out of these 21 reactors, presently 13 reactors with an installed capacity of 4,280 MW are under IAEA Safeguards and use imported fuel. Remaining 8 reactors with an installed capacity of 2,400 MW use indigenous fuel. In addition to above, a 100 MW PHWR RAPP 1 is under long term shutdown since 2004. As on 31.03.2017, the installed capacity of Nuclear power plants in the country was 6,780 MW which is 2.1% of the total installed capacity of the country.

5.2.3 Gas

Addition of gas based capacity is considered necessary to reduce CO_2 emissions and to utilise their capability to fast ramp-up and ramp-down. The advantage of fast ramping capability becomes more important in view of large scale integration of renewable energy. Modern combined cycle gas turbines (CCGTs) have high efficiency of around 55% as compared to coal based plants (Gross efficiency of supercritical units is about 40%). Gas turbines/Engines could be located near the load centre with a view to minimize the requirement of transmission system and could be operated in a manner so as to maximize the output during the peak hours and minimize during the off-peak hours.

However, the production and supply of gas had not been keeping pace with the growing demand of natural gas in the country, including power sector. The gas supply for gas based power stations in the country is inadequate and the country is facing huge generation loss. Presently, existing gas based power plants are operating at very low PLF of about 23% and few gas based power plants are lying idle due to non-availability of domestic natural gas.

As on 31.03.2017, the installed capacity of gas based power stations was 26,167 MW (including liquid based) which is 8 % of the total installed capacity of the country.

5.2.4 Coal/Lignite

Coal based power generation is backbone of Indian Power sector and will continue to dominate power generation in the country. Due to environmental concerns, clean coal technologies such as supercritical technology has been adopted. Capacity totalling to about 35,230 MW based on Super critical technology has been commissioned during 12th plan.

Lignite is available at limited locations such as Neyveli in Tamil Nadu, Surat, Akrimota in Gujarat and Barsingsar, Palana, Bithnok in Rajasthan. Since, lignite is available at a relatively shallow depth and is non-transferable, its use for power generation at pithead stations is found to be attractive.

The coal based installed capacity was 1,92,162.88 MW as on 31.03.2017 which was almost 58.8% of the total installed capacity of the country.

5.3 GENERATION FROM RENEWABLE ENERGY SOURCES

The installed capacity from renewable energy sources was 57,244 MW as on 31.03.2017. Share of Renewable Energy Sources (RES) in the total installed capacity was about 17.5 %. However, the share of renewables will substantially increase in coming years due to major thrust given by Government of India in promoting Renewable energy sources on account of these sources being clean and green energy.

India is one of the best recipient of solar energy due to its location in the solar belt and has vast solar potential of 749 GW for power generation. Also, India has substantial wind potential of 103 GW due to its long coastline. Based on the availability of biomass, the potential of power generation from bio mass has been assessed as around 25 GW. Small hydro of capacity up to 25 MW has a power generation potential of around 20 GW.

However, generation from renewable energy sources especially solar and wind is variable in nature and therefore, requires huge balancing capacity in the system.

5.4 PRINCIPLES OF GENERATION PLANNING

The major aspects considered in planning process are:

- To achieve sustainable development.
- Power Generation Capacity to meet the demand pattern.
- To fulfil desired operational characteristics of the system (to meet varying demand) such as reliability and flexibility.
- Most efficient use of resource i.e. adoption of latest technological advancements in coal based generation, etc.
- Fuel availability.
- Integration of Non Dispatchable Renewable Energy Sources.

The above aspects have been considered within realms of feasibility, while drawing up this National Electricity Plan along with the economics and the status of the various projects.

5.4.1 Sustainable Development

The importance and relevance of power development within the confines of Clean and Green Power is the most essential element. Such a development depends upon the choice of an appropriate fuel / technology for power generation. Accordingly, the Plan takes into account the development of Hydro projects and projects based on renewable energy sources as well as other measures and technologies promoting sustainable development in the country.

5.4.2 Operational Flexibility and Reliability

Generating units utilising different fuels have different operational characteristics. The fuel sources and their respective technologies of power generation are multiple and varied. The demand of our electric system varies with time of the day, season, year and the spatial location. Therefore, matching the generation with demand at all instances of time requires not only installation of adequate capacity but also to be sensitive to the type of generation capacity, each with its unique characteristics of altering its output and the time taken to do so. Accordingly, this requirement of the system also needs to be considered when deciding upon the type of generation. It is, therefore, necessary to widen the scope of the planning process to take into account aspects of ‘reliability’ and ‘quality’ of power, apart from the adequacy and quantum of power.

5.4.2.1 Reliability of Power

Reliable power system operation requires constant balancing of supply and demand in accordance with established operating criteria such as maintaining system voltages and frequency within acceptable limits. Changes in customer demand and generation from renewable energy sources throughout the day and over the seasons are met by controlling generation from conventional sources when needed.

To achieve reliability in the system, adequate reserve capacity, spinning as well as non-spinning, needs to be planned in the system. Aspects related to the operation, ownership, modalities and nature of reserves also need to be determined.

The National Electricity Policy,2005 stipulates creation of spinning reserve of 5% in our system. This has been considered while planning capacity addition requirement during the years 2017-22 and 2022-27.

5.4.2.2 Flexibility of operation

A system that is designed for base-load generation may lack the characteristics to respond dynamically or efficiently to the variation in demand within a short time. Apart from variation in demand, there is expected to be wide variability in generation from renewable energy plants. Since system stability requires matching of generation with the demand at any instance of time, a certain degree of flexibility in terms of ability of the generators to respond rapidly to the changing demand and generation from renewable energy sources must be introduced into the system through appropriate power generating plants and financial mechanism. System should also be able to meet additional demand which arises due to unexpected demand fluctuations and sudden outages of some generating units.

5.4.3 Efficient Use of Resources

The fossil fuels for power generation are scarce and must therefore be used most judiciously. From the point of view of environment also, it is essential that energy produced per kcal of fuel is maximum to the extent possible. This would minimize the pollution caused during the process of power production.

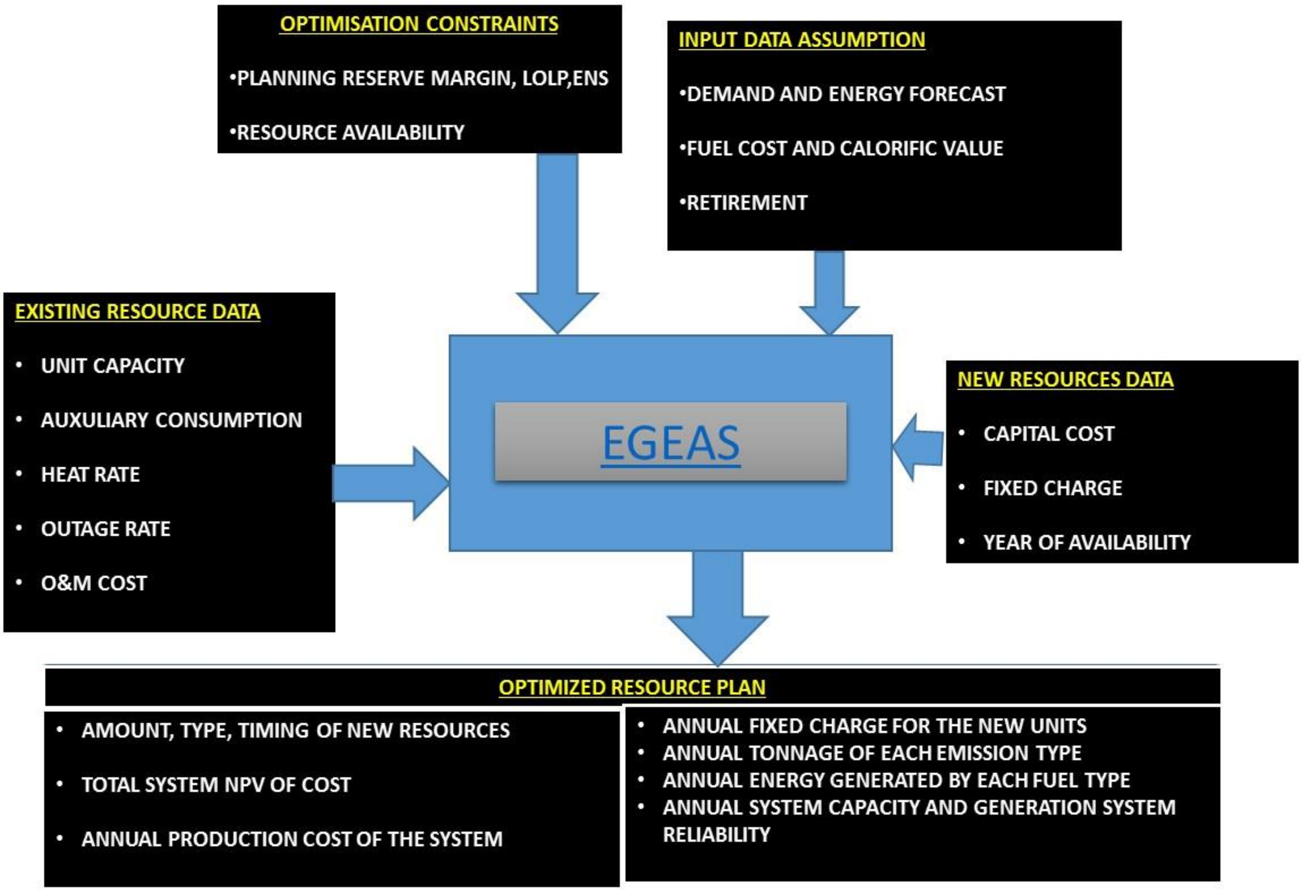
5.5 PLANNING TOOLS - DETAILS OF PLANNING MODELS

Generation expansion studies have been carried out in CEA using the computer software model “Electric Generation Expansion Analysis System” (EGEAS). Salient features of the Planning model are discussed below.

The Electric Generation Expansion Analysis System (EGEAS) is a software package for expansion planning of an electric generation system. In this planning model the operation of the power system is simulated probabilistically. The load on the power system is represented both in terms of magnitude and time variation. The model yields the reliability indices, namely the **Loss-Of-Load-Probability (LOLP),** the expected value of **Energy-Not-Served (ENS),** and the reserve margin for an expansion power plan by minimizing the objective function which is the present worth of 1) the costs associated with operation of the existing and committed generating stations 2) the annualized/ levelised capital cost and operating cost of new generating stations and 3) cost of energy not served. The EGEAS model is capable of giving a number of expansion plans along with their objective functions and the reliability indices for such plans. The optimal power plan is that plan for which the reliability indices are satisfied in accordance with criteria laid down by the planner, and the objective function is the lowest.

The EGEAS model, being essentially deterministic in nature, provides for long range generation expansion planning as it yields very useful quantitative measures of reliability of power supply several years into the future, and at the same time gives an indication of the total cost of operating the existing and committed generating stations and installing and operating the new generating stations. Block Diagram showing various data flows is shown in **Exhibit 5.1.**

Exhibit 5.1



Subsequently, the study results were validated using another generation expansion planning model namely ORDENA . The ORDENA model has following capabilities: -

• The model performs Generation Expansion Planning, Production Costing and also has the capability of modeling renewable energy sources through generation expansion planning.

• The model optimizes transportation of fuel, transmission of power and emissions from power plants while addressing system reliability issues like Loss of Load Probability(LOLP) and Energy Not Served(ENS). The software also does hour-by-hour simulation while recognizing the constraints of dispatch on generation imposed by the transmission system.

• The model has the capability of carrying out All-India studies as well as studies for each State/UT considering import/export of power from one state to another state.

5.6 PLANNING APPROACH

Planning approach has been to meet the peak demand and energy requirements. In view of generation being delicensed and high capacity addition programme from Renewable Energy sources, it becomes imperative to plan for more optimal mix of base-load capacities, peaking capacity and reserve capacities. The base load capacities will take care of 'bulk-power' requirement, while the others will provide the system operator with sufficient reserve capacity and a valuable tool to take care of intermittency of renewable generation, seasonal spikes or time-of-day variations – expected and unexpected in electricity demand. The dynamic response characteristics of such a balanced system would be far superior and would contribute to higher reliability.

As unscheduled intra and inter-regional transfers would pose challenges and therefore a right mix of base load and flexible generating units must preferably be determined and planned for, at the level of the State grid itself. This will ensure the most rapid, real-time response to local peaking needs and variation in generation from RES.
The Planning Approach followed is in the following sequence:

5.6.1 All India Peak Demand and Energy requirement forecast

Generation expansion planning studies have been carried out based on the Electricity demand assessed by the 19th Electric Power Survey (EPS) Report. The estimated peak demand (MW) and Energy requirement (BU) in the years 2021-22 and 2026-27 are given in **Table 5.1**.

Table 5.1
Projected Electricity Demand (as per 19th EPS)

Year	Energy Requirement (BU)	Peak Demand (GW)
2021-22	1566	225.751
2026-27	2047	298.774

5.6.2 Preparation of All India Load profile

The demand data was collected for past three years (2011-12, 2012-13 and 2013-14) on hourly basis (8760 hrs) from various Regional Load Dispatch Centres. The hourly data was analysed and corrected for any discrepancies in terms of load shedding, frequency correction, scheduled power cuts and any data errors. Further, All India Load profile for the year 2021-22 and 2026-27 was generated based on respective projected Peak Demand and Energy Requirement.

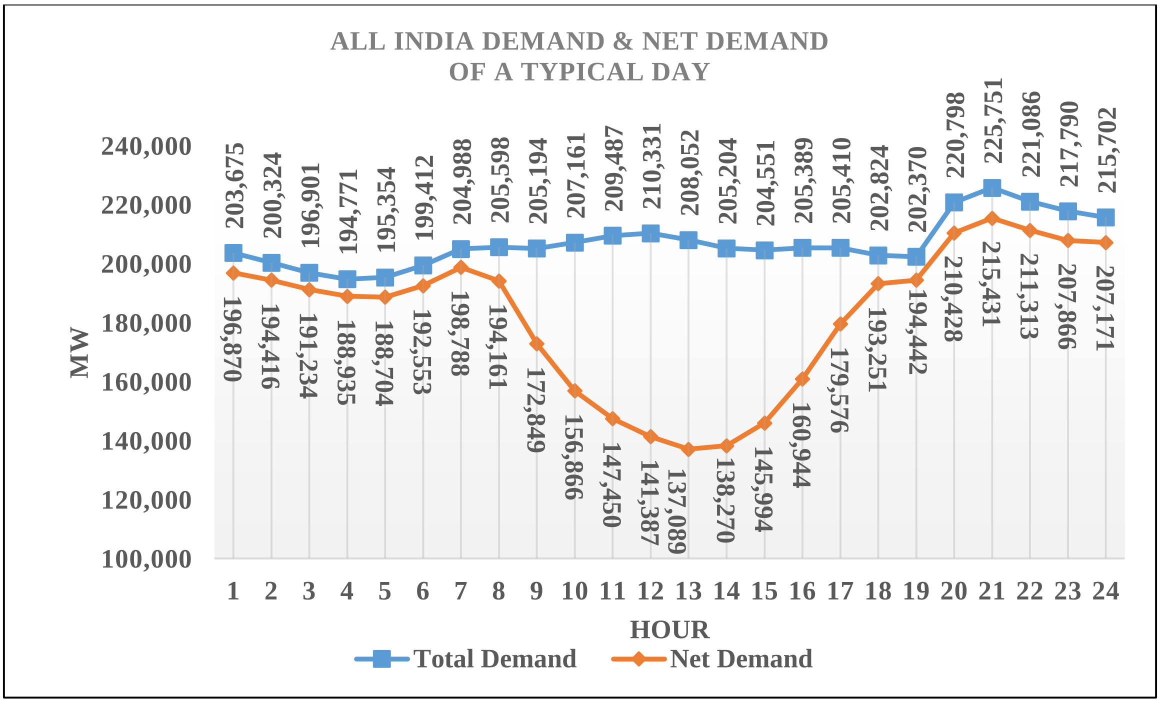
In view of the massive capacity addition programme from renewable energy sources (Solar and wind) during the years from 2017-18 to 2021-22, the All India Net load curve was obtained from the All India Load profile by treating generation from renewable energy sources as negative load.

The methodology adopted for arriving at "All India Net load curve" is as follows:

1) Collection of latest available hourly generation profile data for 8760 hrs of existing solar and wind power projects of various States.
2) Estimating Hourly generation profile data for States where profile was not available by taking inputs from various studies carried out by MNRE.
3) Normalising Hourly generation profile of Solar and Wind plants.
4) Scaling up the hourly generation by proposed capacity addition of each State/UTs including solar rooftops.
5) Aggregating the hourly generation profile of all the States where Solar and Wind power capacity addition is envisaged.
6) Generate All India Net hourly load profile by treating renewable energy generation as negative load.

All India hourly load profile and Net load curve (Duck Curve) is shown in **Exhibit 5.2**.

Exhibit 5.2



Based on the All India load profile and All India Net Load Curve, projected All India Load Duration curve and All India Net Load Duration curve have been generated and are shown in **Exhibit 5.3** and **Exhibit 5.4** respectively.

Exhibit 5.3

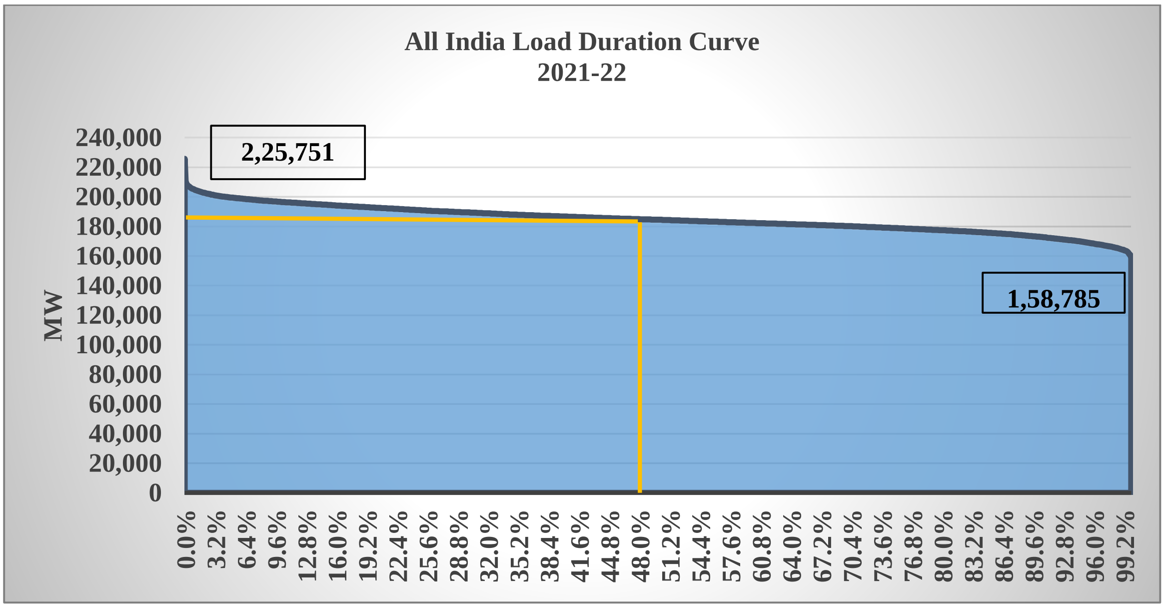
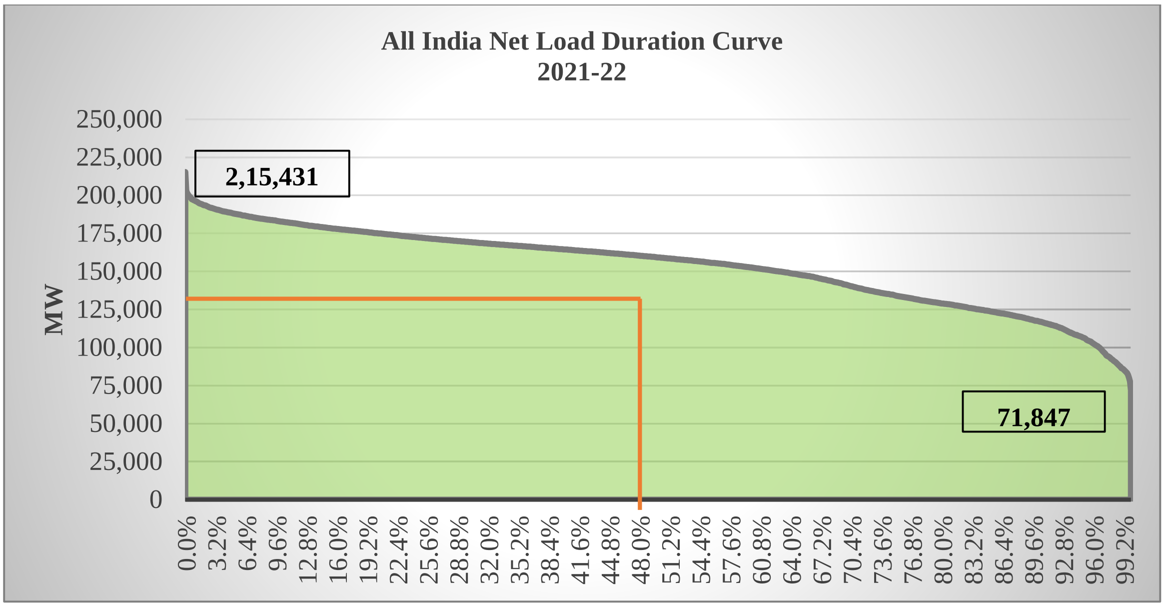


Exhibit 5.4



From **Exhibit 5.4**, it is seen that the system becomes peakier in view of large capacity addition from renewable energy sources.

5.6.3 Reserve capacity

As stipulated by National Electricity Policy 2005, 5% Spinning Reserve is to be provided. The requirement of this Reserve Capacity has been incorporated in the studies by correspondingly reducing availability of conventional plants by 5%. It has been estimated that the likely installed capacity in 2021-22 would be around 479 GW. Of this, RES will contribute around 175 GW. Therefore, 304 GW may be the likely installed capacity from the conventional sources of this, i.e. 15 GW, has been kept as reserve capacity, while doing the Generation Planning.

5.6.4 Generation Expansion Studies

The All India Net load curve has been used to carry out generation expansion studies by EGEAS Software. The estimated energy generation and contribution towards Peak Demand from RES (Solar + Wind) has been reduced from projected Energy requirement and Peak Demand figures as only net load is required to be met through conventional energy sources.

Hydro and Nuclear projects were accorded priority and considered as must run projects on account of their inherent advantages. However, due to non-availability of natural gas, gas based power plants have been restricted to lower PLF. The studies result in the capacity addition requirement of coal based projects to meet the projected Energy requirement and Peak demand considering given reliability criteria.

5.6.5 Retirement of old thermal units

Information was compiled in respect of old thermal power plants which have already retired and plants likely to be considered for retirement in future.

In the base case scenario, a coal based capacity of 22,716 MW (5,927 MW + 16,789 MW) is considered for retirement during 2017-22. This is based upon the assessment made by CEA which consists of 5,927 MW of capacity assuming that the normal trend of past retirement process would continue along with a coal based capacity of 16,789 MW which doesn't have space for installation of FGD (Flu Gas Desulphurization) system to curb SOx emissions. The list of these units considered for retirement during 2017-22(22,716 MW) is placed at Annexure 5.5 and Annexure 5.5(A) respectively.

Additionally, a coal based capacity of 25,572 MW, has been considered for retirement during 2022-27 which will be completing 25 years of operation by March,2027. The list of these units is given in Annexure 5.6.

5.7 NORMS ADOPTED FOR RELIABILITY CRITERIA

The Power System is planned to meet the forecasted demand while ensuring an expected level of reliability. Reliability is a measure of the ability of a system to perform its designated function under the designed conditions. In our Studies, Loss of Load Probability (LOLP) is the criteria adopted to reflect the capacity of the system to meet the peak load and Energy Not Served (ENS) to reflect the Energy Requirement not met in the System. LOLP is the probability that a system will fail to meet its peak load under the specified operating conditions. It is the proportion of days per year or hours per year when the available generating capacity is insufficient to serve the peak demand. This index is dimensionless and can also be expressed as a percentage.

ENS is the expected amount of energy which the system will be unable to supply to the consumers as a fraction of the total energy requirement. This index again is dimensionless and can also be expressed as a percentage. In other words, this indicate as to how many units of energy requirement in a year are not met and correspondingly how many hours in a year the power demand is not met. Various countries in the world have adopted their own Reliability Criteria depending upon the status of their power system and the price affordability of the consumers to pay for the reliability of the system. It is evident that a more stringent and reliable system would yield higher cost of electricity which has to be borne by the consumer. Details of LOLP adopted in some countries are as given in **Table 5.2**.

Table 5.2
LOLP of some countries

Name of country	LOLP(%)
Cambodia	1.8
Laos	0.27
Thailand	0.27
Vietnam	0.27
Hong Kong	0.006
Belgium	0.2
USA	0.03
China	0.14

Source: Information collected from websites of above countries.

As proposed in previous National Electricity Plan, LOLP of 0.2% and the Energy Not Served (ENS) of 0.05% has been adopted for preparation of this National Electricity Plan (NEP).

5.8 PLANNING NORMS

The planning studies require accurate performance parameters of various types of generating units to assess their availability and energy generation capabilities. The peaking availability and energy generation capacity are important parameters for meeting the projected demand of the country including various regions. The key performance factors required for the planning studies are the auxiliary power consumption, heat rate, capital cost of the generating units, fuel cost, gross calorific value, O&M schedules, etc. Different types of generating units have varied operational performance and accordingly different norms have been used for thermal (coal and lignite), combined cycle gas projects, hydro and nuclear projects. The generation planning norms for different sizes of thermal units are different. Accordingly, separate categories based on unit sizes have been derived. Many higher size units of 660 MW and 800 MW have been commissioned and have been treated as separate groups. Combined Cycle Gas Turbines (CCGT) are very efficient and have lower heat rates, however, their availability and PLF depend on the availability of natural gas. The energy of the hydro units has been taken on the basis of the designed energy of the project in 90% dependable year. The peaking availability, auxiliary power consumption, heat rate for various types of generating units, as considered in the expansion planning studies are given in **Table 5.3**, **Table 5.4** and **Table 5.5**.

5.8.1 Peaking Availability

The peaking availability (gross) of the various types of generating units is given in **Table 5.3.**

Table 5.3
Peaking availability (Gross) of the Generating units

(Figures in %)

	Unit Size	Existing Units	Future Units
Thermal (Coal)	800/660 MW	88	88
	500/250/210/200 MW	85	85
	Below 200 MW	75	85
	Below 200 MW operating below 20 % PLF at present	50	-
Gas Based	OCGT all sizes	90	90
	CCGT all sizes	88	88
DG Sets	All sizes	75	75
Lignite Based	All sizes	80	80
Nuclear	All sizes	68	68
Hydro	All sizes	87.5	87.5

5.8.2 Auxiliary Power Consumption

The auxiliary consumption of various types of generating units are given in **Table 5.4.**

Table 5.4
Auxiliary Consumption of Generating Units

(Figures in %)

I	**Coal Based Power stations**	**Auxiliary Power Consumption**
1.	**800/660 MW class units**	5.75
2.	**500 MW class units**	5.75
3.	**300/250/210/200 MW class units**	9
4	**Below 200 MW units**	9
5	**Lignite based units**	10.5 for <200 MW 9 for >200 MW
II	**Gas Based Power Stations**	
1	**Combined cycle**	2.5
2	**Open cycle**	1.0
3	**DG sets/Gas Engines**	1.0
III	**Hydro Power Stations**	0.7
IV	**Nuclear Power Stations**	
	160 MW BWR	9
	220 MW PHWR	10.5 to 11.75
	540 MW PHWR	10.2
	1000 MW LWR	7.8

5.8.3 Machine Heat Rate

The machine heat rates (gross) for various thermal units are given in **Table 5.5.**

Table 5.5
Heat Rates (Gross) of Thermal Units

(Figures in Kcal/kWh)

Unit Size	Gross Heat rate (kcal/kWh)
800 MW (Coal)	2225
660 MW (Coal)	2250
660MW(Sipat+Barh) (Coal)	2300
500 MW (Coal)	2365
200/210/250 MW KWU(Coal)	2400
200/210/250 MW LMZ(Coal)	2500
110 MW (Coal)	2500
250/210/ MW (Lignite)	2580
Below 150 MW (Lignite)	2600
Combined cycle Gas turbine	2000
Open cycle Gas turbine/DG Sets	2900
Combined Cycle Gas Engines	2000

5.8.4 Financial Parameters

Table 5.6
Financial Parameters

(Figures in %)

S.NO	ITEM	VALUE
1	DEBT - % OF CAPITAL COST	70
2	EQUITY - % OF CAPITAL COST	30
3	INTEREST ON DEBT	11.5
4	RETURN ON EQUITY	15.5+Tax
5	DISCOUNT RATE	9.0
6	O&M CHARGES POWER PLANT	As per latest CERC norms
7	DEPRECIATION - POWER PLANT	5.28 for 12 years

5.9 GENERATION EXPANSION PLANNING DURING THE YEARS 2017-22 AND 2022-27 (BASE CASE)

A Study using Computer Model Electric Generation Expansion Analysis System (EGEAS) programme was carried out to assess the installed capacity required to meet the demand projections and projected All India Net load curve for the year 2021-22 and 2026-27. The Studies are based on the following assumptions:

- **Electricity Demand projections considered**

Table 5.7.1

Electricity Demand Projections for 2021-22

Year	Energy Requirement (BU)	Peak Demand (GW)
(Demand CAGR: 6.18%)		
2021-22	1566	225.751
(Demand CAGR: 7.18%)		
2021-22	1641	236.602

Table 5.7.2

Electricity Demand Projections for 2026-27

Year	Energy Requirement (BU)	Peak Demand (GW)
2026-27	2047	298.774

- **Installed Capacity from conventional and renewable sources as on 31.03.2017**

Table 5.8

Installed Capacity as on 31.03.2017

(Figures in MW)

Source	Installed Capacity as on 31.03.2017
Coal	1,92,163
Gas	26,167
Total Thermal	**2,18,330**
Hydro	44,478
Nuclear	6,780
Total Conventional	**2,69,588**
Solar	12,289
Wind	32,280
Others	12,675
Total RES	**57,244**
Total	**3,26,832**

- Capacity addition from conventional energy sources during 12th Plan (2012-17) is **99,209 MW**. (Thermal 91,730 MW, Hydro, 5479.02 MW and Nuclear 2,000 MW).
- As per CEA assessment a coal based capacity of 9,456.5 MW could be retired by the end of 2022 out of which a capacity of 3,530 MW has already been retired. The remaining capacity of 5,927 MW has been considered for retirement by March,2022. Further, a coal based capacity of 16,789 MW (101 units) (as on August,2017) not having sufficient space for installation of FGD to control SOx emissions has been identified. In view of the latest

environmental norms by MoEF, this capacity may have to be retired by 2022. The list of units considered for retirement during 2017-22 is placed at **Annexure 5.5**, **Annexure 5.5(A)** respectively.

- Additionally, a capacity of 25,572 MW shall be completing more than 25 years of their age by 2027 and would have outlived their utility. This capacity of 25,572 MW has been considered for retirement during 2022-27. The list of units considered for retirement during 2022-27 is placed at **Annexure 5.6.**

Table 5.9
Retirement of Coal Based Units

Years	Coal Capacity Retired (MW)
2017-22	22,716
2022-27	25,572

- Studies have been carried out corresponding to RES installed capacity of 1,75,000 MW, by 2021-22 as shown in **Table 5.10** below:

Table 5.10
Expected RES Capacity addition from 2017-22

(All figures in MW)

RES Category	Target RES IC as on 31.03.2022	RES Installed Capacity as on 31.03.2017	Expected RES Capacity addition from 2017-22
Solar	1,00,000	12,289	87,711
Wind	60,000	32,280	27,720
Biomass	10,000	8295	1,705
Small Hydro	5,000	4380	620
Total	**1,75,000**	**57244**	**1,17,756**

Anticipated capacity addition from renewable energy sources during 2022-27 is considered to be of **1,00,000 MW** (**50,000 MW** – Solar, **40,000 MW** Wind, **7,000 MW** Biomass and **3,000 MW** Small Hydro)

- The likely generation considered from Variable Renewable Energy Sources (Solar and Wind) by the end of 2021-22 and 2026-27 is given in **Table 5.11** below:

Table 5.11
Expected RES based Generation

RES Category	Generation (BU) (2021-22)	RES energy contribution (%)	Generation (BU) (2026-27)	RES energy contribution (%)
Solar	162	10.3	243	11.9
Wind	112	7.2	188	9.1
Bio mass & SHP	52	3.3	87	4.3
Total	**326**	**20.1**	**518**	**24.4**

- **5% spinning reserve** as stipulated by National Electricity Policy.
- Reliability Criteria - Loss of Load Probability **(LOLP) ≤ 0.2%** and Energy Not Served **(ENS) ≤ 0.05%.**
- Priority given to hydro projects followed by nuclear and gas based projects.
- Seasonal Studies have been carried out with a view to ensure demand being met in all the seasons.
- Projects of various fuel types considered to be committed in the study during 2017-22 and 2022-27 are given in the **Table 5.12** below:

Table 5.12
Committed Units

(All Figures in MW)

Year	Hydro(MW)	Gas(MW)	Nuclear(MW)	Hydro Import(MW)
2017-22	6,823	406	3,300	4,356
2022-27	12,000	0	6,800	17,244

- **Likely Capacity Addition**

a) Hydro

Considering the status of various hydro projects, a hydro capacity addition of about 6,823 MW is likely during the years 2017-22. Details of hydro projects are furnished in **Annexure 5.1.**
Additionally**,** hydro projects totalling to 12,000 MW have been considered for likely benefit during the years 2022-27**.**
The hydro projects have been considered as must run in the studies in line with our Low Carbon Growth Strategy.

b) Nuclear

A nuclear capacity addition of 3,300 MW has been considered for the period 2017-22 as per the information furnished by DOAE. Details are furnished at **Annexure 5.2.**
A nuclear capacity addition of 6,800 MW during the years 2022-27 has been considered as per the programme of Department of Atomic Energy. Details are furnished at **Annexure 5.3.**

c) Thermal

➢ **Gas Based Plants**
In view of acute shortage of natural gas in the country, many gas based power plant are running at very low Plant Load Factor. A capacity of around 406 MW is ready for commissioning/under construction but stranded due to non-availability of natural gas. The plants have been considered available during the year 2017-22 for the purpose of studies. Also, as the availability of gas is uncertain, no additional gas based projects have been considered during the year 2022-27.

➢ **Coal based Plants**
The balance capacity (after considering the committed capacity addition from hydro, nuclear, gas and RES) to meet the projected demand is proposed to be met from coal based power plants.

- **Imports:**
As shown in Table 5.12, the electricity hydro imports from neighbouring countries during 2017-22 are expected to be **4,356 MW**. The list of these projects is placed at **Annexure 5.7**. Net electricity (Hydro) imports from neighbouring countries during 2022-27 are given in the **Table 5.13** below:

Table 5.13
Hydro Imports and Exports till 2026-27

(All figures in MW)

	Bangladesh	Nepal	Pakistan	Bhutan	Total
Export	1,500	400	500		**2,400**
Import		10,000		14,000	**24,000**
Net Imports					**21,600**

5.10 RESULTS OF GENERATION EXPANSION PLANNING STUDIES FOR THE PERIOD 2017- 22 AND 2022-27

The studies were carried out to assess the total capacity addition requirement to meet the projected demand in the year 2021-22 and 2026-27 with the assumptions mentioned in para 5.9. Hydro, Gas and Nuclear based capacity are given the foremost priority due to their inherent advantages towards a Low Carbon Growth Strategy. Therefore, capacity from these sources which is likely to materialise during the year 2017-22 and 2022-27 has been considered as must run in the various scenarios. Renewable capacity has also been considered as must run capacity.

Details from the study results, with energy generated by coal based power plants, their average PLF (with likely capacity addition of 47,855 MW from coal based power plants (**Annexure 5.4**), already under construction, for benefits during 2017-22) are shown in the **Tables 5.14(a), (b)** and **(c)** given below**.**

Table 5.14(a)

Committed Capacity Addition during 2017-22 and 2022-27

Years	Committed Capacity Addition (MW)			Committed RES Installed Capacity(MW)	Retirement (MW)
	Hydro	Nuclear	Gas		
2017-22	6,823	3,300	406	1,75,000 (By Mar'22)	22,716
2022-27	12,000	6,800	0	2,75,000(By Mar'27)	25,572

With this committed capacity addition, retirements, etc., the additional coal based capacity required by 2021-22 and 2026-27 to meet the peak demand and energy demand would be as follows:

Table 5.14(b)

Capacity Addition Required During 2017-22 and 2022-27

Year	Additional coal based Capacity required(MW)	Remarks
2017-22	6,445	Since 47,855 MW are under different stages of construction and are likely to materialise during 2017-22, so no additional capacity is required.
2022-27	46,420	This is in addition to 47,855 MW of coal based capacity which is in different stages of construction and is likely to materialise during 2017-22.

Table 5.14(c)

Energy Generated from coal and Average PLF of coal based stations

Years	Coal Based Generation (Gross) (GWh) +++	PLF of Coal Based Plants (%)*
2021-22	1,072	56.5
2026-27	1,259	60.5

* PLF has been computed with capacity addition of 47,855 MW from coal based power plants which is under construction and likely to yield benefits during 2017-22,

+++ Auxiliary Power consumption of coal stations as 6.5% has been assumed to arrive at gross generation.

It may be seen from study results shown in Table 5.14 that out of the Coal based capacity of 47,855 MW at various stages of construction and is likely to be commissioned during 2017-22 only 6,445 MW capacity would be required along with committed capacity addition of Hydro 6,823 MW, Gas 406 MW, Nuclear 3,300 MW, RES 1,17,756 MW and considering a retirement of coal based capacity of 22,716 MW.

The overall PLF of coal based capacity during 2021-22 is likely to be 56.5%. However, the plant wise PLF may vary as shown in the **Exhibit 5.5** and **5.6** below.

Exhibit 5.5

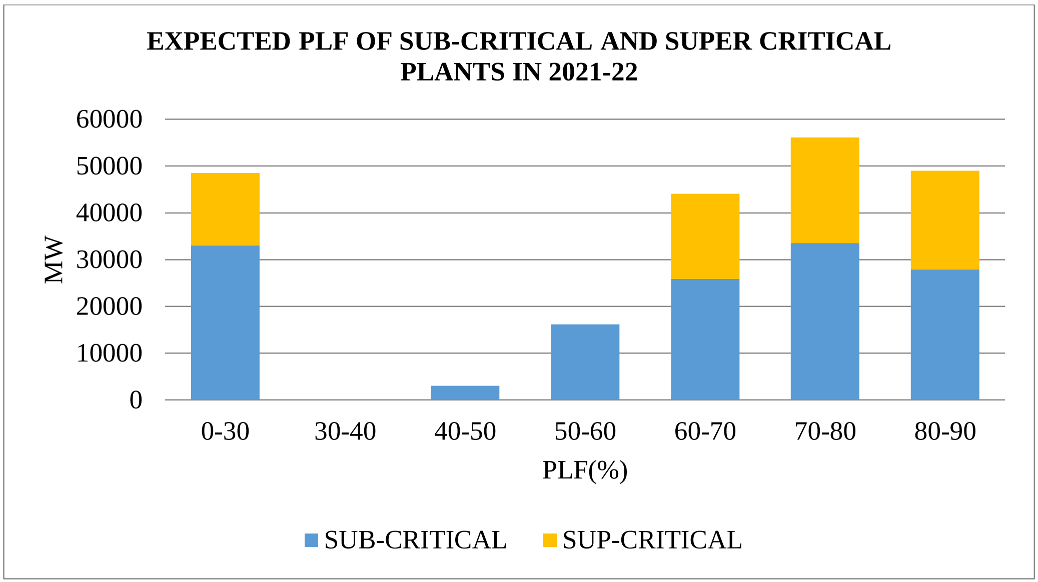
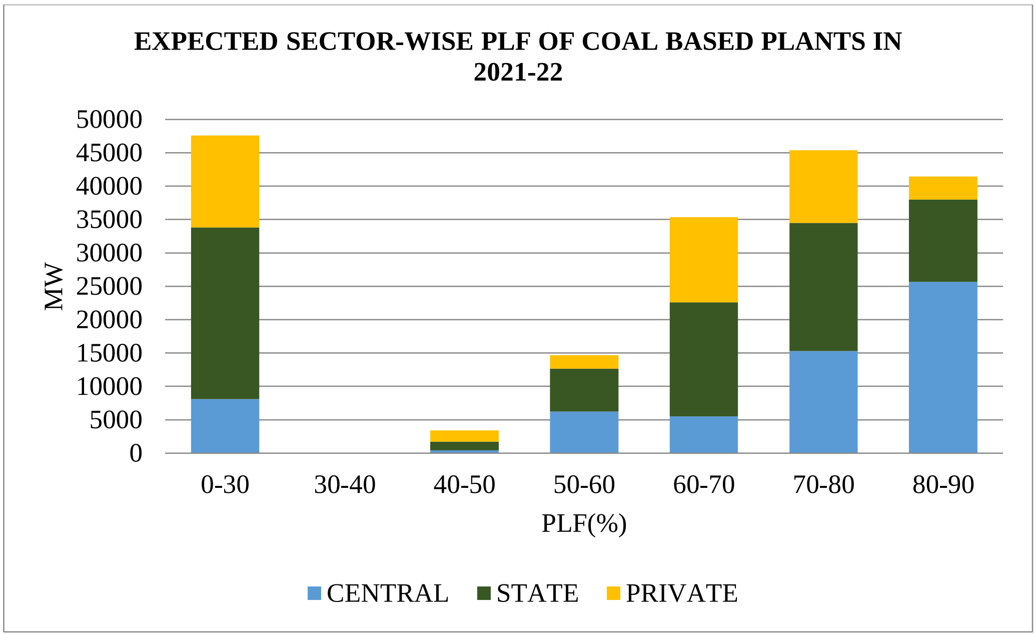


Exhibit 5.6



The likely installed capacity from different fuel types at the end of 2021-22 in base case works out to be **4,79,419 MW** including 47,855 MW of Coal based capacity addition currently under construction and likely to yield benefits during 2017-22 and is given in **Table 5.15** and **Exhibit 5.7**.

Table 5.15
Projected Installed capacity by the end of 2021-22

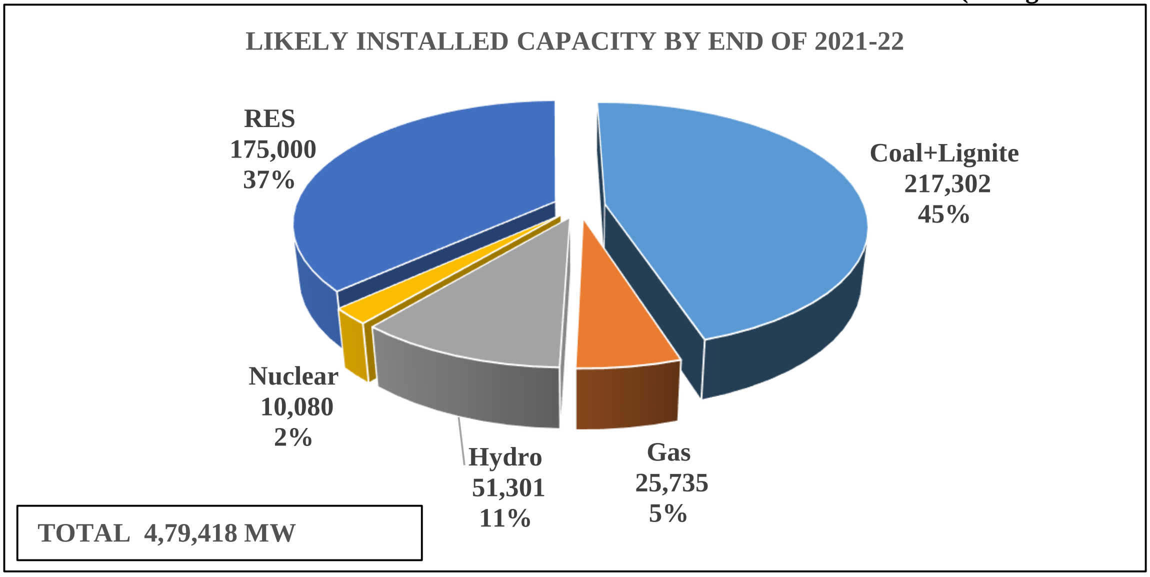
Fuel Type	Capacity (MW)	%
Hydro	51,301	10.7
Coal + Lignite	2,17,302	45.3
Gas	25,735	5.4
Nuclear	10,080	2.1
Total Conventional Capacity *	**3,04,419**	**63.5**
Total Renewable Capacity	**1,75,000**	**36.5**
Total Capacity by 2021-22	**4,79,418**	**100.0**

*This includes 47,855 MW of Coal based capacity addition currently under construction and likely to yield benefits during 2017-22.
* This IC does not include Imports from Neighbouring countries during 2017-22

Note: The actual IC may change to the extent of thermal capacity materialising and actual retirement during 2017 to 2022.

Exhibit 5.7

(All figures in MW)



The likely installed capacity from different fuel type by the end of year 2026-27 is given in **Table 5.16** and **Exhibit 5.8**.

Table 5.16

Projected Installed capacity by the end of 2026-27

Fuel Type	Capacity (MW)	%
Hydro	63,301	10.2
Coal + Lignite	2,38,150	38.5
Gas	25,735	4.2
Nuclear	16,880	2.7
Total Conventional Capacity *	**3,44,066**	**55.6**
Total Renewable Capacity	**2,75,000**	**44.4**
Total Capacity by 2026-27	**6,19,066**	**100.0**

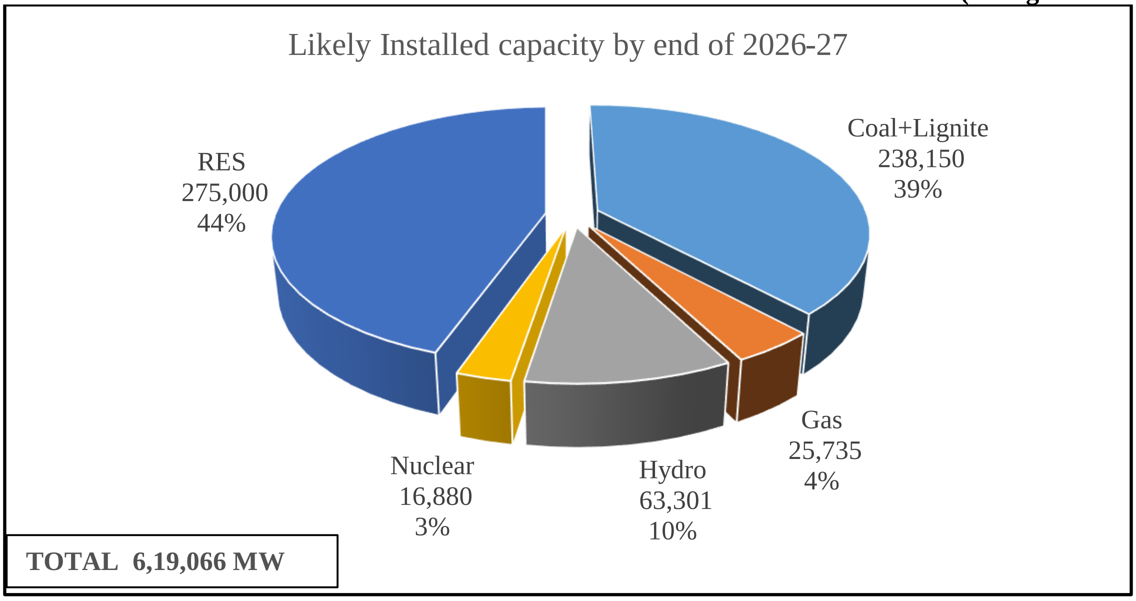
*Including 47,855 MW of Coal based capacity addition currently under construction and likely to yield benefits in 2017-22 and an additional 46,420 MW coal based capacity addition required during 2022-27(**Table 5.13**).

* This IC does not include Imports from Neighbouring countries during 2022-27

Note: The actual IC will change to the extent of thermal capacity materialising and actual retirement taking place between 2022-27.

Exhibit 5.8

(All figures in MW)



Coal based capacity of 47,855 MW which are at various stages of construction and likely to yield benefit during 2017-22 are considered for the studies. Apart from this, coal based capacity of 9,150 MW and gas based capacity of 3501.88 MW **(Annexure 5.8)** are uncertain due to fuel issues. In addition to this, coal based capacity of 88,400 MW **(Annexure 5.9)** are at various stages of planning. Out of under construction hydro projects totalling to 10,608 MW, only hydro projects totalling to 6,823 MW have been considered for studies which are most likely to yield benefits during 2017-22.

5.10.1 Comparison of Study Results with Projected Capacity Addition in Previous NEP

In the previous NEP, the tentative capacity addition requirement during the period 2017-22 was projected as 86,400 MW (however target set for 12th plan was 88,537 MW) based on the projected Peak demand and Energy requirement as per 18th Electric Power Survey (EPS) Report. The projected Peak Demand and Energy requirement in the year 2021-22 was 2,83,470 MW and 1904 BU respectively as per the 18th EPS Report. However, the Peak Demand and Energy Requirement during 2021-22 as projected by 19th EPS report is 2,25,571 MW and 1566 BU respectively. Also, a capacity of 99,209 MW has been commissioned against a target of 88,537 MW during 12th plan (2012-17). Therefore, during 12th plan, capacity addition to the extent of 10,672 MW has been commissioned in excess of 12th Plan target. In addition, Government of India has announced huge capacity addition programme from Renewable Energy sources so as to have installed capacity of 1,75,000 MW from RES by the end of year 2021-22. All these factors have contributed to the reduction in capacity addition requirement during the period 2017-22.

5.11 ALTERNATE SCENARIOS FOR CAPACITY ADDITION

Generation expansion planning is a major part of any power system planning studies and is normally carried out for the next 5-10 years. These studies are performed based on various assumptions and factors prevalent at that time. However, there are various uncertainties associated with the input data such as demand forecasts, availability of fuel, investment, committed units, retirement plans, input fuel prices, availability of technology, various initiatives of Government like promotion of energy efficiency, etc. As a result, generation expansion planning is essentially stochastic in nature.

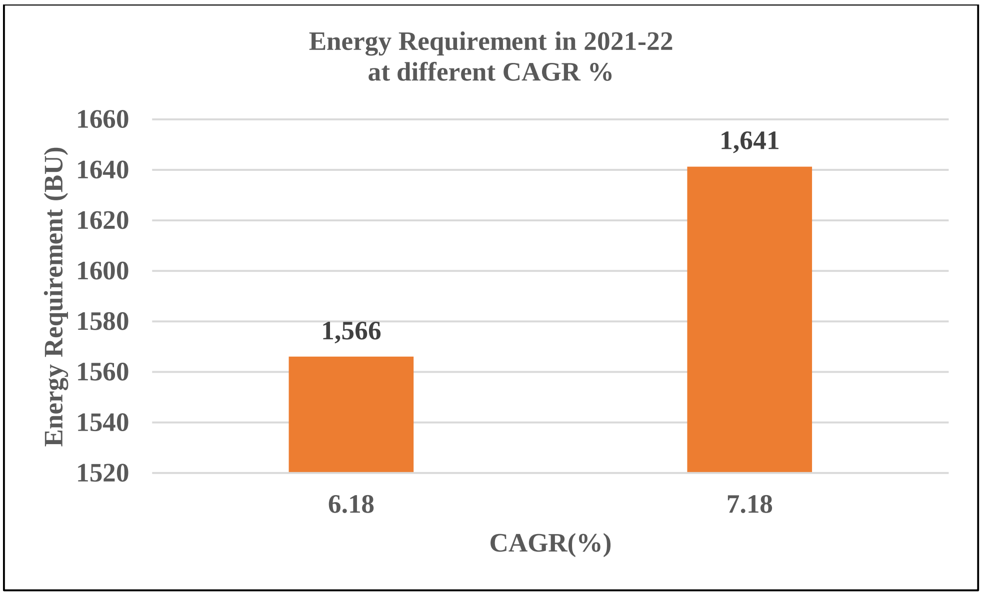
Forecasting electricity demand is most challenging and consequently, a very vital parameter for generation expansion planning. There are numerous ways to forecast electricity demand based on the assumptions made.

Estimation of electricity demand for a developing country like India is much more challenging than that of a developed country. In a developed country, because of the matured stage of development, the growth is considered to be steady and therefore, it is relatively easy to forecast electricity demand. However, in a developing country, there may not be a definite trajectory of growth as it is dependent on the economic performance, Government policies & programmes and their extent of successful implementation thereof, etc.

Based on methodology adopted (Chapter 3) in estimating electricity demand in future years considering DSM measures, the electricity energy requirement for the year 2021-22 has been estimated as 1566 BU with a Compounded Annual Growth Rate (CAGR) of 6.18% with reference to 2016-17. However, due to uncertainties associated with demand forecasting, one additional scenario has been considered in the Generation planning studies i.e. CAGR of 7.18 % as shown in **Exhibit 5.9** below**:**

CAGR: 6.18%: Electricity Demand: 1566 BU
CAGR: 7.18%: Electricity Demand: 1641 BU

Exhibit 5.9



An alternate scenario has been constructed based on variation in projected energy demand to get a clear picture of the effect of variation of Energy Demand on the requirement of additional capacity.

5.11.1 Results of Alternate scenario (2017-22)

The generation planning studies for the period 2017-22 has also been carried out for the demand CAGR of 7.18% and keeping other parameters unchanged as the base case, the coal based capacity addition and their expected Plant Load factor % are shown in the **Tables 5.17(b)** and **(c)** below.

Table 5.17(a)

Year	CAGR from 2016-17 to 2021-22 (%)	Demand	
		Peak(GW)	Energy(BUs)
2021-22	7.18	237	1641

With the committed capacity addition, retirement, etc. (as given in **Table 5.14(a)**), the addition coal based capacity required by 2021-22 to meet the peak demand and energy demand would be as follows:

Table 5.17(b)
Capacity Addition Required During 2017-22

Year	Additional coal based Capacity required	Remarks
2017-22	19,700	Since 47,855 MW are under different stages of construction and are likely to materialise during 2017-22, so no additional capacity is required.

Table 5.17(c)
Energy Generated from coal and Average PLF of coal based stations

Years	Coal Based Generation (Gross) (GWh) +++	PLF of Coal Based Plants (%)*
2021-22	1,151	60.5

* PLF has been computed with capacity addition of 47,855 MW from coal based power plants which is under construction and likely to yield benefits during 2017-22,

+++ Auxiliary Power consumption of coal stations as 6.5% has been assumed to arrive at gross generation.

It may be seen that in this case also <u>no additional coal based capacity addition is required apart from the under construction coal projects likely to benefit during the years 2017-22 to meet the peak and energy demand.</u>

5.11.2 Analysis of Results (2017-22)

1) With committed capacity addition of Hydro 6,823 MW, Gas 406 MW, Nuclear 3,300 MW, RES 1,17,756 MW and considering a retirement of coal based capacity of 22,716 MW with demand CAGR of 6.18% during 2017-22, only 6,445 MW coal based capacity would be required for the said period, whereas coal based capacity of 47,855 MW is at various stages of construction and is likely to be commissioned during 2017-22

2) In the alternate scenarios with demand CAGR of 7.18%, keeping the capacity addition from RES and Hydro, Retirement of units constant, it is observed that coal based capacity addition of 19,700 MW may be required during 2017-22. However, 47,855 MW of coal based plants are in different stages of construction and would yield benefit during 2017-22. With this capacity addition the energy demand and peak demand for 2021-22 would be fully met.

3) The PLF of the thermal plants would be influenced to the extent of achievement of capacity addition from RES, Hydro, etc. and retirement of units.

4) Significant quantum of capacity retirement would have a corresponding significant positive impact on the PLF of the thermal plants.

5.11.3 Analysis of Results (2022-27)

1) It may be seen that capacity addition to the tune of 46,420 MW will be required under the given set of parameters. This will be in addition to the 47,855 MW of coal based capacity which would likely benefit during 2017-22.

2) The excess coal based capacity available by March, 2022 would help to meet the increase in demand during 2022-27 resulting better utilisation of plants.

3) The additional capacity required for 2022-27 should be preferably from flexible sources of generation to meet the peaking, balancing and ramping requirements of the grid.

4) However, if this additional capacity comes from the coal based plants, the PLF of coal based power stations will be in the range of 61-62% by 2026-27.

5) If the additional capacity comes from other flexible sources, the PLF of the coal based plants would further increase.

5.12 CONCLUSIONS

- The Electricity demand projections considered for planning the capacity addition requirement, are as follows:

Year	Energy Requirement (BU)	Peak Demand (MW)
2021-22	1,566	225.751
2026-27	2,047	298.774

These values are in accordance with the Report of 19th Electric Power Survey Committee.

- Considering the demand projections for the year 2021-22 as per the 19th EPS, committed capacity addition from Gas 406 MW, Hydro 6,823 MW, Nuclear 3,300 MW, RES 1,17,756 MW and likely retirement of 22,716 MW of coal based capacity during 2017-22, the study result reveals that coal based capacity addition of 6,445 MW is required during the period 2017-22. However, a total capacity of 47,855 MW coal based power projects are currently under different stages of construction and are likely to yield benefits during the period 2017-22. Thereby, the total capacity addition during 2017-22 is likely to be 1,76,140 MW.

- In view of the prevailing shortage of natural gas in the country, no additional gas based power plant has been planned during 2017-22, except the plants which are presently ready for commissioning /under construction. However, in case availability of natural gas improves, preference may be given to gas based power plants owing to their advantage in efficiently helping in balancing the Grid and reducing emissions.

- Considering the demand projections for the year 2026-27 as per the 19th EPS, coal based capacity addition of 47,855 MW already under construction for benefits during 2017-22, committed capacity addition of Nuclear

6,800 MW, Hydro 12,000 MW, RES 1,00,000 MW and likely retirement of 25,572 MW of coal based capacity during 2022-27, study results reveals that capacity addition of 46,420 MW is required during the period 2022-27. This capacity addition required during 2022-27 as shown in the results is in fact the peaking capacity requirement to be met in the grid. This capacity requirement can be met from any conventional source of energy.

- It is estimated that Generation from RES will contribute almost 20.1 % of the energy requirement in the year 2021-22.

- Net Imports from neighbouring countries will increase from 4,356 MW in the year 2021-22 to 21,600 MW in the year 2026-27.

- The actual CAGR of energy demand between the years 2012-13 to 2015-16 is 4.42%. However, the CAGR of energy demand between 2015-16 and 2021-22 has been estimated as 6.18%. This is substantially higher that of the immediate past keeping in view secular increase in demand and increase due to implementation of PFA and other Government of India programs between the years 2017-22.

- It has been assumed that Gas Power Plants will operate at minimum load as carried out presently during the off-peak hours and ramp up during the time of peaking requirement in the grid. This operation amounts to their combined PLF of around 37%. The gas requirement may decrease provided two shift operation during the day becomes feasible for Gas power stations.

- Energy demand of 1566 BU and Peak Demand of 226 GW in March 2022 with CAGR of 6.18% look realistic and most likely to occur. Even with Energy Demand of 1641 BU and Peak Demand of 237 GW in March 2022 with CAGR of 7.18%, sufficient capacity would be available to meet the demand.

- Even with the incidence of higher demand by 2021-22 like shifting of Captive load to the grid, there would be adequate capacity to take care of this increase in demand.

- Any negative deviation with respect of capacity addition target from RES, Hydro, etc. would have positive impact on the PLF of the coal-based plants.

- Similarly, any positive deviation of projected demand in future would have a positive impact on the PLF of the coal based plants.

- Even retirement to the extent of 22,716 MW during 2017-22 due to strict implementation of environmental norms, would not likely pose any problem in meeting the demand during 2021-22.

- It is envisaged that the rate of capacity addition particularly from coal based stations may outpace the rate of increase in demand during the period from 2017-22. The PLF of the coal based stations is likely to come down to around 56.5% by 2021-22 with the normal retirement of unit, likely demand with CAGR of 6.18% and 175 GW of capacity from RES. Any deviation of the above independent variable would have an impact on the PLF of the coal based stations as already mentioned above.

- During the period of 2022-27, the PLF of the thermal plants shall progressively increase and would be hovering around 60-61% by 2026-27.

- For any capacity addition from conventional sources in future, capability of flexibility of generation should be insisted upon.

- The Hydro Power can also contribute significantly to meet balancing requirement of the grid but is constrained due to vagaries associated with seasonal inflows to the reservoir. Also, the hydro capacity will constitute around 10.7 % of the total Installed Capacity in 2022. The peaking requirement to be met from Gas may also reduce if the Government's policy push for Hydro Power Development is able to yield desired results.

Annexure 5.1

LIST OF HYDRO PROJECTS UNDER CONSTRUCTION/CONCURRED FOR LIKELY BENEFITS DURING 2017-22

(All figures in MW)

I	Projects most likely to yield benefits during 2017-22, considered for Generation planning studies					
Sl. No.	**Project Name**	**State**	**Agency**	**No. of Units x MW**	**Likely Benefits during 2017-22 (MW)**	**Status**
	Central Sector					
1	Kameng	Arunachal Pradesh	NEEPCO	4x150	600	Under construction
2	Parbati St. II	Himachal Pradesh	NHPC	4x200	800	Under construction
3	Kishanganga	Jammu & Kashmir	NHPC	3x110	330	Under construction
4	Tuirial	Mizoram	NEEPCO	2x30	60	Under construction
5	Tapovan Vishnugad	Uttarakhand	NTPC	4x130	520	Under construction
6	Tehri PSS	Uttarakhand	THDC	4x250	1,000	Under construction
7	Vishnugad Pipalkoti	Uttarakhand	THDC	4x111	444	Under construction
8	Rammam - III	West Bengal	NTPC	3x40	120	Under construction
9	Pare	Arunachal Pradesh	NEEPCO	2x55	110	Under construction
	Central Sector Total				**3,984**	
	State Sector					
1	Indira Sagar (Pollavaram MPP)	Andhra Pradesh	APID	12x80	960	Under construction
2	Sainj	Himachal Pradesh	HPPCL	2x50	100	Under construction
3	Shongtong Karcham	Himachal Pradesh	HPPCL	3x150	450	Under construction
4	Swara Kuddu	Himachal Pradesh	HPPCL	3x37	111	Under construction
5	Uhl-III	Himachal Pradesh	BVPC	3x33.3	100	Under construction
6	Pallivasal	Kerala	KSEB	2x30	60	Under construction
7	Pulichintala	Telengana	TSGENC O	4x30	90	Under construction
8	Vyasi	Uttarakhand	UJVNL	2x60	120	Under construction
9	New Umtru	Meghalaya	MePGCL	2x20	40	Commissioned
10	Parnai	J&K	JKSPDC	3x12.5	37.5	Under construction
11	Lower Kalnai	J&K	JKSPDC	2x24	48	Under construction

	State Sector Total				**2,116.5**	
	Private Sector					
1	Bajoli Holi	Himachal Pradesh	GMR	3x60	180	Under construction
2	Chanju I	Himachal Pradesh	IA Energy	3x12	12	1 Unit Under Construction
3	Dikchu	Sikkim	Sneha Kinetic	2x48	96	Commissioned
4	Rangit-II	Sikkim	SHPL	2x33	66	Under construction
5	Rongnichu	Sikkim	MBPCL	2x48	96	Under construction
6	Tashiding	Sikkim	Shiga Energy	2x48.5	97	Under construction
7	Phata Byung	Uttarakhand	LANCO	2x38	76	Under construction
8	Singoli Bhatwari	Uttarakhand	L&T	3x33	99	Under construction
	Private Sector Total				**722**	
	Sub Total I				**6,822.5**	
II	**Other Hydro projects which may come during 2017-22 but have not been considered for Generation Planning Studies(presently stalled due to various reasons)**					
	Central Sector					
1	Subansiri Lower	Arunachal Pradesh	NHPC	8x250	2,000	Under construction
	Central Sector Total				**2,000**	
	State Sector					
1	Thottiyar	Kerala	KSEB	1x30+1x10	40	Under construction
2	Koyna Left Bank PSS	Mahar	WRD, GO Mah.	2x40	80	Under construction
3	Shahpurkandi	Punjab	Irr. Deptt. & PSPCL	3x33+3x33+1 x8	206	Under construction
	State Sector Total				**326**	
	Private Sector					
1	Gongri	Arunachal	DEPL	2x72	144	Under construction
2	Sorang	Himachal	HSPL	2x50	100	Under construction
3	Tangnu Romai- I	Himachal	TRPG	2x22	44	Under construction
4	Tidong-I	Himachal	M/s NSL	2x50	100	Under construction
5	Maheshwar	MP	SMHPCL	10x40	400	Under construction
6	Bhasmey	Sikkim	Gati	3x17	51	Under construction
7	Rangit-IV	Sikkim	Jal Power	3x40	120	Under construction

8	Teesta- VI	Sikkim	LANCO	4x125	500	Under construction
	Private Sector Total				**1,459**	
	Subtotal II				**3,785**	
	TOTAL (I+II)				**10,607.5**	

Annexure 5.2

LIST OF NUCLEAR PROJECTS UNDER CONSTRUCTION FOR LIKELY BENEFITS DURING 2017-22

(All figures in MW)

Sl. No.	Project Name	State	Agency	No. of Units x MW	Likely Benefits during 2017-22 (MW)
1	Kakrapar Atomic Power Plant	Gujarat	NPCIL	2x700	1,400
2	Rajasthan Atomic Power Station	Rajasthan	NPCIL	2x700	1,400
3	PFBR	Tamil Nadu	Bhavini	1x500	500
	Total (2017-22)				**3,300**

LIST OF GAS PROJECTS UNDER CONSTRUCTION FOR LIKELY BENEFITS DURING 2017-22

Sl. No.	Project Name	State	Agency	No. of Units	Likely Benefits during 2017-22 (MW)
1	Namrup CCGT	Assam	APGCL / BHEL	ST	36.15
2	Yelahanka CCPP	Karnataka	KPCL	GT+ST	370
	Total (2017-22)				**406.15**

Annexure 5.3

LIST OF NUCLEAR PROJECTS UNDER CONSTRUCTION FOR LIKELY BENEFITS DURING 2022-27

(All figures in MW)

Sl. No.	Project Name	State	Agency	No. of Units x MW	Likely Benefits during 2022-27 (MW)
1	Kudankulam Nuclear Power Project (Expansion)	Tamil Nadu	NPCIL	4x1000	4,000
2	Gorakpur Haryana Anu Vidyut Pariyojana	Haryana	NPCIL	2x700	1,400
3	New PHWR*	Madhya Pradesh	NPCIL	2x700	1,400
	Total (2022-27)				**6,800**

*Note :Procurement of Land in advance stage

Annexure 5.4

LIST OF COAL BASED PROJECTS UNDER CONSTRUCTION FOR LIKELY BENEFITS DURING 2017-22 AS ON 31.03.2017

S.No.	Project Name / Implementing Agency	Sector	Unit No	Cap. (MW)
	CENTRAL SECTOR			
1	Bongaigaon TPP/NTPC	C	U-3	250
2	Barh STPP-I /NTPC	C	U-1	660
3	Barh STPP-I /NTPC	C	U-2	660
4	Barh STPP-I /NTPC	C	U-3	660
5	Nabi Nagar TPP / JV of NTPC & Rly.	C	U-2	250
6	Nabi Nagar TPP / JV of NTPC & Rly.	C	U-3	250
7	Nabi Nagar TPP / JV of NTPC & Rly.	C	U-4	250
8	New Nabi Nagar TPP /JV of NTPC & BSPGCL	C	U-1	660
9	New Nabi Nagar TPP /JV of NTPC & BSPGCL	C	U-2	660
10	New Nabi Nagar TPP /JV of NTPC & BSPGCL	C	U-3	660
11	North Karanpura TPP/ NTPC	C	U-1	660
12	North Karanpura TPP/ NTPC	C	U-2	660
13	North Karanpura TPP/ NTPC	C	U-3	660
14	Kudgi STPP Ph-I/ NTPC	C	U-3	800
15	Solapur STPP/ NTPC	C	U-1	660
16	Solapur STPP/ NTPC	C	U-2	660
17	Gadarwara TPP/ NTPC	C	U-1	800
18	Gadarwara TPP/ NTPC	C	U-2	800
19	Khargone TPP/ NTPC	C	U-1	660
20	Khargone TPP/ NTPC	C	U-2	660
21	Darlipalli STPP/ NTPC	C	U-1	800
22	Darlipalli STPP/ NTPC	C	U-2	800
23	Neyveli New TPP/ NLC	C	U-1	500
24	Neyveli New TPP/ NLC	C	U-2	500
25	Telangana Ph-I/NTPC	C	U-1	800
26	Telangana Ph-I/NTPC	C	U-2	800
27	Lara STPP / NTPC	C	U-1	800
28	Lara STPP / NTPC	C	U-2	800
29	Meja STPP/ JV of NTPC & UPRVUNL	C	U-1	660
30	Meja STPP/ JV of NTPC & UPRVUNL	C	U-2	660

31	Tanda TPP/ NTPC	C	U-1	660
32	Tanda TPP/ NTPC	C	U-2	660
33	Ghatampur TPP/ NLC JV	C	U-1	660
34	Ghatampur TPP/ NLC JV	C	U-2	660
35	Ghatampur TPP/ NLC JV	C	U-3	660
35	Barsingsar TPP ext/NLC	C	U-1	250
36	Bithnok TPP /NLC	C	U-1	250
	TOTAL (CENTRAL SECCTOR)			**22,900**
	STATE SECTOR			
1	Rayalaseema TPP St-IV / APGENCO	S	U-6	600
2	Dr N T Rao TPS St-V/APGENCO	S	U-1	800
3	Sri Damodaram TPS St-II/APGENCO	S	U-1	800
4	Barauni TPS Extn./ BSEB	S	U-8	250
5	Barauni TPS Extn./ BSEB	S	U-9	250
6	Wanakbori TPS Extn. / GSECL	S	U-8	800
7	Shri Singhaji TPP-II / MPGENCO	S	U-3	660
8	Shri Singhaji TPP-II / MPGENCO	S	U-4	660
9	Ib valley TPP / OPGCL	S	U-3	660
10	Ib valley TPP / OPGCL	S	U-4	660
11	Chhabra TPP Extn. / RRVUNL	S	U-5	660
12	Chhabra TPP Extn. / RRVUNL	S	U-6	660
13	Suratgarh TPS/ RRVUNL	S	U-7	660
14	Suratgarh TPS/ RRVUNL	S	U-8	660
15	Kothagudem TPS St-VII / TSGENCO	S	U-1	800
16	Bhadradri TPP / TSGENCO	S	U-1	270
17	Bhadradri TPP / TSGENCO	S	U-2	270
18	Bhadradri TPP / TSGENCO	S	U-3	270
19	Bhadradri TPP / TSGENCO	S	U-4	270
20	Ennore exp. SCTPP(Lanco) / TANGEDCO	S	U-1	660
21	Ennore SCTPP / TANGEDCO	S	U-1	660
22	Ennore SCTPP / TANGEDCO	S	U-2	660
23	North Chennai TPP St-III/TANGEDCO	S	U-1	800
24	Uppur SCTPP/TANGEDCO	S	U-1	800
25	Uppur SCTPP/TANGEDCO	S	U-2	800
26	Harduaganj Exp.-II TPP / UPRVUNL	S	U-1	660
27	Jawaharpur STPP/ UPRVUNL	S	U-1	660
28	Jawaharpur STPP/ UPRVUNL	S	U-2	660
29	Obra-C STPP/ UPRVUNL	S	U-1	660
30	Obra-C STPP/ UPRVUNL	S	U-2	660

	TOTAL (STATE SECCTOR)			**18,340**
	PRIVATE SECTOR			
1	Thamminapatnam TPP stage -II / Meenakshi Energy Pvt. Ltd.	P	U-3	350
2	Thamminapatnam TPP stage -II / Meenakshi Energy Pvt. Ltd.	P	U-4	350
3	Akaltara TPP (Naiyara) / KSK Mahandi Power Company Ltd.	P	U-3	600
4	Akaltara TPP (Naiyara) / KSK Mahandi Power Company Ltd.	P	U-4	600
	Nawapara TPP / TRN Energy Pvt Ltd	P	U-2	300
5	Binjkote TPP/ SKS Power Generation (Chhattisgarh) Ltd.	P	U-1	300
6	Binjkote TPP/ SKS Power Generation (Chhattisgarh) Ltd.	P	U-2	300
7	Nasik TPP Ph-I / Ratan India Nasik Power Pvt. Ltd.	P	U-3	270
8	Nasik TPP Ph-I / Ratan India Nasik Power Pvt. Ltd.	P	U-4	270
9	Nasik TPP Ph-I / Ratan India Nasik Power Pvt. Ltd.	P	U-5	270
10	Shirpur TPP/ Shirpur Power Pvt Ltd	P	U-1	150
11	Shirpur TPP/ Shirpur Power Pvt Ltd	P	U-2	150
12	Uchpinda TPP/ RKM Powergen. Pvt. Ltd.	P	U-3	360
13	Uchpinda TPP/ RKM Powergen. Pvt. Ltd.	P	U-4	360
14	Tuticorin TPP St-IV / SEPC	P	U-1	525
15	Prayagraj (Bara) TPP / PPGENCO	P	U-3	660
16	India Power TPP / Haldia Energy Ltd.	P	U-1	150
17	India Power TPP / Haldia Energy Ltd.	P	U-2	150
18	India Power TPP / Haldia Energy Ltd.	P	U-3	150
19	Utkal TPP/Ind Bharat	P	U-2	350
	TOTAL (PRIVATE SECCTOR)			6,615
	GRAND TOTAL			**47,855**

Annexure 5.5

LIST OF PROJECTS CONSIDERED FOR RETIREMENT BY MARCH, 2022

As on August,2017

S.No.	Name of the Utility	Name of the Station	Unit No.	Capacity (MW)	Remarks
1	DPL	DPL TPS	3	70	
2	DPL	DPL TPS	4	75	
3	DPL	DPL TPS	5	75	
4	ASEB	Chandrapur TPS	1	30	
5	ASEB	Chandrapur TPS	2	30	
6	GSECL	Sikka TPS	1	120	
7	GSECL	Ukai TPS	1	120	
8	GSECL	Ukai TPS	2	120	
9	IPGCL	Rajghat TPS	1	67.5	
10	IPGCL	Rajghat TPS	2	67.5	
11	MPPGCL	Satpura TPS	6	200	
12	MPPGCL	Satpura TPS	7	210	
13	UPRVUNL	Harduaganj	5	60	Under s/d since Feb.,2015.
14	UPRVUNL	Obra TPS	8	94	
15	NLC	Nevyeli LigniteTPS-I	1	50	Units will be retired after commissioning of first unit of 2x500 MW TPS.
16	NLC	Nevyeli LigniteTPS-I	2	50	
17	NLC	Nevyeli LigniteTPS-I	3	50	
18	NLC	Nevyeli LigniteTPS-I	4	50	
19	NLC	Nevyeli LigniteTPS-I	5	50	
20	NLC	Nevyeli LigniteTPS-I	6	50	
21	NLC	Nevyeli LigniteTPS-I	7	100	
22	NLC	Nevyeli LigniteTPS-I	8	100	
23	NLC	Nevyeli LigniteTPS-I	9	100	
24	TSPGCL	Kothadudem TPS	1	60	Retirement of units is being expedited with the utililty.
25	TSPGCL	Kothadudem TPS	2	60	
26	TSPGCL	Kothadudem TPS	3	60	
27	TSPGCL	Kothadudem TPS	4	60	
28	PSPCL	GND (Bathinda) TPS	1	110	Board approval by utility under process.
29	PSPCL	GND (Bathinda) TPS	2	110	
30	CSPGCL	DSPM Korba TPS	1	50	
31	CSPGCL	DSPM Korba TPS	2	50	
32	CSPGCL	DSPM Korba TPS	3	50	
33	CSPGCL	DSPM Korba TPS	4	50	
34	MPPGCL	Satpura TPS	8	210	
35	MPPGCL	Satpura TPS	9	210	
36	UPRVUNL	Obra TPS	1	40	
37	UPRVUNL	Obra TPS	2	50	
38	UPRVUNL	Panki TPS	3	105	Board Approval for retirementyet to be obtained. Replacement

					Proposal under consideration.
39	UPRVUNL	Panki TPS	4	105	
40	TSPGCL	Kothadudem TPS	5	120	Due to Power shortage in the state, Utility wants to run the plant till commissioning of 800 MW Super Critical unit for which order has been placed & which is expected to be commissioned in 2018-19.
41	TSPGCL	Kothadudem TPS	6	120	
42	TSPGCL	Kothadudem TPS	7	120	
43	TSPGCL	Kothadudem TPS	8	120	
44	TSPGCL	Ramagundem-B TPS	1	62.5	
45	PSPCL	Ropar TPS	1	210	Utility is exploring possibility to set up 3x800 MW super-critical Unilt as replacement.
46	PSPCL	Ropar TPS	2	210	
47	PSPCL	Ropar TPS	3	210	
48	PSPCL	Ropar TPS	4	210	
49	MSPGCL	Koradi TPS	5	200	To be retired after completion of LE works of Unit-6.
50	PVUNL	Patratu TPS	4	50	Units could be retired after 800 MW Unilt is commissioned.
51	PVUNL	Patratu TPS	6	100	
52	PVUNL	Patratu TPS	9	110	
53	PVUNL	Patratu TPS	10	110	
54	PVUNL	Patratu TPS	7	110	Under long shut down. Decision pending.
55	NTPC LTD.	Badarpur TPS	1	95	Decision by NTPC Board pending.
56	NTPC LTD.	Badarpur TPS	2	95	
57	NTPC LTD.	Badarpur TPS	3	95	
58	DVC	Chandrapur TPS	2	130	To be retired after augmentation of Transmission scheme. Proposed to be retired in 2019-20.
59	DVC	Chandrapur TPS	3	130	
	TOTAL			**5,926.5**	

Annexure 5.5(A)

LIST OF PROJECTS CONSIDERED FOR RETIREMENT AS PER NEW ENVIRONMENTAL NORMS

(Thermal station units without space for FGD installation and shall attain age of =>25 years on 1/1/2022)
(as on August,2017)

Sr. No.	Developer	Name of Project	Sector	State	Region	Unit No	Total Capacity
1	BSEB	BARAUNI TPS	State Sector	Bihar	ER	6	105
2	BSEB	BARAUNI TPS	State Sector	Bihar	ER	7	105
3	NTPC & Bihar	MUZAFFARPUR TPS	Central Sector	Bihar	ER	1	110
4	NTPC & Bihar	MUZAFFARPUR TPS	Central Sector	Bihar	ER	2	110
5	D.V.C	BOKARO `B` TPS	Central Sector	Jharkhand	ER	1	210
6	D.V.C	BOKARO `B` TPS	Central Sector	Jharkhand	ER	2	210
7	D.V.C	BOKARO `B` TPS	Central Sector	Jharkhand	ER	3	210
8	TenughatVN Ltd	TENUGHAT TPS	State Sector	Jharkhand	ER	1	210
9	TenughatVN Ltd	TENUGHAT TPS	State Sector	Jharkhand	ER	2	210
10	Ind barath	IND BARATH TPP	Private Sector	Odisha	ER	1	350
11	NTPC	TALCHER (OLD) TPS	Central Sector	Odisha	ER	1	60
12	NTPC	TALCHER (OLD) TPS	Central Sector	Odisha	ER	2	60
13	NTPC	TALCHER (OLD) TPS	Central Sector	Odisha	ER	3	60
14	NTPC	TALCHER (OLD) TPS	Central Sector	Odisha	ER	4	60
15	NTPC	TALCHER (OLD) TPS	Central Sector	Odisha	ER	5	110
16	NTPC	TALCHER (OLD) TPS	Central Sector	Odisha	ER	6	110
17	C.E.S.C. Pvt.	TITAGARH TPS	Private Sector	West Bengal	ER	1	60
18	C.E.S.C. Pvt.	TITAGARH TPS	Private Sector	West Bengal	ER	2	60
19	C.E.S.C. Pvt.	TITAGARH TPS	Private Sector	West Bengal	ER	3	60
20	C.E.S.C. Pvt.	TITAGARH TPS	Private Sector	West Bengal	ER	4	60
21	D.V.C	DURGAPUR TPS	Central Sector	West Bengal	ER	4	210
22	WBPDC	BAKRESWAR TPS	State Sector	West Bengal	ER	1	210
23	WBPDC	BAKRESWAR TPS	State Sector	West Bengal	ER	2	210
24	WBPDC	BAKRESWAR TPS	State Sector	West Bengal	ER	3	210
25	WBPDC	BAKRESWAR TPS	State Sector	West Bengal	ER	4	210
26	WBPDC	BAKRESWAR TPS	State Sector	West Bengal	ER	5	210

27	WBPDC	BANDEL TPS	State Sector	West Bengal	ER	1	60
28	WBPDC	BANDEL TPS	State Sector	West Bengal	ER	2	60
29	WBPDC	BANDEL TPS	State Sector	West Bengal	ER	3	60
30	WBPDC	BANDEL TPS	State Sector	West Bengal	ER	4	60
31	WBPDC	BANDEL TPS	State Sector	West Bengal	ER	5	210
32	NTPC	BADARPUR TPS	Central Sector	Delhi	NR	4	210
33	NTPC	BADARPUR TPS	Central Sector	Delhi	NR	5	210
34	HGP Corpn	PANIPAT TPS	State Sector	Haryana	NR	5	210
35	PSEB	GND TPS(BHATINDA)	State Sector	Punjab	NR	3	110
36	PSEB	GND TPS(BHATINDA)	State Sector	Punjab	NR	4	110
37	PSEB	ROPAR TPS	State Sector	Punjab	NR	5	210
38	PSEB	ROPAR TPS	State Sector	Punjab	NR	6	210
39	RRVUNL	KOTA TPS	State Sector	Rajasthan	NR	1	110
40	RRVUNL	KOTA TPS	State Sector	Rajasthan	NR	2	110
41	RRVUNL	KOTA TPS	State Sector	Rajasthan	NR	3	210
42	RRVUNL	KOTA TPS	State Sector	Rajasthan	NR	4	210
43	RRVUNL	KOTA TPS	State Sector	Rajasthan	NR	5	210
44	NTPC	TANDA TPS	Central Sector	Uttar Pardesh	NR	1	110
45	NTPC	TANDA TPS	Central Sector	Uttar Pardesh	NR	2	110
46	NTPC	TANDA TPS	Central Sector	Uttar Pardesh	NR	3	110
47	NTPC	TANDA TPS	Central Sector	Uttar Pardesh	NR	4	110
48	UPRVUNL	HARDUAGANJ TPS	State Sector	Uttar Pardesh	NR	7	105
49	UPRVUNL	OBRA TPS	State Sector	Uttar Pardesh	NR	7	94
50	UPRVUNL	PARICHHA TPS	State Sector	Uttar Pardesh	NR	1	110
51	UPRVUNL	PARICHHA TPS	State Sector	Uttar Pardesh	NR	2	110
52	APGENCO	Dr. N.TATA RAO TPS	State Sector	Andhra Pradesh	SR	1	210
53	APGENCO	Dr. N.TATA RAO TPS	State Sector	Andhra Pradesh	SR	2	210
54	APGENCO	Dr. N.TATA RAO TPS	State Sector	Andhra Pradesh	SR	3	210
55	APGENCO	Dr. N.TATA RAO TPS	State Sector	Andhra Pradesh	SR	4	210
56	APGENCO	Dr. N.TATA RAO TPS	State Sector	Andhra Pradesh	SR	5	210
57	APGENCO	Dr. N.TATA RAO TPS	State Sector	Andhra Pradesh	SR	6	210
58	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	1	210
59	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	2	210
60	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	3	210
61	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	4	210
62	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	5	210
63	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	6	210
64	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	7	210
65	KPCL	RAICHUR TPS	State Sector	Karnataka	SR	8	250
66	Ind barath	TUTICORIN (P) TPP	Private Sector	Tamil Nadu	SR	1	150

67	Ind barath	TUTICORIN (P) TPP	Private Sector	Tamil Nadu	SR	2	150
68	NEYVELI LIGNITE	NEYVELI (EXT) TPS	Central Sector	Tamil Nadu	SR	1	210
69	NEYVELI LIGNITE	NEYVELI (EXT) TPS	Central Sector	Tamil Nadu	SR	2	210
70	NEYVELI LIGNITE	NEYVELI TPS- II	Central Sector	Tamil Nadu	SR	1	210
71	NEYVELI LIGNITE	NEYVELI TPS- II	Central Sector	Tamil Nadu	SR	2	210
72	NEYVELI LIGNITE	NEYVELI TPS- II	Central Sector	Tamil Nadu	SR	3	210
73	NEYVELI LIGNITE	NEYVELI TPS- II	Central Sector	Tamil Nadu	SR	4	210
74	NEYVELI LIGNITE	NEYVELI TPS- II	Central Sector	Tamil Nadu	SR	5	210
75	NEYVELI LIGNITE	NEYVELI TPS- II	Central Sector	Tamil Nadu	SR	6	210
76	NEYVELI LIGNITE	NEYVELI TPS- II	Central Sector	Tamil Nadu	SR	7	210
77	TNEB	METTUR TPS	State Sector	Tamil Nadu	SR	1	210
78	TNEB	METTUR TPS	State Sector	Tamil Nadu	SR	2	210
79	TNEB	METTUR TPS	State Sector	Tamil Nadu	SR	3	210
80	TNEB	METTUR TPS	State Sector	Tamil Nadu	SR	4	210
81	TNEB	NORTH CHENNAI TPS	State Sector	Tamil Nadu	SR	1	210
82	TNEB	NORTH CHENNAI TPS	State Sector	Tamil Nadu	SR	2	210
83	TNEB	NORTH CHENNAI TPS	State Sector	Tamil Nadu	SR	3	210
84	TNEB	TUTICORIN TPS	State Sector	Tamil Nadu	SR	1	210
85	TNEB	TUTICORIN TPS	State Sector	Tamil Nadu	SR	2	210
86	TNEB	TUTICORIN TPS	State Sector	Tamil Nadu	SR	3	210
87	TNEB	TUTICORIN TPS	State Sector	Tamil Nadu	SR	4	210
88	TNEB	TUTICORIN TPS	State Sector	Tamil Nadu	SR	5	210
89	TSGENCO	KOTHAGUDEM TPS (NEW)	State Sector	Telangana	SR	9	250
90	TSGENCO	KOTHAGUDEM TPS (NEW)	State Sector	Telangana	SR	10	250
91	CSPGCL	KORBA-III	State Sector	Chhattisgarh	WR	1	120
92	CSPGCL	KORBA-III	State Sector	Chhattisgarh	WR	2	120
93	CSPGCL	KORBA-WEST TPS	State Sector	Chhattisgarh	WR	1	210
94	CSPGCL	KORBA-WEST TPS	State Sector	Chhattisgarh	WR	2	210
95	CSPGCL	KORBA-WEST TPS	State Sector	Chhattisgarh	WR	3	210
96	CSPGCL	KORBA-WEST TPS	State Sector	Chhattisgarh	WR	4	210
97	GSECL	SIKKA REP. TPS	State Sector	Gujarat	WR	2	120

98	Torrent Power Generation Ltd,.	SABARMATI	Private Sector	Gujarat	WR	15	30
99	Torrent Power Generation Ltd,.	SABARMATI	Private Sector	Gujarat	WR	16	30
100	Gupta Energy P L	GEPL TPP Ph-I	Private Sector	Maharashtra	WR	1	60
101	Gupta Energy P L	GEPL TPP Ph-I	Private Sector	Maharashtra	WR	2	60
	TOTAL						**16,789 MW**

Annexure 5.6

LIST OF PROJECTS CONSIDERED FOR RETIREMENT DURING 2022-27

(Thermal station units which shall attain age of =>25 years on 1/1/2022)

(as on August,2017)

Sr. No.	Developer	Name of Project	Sector	State	Region	Unit No	Total Capacity
Sr. No.	Developer	Name of Project	Sector	State	Region	Unit No	Total Capacity
1	NTPC	KAHALGAON TPS	C	Bihar	ER	1	210
2	NTPC	KAHALGAON TPS	C	Bihar	ER	2	210
3	NTPC	KAHALGAON TPS	C	Bihar	ER	3	210
4	NTPC	KAHALGAON TPS	C	Bihar	ER	4	210
5	NTPC	TALCHER STPS	C	Odis.	ER	1	500
6	NTPC	TALCHER STPS	C	Odis.	ER	2	500
7	OPGCLtd	IB VALLEY TPS	S	Odis.	ER	1	210
8	OPGCLtd	IB VALLEY TPS	S	Odis.	ER	2	210
9	C.E.S.C. Pvt.	SOUTHERN REPL.	P	WB	ER	1	68
10	C.E.S.C. Pvt.	SOUTHERN REPL	P	WB	ER	2	68
11	D.P.L.	D.P.L. TPS	S	WB	ER	6	110
12	D.V.C	MEJIA TPS	C	WB	ER	1	210
13	D.V.C	MEJIA TPS	C	WB	ER	2	210
14	NTPC	FARAKKA STPS	C	WB	ER	1	200
15	NTPC	FARAKKA STPS	C	WB	ER	2	200
16	NTPC	FARAKKA STPS	C	WB	ER	3	200
17	NTPC	FARAKKA STPS	C	WB	ER	4	500
18	NTPC	FARAKKA STPS	C	WB	ER	5	500
19	WBPDC	KOLAGHAT TPS	S	WB	ER	1	210
20	WBPDC	KOLAGHAT TPS	S	WB	ER	2	210
21	WBPDC	KOLAGHAT TPS	S	WB	ER	3	210
22	WBPDC	KOLAGHAT TPS	S	WB	ER	4	210
23	WBPDC	KOLAGHAT TPS	S	WB	ER	5	210
24	WBPDC	KOLAGHAT TPS	S	WB	ER	6	210
25	NTPC	DADRI (NCTPP)	C	UP	NR	1	210
26	NTPC	DADRI (NCTPP)	C	UP	NR	2	210
27	NTPC	DADRI (NCTPP)	C	UP	NR	3	210
28	NTPC	DADRI (NCTPP)	C	UP	NR	4	210
29	NTPC	RIHAND STPS	C	UP	NR	1	500
30	NTPC	RIHAND STPS	C	UP	NR	2	500
31	NTPC	SINGRAULI STPS	C	UP	NR	1	200

32	NTPC	SINGRAULI STPS	C	UP	NR	2	200
33	NTPC	SINGRAULI STPS	C	UP	NR	3	200
34	NTPC	SINGRAULI STPS	C	UP	NR	4	200
35	NTPC	SINGRAULI STPS	C	UP	NR	5	200
36	NTPC	SINGRAULI STPS	C	UP	NR	6	500
37	NTPC	SINGRAULI STPS	C	UP	NR	7	500
38	NTPC	UNCHAHAR TPS	C	UP	NR	1	210
39	NTPC	UNCHAHAR TPS	C	UP	NR	2	210
40	UPRVUNL	ANPARA TPS	S	UP	NR	1	210
41	UPRVUNL	ANPARA TPS	S	UP	NR	2	210
42	UPRVUNL	ANPARA TPS	S	UP	NR	3	210
43	UPRVUNL	ANPARA TPS	S	UP	NR	4	500
44	UPRVUNL	ANPARA TPS	S	UP	NR	5	500
45	UPRVUNL	OBRA TPS	S	UP	NR	9	200
46	UPRVUNL	OBRA TPS	S	UP	NR	10	200
47	UPRVUNL	OBRA TPS	S	UP	NR	11	200
48	UPRVUNL	OBRA TPS	S	UP	NR	12	200
49	UPRVUNL	OBRA TPS	S	UP	NR	13	200
50	APGENCO	RAYALASEEMA TPS	S	AP	SR	1	210
51	APGENCO	RAYALASEEMA TPS	S	AP	SR	2	210
52	NTPC	RAMAGUNDEM STPS	C	Telang.	SR	1	200
53	NTPC	RAMAGUNDEM STPS	C	Telang.	SR	2	200
54	NTPC	RAMAGUNDEM STPS	C	Telang.	SR	3	200
55	NTPC	RAMAGUNDEM STPS	C	Telang.	SR	4	500
56	NTPC	RAMAGUNDEM STPS	C	Telang.	SR	5	500
57	NTPC	RAMAGUNDEM STPS	C	Telang.	SR	6	500
58	NTPC	KORBA STPS	C	Chhatt.	WR	1	200
59	NTPC	KORBA STPS	C	Chhatt.	WR	2	200
60	NTPC	KORBA STPS	C	Chhatt.	WR	3	200
61	NTPC	KORBA STPS	C	Chhatt.	WR	4	500
62	NTPC	KORBA STPS	C	Chhatt.	WR	5	500
63	NTPC	KORBA STPS	C	Chhatt.	WR	6	500
64	GSECL	GANDHI NAGAR TPS	S	Guj.	WR	3	210

65	GSECL	GANDHI NAGAR TPS	S	Guj.	WR	4	210
66	GSECL	KUTCH LIG. TPS	S	Guj.	WR	1	70
67	GSECL	KUTCH LIG. TPS	S	Guj.	WR	2	70
68	GSECL	KUTCH LIG. TPS	S	Guj.	WR	3	75
69	GSECL	UKAI TPS	S	Guj.	WR	3	200
70	GSECL	UKAI TPS	S	Guj.	WR	4	200
71	GSECL	UKAI TPS	S	Guj.	WR	5	210
72	GSECL	WANAKBORI TPS	S	Guj.	WR	1	210
73	GSECL	WANAKBORI TPS	S	Guj.	WR	2	210
74	GSECL	WANAKBORI TPS	S	Guj.	WR	3	210
75	GSECL	WANAKBORI TPS	S	Guj.	WR	4	210
76	GSECL	WANAKBORI TPS	S	Guj.	WR	5	210
77	GSECL	WANAKBORI TPS	S	Guj.	WR	6	210
78	Torrent	SABARMATI	P	Guj.	WR	1	120
79	Torrent	SABARMATI	P	Guj.	WR	2	121
80	Torrent	SABARMATI	P	Guj.	WR	3	121
81	MPPGCL	SANJAY GANDHI TPS	S	MP	WR	1	210
82	MPPGCL	SANJAY GANDHI TPS	S	MP	WR	2	210
83	NTPC	VINDHYACHAL STPS	C	MP	WR	1	210
84	NTPC	VINDHYACHAL STPS	C	MP	WR	2	210
85	NTPC	VINDHYACHAL STPS	C	MP	WR	3	210
86	NTPC	VINDHYACHAL STPS	C	MP	WR	4	210
87	NTPC	VINDHYACHAL STPS	C	MP	WR	5	210
88	NTPC	VINDHYACHAL STPS	C	MP	WR	6	210
89	MAHAGENCO	BHUSAWAL TPS	S	Maha	WR	2	210
90	MAHAGENCO	BHUSAWAL TPS	S	Maha	WR	3	210
91	MAHAGENCO	CHANDRAPUR STPS	S	Maha	WR	3	210
92	MAHAGENCO	CHANDRAPUR STPS	S	Maha	WR	4	210
93	MAHAGENCO	CHANDRAPUR STPS	S	Maha	WR	5	500
94	MAHAGENCO	CHANDRAPUR STPS	S	Maha	WR	6	500

95	MAHAGENCO	KHAPARKHEDA TPS	S	Maha	WR	1	210
96	MAHAGENCO	KHAPARKHEDA TPS	S	Maha	WR	2	210
97	MAHAGENCO	KORADI TPS	S	Maha	WR	6	210
98	MAHAGENCO	KORADI TPS	S	Maha	WR	7	210
99	MAHAGENCO	NASIK TPS	S	Maha	WR	3	210
100	MAHAGENCO	NASIK TPS	S	Maha	WR	4	210
101	MAHAGENCO	NASIK TPS	S	Maha	WR	5	210
102	MAHAGENCO	PARLI TPS	S	Maha	WR	4	210
103	MAHAGENCO	PARLI TPS	S	Maha	WR	5	210
	TOTAL						**25,572**

Annexure 5.7

LIST OF PROJECTS OF HYDRO IMPORTS FROM NEIGHBOURING COUNTRIES DURING 2017-22

(All Figures in MW)

Sl. No.	Plant Name	Country	Capacity (MW)
1	Chuka	Bhutan	336
2	Tala	Bhutan	1,020
3	Kuruchu	Bhutan	60
4	Puntsagchu-I	Bhutan	1,200
5	Puntsagchu-II	Bhutan	1,020
6	Mangdechu	Bhutan	720
	Total		**4,356**

Annexure 5.8

LIST OF THERMAL PROJECTS UNCERTAIN FOR BENEFITS DURING 2017-22

Sl. No.	Project Name	Fuel	State	Agency	Unit No.	Likely Benefits during 2017-22 (MW)
1	Panduranga CCPP	Gas	Andhra Pradesh	Panduranga Pvt. Ltd.	Module 1	116
2	RVK Gas Engine	Gas	Andhra Pradesh	Rajahmundry Pvt.Ltd	GE 1-4	38
3	RVK Gas Engine	Gas	Andhra Pradesh	Rajahmundry Pvt.Ltd	GE 5-8	38
4	RVKCCPP	Gas	Andhra Pradesh	Rajahmundry Pvt.Ltd	Module 1 -3	360
5	Samalkot CCPP-II	Gas	Andhra Pradesh	Reliance Power	Module 1-6	2400
6	Astha Gas Engines	Gas	Telangana	Astha	4 Engines	34.88
7	Ind Barath Gas Project	Gas	Tamil Nadu	Ind Barath	Block I	65
8	Beta CCPP	Gas	Uttarakhand	BIPL	GT+ST	225
9	Kashipur CCPP-II	Gas	Uttarakhand	Sravanthi Energy Pvt. Ltd	GT+ST	225
	Sub-total (GAS)					**3,501.88**
10	Bhavanapadu TPP Ph-I	Coal	Andhra Pradesh	East Coast Energy Ltd.	U 1,2	1320
11	Singhitarai TPP	Coal	Chhattisgarh	Athena Chhattisgarh Power Ltd.	U 1,2	1200
12	Matrishri Usha TPP Ph-I	Coal	Jharkhand	Corporate Power Ltd.	U 1,2	540
13	Tori TPP PH-I	Coal	Jharkhand	Essar Power Ltd.	U 1,2	1200
14	Lanco Babandh TPP	Coal	Odisha	LBP Ltd	U 1,2	1320
15	Lanco Vidarbha TPP	Coal	Maharashtra	LVP Pvt. Ltd.	U 1,2	1320
16	Malibrahmani TPP	Coal	Odisha	MPCL	U 1,2	1050
17	Akaltara TPP (Naiyara)	Coal	Chhattisgarh	KSK Mahandi Power Company Ltd.	U 5,6	1200
	Sub-total(COAL)					**9,150**
	Total Thermal					**12,651.88**

Annexure 5.9

LIST OF THERMAL PROJECTS UNDER VARIOUS STAGES LIKELY TO COME BEYOND 2021-22

S. No	Project Name / Implementing Agency	Unit No	Cap. (MW)	Fuel
	Central Sector			
1	Patratu /NTPC	U-1	800	Coal
2	Patratu /NTPC	U-2	800	Coal
3	Patratu /NTPC	U-3	800	Coal
4	Raghunathpur St-II/DVC	U-1	660	Coal
5	Raghunathpur St-II/DVC	U-2	660	Coal
6	Katwa/ NTPC	U-1	800	Coal
7	Katwa/ NTPC	U-2	800	Coal
8	Barethi/NTPC	U-1	800	Coal
9	Barethi/NTPC	U-2	800	Coal
10	Pudimdaka/NTPC	U-1	1000	Coal
11	Pudimdaka/NTPC	U-2	1000	Coal
12	Pudimdaka/NTPC	U-3	1000	Coal
13	Pudimdaka/NTPC	U-4	1000	Coal
14	Bhilur/NTPC	U-1	660	Coal
15	Bhilur/NTPC	U-2	660	Coal
16	Teiangana St II/ NTPC	U-1	800	Coal
17	Teiangana St II/ NTPC	U-2	800	Coal
18	Teiangana St II/ NTPC	U-3	800	Coal
19	Lara StI/ NTPC	U-1	800	Coal
20	Lara StI/ NTPC	U-2	800	Coal
21	Lara StI/ NTPC	U-3	800	Coal
22	Buxar/ SJVN	U-1	660	Coal
23	Buxar/ SJVN	U-2	660	Coal
24	THDC	U-1	660	Coal
25	THDC	U-2	660	Coal
26	Sirkali/ NLC	U-1	660	Coal
27	Sirkali/ NLC	U-2	660	Coal
28	Sirkali/ NLC	U-3	660	Coal
29	Pirpainti/ PBCPL	U-1	660	Coal
30	Pirpainti/ PBCPL	U-2	660	Coal
31	Lakhisarai/LBCPL	U-1	660	Coal
32	Lakhisarai/LBCPL	U-2	660	Coal
33	Bhaiathan/ ICPL	U-1	660	Coal
34	Bhaiathan/ ICPL	U-2	660	Coal
35	Pench/NTPC	U-1	660	Coal
36	Pench/NTPC	U-2	660	Coal
37	Margerhita/NEEPCO	U-1	660	Coal
38	MCL	U-1	660	Coal
39	MCL	U-2	660	Coal
	Subtotal (Central Sector)		**28,920**	
	State Sector			
40	Obra "C/"UPRVUNL	U-1	660	Coal
41	Obra "C/"UPRVUNL	U-2	660	Coal
42	Jawaharpur/ UPRVUNL	U-1	660	Coal

43	Jawaharpur/ UPRVUNL	U-2	660	Coal
44	Panki Extr/ UPRVUNL	U-1	660	Coal
45	Hazipur/ PSPCL	U-1	660	Coal
46	Hazipur/ PSPCL	U-2	660	Coal
47	Edlapur/ KPCL	U-1	800	Coal
48	DCRTPP (Yamunanagar)/ HPGCL	U-1	660	Coal
49	Panipat / HPGCL	U-1	800	Coal
50	Korba South	U-1	1000	Coal
51	Satpura/ MPPGCL	U-1	660	Coal
52	Nasik / MSPGCL	U-6	660	Coal
53	Bhusawal / MSPGCL	U-6	660	Coal
54	Duwasan/ GSECL	U-1	660	Coal
55	Duwasan/ GSECL	U-2	660	Coal
56	Sinor/ GSECL	U-2	660	Coal
57	Udangudi St-I/ TANGEDCO	U-1	660	Coal
58	Udangudi St-I/ TANGEDCO	U-2	660	Coal
59	Srikakulam/ APGENCO	U-1	800	Coal
60	Srikakulam/ APGENCO	U-2	800	Coal
61	Srikakulam/ APGENCO	U-3	800	Coal
62	Tenughat/ TVNL	U-1	660	Coal
63	Tenughat/ TVNL	U-2	660	Coal
64	Kamakhyanagar/OTPCL	U-1	800	Coal
65	Kamakhyanagar/OTPCL	U-2	800	Coal
66	Kamakhyanagar/OTPCL	U-3	800	Coal
67	Bakreshwar/ WBPDCL	U-6	660	Coal
68	Santaldih/ WBPDCL	U-7	660	Coal
	Subtotal (State Sector)		**20,600**	
	Private Sector			
69	Binjkote TPP/ SKS Power Generation (Chhattisgarh) Ltd.	U-3	300	Coal
70	KVK Nilanchal TPP/ KVK Nilanchal	U-2	350	Coal
71	KVK Nilanchal TPP/ KVK Nilanchal	U-3	350	Coal
72	Nasik TPP Ph-II / Ratan India Nasik Power Pvt. Ltd.	U-1	270	Coal
73	Nasik TPP Ph-II / Ratan India Nasik Power Pvt. Ltd.	U-2	270	Coal
74	Nasik TPP Ph-II / Ratan India Nasik Power Pvt. Ltd.	U-3	270	Coal
75	Nasik TPP Ph-II / Ratan India Nasik Power Pvt. Ltd.	U-4	270	Coal
76	Nasik TPP Ph-II / Ratan India Nasik Power Pvt. Ltd.	U-5	270	Coal
77	Amravati TPP Ph-II / Ratan India Power Pvt. Ltd.	U-1	270	Coal
78	Amravati TPP Ph-II / Ratan India Power Pvt. Ltd.	U-2	270	Coal
79	Amravati TPP Ph-II / Ratan India Power Pvt. Ltd.	U-3	270	Coal
80	Amravati TPP Ph-II / Ratan India Power Pvt. Ltd.	U-4	270	Coal
81	Amravati TPP Ph-II / Ratan India Power Pvt. Ltd.	U-5	270	Coal
82	Tori / Essar Power	U-3	600	Coal
83	Visa / Visa Power	U-2	660	Coal
84	Dhenkanal/ CESC	U-1	660	Coal
85	Dhenkanal/ CESC	U-2	660	Coal

86	Matrishri Usha Ph-I / Corporate Power Ltd.	U-1	270	Coal
87	Matrishri Usha Ph-I / Corporate Power Ltd.	U-2	270	Coal
88	Kawai Ext	U-1	800	
89	Kawai Ext	U-2	800	
90	Udipi Ext	U-1	800	
91	Udipi Ext	U-2	800	Coal
92	Jharkhand	U-1	800	
93	Jharkhand	U-2	800	
94	Pench	U-1	660	
95	Pench	U-2	660	
96	Dahej	U-1	660	
97	Dahej	U-2	660	
98	Dahej	U-3	660	
99	Dahej	U-4	660	
100	Badreshwar	U-1	660	
101	Badreshwar	U-2	660	
102	Badreshwar	U-3	660	
103	Badreshwar	U-4	660	
104	Badreshwar	U-5	660	
	Subtotal (Private Sector)		**18,880**	
	5 UMPPs		**20,000**	
	TOTAL		**88,400**	

CHAPTER 6
RENEWABLE ENERGY SOURCES

6.0 INTRODUCTION

The World Energy Forum has predicted that fossil-based oil, coal and gas reserves will be exhausted in less than another 10 decades. This coupled with the urgent need of arresting the adverse climatic changes has forced planners and policy makers to look for alternate sources.

The 2015 United Nation Climate Conference in Paris is a milestone in global climatic co-operation. It reaffirmed the need to have a rapid and global transition to renewable energy technologies to achieve sustainable development and avoid catastrophic climatic change. 195 countries adopted the first universal, legally binding global climate deal.

In fact, many of the countries throughout the world have already embraced renewable energy technologies significantly in order to meet their electricity demand and reduce emissions.

6.1 GLOBAL SCENERIO OF ELECTRICITY GENERATION FROM RENEWABLE ENERGY SOURCES

The International Energy Agency's World Energy Outlook projects a growth of renewable energy supply from 1,700 GW in 2014 to 4,550 GW in 2040 on a global basis.

Global renewable generation capacity at the end of 2015 stood at 1,985 GW. 152 GW renewable generation capacity was added in 2015. The growth in renewable capacity addition during 2015 was 8.3%. Share of Asia in renewable capacity addition in 2015 was 58%. (Source: IRENA)

In 2015, **California** received over 20% of its electricity from renewable energy (excluding large hydro). By 2020, California's Renewable Portfolio Standard Policy requires a 33% share of renewables.

In October 2015, the Government of **Argentina** passed a new law to raise the share of renewables to 20% by 2025, and this includes a number of new measures to realize this target.

Germany is a global leader in adopting high share of renewable energy. Renewables already provide close to 30% of Germany's power on an average basis. On some peak days in 2014, solar and wind alone supplied close to 80% of peak power demand at specific times of the day. Germany is targeting a 50% share of renewables by 2030 and 80% by 2050 and planned to phase out nuclear power by 2022.

Denmark is a world leader in wind power, with 39% of the country's electricity coming from wind in 2015. Denmark is targeting 50% of its electricity from wind power by 2020, and 100% of its electricity from all forms of renewables by 2035.

In December 2014, the **Turkish** Government approved its National Renewable Energy Action Plan, targeting a 30% renewable energy share in power generation and 10% in transport by 2023.

The **European Union (EU)** as a whole had a 27% renewable share in 2014.

Among developing countries, China, India, South Africa, and several other countries have already initiated ambitious plans of capacity addition from Renewable Energy Sources(RES).
China's solar PV target for 2015 increased from 17.8 GW to 23.1 GW, which includes projects that began construction in 2015 and will be commissioned by the end of June 2016. This increase suggests that the 2020 target could be revised upward from 100 to 150 GW for solar PV and from 200 to 250 GW for wind, with strong interest and engagement from provinces.
In October 2015, the **Association of Southeast Asian Nations** (ASEAN) set a 23% renewable energy target for primary energy to be reached by 2025.
In early 2015, the **Economic Community of West African States** (ECOWAS) released its region-specific renewable electricity target of 75.6 terawatt-hours (TWh), which would be 31% of total generation in 2030.

In India, as on 31st March,2017, the total RES capacity was 57,244.24 MW out of total installed generation capacity of 326,832.6 MW. This represents almost 17.5% of the total installed capacity. An Action Plan has been formulated by Government of India for achievement of a total capacity of 1,75,000 MW from Renewable Energy Sources by March, 2022.

6.2 RENEWABLE ENERGY SOURCES

Renewable energy sources are those that are continually replenished by nature and derived directly from the sun (such as thermal, photo-chemical, and photo-electric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanism of the environment (such as geothermal and tidal energy). This includes electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources and biofuels.

A description of the dominant forms of Renewable Energy Sources is outlined below:-

6.2.1 Solar Power

Solar energy generation involves the use of the sun's energy to provide hot water via solar thermal system or electricity via solar photovoltaic (PV) and concentrated solar power (CSP) systems. These technologies are technically well proven with numerous systems installed around the world over the last few decades.

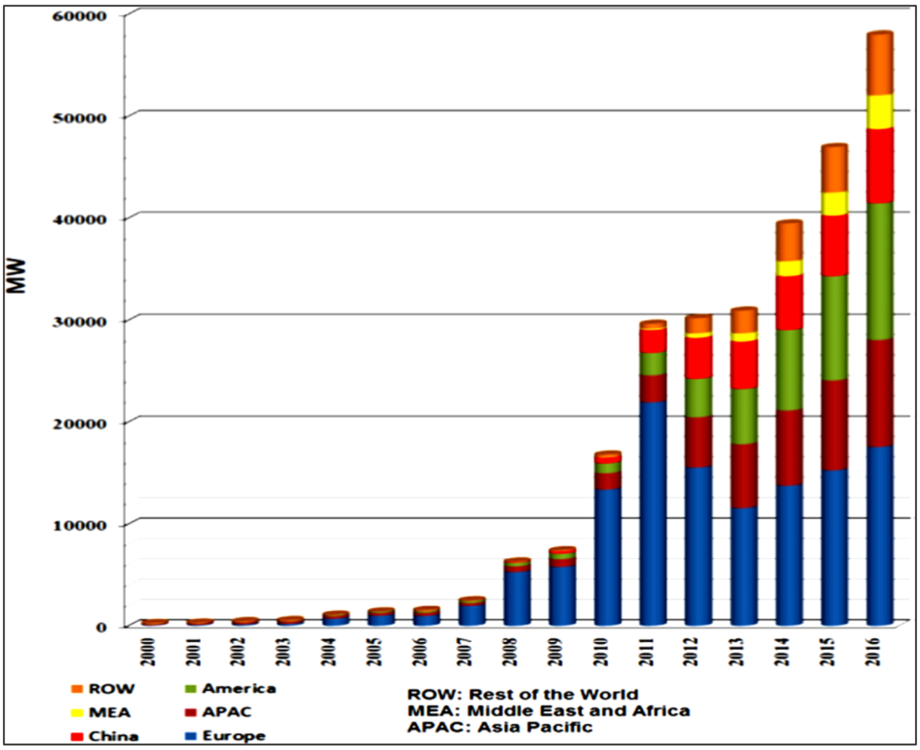
6.2.1.1 Solar Photovoltaic

Solar photovoltaic (PV) systems directly convert solar energy into electricity. The basic building block of a PV system is the PV cell, which is a semiconductor device that converts solar energy into direct-current electricity. PV module is formed by interconnecting a large number of PV cells. The PV modules are combined with a set of application-dependent system components to form a PV system. Modular PV systems are linked together to provide power ranging from a few watts to tens of megawatts.

The most established solar PV technologies are silicon based systems. More recently, thin film modules consisting of non-silicon semiconductor materials have become important. Thin films generally have a lower efficiency than silicon modules. However, price per unit of capacity is lower in thin films.

Solar PV has the advantage of economies of scale as module manufacturing can be done in large plants. Further, in addition to direct sunlight, it can use diffused sunlight which helps it to produce power when sky is not clear. **Exhibit 6.1** shows global annual PV market till 2016.

Exhibit 6.1



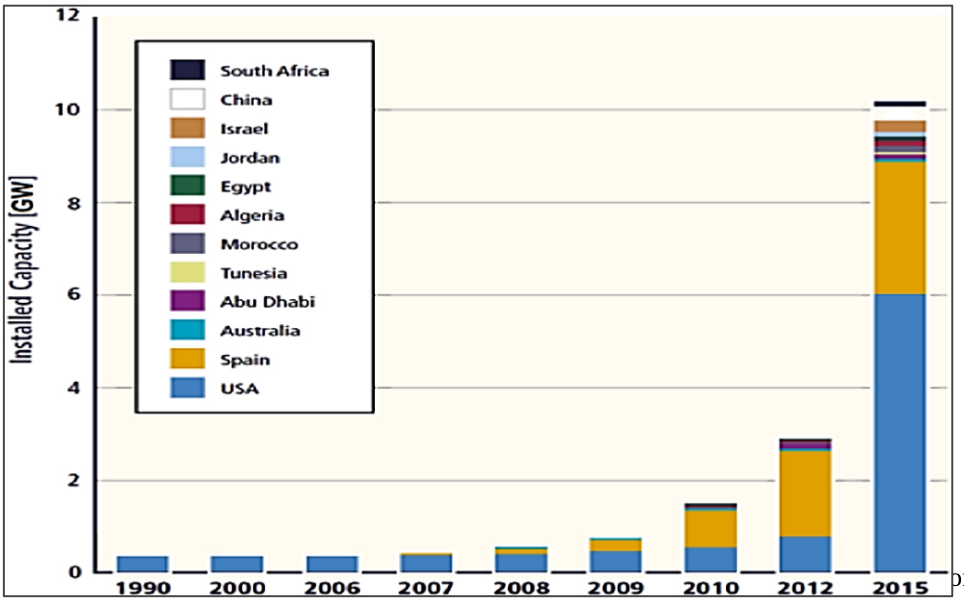
(Source: European Photovoltaic Industry Association, ⟨www.epia.org⟩).

6.2.1.2 Concentrated Solar Power

In Concentrated Solar Power (CSP) technology, a concentrated direct beam solar irradiance is used to heat a liquid, solid or gas that is used in a downstream process for electricity generation. Large scale CSP plants most commonly concentrate sunlight by reflection, as opposed to refraction with lenses. Concentration is done on to a line (linear focus) as in central receiver or on a dish system. CSP technology can be used to produce electricity from small distributed systems of tens of kW to large centralized power station of hundreds of MW.

Exhibit 6.2 shows the global installed and planned Concentrated Solar Power (CSP) capacity distributed by country.

Exhibit 6.2



rg; 2012.)

6.2.2 Wind Power

Wind power is produced through conversion of kinetic energy associated with wind to mechanical energy first and then to electrical energy. The amount of kinetic energy in the wind that is theoretically available for extraction increases with the cube of the wind speed. However, a turbine only captures a fraction of that available energy (40-50%). In order to maximize energy capture, turbine designs, including materials used for turbine, blade sizes etc., have been undergoing changes. The objective has been to minimize total cost of power produced from wind turbine by capturing maximum wind energy and efficient conversion thereof into reliable electrical energy.

Electrical conversion system is very important as far as reliability is concerned. For large grid-connected turbines, electrical conversion system comes in different forms:

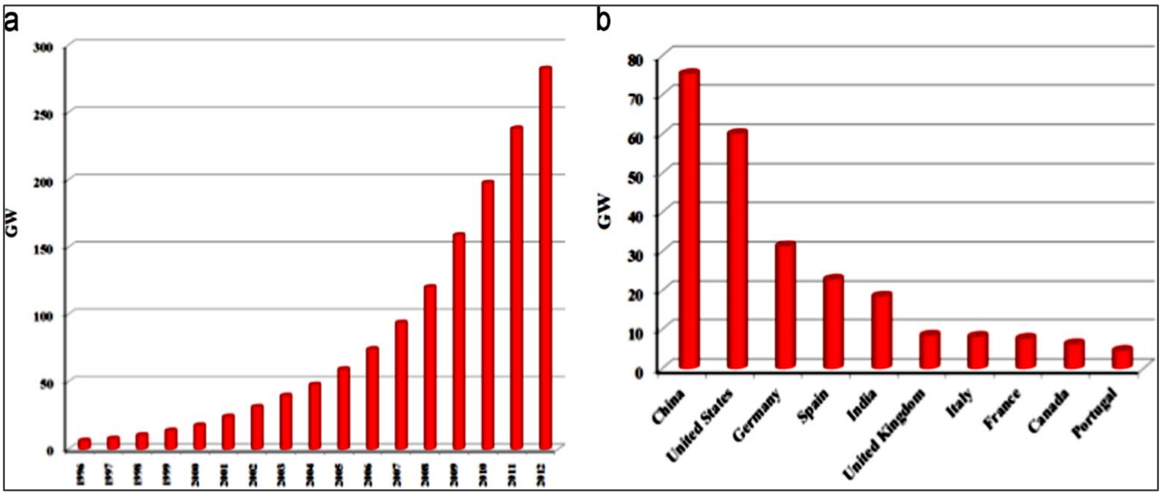
i) Fixed Speed Induction Generators

ii) Variable Speed Machines.

The fixed speed induction generator wind turbines are net consumers of reactive power that has to be supplied by the electric network. These turbines can provide real and reactive power as well as some fault ride-through capability, all of which are required by electric network operators.

Exhibit 6.3 shows the global installed wind power capacity as well as installed capacity of top 10 wind power generating countries.

Exhibit 6.3



(a) Wind power total world capacity, 1996–2012, (b) wind power capacity, top 10 countries, 2012

(Source: REN21, Renewables 2013: global status report ⟨www.ren21.net⟩)

6.2.3 Biomass Power

Biomass energy is the use of living and recently dead biological material as an energy source. As an energy source, biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of bio fuel. Most of today's biomass power plants are direct-fired systems, which are similar to most fossil-fuel fired power plants. The renewable biomass fuels are converted to heat and then to electricity. Theoretically, it is a carbon neutral source of energy.

The biomass used for electricity generation range from forest by-products (wood residues), agricultural waste (sugar cane residue & rice husk) and animal husbandry residues (poultry litter etc.).

6.2.4 Small Hydro Power

Small hydro power plants utilize the flow of water to rotate the blades of the turbine which in turn drives the generator for producing electrical energy. The amount of energy generated depends on the amount of water flowing through the turbine as well as the size of the turbine. Small hydro power plants are generally used as standalone power systems in remote areas.

6.2.5 Wave and Tidal Power

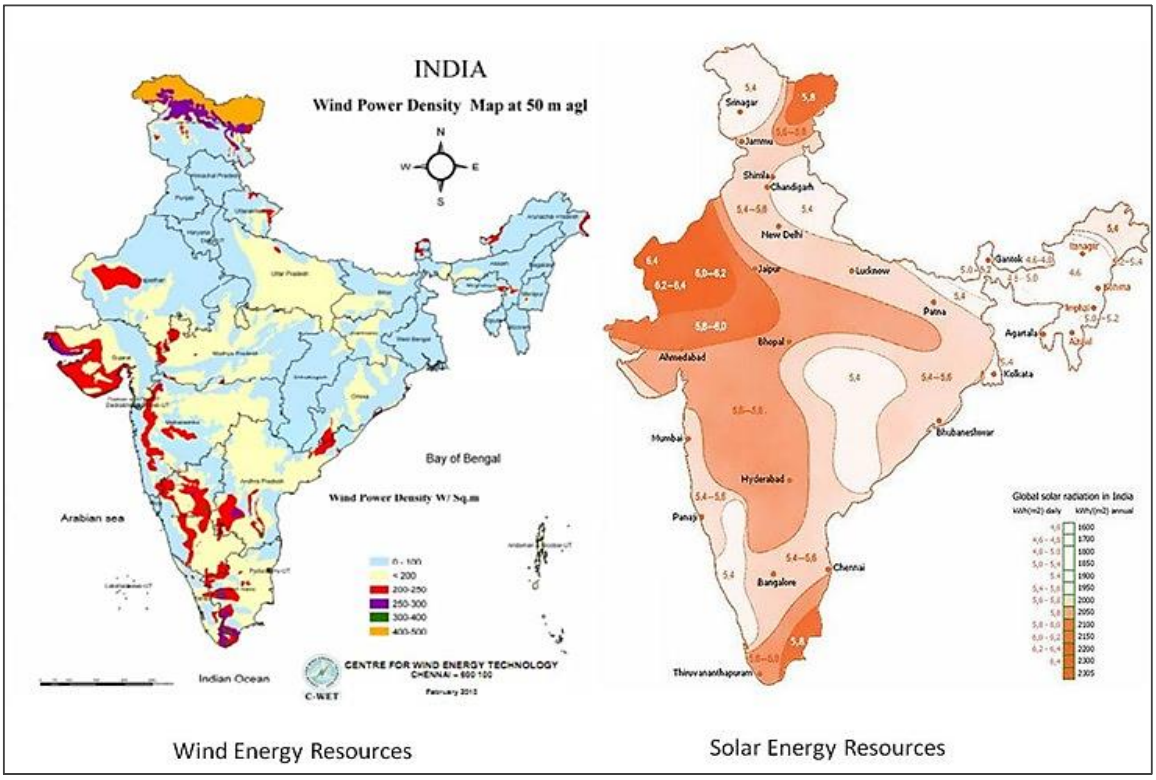
Wave power, which captures the energy of ocean surface waves, and tidal power, which converts the energy of tides, are two forms of hydro power with future potential. However, they are not yet widely employed commercially.

6.3 POTENTIAL OF RENEWABLE ENERGY GENERATION IN INDIA

In order to arrest the climate change and in view of the depleting conventional energy sources, India is taking firm steps towards the development of renewable energy. India has significant potential of electricity generation from Renewable Energy Sources (RES). The Renewable Energy (RE) potential in India is estimated at 8,96,602 MW comprising of 7,48,991 MW of Solar Power, 1,02,772 MW of Wind Power, 19,749 MW of Small Hydro Power and 25,090 MW of Bio-Energy**.** The State-wise estimated potential of renewable power in the country is placed at **Annexure-6.1** (Source: MNRE).

The Government of India, in pursuit of energy security and for minimizing impact on environment, has been prioritizing the development of RE sector through its policies and programmes. Wind, Solar and Small Hydro are three emerging renewable energy sources. Wind energy and solar energy resources maps of India are shown in **Exhibit 6.4**.

Exhibit 6.4



(Source CWET, Chennai)

The description of dominant forms of the renewable energy sources in India is outlined below:

6.3.1 Solar

It has been observed that solar as viable alternative for power generation among the available clean energy sources, has the highest global warming mitigation potential. India is one of the best recipients of solar energy due to its favourable location in the solar belt (40^0 S to 40^0 N). India has a vast potential for solar power generation since about 58% of the total land area (1.89 million km^2) receives annual average global insolation above 5 kWh/m^2/day. The Gangetic plains (trans, middle and upper), plateau (central, western and southern) region, western dry region, Gujarat plains and hill region as well as the west coast plains and Ghat region receive annual global insolation above 5 kWh/m^2/day. These zones include states of Karnataka, Gujarat, Andhra Pradesh, Maharashtra, Madhya Pradesh, Rajasthan, Tamil Nadu, Haryana, Punjab, Kerala, Bihar, Uttar Pradesh and Chhattisgarh. The eastern part of Ladakh region (Jammu & Kashmir) and minor parts of Himachal Pradesh, Uttarakhand and Sikkim which are located in the Himalayan belt also receive similar average global insolation annually. The eastern Himalayan states of Arunachal Pradesh, Nagaland and Assam receive annual average global insolation below 4 kWh/m^2/day.

6.3.2 Wind

The development of wind power in India began in the 1986 with first windfarms being set up in coastal areas of Maharashtra (Ratnagiri), Gujarat (Okha) and Tamil Nadu (Tuticorin) with 55 kW Vestas wind turbines. The capacity has significantly increased in the last few years. Although a relative newcomer to the wind industry, India has the fourth largest installed wind power capacity in the world after China, USA and Germany. The short gestation periods for installing wind turbines, and the increasing reliability and performance of wind energy machines has made wind power a favoured choice for electricity generation in India. The wind power projects in India are mainly spread across south, west and north regions while east and north-east regions have no grid connected wind power plant.

Wind power generation in India is highly influenced by the monsoon in India. The strong south-west monsoon, starts in May-June, when cool, humid air moves towards the land and the weaker north-east monsoon, starts in October, when cool dry air moves towards the ocean. During the period of March to August, the winds are uniform and strong over the whole Indian peninsula, except the eastern peninsular coast. Wind speed during the period of November to March is relatively weak.

No offshore wind farm utilizing traditional fixed-bottom wind turbine technology in shallow sea areas or floating wind turbine technology in deep sea areas are under implementation. An offshore wind policy was announced in 2015 and presently weather stations and LIDARS(light detection and ranging) are being set up by National Institute of Wind Energy (NIWE) at some locations.

6.3.3 Biomass

About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs. The current availability of biomass in India is estimated at about 500 million metric tonnes per year, covering agricultural and forestry residues corresponding to a potential of about **18,000 MW**. Additional 7,000 MW power could be generated through bagasse based cogeneration in the country.

6.3.4 Small Hydro

Hydro power plants of capacity up to 25 MW are categorized as small hydro power plants. The estimated potential for power generation in the country from such plants is about 20,000 MW. Most of the potential is in Himalayan States as river-based projects and in other States on irrigation canals.

6.4 DEVELOPMENT OF RENEWABLES IN INDIA

There has been a significant increase in renewable energy capacity in the country during the last decade. The installed capacity of renewables in India was 7,761 MW as at the end of 10th plan (i.e. on 31st March,2007) and the same had grown to 24,504 MW at the end of 11th plan (i.e. on 31st March,2012). With a consistent growth, the installed capacity of renewable energy sources has reached 57,244.24 MW as on 31st March,2017. The installed capacity of grid connected renewable power plants in India is shown in **Table 6.1**.

Table 6.1

Installed Capacity of Grid-connected Renewable Power Plants

(As on 31.03.2017)

(All figures in MW)

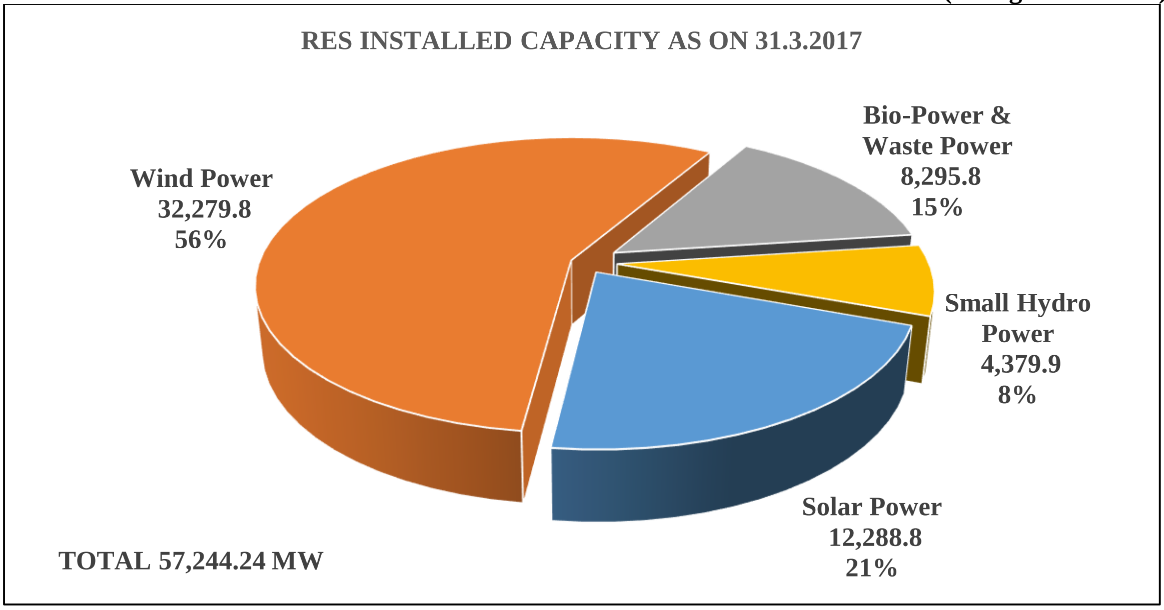
Renewable Energy Source	Installed capacity (MW)
Solar Power	12,288.83
Wind Power	32,279.77
Bio-Power & Waste Power	8,295.78
Small Hydro Power	4,379.86
Total	**57,244.24**

The installed capacity of Wind power in India as on 31st March,2017 was 32,279.77MW, which is 56.4% of total Renewable installed capacity, mostly located in South, West and North regions. This capacity of wind power is mainly spread across Tamil Nadu (7861.46 MW), Gujarat (5340.62 MW), Maharashtra (4771.33 MW), Rajasthan (4281.72 MW), Karnataka (3751.40 MW), Andhra Pradesh (3618.85 MW), Madhya Pradesh (2497.79 MW), Telangana (100.8 MW), Kerala (51.5 MW) and other States (4.30 MW). Tamil Nadu has become a leader in Wind Power in India. Muppandal windfarm in Tamil Nadu with the total capacity of 1500 MW, is the largest in the country.

The National Solar Mission (NSM) launched in January 2010 has given a great boost to the solar scenario in the country. As of 31st March,2017, the installed capacity of solar power in India was 12,288.83 MW, which is 21.5 % of total Renewable installed capacity in India. This solar capacity is mainly spread across Andhra Pradesh (1867.23 MW), Rajasthan (1812.93 MW), Tamil Nadu (1691.83 MW), Telangana (1286.98 MW), Gujarat (1249.37 MW), Madhya Pradesh (857.04 MW), Punjab (793.95 MW), etc. The installed capacity of biomass power in India as on 31st March,2017 was 8295.78 MW, which is 14.5% of total renewable installed capacity in India. Small hydropower with capacity of 4379.86 MW as on 31st March,2017 represents 7.17% of total renewable installed capacity in India. Total renewable installed capacity in India is shown in **Exhibit 6.5**.

Exhibit 6.5

(All figures in MW)



The State-wise Installed Capacity of Grid Interactive Renewable Power as on 31.3.2017 is placed at **Annexure-6.2.**

6.5 RENEWABLE ENERGY TARGET BY 2022

Over the years, renewable energy sector in India is emerging as a significant player in the grid connected power generation capacity. It is well recognized that renewable energy has to play a much bigger role in achieving energy security in the years ahead and to be an integral part of the energy planning process. Renewable energy sector is now poised for a quantum jump as India has reset its renewable energy capacity addition target so as to have an installed capacity of 175 GW by 2022, in view of the significant renewable energy potential in the country and commitment made by the investors/stakeholders. The targeted contribution of the major renewable energy sources to reach the capacity of 175 GW by 2022 is shown in **Table 6.2.**

Table 6.2

Targeted contribution of the major Renewable Energy Sources

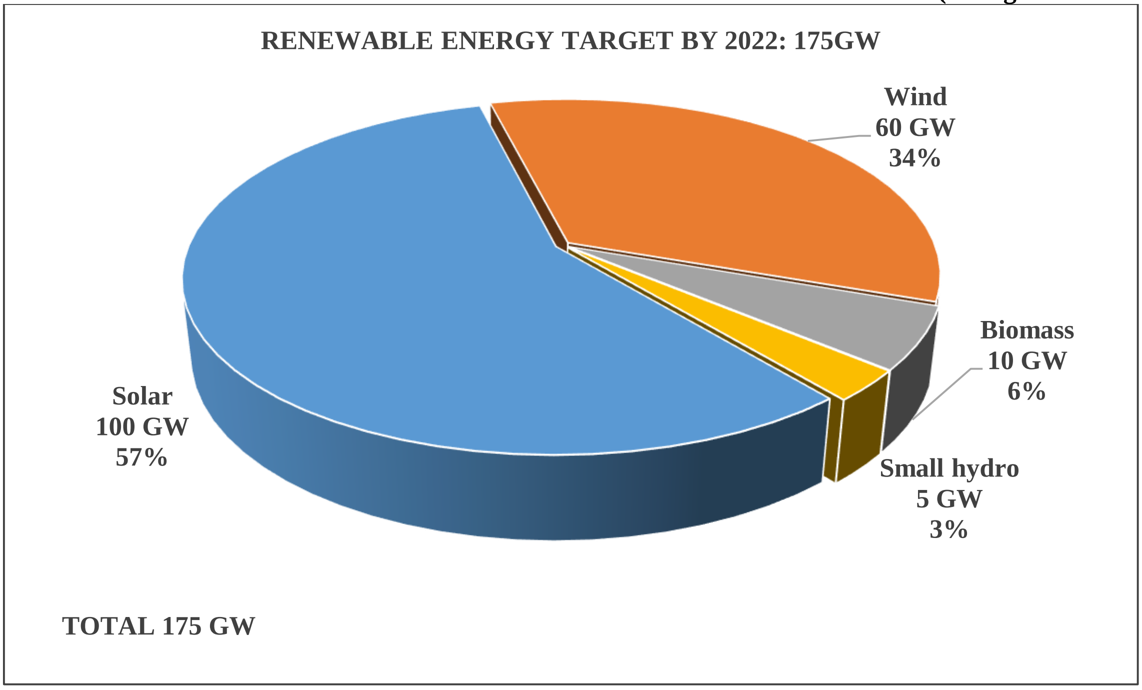
(All figures in GW)

Sl. No.	Renewable Energy Source	Targeted Installed Capacity by 2022
1.	Solar	100
2.	Wind	60
3.	Biomass	10
4.	Small Hydro	5
	Total	**175**

The substantial higher capacity target of renewables will ensure greater energy security, improved energy access and enhanced employment opportunities. With the accomplishment of these ambitious targets, India will become one of the largest Green Energy producers in the world, surpassing several developed countries. Renewable Energy target of India type-wise and region-wise, by 2022 is shown in **Exhibit 6.6** and **Exhibit 6.7** respectively.

Exhibit 6.6

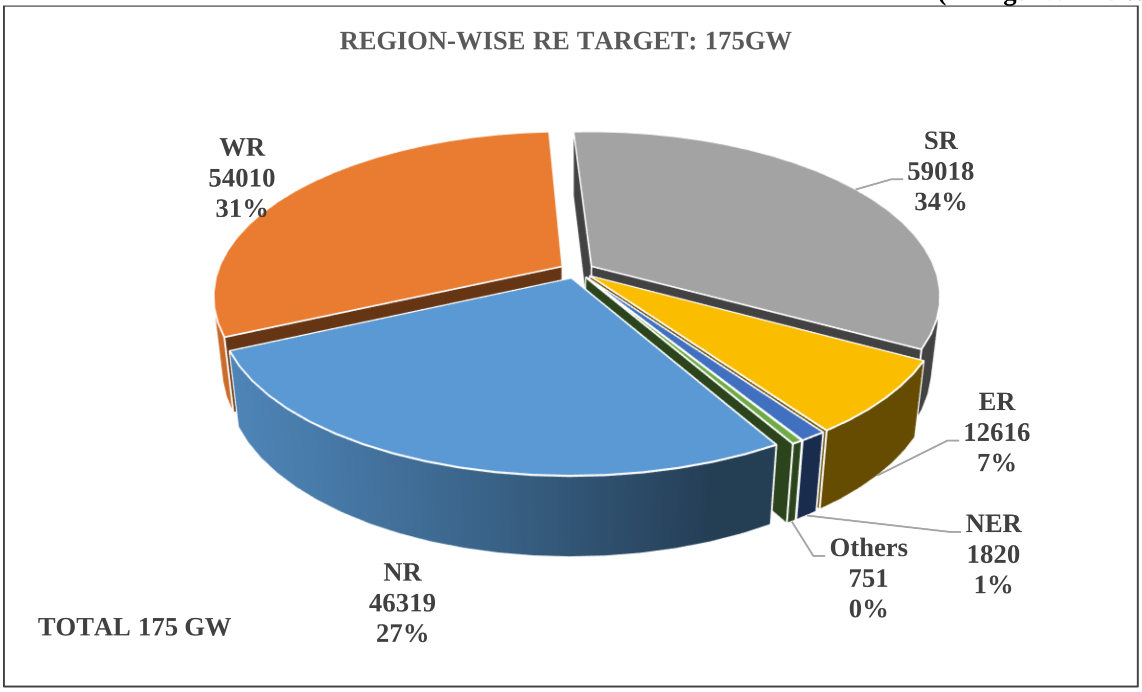
(All figures in GW)



A comparison between **Exhibit 6.5** and **Exhibit 6.6** indicates that even though wind plants are predominant today, in future solar plants shall have more installed capacity than that of wind plants.

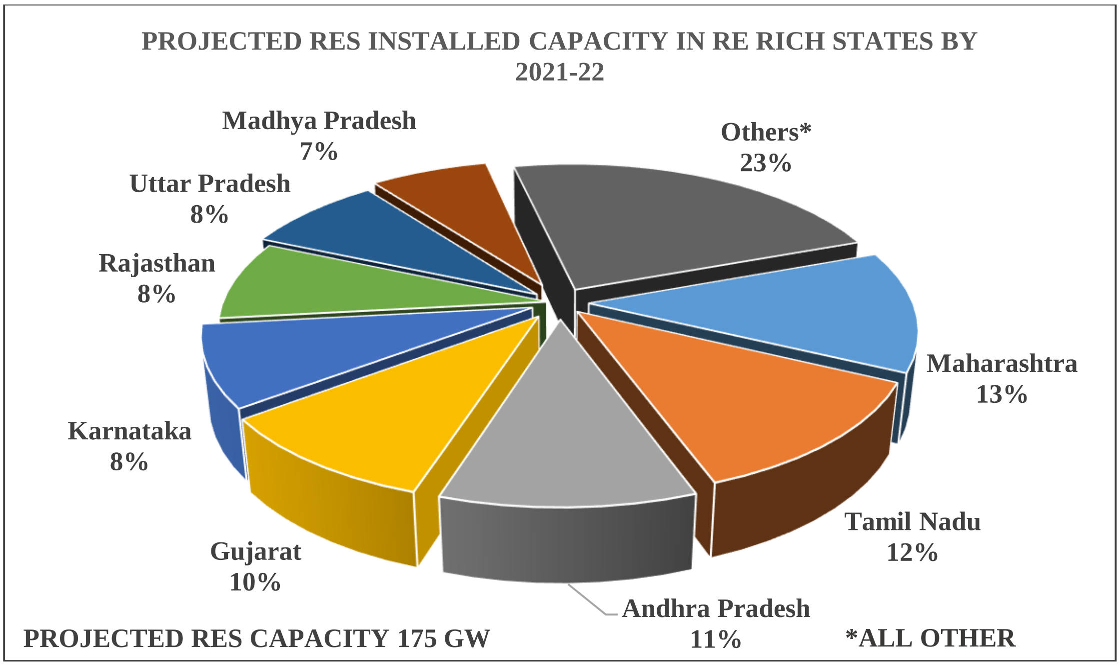
Exhibit 6.7

(All figures in GW)



The tentative State-wise break-up of Renewable Power target corresponding to installed capacity of 175 GW to be achieved by the year 2022 is shown in **Exhibit 6.8**. Details are placed at **Annexure-6.3.**

Exhibit 6.8



It can be seen that 8 States in India shall contribute about 77% of the Renewable installed capacity by 2022. The year-wise targets set by Ministry of New & Renewable Energy (MNRE) to accomplish the scaled-up target of 1,75,000 MW installed capacity of renewables by 2022 are given in **Table 6.3.**

Table 6.3

Year-wise targets of Renewable Energy Sources

(All figures in MW)

Category	**Capacity addition***				
	2017-18	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Rooftop Solar	5,000	6,000	9,000	9,000	10,311
Ground Mounted Solar	10,000	10,000	10,000	10,000	8,400
Total Solar	**15,000**	**16,000**	**19,000**	**19,000**	**18,711**
Wind	**4,700**	**5,300**	**6,000**	**6,000**	**5,720**
Biomass	**350**	**350**	**350**	**350**	**304**
Small Hydro Power	**100**	**100**	**100**	**100**	**220**
TOTAL	**20,150**	**21,750**	**25,450**	**25,450**	**24,955**

***The capacity has been adjusted to arrive at total RES capacity of 175 GW by 2021-22**

6.6 PROJECTION OF RENEWABLE ENERGY GENERATION

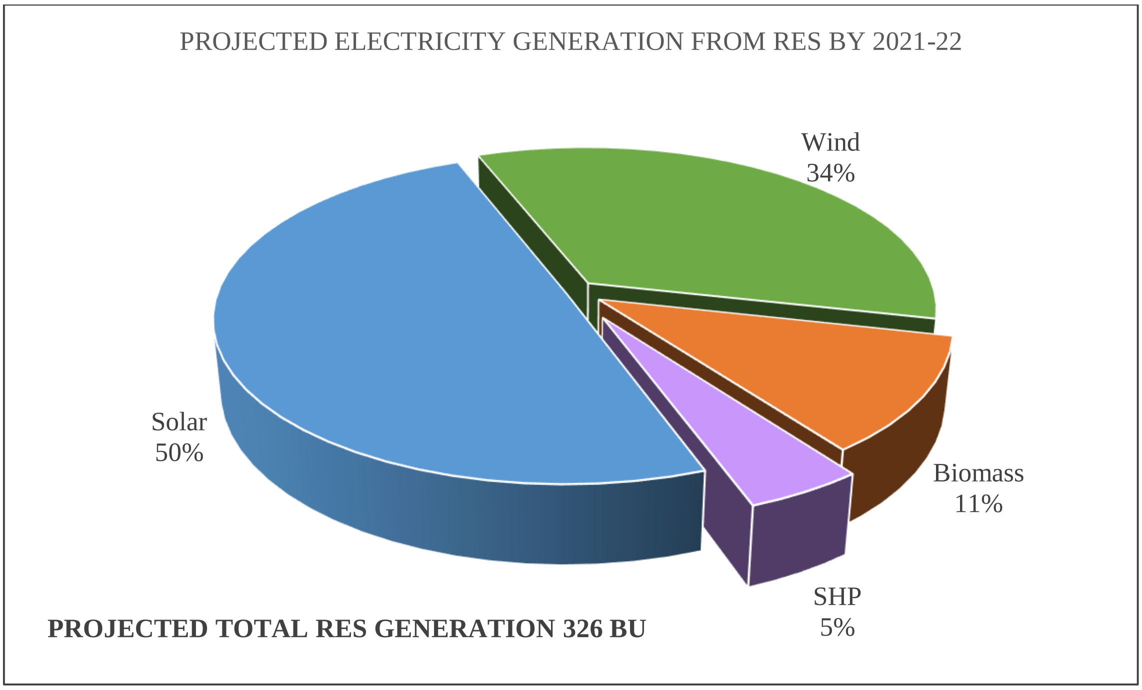
Based on the projections of capacity addition targets from Renewable Energy Sources by the year 2021-22 as furnished by MNRE and considering an RES capacity addition of 1,00,000 MW during the period 2022-27, expected electricity generation from various renewable energy sources has been estimated and is given in **Table 6.4** and **Exhibit 6.9**. It can be seen that contribution of RES will be around 21% of the total energy of the country in the year 2021-22 and 24% by 2026-27.

Table 6.4

Estimated Electricity Generation from RES in years 2021-22 and 2026-27

Year	Installed capacity of RES (GW)	Expected Generation in (BU)					Contribution of RES to Total Energy Demand(%)
		Solar	Wind	Biomass	SHP	Total	
2021-22	175	162	112	37	15	326	**20.1%**
2026-27	275	243	188	63	24	518	**24.4%**

Exhibit 6.9



6.7 RECENT ACHIEVEMENTS IN DEVELOPMENT OF RENEWABLE ENERGY

1) Solar project of capacity 20,904 MW were tendered in 2015-16. Of these 11,209 MW have already been awarded and 9,695 MW are in process of getting awarded.
2) International Solar Alliance of 121 tropical countries to develop and promote solar energy, to be headquartered in India.
3) 34 Solar parks of capacity 20,000 MW in 21 States have been sanctioned.
4) Green Energy Corridor worth ₹ 38,000 crores being set up to ensure evacuation of power generated from renewable energy sources.
5) Clean environment cess increased 8 times from ₹ 50 to ₹ 400 per tonne to finance Clean Energy Projects and Ganga Rejuvenation.

6.8 RECENT RENEWABLE ENERGY INITIATIVES

6.8.1 Solar Parks

Government of India has chalked out the target of developing 100 GW of solar power plants by 2022. Solar parks are basically clearly demarcated development zones with proper infrastructure like roads and other amenities. State Governments or EPC developers acquire the land, put up transmission lines, get the required government permissions and approvals, and offer the facility to the companies who can put up their solar projects on the land and offer the operators a fee. Thus, the risk associated with the projects are greatly minimized.

The first solar park in the country was established at Charanka solar park in Gujarat. This was closely followed by the Bhadla solar park in Rajasthan. The concept of solar parks has given an impetus for rapid development of solar power projects in the country. 34 no of solar parks in 21 States with an aggregate capacity of 20,000 MW have been approved. Large size projects have a potential to bring down the cost of solar power. Therefore, Ultra-Mega Solar power projects having capacity of 500 MW or above have been proposed. Large chunks of land are available in a few States for solar park development.

6.8.2 National Offshore Wind Energy Policy, 2015

Under the policy, the Ministry of New & Renewable Energy (MNRE) has been authorized as the nodal Ministry for the use of offshore area within the Exclusive Economic Zone (EEZ) of the country and the National Institute of Wind Energy (NIWE) has been authorized as the nodal agency for development of offshore wind energy in the country and to carry out the allocation of offshore wind energy blocks, coordination and allied functions with related ministries and agencies. It would pave the way for offshore wind energy development including setting up of offshore wind power projects and research and development activities, in waters, in or adjacent to the country, up to the seaward distance of 200 nautical miles (EEZ of the country) from the base line. Preliminary assessments along the 7,600 km long Indian coastline have indicated prospects of development of offshore wind power. With the introduction of the National Offshore Wind Energy Policy, the Government is attempting to replicate the success of the onshore wind power development in the area of offshore wind power development.

The scheme would be applicable throughout the country depending upon the offshore wind potential availability.

6.8.3 Indian Wind and Solar Resources Atlas 2015

Wind Energy Resources Map of India at 100 meter above ground level and Solar Radiation Map at ground level on online Geographic Information System (GIS) platform has been launched. This online Wind Atlas is available online on the NIWE website www.niwe.res.in. The Wind and Solar Resource maps will not only help and guide the wind & solar power developers and other stakeholders in identifying potential areas for the development of wind & solar power projects in the country but also help the central and state agencies in planning and developing the infrastructure including transmission system, required for installing renewable power projects in these potential areas.

6.8.4 Solar Cities

Under the programme of development of Solar Cities, the Ministry of New & Renewable Energy(MNRE) has approved 56 solar city projects, against the target of development of 60 nos. of Solar Cities. The Solar Cities programme is designed to support/encourage urban local bodies to prepare a road map to guide their cities in becoming renewable energy cities or Solar Cities.

The ministry has already initiated various programmes in the urban sector for promoting solar water heating systems in homes, hotels, hostels, hospitals and industry; deployment of SPV systems/devices in urban areas for demonstration and awareness creation; establishment of 'Akshya Urja Shops'; design of Solar Buildings and promoting urban and industrial waste/biomass to energy projects. The solar city programme aims to consolidate all the efforts of the ministry in the urban sector and address the energy problem of the urban areas in a holistic manner.

The Solar City programme aims to:

- Enable and empower urban local governments to address energy challenges at city-level.
- Provide a framework and support to prepare a Master Plan including assessment of current energy situation, future demand and action plans.
- Build capacity in the urban local bodies and create awareness among all sections of civil society.
- Involve various stakeholders in the planning process.

- Oversee the implementation of sustainable energy options through public-private partnerships.

6.8.5 Solar pump

The Government has implemented a scheme to install one lakh solar pumps for irrigation and drinking water through state nodal agencies and NABARD. These pumps would help lakhs of farmers in increasing outputs, income and also in providing drinking water. According to estimates, drinking water problems will be solved for more than 7.6 lakh families through solar pumps for drinking water. MNRE provides 30% capital subsidy to farmers for installation of solar pumps for irrigation purpose through state nodal agencies. The state governments can give additional subsidy. The Government presented 40% subsidy with mandatory loan to farmers for irrigation purpose through NABARD. The ministry has issued supplementary guidelines for 1,00,000 solar pumps during 2014-15 and a sum of ₹ 353.50 crores was released to various agencies for the purpose.

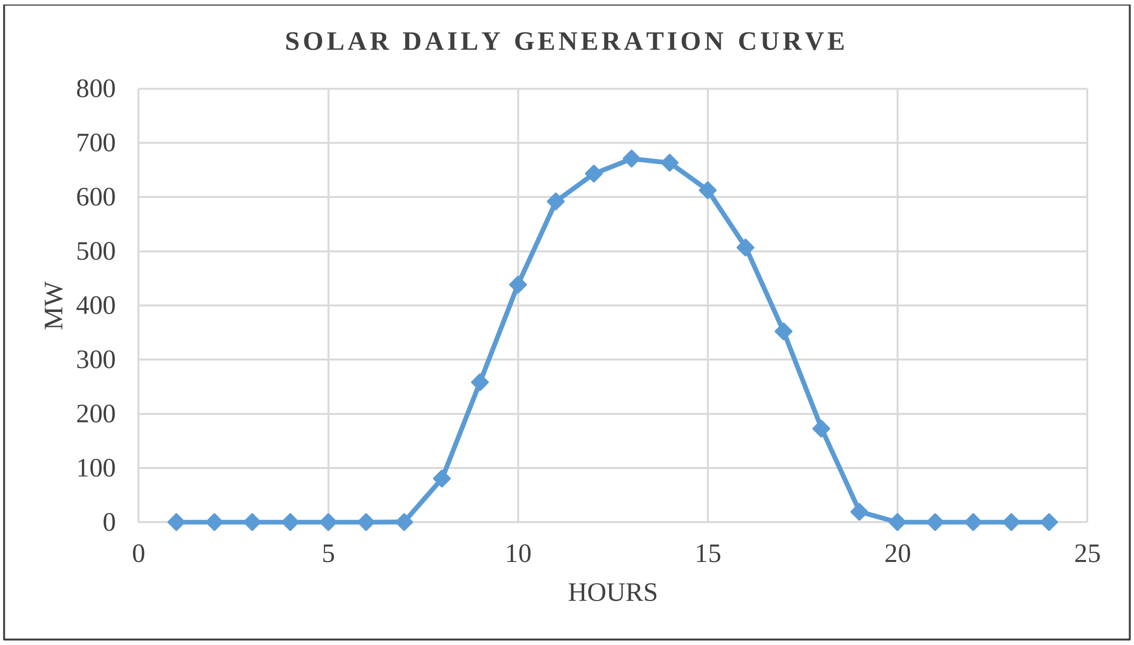
6.8.6 Solar projects under National Solar Mission

Union Cabinet approved the implementation of scheme for setting up of 15,000 MW of grid-connected solar PV power projects under the National Solar Mission through NTPC/NTPC Vidyut Vyapar Nigam Limited (NVVNL) in the three tranches namely, 3000 MW under tranche-I under mechanism of bundling with unallocated coal based thermal power and fixed levellised tariffs, 5,000 MW under tranche-II with support from government to be decided after getting some experience while implementing tranche-I and balance 7,000 MW under tranche-III without any financial support from the government. Successful completion of additional 15,000 MW capacity of grid-connected solar PV power generation projects with largely private investment under the National Solar Mission would accelerate the process of achieving grid tariff parity for solar power and would also help in reducing consumption of kerosene and diesel, which is presently in use to meet the unmet demand.

6.9 GENERATION PROFILE OF SOLAR AND WIND

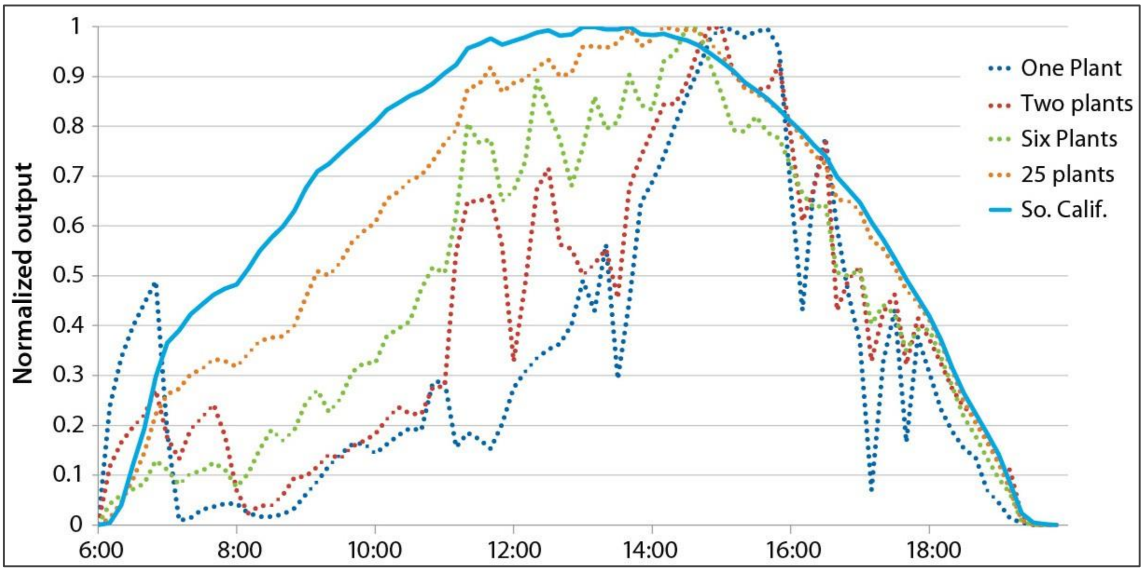
Normally generation from a solar plant gradually increases after dawn and reaches a maximum around noon and then gradually decreases and becomes zero with the advent of evening. An ideal generation profile of a solar plant is shown in **Exhibit 6.10.**

Exhibit 6.10



However, the generation from an individual PV system may not be very smooth. Because of the cloud movement, the generation would be affected. Cloud movement is highly unpredictable. This makes the output from a solar plant uncertain. Cloud cover can result in very rapid changes in the output of individual PV systems. The uncertainty associated with the output of a single PV system can be smoothened out in two ways- i) aggregating a large no. of PV systems and ii) aggregating the output of different PV systems scattered at dispersed geographic locations. As the number of PV plants increases, their normalized, aggregate output becomes smoother as shown in **Exhibit 6.11.**

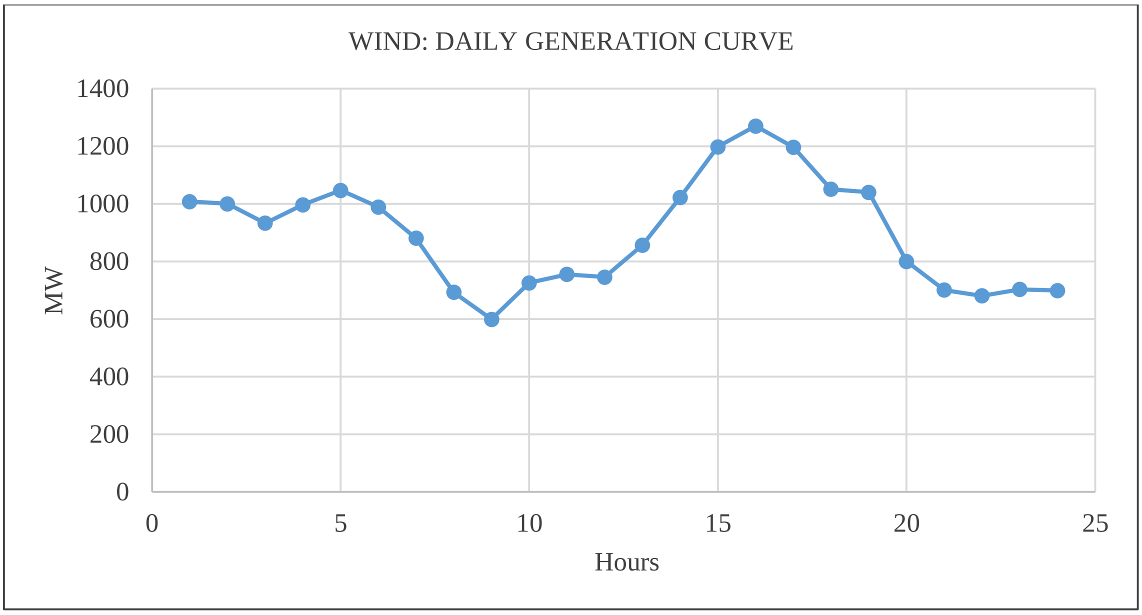
Exhibit 6.11



(Source: NREL)

Wind energy is subjected to daily and seasonal weather patterns. Changes in wind generation occur slowly during the course of hours during approaching storm. This is different from the solar generation where changes occur rapidly and variation may be from second to second due to cloud cover. A typical daily wind generation curve is shown in **Exhibit 6.12.**

Exhibit 6.12



6.9.1 Combined Solar and Wind Generation Curve

As per the program chalked out by Government of India, total RES capacity by March, 2022 will be 175 GW comprising of 100 GW solar, 60 GW wind, 10 GW bio-mass and 5 GW small hydro. Solar and wind plants would be scattered throughout the country. The total generation on account of VRE (i.e. solar and wind) in 2021-22 at any instant of time shall be the aggregate of the generation from all the solar plants and wind plants. Expected generation patterns of solar and wind for different seasons are given in the **Exhibit 6.13 (a) to (e).**

Seasonal variation of RES Generation

Exhibit 6.13(a)

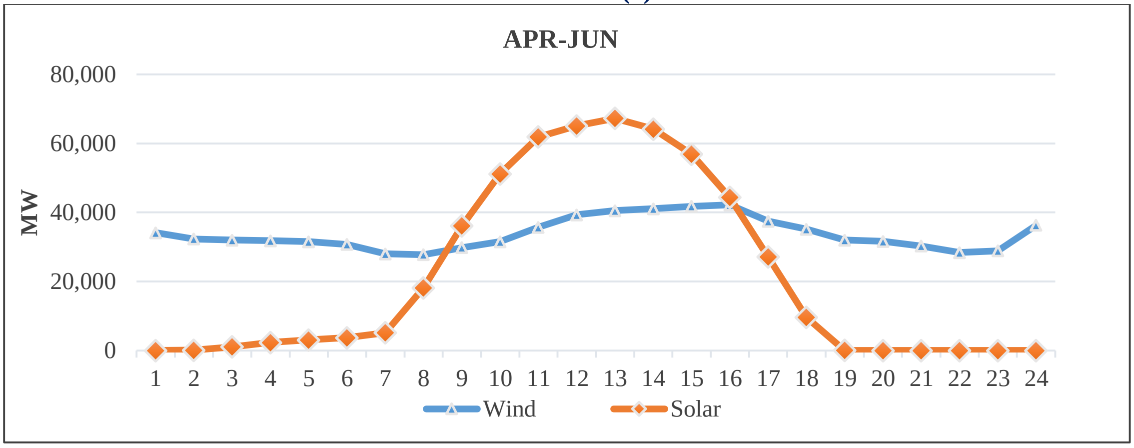


Exhibit 6.13(b)

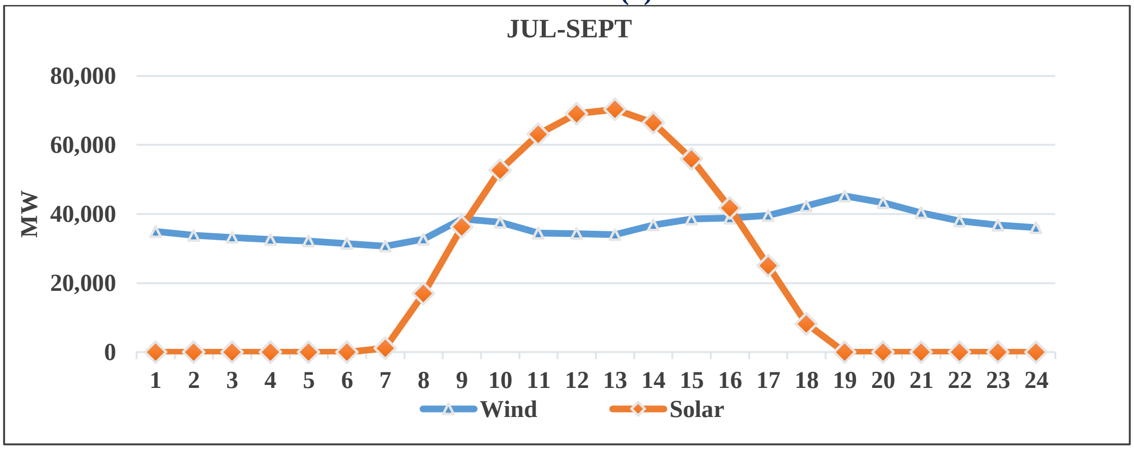


Exhibit 6.13(c)

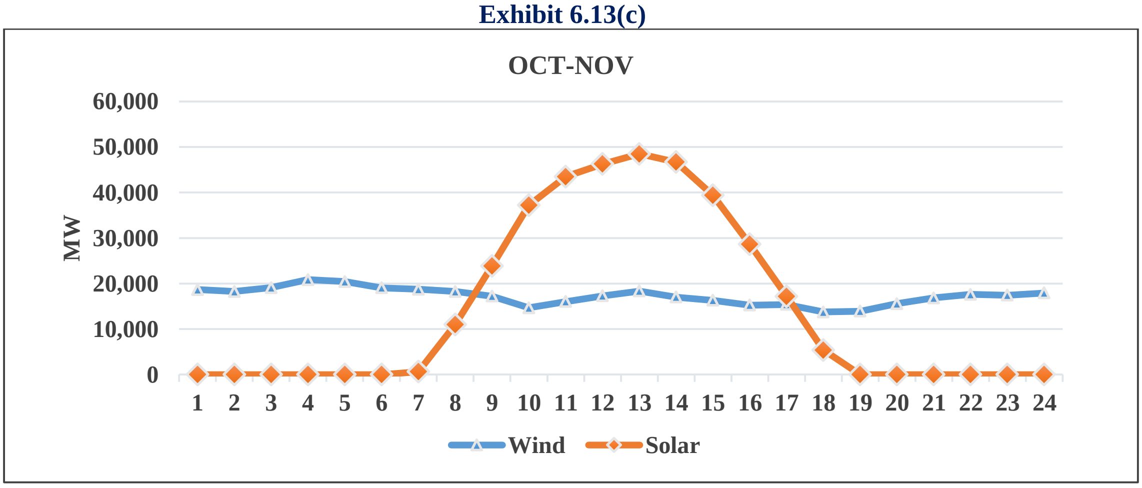


Exhibit 6.13(d)

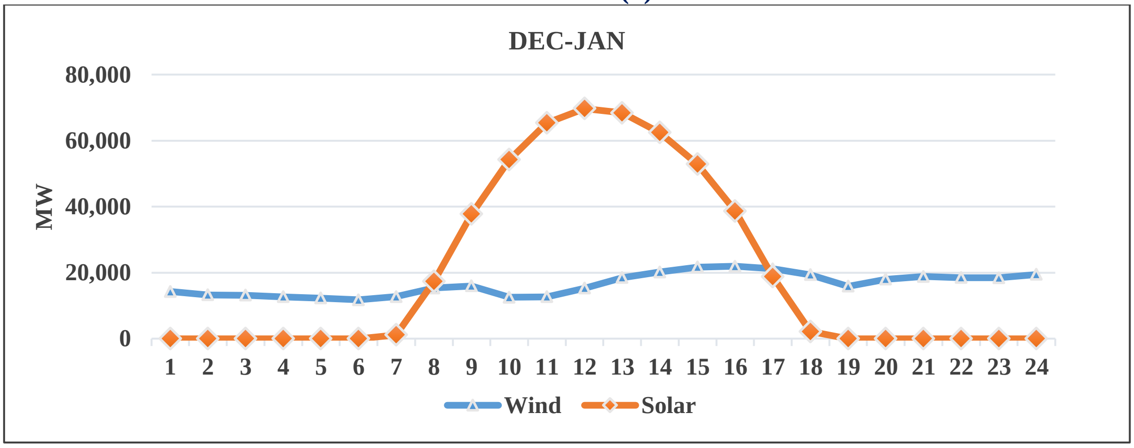
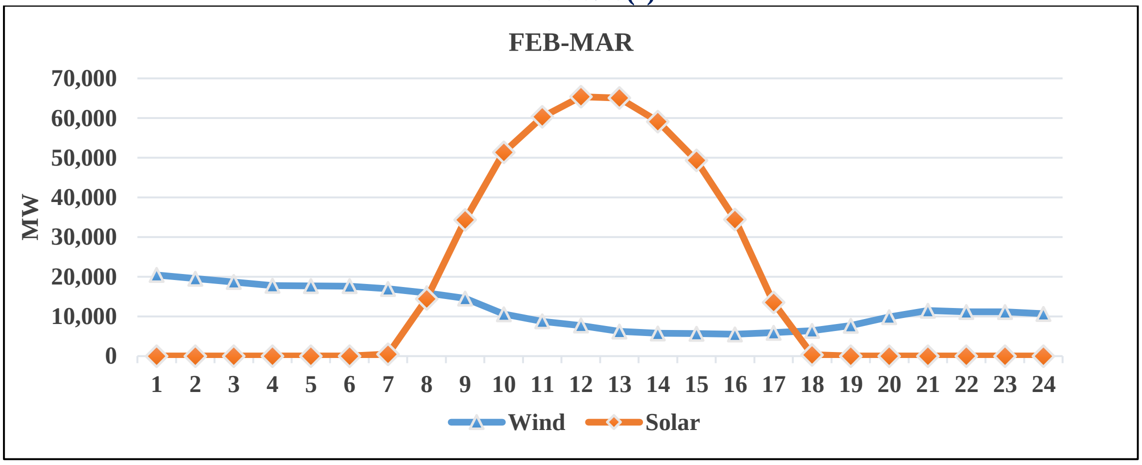
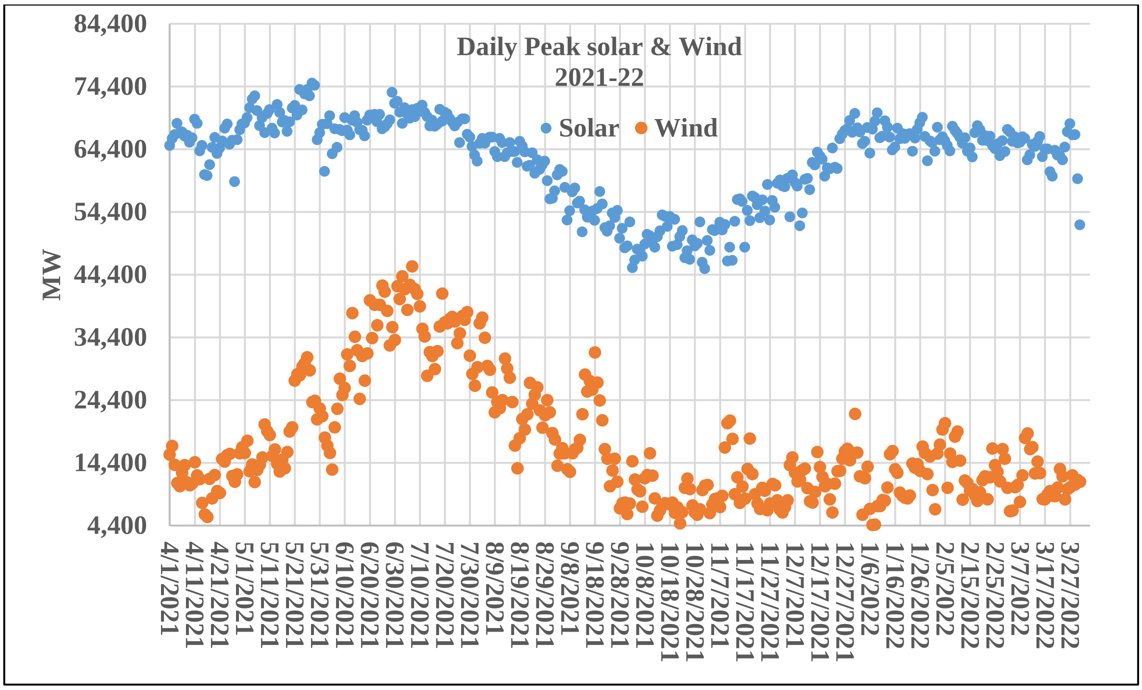


Exhibit 6.13(e)



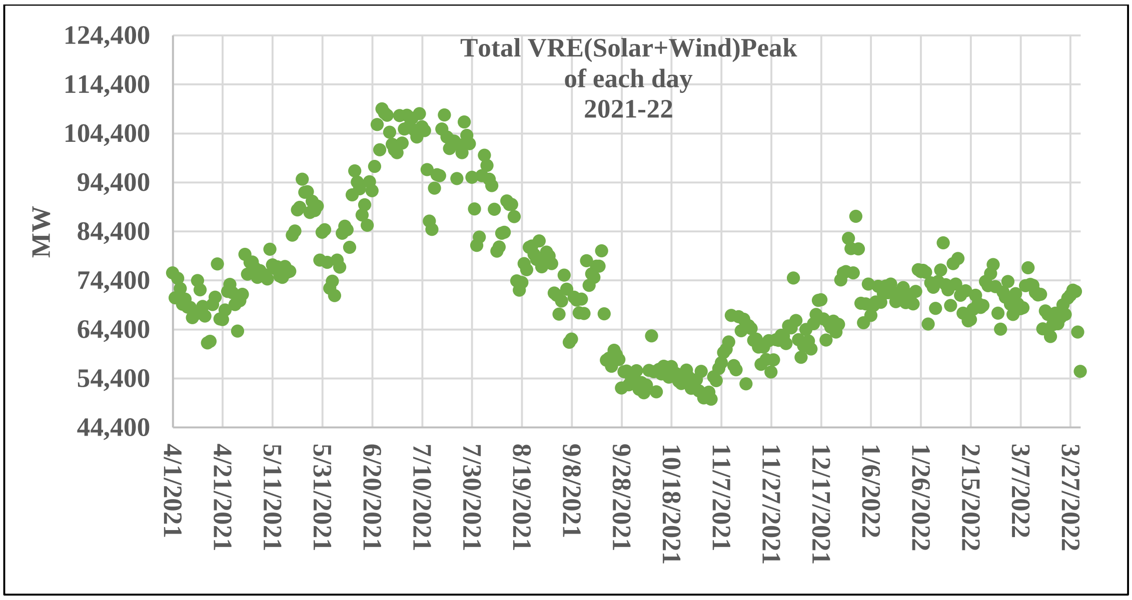
The solar and wind energy generation varies from not just one day to another but also from one season to other over the year. The variations of projected maximum solar and wind generation for each day over the year 2021-22 are shown in **Exhibit 6.14**. As can be seen from the graph, months of June to September have high generation from both solar and wind sources. However, it may be noted that the solar and wind peaks don't occur simultaneously. Therefore, at any hour during the day, the total projected VRE generation will always be less than the algebraic sum of the individual projected peak solar and peak wind generation.

Exhibit 6.14



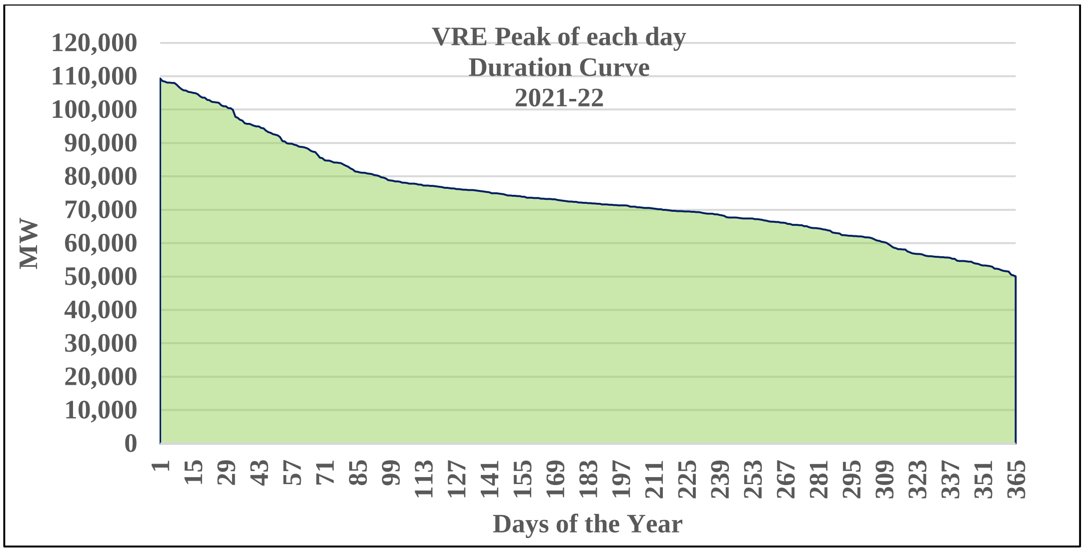
The variations of projected peak solar + wind generation for each day over the year 2021-22 are shown in **Exhibit 6.15.** Again as seen above**,** months of June to September have highest combined generation from solar and wind sources.

Exhibit 6.15



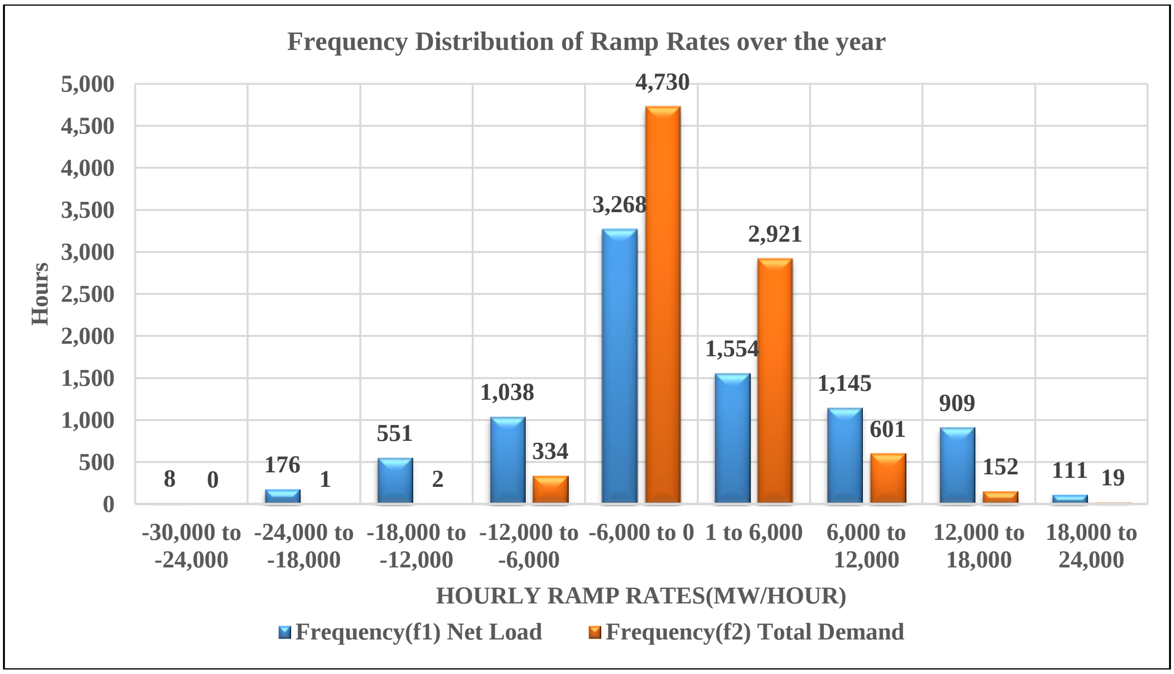
The duration curve of projected peak all India variable generation from renewable sources (Solar + wind) is shown in **Exhibit 6.16** below. It can be seen that the peak All India VRE generation for 100 days out of 365 days in the year will be more than 78 GW.

Exhibit 6.16



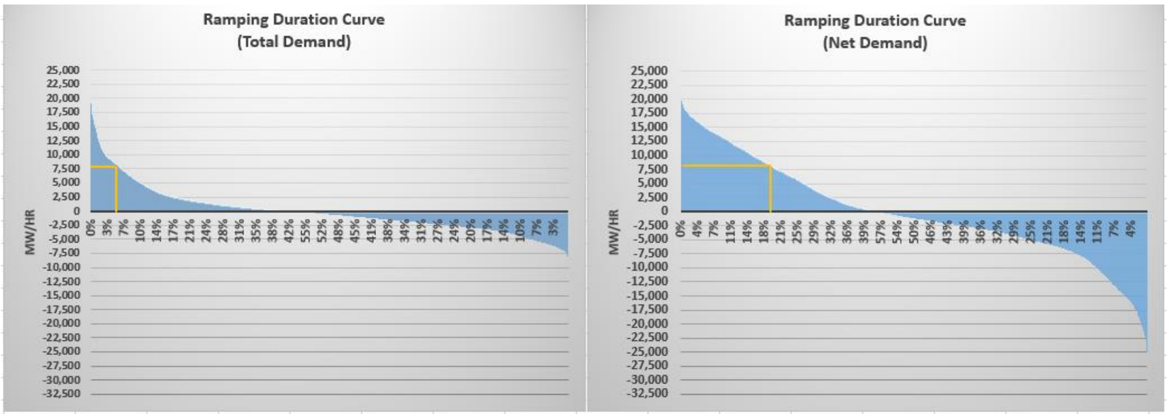
It can be seen that the maximum generation from VRE sources would be available during the day at noon time when the system demand is very low. During evening, the availability of generation from VRE is very limited. In India, normally the peak demand occurs in the evening. During that time, limited generation from VRE would be available. This would make the Net Demand Curve very steep requiring the availability of flexible generation that can ramp-up very quickly. The ramping requirement for 2021-22 for 8760 hours (24X365) has been estimated and is shown in **Exhibit- 6.17**.

Exhibit 6.17



A comparison of the ramping duration curve for the Total Demand and Net Demand is shown at **Exhibit 6.18**.

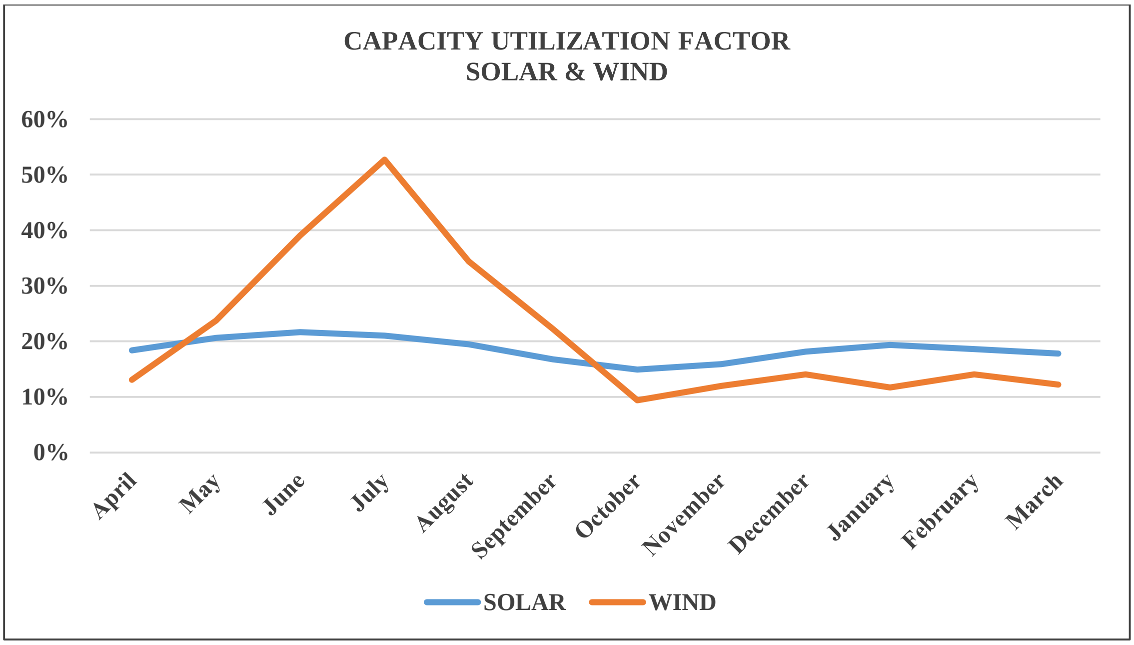
Exhibit 6.18



It is evident from the curves that the ramping requirements for Net Load Curve is much higher than the original Load Curve.

Capacity Utilization Factor (CUF) is the ratio of the actual output from a plant over the period to the maximum possible output from it for the period under ideal conditions. CUF for RES is generally very low. A typical example of the change of CUF for wind generator and a solar generator over different months of the year is shown in **Exhibit 6.19.**

Exhibit 6.19



6.10 INTEGRATION OF RENEWABLE ENERGY SOURCES IN THE GRID

The share of renewables in the overall generation mix of the country is increasing steadily. The Government of India's ambitious plan of having RES capacity of 175 GW by March, 2022 has accelerated the capacity addition from Renewable Energy Sources(RES). The capacity addition from RES has opened up opportunities as well as challenges. A distinct difference exists between conventional generating plants and RES. The generation from the conventional plants can be programmed to vary as per the requirement of loads. That is why it is called dispatchable generation. Generation from Variable Renewable Energy Sources like wind and solar power depends on nature and hence is called non-dispatchable. Further **variability** and **uncertainty** are the two aspects associated with generation from Variable Renewable Energy (VRE). **Variability** refers to the variation of generation over a period of time. For example, generation from solar plants is expected to follow a fixed pattern like maximum generation during noon time and "NIL" at night. Similarly, generation from wind follows seasonal pattern- maximum during monsoon.

Uncertainty refers to the unpredictability of generation from VRE. For example, generation from solar plants are expected to be maximum during noon. But due to cloud cover, the generation may get affected. This is the uncertainty part of solar generation. Furthermore, in conventional power plants, power generated from the plants are transported through high voltage transmission links and then distributed to the consumers through distribution networks. In case of RES, the generating plants are mostly connected at the distribution levels or at customers' end. There may be bi-directional flow of electricity- from grid to customers and from customers to the grid. As the generation from VRE are variable and uncertain, requisite balancing power from conventional sources and energy storage devices is required to be made available as reserve to ensure that demand at any time is fully met. Another aspect that needs consideration is that the generation from solar plants peaks when the demand during the day is low and has zero generation in the evening when the load on the grid is maximum. This requires fast ramping up capabilities of conventional generators. Therefore, integrating this VRE sources into the existing grid offers a challenge. The basic principle governing the integration of VRE sources into the grid is to ensure the integrity, security and reliability of the grid. More than anything else, integration of VRE into the grid poses technological and operational challenges.
Some of the challenges that need to be addressed are discussed below:

6.10.1 Flexibility Associated with Conventional Generating Units

To accommodate the variability and uncertainty of generation from RES, the conventional generating plants must be flexible. The flexibility of generating station refers to its ability (i) to cycle on and off including its lead time required; (ii) the ramping rate at which it can vary the generation; and (iii) maximum and minimum output while it is in operation.

The IEA provides a generic characterization of the differences between flexible and inflexible plants. Flexible coal plants offer ramping rates of 4-8%/minute, 2-5-hour start-up times, and minimum output limits of 20-40% (of maximum), compared to inflexible plants with ramping rates of less than 4%/minute, 5-7-hour start-up times and minimum output limits of 40-60%. Flexible natural gas plants show similar improvements, with minimum output limits of 15-30% compared to 40-50% for inflexible plants. A "fast-acting" gas turbine plants on the market today can offer start-up times of just 40 minutes. Flexible nuclear plants offer minimum output limits of 30-60%, compared to 100% for inflexible plants. In France, existing nuclear plants can ramp down to 30%, with ramp rates of up to 1%/minute.

In terms of flexibility, hydro plants, pumped storage plants, open cycle gas turbine, gas engines etc. are very suitable.

Coal plants are classified as constant output or baseload plants and are rarely turned down or turned off frequently. Essentially, they are considered as inflexible. These plants experience reduced efficiency, more maintenance, lower equipment lifetime and reduced cost etc. if subjected to cycling or frequent ramp up and ramp down. However, existing coal based plant can be redesigned/retrofitted to enable quick start-ups and ramping.

In Denmark and Germany, thermal stations are extensively used for cycling as well as ramping.

Combined-cycle natural gas power plants normally run as baseload plants or intermediary load plants. While open cycle gas power plants are capable of cycling and ramping, combined-cycle natural gas power plants are also flexible to some extent and may be retrofitted to be more flexible. These, however, will lead to some loss of generation efficiency, high maintenance cost and higher emissions.

Nuclear power plants are considered to be the most inflexible of baseload plants. But this plant can also be operated as a flexible plant, if designed properly. In Germany and France, nuclear plants offer flexibility in operation. In India, the nuclear plants are operated as base load plants, with minimum variability from the point of consideration of safety and security. Also, with the rapid advancements in energy storage technology, in future if it becomes economically viable, then it can also prove to be a vital resource for providing balancing power.

6.10.2 Transmission Strengthening

Solar and wind map of India indicates that the potential of solar and wind power is concentrated mostly in few solar and wind rich States. In fact, 8 States in India accounts for more than 77% of the RE capacity addition by 2022. The solar and wind power generated by these states may not be consumed fully by these states. Power generated from RES by these states needs to be transported to the load centers through transmission networks. This may require strengthening of existing grid networks or alternately the use of storage devices.

In India, Green Energy Corridors for evacuation of power from the regions having high concentration of RES is in the process of implementation.

6.10.3 Advanced Forecasting

Wind and solar power forecasting can help reduce the uncertainty of variable renewable generation. Better forecasting helps grid operators to commit or de-commit generators in accommodating changes in wind and solar generation more efficiently and prepare for extreme events in which renewable generation is unusually high or low. Forecasts can help reduce the amount of fast response operating reserves needed for the system, thereby reducing costs of balancing the system.

Internationally, improvements have been made in recent years towards reducing mean average forecast errors. Day-ahead forecasts can be used to make day-ahead unit commitment decisions. This will drive operational efficiency and cost savings. Short-term forecasts can be used to determine the need for a quick-start generator, demand response, or other mitigating options and thus drive reliability.

Clouds are the primary cause of variability for solar generation, aside from the predictable changes during the course of the day and throughout the year. The ability to accurately forecast solar power depends on the character of cloud cover, including the amount of water or ice in clouds and aerosols. To assess near-term impacts of approaching clouds on solar generation, sky imagers can be used. To predict impacts during the next few hours, satellite images can be used to assess the direction and speed of approaching clouds. For longer periods, weather models can be used to determine how clouds may form and change.

In India, RES generators and system operators need to partner with IMD and ISRO for forecasting of weather and monitoring the cloud movement to improve forecast of power output from RES.

6.10.4 Market Design

Market design affects the quantity of flexible resources. The flexibility needs of the variable renewables may be addressed in a variety of ways including pricing, schedule/dispatch interval, ancillary service market and requirement, capacity market etc. Through proper market design, the roles of capacity market and ramping market, the roles of distributed generation, storage and demand response into wholesale and ancillary market, economic curtailment of renewables, resource aggregators etc. can be clearly spelt out.

6.10.5 Demand Response

Demand side management measures encourage the customers to maximize the use of variable renewable energy sources while the supply is naturally high. For example, when wind and solar PV are producing more than the demand, demand response can incentivize consumers to use more power during that time through appropriate price signals of low rates, thus helping shift the load and ensuring better utilization of generation resources. The change in load may occur automatically in response to time of use or dynamic rates or due to the direct control by the grid operator or due to participation of demand response in wholesale, ancillary or capital market. To have effective demand response, smart-grid technologies involving smart meters, communication and other methods are used. Electric vehicle "smart charging" is based on V2G and G2V concept where electric vehicle can become an integral part of the grid and are charged or discharged in response to external signals or dynamic prices.

6.10.6 Grid Integration Cost

Integration of variable RES involves two types of costs namely **Grid Infrastructure Cost** and **System Operation Cost**. **Grid infrastructure costs** include **grid connection** and **grid upgrading costs**.

Grid connection costs include the cost of a new transmission line from the variable RES plant to the existing grid, which would be higher than those for a coal based plant, due to lower CUF. This cost depends basically on the distance between the plant and the grid, the voltage level of the connection line, and the availability of standard equipment. The grid connection cost is an important economic constraint for renewables development in remote locations. However, these can be overcome to some extent by using energy storage devices, Phase Shift Transformers (PSTs) and FACTS devices.

Grid upgrading costs include the cost of additional network equipment needed to strengthen the grid in order to integrate renewable power into the existing grids. They depend mostly on the amount of renewable capacity, the location of the power plants and the structure of the existing grid. These costs can also be mitigating by using energy storage devices, Phase Shift Transformers (PSTs) and FACTS devices.

System operation costs can be divided into ***system profile costs*** and ***short-term system balancing costs***. These account for the extra costs of the conventional part of the power system caused by the integration of variable renewable power.

Profile costs is a broad concept that captures all three impacts of the temporal mismatch between VRE generation and load profile: 1) capacity costs (adequacy costs) due to a low VRE capacity credit; 2) reduced average utilization of thermal power plants; and 3) curtailed VRE generation to maintain grid security when power supply exceeds demand.

Short-term system balancing costs: Due to the variability and uncertainty properties of VRE generators, the reserve capacity needed for up-and down-regulation increases as compared to the case where the same energy is delivered by conventional generation. The increased requirements for reserve power lead to the extra costs for the conventional part of the power system. These extra costs originate from the measures taken to ascertain increased reserve power, for example, by the operation of conventional plants at partial load, the start-up costs and contribution of conventional power plants with higher operating costs in the power system, increased wear-and-tear and maintenance costs of plants.

6.11 BALANCING RESERVES

In a synchronous electrical system, the demand and supply of electricity must balance at every instant of time. Any imbalance is reflected in the variation of frequency. Therefore, in case of imbalance, the system is to be balanced by providing balancing power.

Based on purpose, response time, and the way they are activated, balancing power can be categorized as **Primary Control(PC)**, **Secondary Control(SC)** and **Tertiary Control(TC)**.

PC can be fully deployed within 30 seconds. It is activated by locally measured frequency deviation. PC can be classified as a fast, automatic, spinning reserve that is used to balance the synchronous system both up and downwards.

SC has to be available within five minutes after activation. It is activated automatically and centrally by System Operators. SC is used to supplement PC for frequency restoration, and to re-balance the respective balancing area. SC can be supplied mainly by some hydro plants and gas based plants and to some extent by synchronized thermal generators. Hence, it is an automatic reserve that balances both the synchronous system and the balancing area up and down. To a large extent, it is a spinning reserve.

TC is used to replace SC over time. It is either directly activated or in schedules of 15 minutes. Activation is a manual decision usually based on current and expected deployment of SC. TC is mostly supplied by stand-by thermal generators.

The concept of Balancing power has assumed a great significance nowadays with the infusion of Variable Renewable Energy(VRE) into the system. VRE generators are weather dependent and are, as such, inherently stochastic in nature. There would be deviation between actual generation and forecast generation from the VRE generators. This deviation may be positive or negative. In case of positive deviation, balancing power needs to be pressed into service. In case of negative deviation, backing down of generation takes place or alternatively through absorption of extra power by energy storage devices.

While carrying out balancing, the concept of balancing area and synchronous system are used. In India, the synchronous system is the entire integrated grid comprising of the five regions and Bhutan. Balancing area is a geographical subset of the synchronous system where imbalance occurs. So the balancing area may be a state or a region. In the event of an imbalance, the target set point for the synchronous system is the frequency. That is the system frequency is to be brought to their normal value. However, the target set point for the balancing area is to bring the net deviation between balancing area and the rest of the synchronous system to ZERO from schedule.

At present system operators in India (SLDCs and RLDCs) are playing an active role in balancing the system.

Internationally, the developed countries have adopted the integrated approach, involving system operator, balance responsible parties, supplier of balancing power and regulators. All of these play the role of the system operator and market operators. In India, the market operation is performed mainly by the power exchanges. They must work in tandem for implementing and effective balancing system. The role of the different entities in the integrated approach are described below:

Balance Responsible Parties (BRPs) or ‘program responsible parties’ are market entities that have the responsibility of balancing a portfolio of generators and/or loads. BRPs can be utilities, and industrial consumers, etc. They deliver binding schedules to system operators for each quarter-hour of the next day, and are financially accountable for deviations from these schedules.

System operators activate balancing power to physically balance demand and supply if the sum of BRP imbalances is non-zero. Specifically, system operators have four obligations:

1. determine the amount of capacity that has to be reserved for balancing, ex ante
2. acquire the required balancing power reserves and determine the price paid for capacity and energy, ex ante
3. activate balancing power in moments of physical imbalance, real time
4. determine the imbalance price, and clear the system financially, ex post.

Suppliers of balancing power reserve the supply capacity, and deliver energy once activated by the system operator. They are obliged to deliver energy under pre-specified terms, for example, within a certain time frame and with certain ramp rates. Suppliers are traditionally mostly generators, but can also be consumers. Typically, payments received by the suppliers of balancing power have two components: capacity payment because capacity reservation occasions opportunity costs, and/or energy payment.

A system is said to be “**actively balanced**” when the system operators deploy balancing power. The price paid for this service is the capacity and the energy payment for balancing power. Similarly, if the Balance Responsible Parties(BRP) takes the price signal and balance the system, it is said to be “***passively balanced***”. Hence, system operators can either actively balance the system ordering adjustments via contracted balancing power, or passively balance the system via sending imbalance price signals to BRPs. This is also called ***‘self-balancing’.*** The time scale of passive balancing can be of several minutes. Hence, it cannot replace balancing power required to respond to stochastic disturbances.

Determining the balancing reserve is a challenge under high VRE infusion scenario. There is no unique acceptable methodology for this. Nowadays, instead of deterministic approach, stochastic approach is widely utilized. From the historical data, the forecast errors for wind and solar generations are found out. The errors are assumed to be normally distributed. Taking a confidence limit of 95 or 99%, the reserve requirements are estimated.

6.12 CONCLUSIONS

- India has achieved a total installed capacity of 57,244.24 MW from Renewable Energy Sources as on 31st March,2017.

- The country has set its Renewable Energy capacity addition target to 175 GW by 2022 in view of the significant renewable energy potential in the country. To achieve this, some portion of land within the power stations can be utilized for installation of solar PV power generation projects.
- Accelerated development of RES requires adequate indigenous manufacturing facility for RES related equipment. Policy framework may be developed to encourage setting up of RES related equipment manufacturing facility in the country This would be consistent with the Government of India's "Make in India" policy. Further, indigenous technologies (renewable as well as energy efficient technologies) should be given preference in procurement.
- Preparation of biomass atlas is required.
- Adequate incentive mechanism may be provided for the SPV installation both for the new houses as well as old houses/buildings.
- Repowering of existing wind power projects under the existing "Policy for Repowering of Wind Power Projects" may be encouraged along with new wind power projects to obtain more generation from the same location as well as a higher CUF.

Annexure-6.1

STATE-WISE DETAILS OF ESTIMATED POTENTIAL FOR RENEWABLE POWER IN INDIA (ALL FIGURES IN MW)

SI. No.	States / UTs	Wind Power	Small Hydro Power	Bio-Energy		Solar Power	Total Estimated Potential
				Biomass Power/ Bagasse Cogen.	Waste to Energy		
1	Andhra Pradesh	14,497	978	578	423	38,440	54,916
2	Arunachal Pradesh	236	1,341	8	0	8,650	10,236
3	Assam	112	239	212	8	13,760	14,330
4	Bihar	144	223	619	373	11,200	12,559
5	Chhattisgarh	314	1,107	236	24	18,270	19,951
6	Goa	0	7	26	0	880	912
7	Gujarat	35,071	202	1,221	462	35,770	72,726
8	Haryana	93	110	1,333	374	4,560	6,470
9	Himachal Pradesh	64	2,398	142	2	33,840	36,446
10	Jammu & Kashmir	5,685	1,431	43	0	1,11,050	1,18,208
11	Jharkhand	91	209	90	10	18,180	18,580
12	Karnataka	13,593	4141	1,131	450	24,700	44,015
13	Kerala	837	704	1,044	36	6,110	8,732
14	Madhya Pradesh	2,931	820	1,364	78	61,660	66,853
15	Maharashtra	5,961	794	1,887	1,537	64,320	74,500
16	Manipur	56	109	13	2	10,630	10,811
17	Meghalaya	82	230	11	2	5,860	6,185
18	Mizoram	0	169	1	2	9,090	9,261
19	Nagaland	16	197	10	0	7,290	7,513
20	Odisha	1,384	295	246	22	25,780	27,728
21	Punjab	0	441	3,172	345	2,810	6,768
22	Rajasthan	5,050	57	1,039	62	1,42,310	1,48,518
23	Sikkim	98	267	2	0	4,940	5,307
24	Tamil Nadu	14,152	660	1,070	601	17,670	34,152
25	Telangana	0	0	0	0	20,410	20,410
26	Tripura	0	47	3	2	2,080	2,131
27	Uttar Pradesh	1,260	461	1,617	1,426	22,830	27,593
28	Uttarakhand	534	1708	24	5	16,800	19,071
29	West Bengal	22	396	396	148	6,260	7,222

SI. No.	States / UTs	Wind Power	Small Hydro Power	Bio-Energy		Solar Power	Total Estimated Potential
				Biomass Power/ Bagasse Cogen.	Waste to Energy		
30	Andaman & Nicobar	365	8	0	0	0	373
31	Chandigarh	0	0	0	6	0	6
32	Dadar & Nagar Haveli	0	0	0	0	0	0
33	Daman & Diu	4	0	0	0	0	4
34	Delhi	0	0	0	131	2,050	2,181
35	Lakshadweep	0	0	0	0	0	0
36	Pondicherry	120	0	0	3	0	123
37	Others	0	0	0	1,022	790	1,812
	Total	**1,02,772**	**19,749**	**17,536**	**7,554**	**7,48,991**	**8,96,602**

(SOURCE: MINISTRY OF NEW AND RENEWABLE ENERGY, INDIA)

Annexure-6.2

STATE-WISE INSTALLED CAPACITY OF GRID INTERACTIVE RENEWABLE POWER AS ON 31.03.2017 (ALL FIGURES IN MW)

Sl. No.	State /UT	Wind Power (MW)	Small Hydro Power (MW)	Bio Power (MW)		Solar Power (MW)	Total Capacity
				BM Power/ Cogen.	Waste to Energy		
1	Andhra Pradesh	3,618.85	241.98	378.2	58.16	1867.23	**6,164.42**
2	Arunachal Pradesh		104.605			0.27	**104.875**
3	Assam		34.11			11.78	**45.89**
4	Bihar		70.7	113		108.52	**292.22**
5	Chhatisgarh		76	228		128.86	**432.86**
6	Goa		0.05			0.71	**0.76**
7	Gujarat	5,340.62	16.6	65.3		1,249.37	**6,671.89**
8	Haryana		73.5	96.4		81.4	**251.30**
9	Himachal Pradesh		831.81			0.73	**832.54**
10	Jammu & Kashmir		158.03			1.36	**159.39**
11	Jharkhand		4.05			23.27	**27.32**
12	Karnataka	3,751.40	1,225.73	1,452.00	1	1027.84	**7,457.97**
13	Kerala	51.5	213.02			74.2	**338.72**
14	Madhya Pradesh	2,497.79	86.16	93	3.9	857.04	**3,537.89**
15	Maharashtra	4,771.33	346.175	2,065.00	12.72	452.37	**7,647.60**
16	Manipur		5.45			0.03	**5.48**
17	Meghalaya		31.03			0.01	**31.04**
18	Mizoram		41.47			0.1	**41.57**
19	Nagaland		30.67			0.5	**31.17**
20	Orissa		64.625	50.4		79.42	**194.45**
21	Punjab		170.9	179	9.25	793.95	**1,153.10**
22	Rajasthan	4,281.72	23.85	119.3		1,812.93	**6,237.80**
23	Sikkim		52.11			0	**52.11**
24	Tamil Nadu	7,861.46	123.05	878	8.05	1,691.83	**10,562.39**
25	Telangana	100.8		158.1		1286.98	**1,545.88**
26	Tripura		16.01			5.09	**21.10**
27	Uttar Pradesh		25.1	1,933.00	5	336.73	**2,299.83**
28	Uttarakhand		209.32	73		233.49	**515.81**
29	West Bengal		98.5	300		26.14	**424.64**
30	Adaman & Nicobar		5.25			6.56	**11.81**

31	Chandigarh					17.32	**17.32**
32	Dadar & Nagar Haveli					2.97	**2.97**
33	Daman & Diu					10.46	**10.46**
34	Delhi				16	40.27	**56.27**
35	Lakshwadeep					0.71	**0.71**
36	Pondicherry					0.08	**0.08**
37	Others	4.3				58.31	**62.61**
	Total	**32,279.77**	**4,379.86**	**8,181.70**	**114.08**	**12,288.83**	**57,244.24**

ANNEXURE-6.3

TENTATIVE STATE-WISE BREAK-UP OF RENEWABLE POWER TARGET TO BE ACHIEVED BY THE YEAR 2022 FOR CUMULATIVE ACHIEVEMENT OF 175 GW INSTALLED CAPACITY

(ALL FIGURES IN MW)

State/UTs	Solar Power	Wind Power	Small Hydro Power+ Biomass Power	TOTAL
Delhi	2,762		32	2794
Haryana	4,142		234	4,376
Himachal Pradesh	776		1,500	2,276
Jammu & Kashmir	1,155		158.03	1,313
Punjab	4,772		359.15	5,131
Rajasthan	5,762	8,600	143	14,505
Uttar Pradesh	10,697		2524	13,221
Uttarakhand	900		897	1,797
Chandigarh	153			153
Northern Region	**31,119**	**8,600**	**5,847**	**45,566**
Goa	358			358
Gujarat	8,020	8,800	313	17,133
Chhattisgarh	1,783		304	2,087
Madhya Pradesh	5,675	6,200	183.06	12,058
Maharashtra	11,926	7,600	2519	22,045
D. & N. Haveli	449			449
Daman & Diu	199			199
Western Region	**28,410**	**22,600**	**3,319**	**54,329**
Andhra Pradesh	9,834	8,100	678.34	18,612
Telangana		2,000	158	2,158
Karnataka	5,697	6,200	2920	14,817
Kerala	1,870		213.02	2,083
Tamil Nadu	8,884	11,900	1009.10	21,793
Puducherry	246			246
Southern Region	**26,531**	**28,200**	**4,979**	**59,710**
Bihar	2,493		269	2,762
Jharkhand	1,995		10	2,005
Orissa	2,377		115	2,492
West Bengal	5,336		398.5	5,735
Sikkim	36		52.11	88
Eastern Region	**12,237**		**845**	**13,082**
Assam	663		34.11	697
Manipur	105		5.45	110
Meghalaya	161		31.03	192

State/UTs	Solar Power	Wind Power	Small Hydro Power+ Biomass Power	TOTAL
Nagaland	61		30.67	92
Tripura	105		16.01	121
Arunachal Pradesh	39		200	239
Mizoram	72		41.47	113
North Eastern Region	**1,206**		**359**	**1565**
Andaman & Nicobar Islands	27		5.25	27
Lakshadweep	4			4
Other (New States)	58.31	600	120	720
All India	**99,592**	**60,000**	**15,474**	**1,75,066**

CHAPTER 7
HYDRO POWER IN INDIA

7.0 INTRODUCTION

India has considerable hydro power potential, which being a renewable source of energy can play a key role in reducing the carbon footprint of the Indian power sector and efforts are being set afoot in this direction. A Hydro Electric Project has a long useful life extending to well over 50 years and helps in conserving scarce fossil fuels. Development of hydro projects is important to meet the objective of sustainable development and for energy security of the country. Development of hydro power projects also provides the added advantage of opening up avenues for development of remote and backward regions of the country. Hydro power stations have the inherent ability for instantaneous starting, stopping and managing load variability which helps in improving reliability of the power system. Hydro Electric Projects are ideal for meeting the peak requirement and the balancing requirement arising due to variability of renewable energy sources.

7.1. HYDRO-ELECTRIC POWER POTENTIAL AND DEVELOPMENT

7.1.1 Hydro-Electric Potential

An assessment was made of the hydro-electric potential in the country by CEA in the year 1987, based on observed basic data on topographic features of river basins, discharge characteristics of rivers at a large number of sites, geological and other information. According to the assessment, the total Hydro Electric Power potential in the country was assessed as 84,044 MW (at 60% load factor) from a total of 845 number of identified H.E. Schemes which when fully developed would result in an installed capacity of about 1,48,701 MW on the basis of probable average load factor. The total hydro energy potential is assessed as 600 billion units per year. The Great Indus, the Ganga and the Brahmaputra rivers with their innumerable tributaries originating from the Himalayas constitute about 70% of the country's assessed hydropower potential. In addition, the assessment studies have also identified 63 sites for Pumped Storage Schemes (PSS) with total installation of about 96,000 MW. In addition to above, a sizable potential was identified by CEA for development of micro, mini and small hydro schemes on rivulets and canal drops. 1,512 no. of small hydro-electric schemes having aggregate installed capacity of above 6,782 MW on canal falls/rivers have been identified. The matter relating to H.E. Projects up to 25 MW is being looked after by MNRE and the potential of small H.E. Projects has been assessed by MNRE as 19,749 MW.

As on 31st March,2017, Hydro Electric Schemes (above 25 MW capacity) have a total installed capacity of 44,478 MW including Pumped storage schemes (PSS) capacity of 4,785 MW. The hydro schemes under construction, account to capacity of 10848.5 MW (excluding PSS of 1,080 MW). Hydro Electric schemes totaling to capacity of 25,160 MW are concurred by CEA and yet to be taken up for construction, schemes totaling to 6,414 MW are under examination in CEA, DPRs of capacity totaling to 8,094 MW has been appraised but returned for resubmission, schemes totaling to 6,327 MW are under study and investigation(S&I) and schemes totaling to 13,857 MW on which Study & Investigation is held up or yet to be taken up. Summary of the status of Hydro Electric Potential development in the country is indicated in **Tables 7.1.**

Table 7.1

Summary of the status of Hydro Electric Potential

(As on 31st March ,2017)

	Conventional			Pumped Storage		
	Nos.	**Capacity (MW)**	**(%)**	**Nos.**	**Capacity (MW)**	**(%)**
Total Potential		145320*			96524	
Schemes under Operation	193*	39692.8	27.31	9	4785.6	4.96
Schemes under Construction	41	10848.5	7.47	2	1080	1.12
DPRs Concurred by CEA & yet to be taken up for construction	43	25160	17.31	1	1000	1.04
DPRs under Examination by CEA	9	6414	4.41	0	0	0
DPRs returned by CEA for resubmission	26	8094	5.57	1	500	0.52
Under S & I for preparation of DPRs	40	6327	4.35	0	0	0
Schemes under S&I- Held up	42	13857	9.54	0	0	0
Total Developed/ under Development	**394**	**110393.3**	**75.97**	**13**	**7365.6**	**7.63**

Note: - The matters relating to hydro projects below 25 MW are looked after by Ministry of New & Renewable Energy (MNRE).

[#] 1 Unit (40 MW) of Panchet and 1 unit (110 MW) of Nagarjunasagar included in PSS.

* Excluding projects below 25MW. (148,701 MW including below 25 MW power projects)

Region wise and basin wise status of hydroelectric capacity is given in **Table 7.2**, **Table 7.3** and **Exhibit 7.1.**

Table 7.2

Region wise Status of Hydro Electric Capacity

(In terms of Installed Capacity-above 25 MW as on 31st March,2017)

Region/ State	Identified Capacity as per Assessment study (MW)		Capacity Developed		Capacity Under construction		Capacity yet to be developed	
	Total (MW)	**Above 25 MW**	**(MW)**	**(%)**	**(MW)**	**(%)**	**(MW)**	**(%)**
Northern	53395	52263	18527.3	35.45	4898.5	9.37	28837.3	55.18
Western	8928	8131	5552.0	68.28	400.0	4.92	2179.0	26.80
Southern	16458	15890	9653.1	60.75	1150.0	7.24	5086.9	32.01
Eastern	10949	10680	4718.5	44.18	1446.0	13.54	4515.6	42.28
North Eastern	58971	58356	1242.0	2.13	2954.0	5.06	54160.0	92.81
All India	**148701**	**145320**	**39692.8**	**27.31**	**10848.5**	**7.47**	**94778.7**	**65.22**

Note: - 1. In addition to above 4785.60 MW PSS are under operation and 1080 MW PSS under construction.

Exhibit 7.1

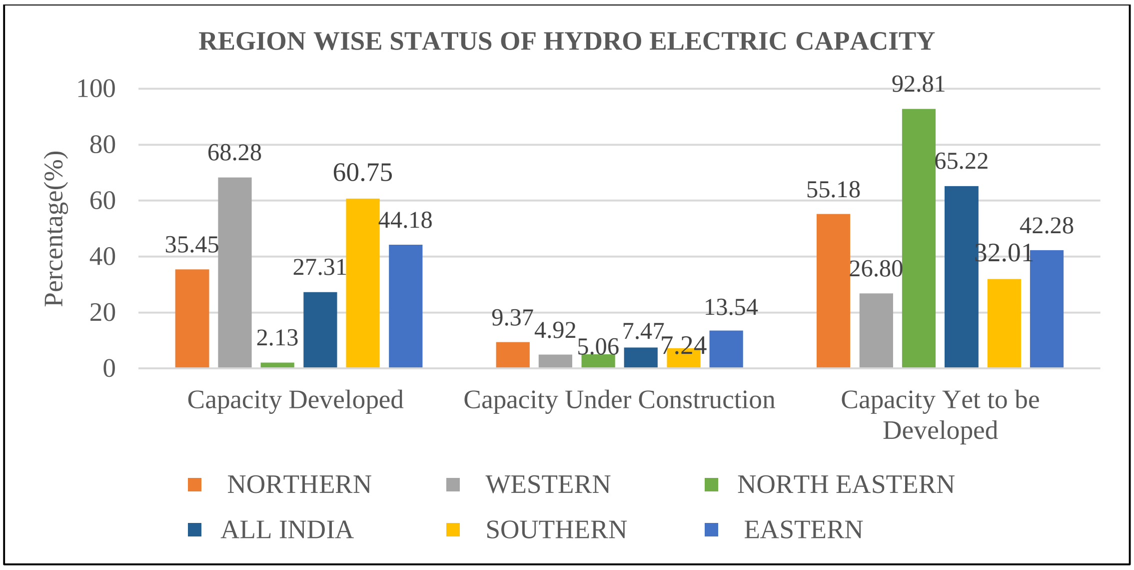


Table 7.3

Basin wise Status of H.E. Potential Development-Basin wise

(In Terms of Installed Capacity-Above 25 MW as on 31st March,2017)

River Basin	Identified Capacity as per Reassessment Study (MW)		Capacity Developed		Capacity Under Construction		Capacity Yet to be Developed	
	Total	Above 25 MW	(MW)	(%)	(MW)	(%)	(MW)	(%)
Indus	33832	33028	13798.3	41.78	3357.5	10.17	15872.2	48.06
Ganga	20711	20252	5317.2	26.26	1541.0	7.61	13393.6	66.14
Central Indian River System	4152	3868	3147.5	81.37	400.0	10.34	320.5	8.29
West Flowing Rivers System	9430	8997	5681.7	63.15	100.0	1.11	3215.3	35.74
East Flowing Rivers System	14511	13775	8163.2	59.26	1050.0	7.62	4561.9	33.12
Brahmaputra	66065	65400	3585.0	5.48	4400.0	6.73	57415.0	87.79
Total	**148701**	**145320**	**39692.9**	**27.31**	**10848.5**	**7.47**	**94778.7**	**65.22**

Note: - 1. In addition to above 4785.60 MW PSS are under operation and 1080 MW PSS under construction.

7.1.2 Share of Hydro-electric Installed Capacity & Generation

A small Hydro-Electric Plant (130 kW) established near Darjeeling, West Bengal in 1897 ushered the beginning of hydro-electric power development in the country. Since then, development of hydro-electric power in the country has made rapid strides. The hydro installed capacity which was only 508 MW in 1947 with 12 no. of HEP (51 units), with maximum unit size of 22 MW at Bhira HEP of Tata Power, has risen to 44,478.5 MW as on 31st March,2017 from Hydro Electric stations above 25 MW capacity. Conventional Hydro Electric Stations of run-of-river type, single purpose hydroelectric stations with storage, multipurpose projects as well as pumped storage projects have been executed throughout the country. The maximum unit size is now 250 MW at Koyna Stage-IV of MAHAGENCO, Nathpa Jhakri of SJVNL, Tehri of THDC and Karcham Wangtoo of JPVL.

The installed capacity of Hydro-Electric Stations vis-à-vis total capacity, the contribution in generation by hydro plants and trend of hydro capacity & generation over the years are indicated in **Table-7.4** and at **Exhibit 7.2.** From **Table 7.4**, it may be observed that the overall share of hydro in terms of installed capacity in the country has risen from 37.30% at the end of 1947 to 50.61% during 1962-63 and thereafter declined to 13.6% at the end of 2016-17. The generation from hydro stations during the year 2016-17, accounts for 10.59% of the total energy generation in the country. Region wise summary of hydro Installed capacity are indicated in **Table 7.5.**

Sector wise contribution of hydro generation during the year 2016-17 in Central, State and Private sectors were 47.3%, 42.0% and 10.7% respectively while sector-wise distribution of hydro installed capacity as on 31st March,2017 in Central, State and Private Sectors is 26.2%, 66.7% and 7.1% respectively. These details are illustrated in **Exhibit 7.3**.

Table 7.4
Hydro-Electric Capacity & Generation Vis-À-Vis Total Capacity & Generation

Year	Installed Capacity			Generation		
	Total (MW)	Hydro (MW)	Hydro as % of To	Total (MU)	Hydro (MU)	Hydro as % of Total
1947	1362	508	37.30	4072	2194	53.88
1950	1713	560	32.63	5106	2519	49.33
1955-56	2886	1061	36.76	9145	4295	46.97
1960-61	4653	1917	41.20	16937	7837	46.27
1962-63	5801	2936	50.61	22365	11805	52.78
1965-66	9027	4124	45.68	32890	15225	46.29
1968-69	12957	5907	45.59	47434	20723	43.69
1973-74	16664	6966	41.80	66689	28972	43.44
1978-79	26680	10833	40.60	10252	47159	46.00
1979-80	28448	11384	40.02	10462	45478	43.47
1984-85	42585	14460	33.96	15685	53948	34.39
1989-90	63636	18307	28.77	24543	62116	25.31
1991-92	69065	19194	27.79	28702	72757	25.35
1996-97	85795	21658	25.24	39588	68901	17.40
1997-98	89203	21904	24.58	42174	74582	17.68
1998-99	92269	22479	24.10	44746	82923	18.53
1999-00	97837	23857	24.37	48112	80755	16.78
2000-01	101450	25153	24.75	49942	74362	14.89
2001-02	105046	26269	25.01	51506	73759	14.32
2002-03	107877	26767	24.81	53160	63834	12.01
2003-04	112684	29507	26.19	55811	73775	13.22
2004-05	118419	30936	26.12	58741	84495	14.38
2005-06	124287	32326	26.01	62463	101293	16.22
2006-07	132321	34662	26.19	65951	113359	17.19
2007-08	143061	37002	25.86	70446	123424	17.52
2008-09	147917	36846	24.91	71465	109840	15.37
2009-10	159398	36863	23.13	76342	103916	13.61
2010-11	173626	37567	21.64	80553	114257	14.18
2011-12	199877	38990	19.51	871602	130510	14.97
2012-13	223344	39491	17.68	907262	113720	12.53
2013-14	243029	40531	16.68	961552	134848	14.02
2014-15	267637	41267	15.42	1043665	129244	12.38
2015-16	302088	42783	14.16	1102578	121376	11.00
2016-17	326832	44478	13.6	1154523	122377	10.59

Note: Capacity above 25 MW only has been considered. Generation from only Conventional Sources considered

Exhibits 7.2

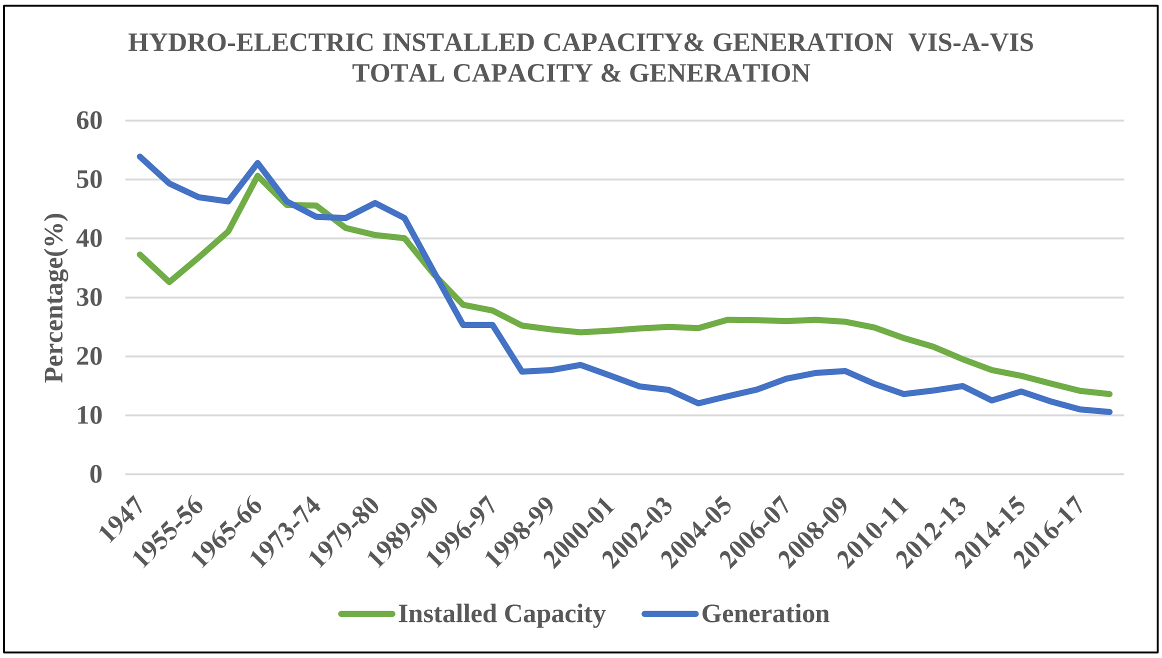
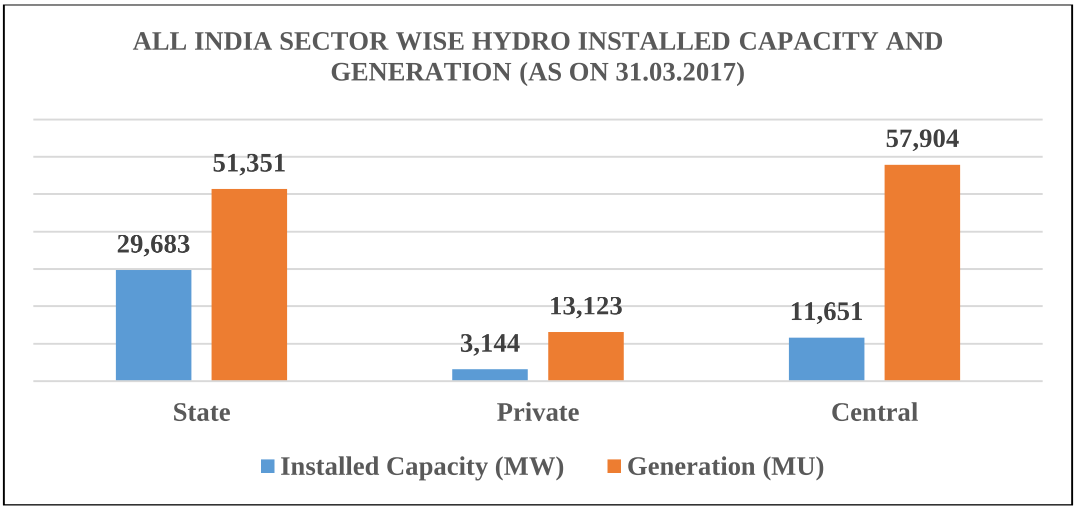


Table 7.5

Region-wise summary of Hydro Electric Installed Capacity
(Above 25 MW Capacity as On 31st March,2017)

REGION	NO. OF STATIONS	NO. OF UNITS	CAPACITY (MW)
NORTHERN	71	238	18527.27
WESTERN	29	101	7392.00
SOUTHERN	70	252	11773.45
EASTERN	20	74	5543.70
NORTH EASTERN	10	29	1242.00
ALL INDIA (TOTAL)	**198**	**694**	**44478.42**

Exhibit 7.3



Typical variation in hydro generation in different seasons are shown in **Exhibit 7.4**.

Exhibit 7.4(a)

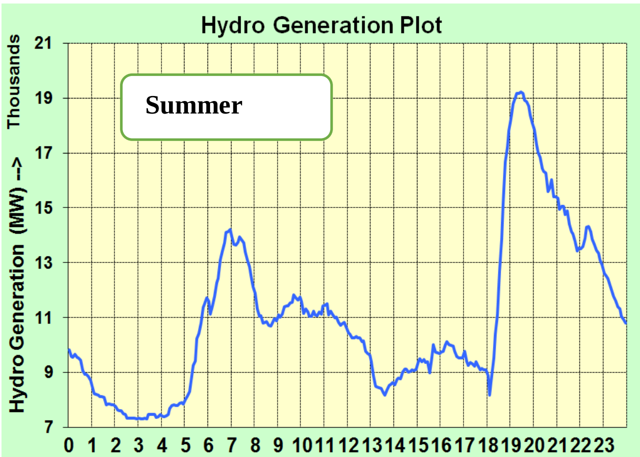


Exhibit 7.4(b)

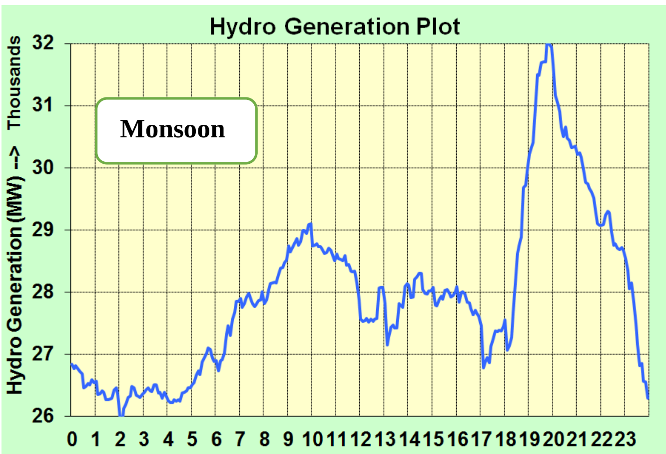
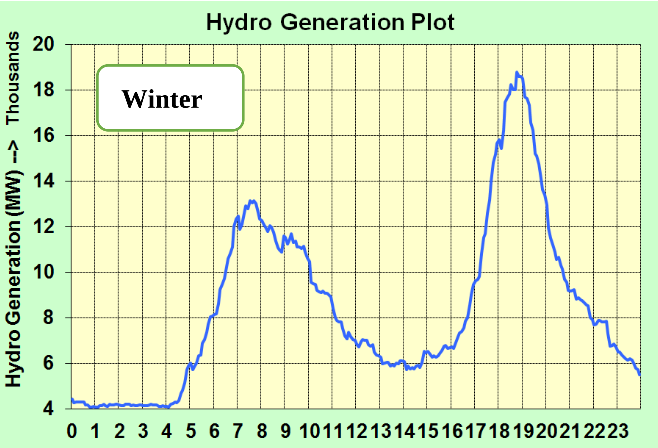


Exhibit 7.4(c)



7.2 HYDRO POWER – A FLEXIBLE SOLUTION

The power system operation stability requires the system to minimise fluctuations between demand and supply. This encompasses, for example, short term reserves (generation, storage, demand response) to cover potential incidents, which decrease power supply to the system, or to respond to short-term variations in demand and generation. Hydropower therefore provides an ideal solution for the challenges of a transitioning power system.

Hydropower brings a strong contribution to flexibility in the power system today filling the gap between supply and demand that has been induced by the non-dispatchable variability of RES. The storage capabilities of many hydropower plants make them a perfect instrument for optimising the use of variable RES over shorter and longer periods. Hydropower also provides a number of ancillary services which are needed in order to manage a transmission system in a way that secures system stability and security of supply. Moreover, during power system restoration, such as in the case of an extreme event (e.g. blackout), auxiliary loads of conventional thermal and nuclear power plants need external power source, which can be provided quickly by hydropower.

Hydropower plants with reservoirs reduce the dependency on the variability of the natural inflow and enable adjustments of power generation to the variability in demand. These plants are operated on a scheduled basis taking into account data regarding water flow forecast and consumption patterns. They are commonly used for intense load following and to meet peak demand. The generation of peak-load energy from reservoir type hydropower plants allows the optimisation of base-load power generation from other less flexible electricity sources, such as nuclear and thermal power plants. Besides contributing to water management activities (flood control, irrigation, drinking water, etc.), hydropower plants with reservoirs also introduce unique benefits to the electricity system. There are different types of hydropower plants with reservoirs.

Storage hydro plant (or conventional reservoir-type hydropower plant) takes advantage of large reservoirs with natural inflow of water and the possibility to reduce or increase the water outflow instantaneously. The water is stored in the reservoir and no pumps are needed. Pumped storage power plants store energy by pumping water from a lower to a higher reservoir and converting the potential energy back into electricity. These reservoirs can be natural or artificial. Both types of pumped storage plants enable the power system to receive and store energy in periods of low demand or excessive generation, and generate electricity in times of higher demand. The role of pumped storage hydropower plants is twofold: they balance the grid for demand-driven fluctuations, and balance generation-driven fluctuations. Storage possibilities combined with the instant start and stop of generation make hydropower plants very flexible. Pumped storage and storage hydro with peak generation are able to cope with high generation-driven fluctuations and can provide active power within a short period of time.

Conventional reservoir-type hydropower plants and pumped storage power plants can provide the full range of grid-stabilising services in view of their ability to follow demand or generation fluctuations within only a few minutes. There are several different ancillary services or grid stabilising services of hydropower, thus facilitating the integration of variable RES into the power system and providing a key tool to maintain a stable and balanced grid:

• **Back-up and reserve:** hydropower plants have the ability to enter load into an electrical system from a source that is not on-line. Hydropower can provide this service while not consuming additional fuel, thereby ensuring minimal emissions.

• **Quick-start capability:** hydropower`s quick-start capability takes just a few minutes.

• **Black start capability:** hydropower plants have the capability to run at a zero load. When loads increase, additional power can be delivered rapidly to the system in order to meet demand.

• **Regulation and frequency response:** hydro plants contribute towards maintaining the frequency within the given margins through continuous modulation of active power and to address moment-to moment fluctuations in system power requirements. Hydropower`s fast response ability makes it especially valuable in covering steep load gradients (ramp rates) through its fast load-following.

• **Voltage support:** hydropower plants have the ability to control reactive power, thereby ensuring that power will flow from generation to load. They also contribute to maintain voltage by injecting or absorbing reactive power to the system/Grid.

• **Spinning reserve:** hydropower supports the dynamic behaviour of the grid operation. Hydropower plants can provide spinning reserve – additional power supply that can be made available to the transmission system within a few seconds in case of unexpected load changes in the grid.

Hydropower plants with a small reservoir are sometimes also called pondage plants. These are designed to modulate generation on a daily or weekly basis. Pondage plants can provide flexibility services mainly through balancing power. They also provide frequency and voltage control as ancillary services.

Run-of-river hydro plants have little or no storage capacity. They therefore offer short-term storage possibilities (few minutes' dynamic cycle), thus allowing for some adaptation to demand, especially for ancillary services, such as frequency and voltage control.

To sum up, flexibility solutions of hydropower include:

- accommodating large variations in residual demand (to counter variability of RES, as sun does not always shine and wind does not blow constantly),
- providing increasing ramp rates in real time, caused by sudden changes of generation
- offsetting unexpected variations in production due to forecast errors in the intra-day markets or in the form of balancing power or ancillary services.

The hydro capacity of 44,479 MW (as on 31st March,2017) consist of **3611.67** MW Run of River(RoR); **15,139** MW RoR with pondage; **20,942** MW storage type includes 4785.6 MW of pump storage type. The region wise types of hydro are detailed in **Table 7.6.**

Table 7.6

Region Wise- Type Wise Hydro Installed Capacity (AS ON 31.03.2017)

(All Figures in MW)

REGION	Type of Hydro Projects				Total Capacity (MW)
	ROR	ROR (P)	STORAGE	PSS	
NORTHERN	3375.67	9641.00	5510.60	0.00	18527.27
WESTERN	30.00	1059.00	4463.00	1840.00	7392.00
SOUTHERN	60.00	1354.00	8353.85	2005.60	11773.45
EASTERN	146.00	2334.00	2123.70	940.00	5543.70
NORTH EASTERN	0.00	751.00	491.00	0.00	1242.00
	3611.67	**15139.00**	**20942.15**	**4785.60**	**44478.42**

Considering 80% availability of storage type plant and 50% availability of RoR with pondage type plants, the ramp up capacity provided by hydro plants would be more than 25000 MW.

7.3 PUMPED STORAGE PLANTS – BEST FRIEND OF ELECTRICITY GRID

While many forms of energy storage systems have been installed globally, Pumped Storage Plants (PSP) are playing an increasingly important role in providing peaking power and maintaining system stability in the power system of many countries. Pumped storage technology is the long term technically proven, cost effective, highly efficient and operationally flexible way of energy storage on a large scale to store intermittent and variant energy generated by solar and wind.

PSPs improve overall economy of power system operation, increase capacity utilization of thermal stations and reduce operational problems of thermal stations during light load period. The other advantages of pumped storage development are availability of spinning reserve at almost no cost to the system and regulating frequency to meet sudden load changes in the network. PSPs have the ability to provide ancillary benefits such as flexible capacity, voltage support and Black-start facility etc. Pumped storage technology has advanced significantly since its original introduction and now includes adjustable speed pumped turbines which can quickly shift from motor, to generator, to synchronous condenser modes, for easier and more flexible operation of the Grid.

Out of 96,524 MW of pumped storage potential identified in India by CEA at 63 sites, at present 9 pumped storage schemes with aggregate installed capacity of 4,786 MW are in operation out of which only 5 Nos. plants with aggregate installed capacity of 2,600 MW are being operated in pumping mode. The remaining 4 Nos. plants with an installed capacity of about 2,200 MW are not operating in pumping mode mainly because the 2nd reservoir is either under construction or the same has not been constructed. Efforts should be made to complete and operationalize the pump storage projects not running in PSP mode by resolving the issues. A PSP operation of a typical day is shown in **Exhibit 7.5.**

Exhibit 7.5(a)

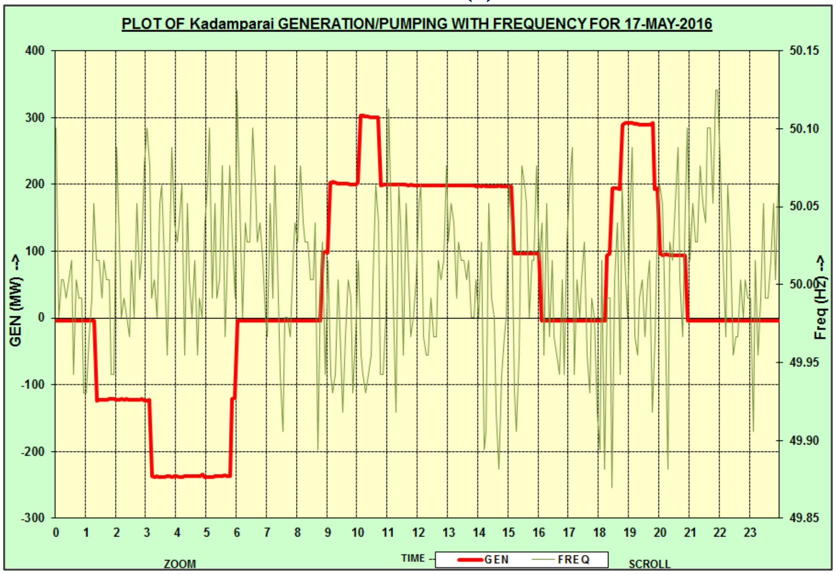


Exhibit 7.5(b)

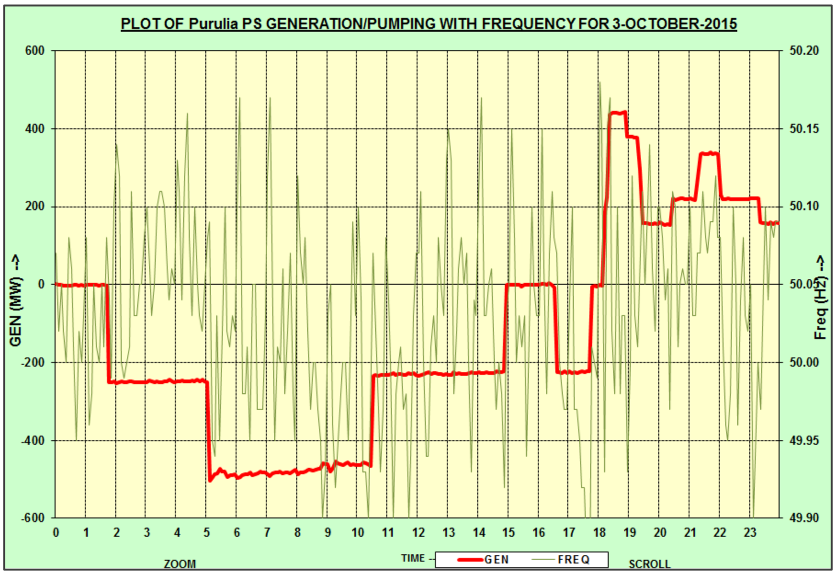
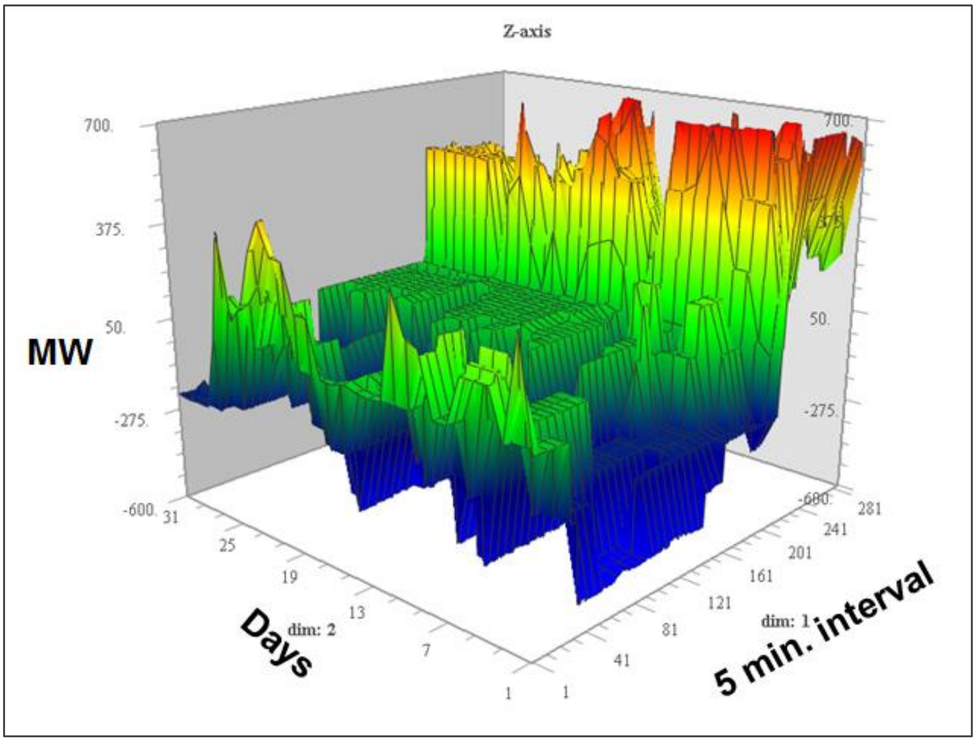


Exhibit 7.5(c)
Typical Pumped Storage Operation over a month



Since the energy gained from Pumped Storage Plants (PSP) is less than the energy input, it is necessary that off-peak power to be used as input may be available at reasonable tariff for making the Pumped Storage Plants commercially viable. An analysis of the Market Clearing Price (MCP) in the Peak and Off-Peak hours in the Power Exchange is presented in **Table 7.7**.

Table 7.7
Market Clearing Price (MCP) in ₹/kWh

Year	Peak	Night	Day	Peak/Off peak prices
	(18-23 hours)	(23-06 hours)	(11-17 hours)	
	A	B	C	D=A/B
2008	8.27	6.10	8.20	**1.36**
2009	6.08	4.53	6.64	**1.34**
2010	4.28	2.99	3.99	**1.43**
2011	4.20	2.88	3.83	**1.46**
2012	3.93	3.17	3.75	**1.24**
2013	3.14	2.33	3.13	**1.35**
2014	4.02	2.92	3.96	**1.38**
2015	3.13	2.37	3.05	**1.32**
2016	2.68	2.24	2.68	**1.20**

Source: IEX Website

If a PSP pumps for 7 hours in a day, then, it can generate for 5.25 hours assuming 75% overall efficiency. It is seen, from the above analysis, that as long as the price for 5.25 hours is more than (7/5.25 ~ 1.33) times the pumping price, it implies payment for only fixed costs of pumped storage. If the overall efficiency improves to 80%, the need for price differential in peak hours reduces to 25%.

In view of infusion of high RES, Pump Storage Development has to be treated as a separate category. Separate Policy instrument is required to incentivize PSPs. The pumped storage capacity was assessed by CEA in 1987, since then there have been many changes in environment laws & technology which calls for re-assessment of the potential.

In India, with increased penetration of RES in the grid, present practice of real time imbalance management may not be sufficient for handling large scale uncertainty in RES and limit the integration of renewable energy generation. The transmission corridors for evacuation of renewable power is being firmed up for the plan of having 175 GW of RE power in next 5 years**,** it is imperative to develop more PSPs and the benefits being given to RE projects may also be extended to the PSPs. The development of pumped storage particularly in the areas with concentrated wind and solar generation would significantly improve the grid reliability and it would act as the best partner for the Renewable Energy integration.

While benefits of having pumped storage hydro power are known but current market structures and regulatory frameworks do not present an effective means of achieving this goal. There is need for regulatory mechanism/ market incentives for effective integration of new generation, energy storage and transmission or that makes the PSP a commercially viable proposition. Regulatory Commissions may incentivize Tariff for PSPs and financial institutions should consider providing attractive terms for financing of PSPs.

7.4 IMPORTANCE OF HYDRO IN PRESENT SCENARIO

The current development profile and trends in generation capacity addition in India have resulted in the following aspects:

• Skewed development pattern between different generation technologies: The current portfolio of installed capacity of 3,26,832.5 MW as on 31.03.2017 is dominated by thermal power with around 66.8% share. Hydro, with an installed capacity of 44,478.5 MW has a share of around 13.6%. Adequate diversity in generation asset base has not been maintained with growth in hydro assets not being concomitant with growth in the thermal asset base. This also impacts the long-term least cost development pattern with over reliance on 25-year thermal plants vis- à-vis more than 40-year hydro assets.

• Inadequate peaking and quick response capability: While regional grids have been integrated and frequency regimes have been streamlined, the country faces lack of assets capable of meeting peaking deficits and with quick response characteristics. For meeting peak requirement and to mitigate the variability due to renewable energy sources of the order of 175 GW by 2022 and in the shortage of gas, the peak and the balancing requirement is to be primarily met by Hydro Electric Projects.

• Sustainable low carbon development: While India is considering a low carbon strategy and actively considering focusing on Energy Efficient Renovation & Modernization to utilise existing assets, the low carbon strategy can be fostered further with a higher thrust on green capacity additions via hydropower development. These factors necessitate renewed emphasis on 'responsible hydropower development' to promote economic growth. Hydro's critical role in sustainable development and energy security for the country is based on the elements of sustainability, availability and affordability.

7.5 CURRENT ISSUES AND CHALLENGES

Development of hydro power projects is fraught with a number of uncertainties. Broadly, the problems faced by developers can be grouped into those related to the project location, to its geology, and to issues of resettlement and rehabilitation. Typically, hydro projects are high cost, long gestation projects and are highly vulnerable to any uncertainties.

1) Land Acquisition Issues

Land availability and acquisition are among the core structural issues that impact almost all infrastructure sectors. Problems arising in the acquisition of land for hydropower projects are causing suspension and delay in construction activities.

2) Environment and Forest issues

Hydropower projects often require forest areas for their implementation and compensatory afforestation on non-forest lands. Progress of many projects has been affected on account of delay and non-clearance on environment and forest aspects. Construction and operation of hydropower dams can significantly affect natural river systems as well as fish and wildlife populations.

3) Rehabilitation & Resettlement Issues

Hydropower projects involve submergence causing the displacement of project area people. The rehabilitation of project affected people is also a major issue which is more pronounced in the case of storage-based hydropower projects.

4) Enabling infrastructure

A number of hydropower projects are located in remote sites in States which do not have adequate demand for electricity. This creates the requirement for developing enabling infrastructure for power evacuation. The 'chicken neck' presents geographical constraints in developing requisite transmission infrastructure for hydropower evacuation from the north east. There are certain other challenges for the coordinated development of the transmission network, e.g. identifying beneficiaries well in advance, developing excess evacuation capacity keeping in mind the future development of projects (especially where there are Right of Way (RoW) issues). Furthermore, the Plant Load Factor (PLF) for hydropower projects is typically less than 50%, as a result of which significant transmission capacity is under-utilised. All these result in higher transmission costs.

Hydropower projects also require the development of associated infrastructure such as roads and bridges in the area. Inclusion of the cost of development of such associated infrastructure increases the cost of power generated affecting project viability and sustainability. Lack of infrastructure such as schools, hospitals and difficult access to sites often become blocks to moving skilled manpower to difficult project sites.

5) Law & Order / Local issues

Protests by the local people against the construction activities like blasting, muck disposal etc. and demands for employment, extra compensation etc. often create law and order problems which delays the commencement and affects progress of the works.

6) Technical challenges

Techno economic viability of hydropower projects depends on the geology, topography, hydrology and accessibility of the project site. Even if extensive investigations using State-of the-art investigation and construction techniques are adopted, an element of uncertainty remains in the sub-surface geology. Geological surprises during actual construction cannot be ruled out. This unpredictable geology is more pronounced in the young fold Himalayas where most of the Indian hydropower potential resides. Such technical challenges add to construction risks.

7) Natural Calamities

Natural calamities like unprecedented rain / flash floods, cloud burst, earthquake etc delay the completion of project.

8) Inter-State Issues

Planning for hydropower development in India has generally been oriented toward individual projects. However, this approach has several limitations for sustainable development of an entire river basin. Inter-State disputes are another aspect which hinders integrated river basin development for hydropower projects. A large number of hydropower projects with common river systems between adjoining States are held up due to a lack of inter-State agreements and disputes on water-sharing.

9) Tariff Design for Hydro

Tariffs remaining static for the entire life time of the hydro project doesn't send the right signal as far as hydro dispatch is concerned. The tariff design therefore needs to reflect the current capital cost and value of the hydro energy with the gains split between the power plant and its beneficiaries as decided by the Appropriate Commission.

There is need for all hydro power to have a two-part tariff comprising of a fixed cost and variable cost. Conventionally, the variable cost of hydro power stations is considered as NIL; so a hybrid tariff model is required for all hydro power stations similar to that prevailing for the power stations whose tariff is decided by the Central Electricity Regulatory Commission (CERC). Currently, the Annual Fixed Charges (AFC) of such power plants is divided equally into Fixed Charge and Energy Charge with the latter apportioned amongst the saleable Design Energy (DE) for the whole year.

The DE figures should be available both on ten daily basis as well as monthly basis for 50% and 90% dependable years and these figures should be available on public domain. Policy needs to promote coordination between IMD and CWC for creating infrastructure for inflow forecasting and precipitation forecasting in the catchment area of a river basin.

10) Non-availability of Grid power during initial stage

During construction stage the grid power supply is generally not available at construction site. Hence the construction power is being fed through the DG sets the supply to diesel to such remote location takes huge time which delays the commencement and effect progress of the work.

11) Safety and security problem

Most of the untapped hydro projects of the country are in remote and border areas like J&K, Arunachal Pradesh etc. disturbance from locals and security threats in border area is being faced.

7.6 POLICY INITIATIVES TAKEN FOR INCREASING THE HYDRO CAPACITY

The Government has taken several policy initiatives/measures to tap the hydro potential and to boost hydro power development in the country. The details are given below:

7.6.1 National Electricity Policy, 2005

National Electricity Policy, 2005 was notified by Govt. of India on 12.2.2005. The salient features of the policy are given below:

- The policy lays maximum emphasis on full development of the feasible hydro potential in the country which will facilitate economic development of States, particularly North Eastern States, Uttarakhand, Himachal Pradesh and Jammu & Kashmir.
- Since the hydel projects call for comparatively larger capital investment, debt financing of longer tenure has been recommended.
- The State Governments have been advised to review procedure for land acquisition and other approvals/ clearances for speedy implementation of hydro projects.
- Full support of Central Government has been extended for hydel development by offering the services of CPSUs like NHPC, NEEPCO, SJVNL, THDC etc.

7.6.2 Hydro Power Policy- 2008: Salient Features

Hydro Power Policy, 2008 has been notified by Govt. of India on 31st March,2008. The salient features of the policy are given below:

- Transparent selection criteria for awarding sites to private developers.
- Enables developer to recover his additional costs through merchant sale of upto a maximum of 40% of the saleable energy.
- Developer to provide 100 units of electricity per month to each Project Affected Family - in cash or kind or a combination of both for 10 years from the COD.

- Developer to assist in implementing rural electrification in the vicinity of the project area & contribute 10% share of the State Govt. under the RGGVY scheme.
- Additional 1% free power from the project (over and above 12% free power earmarked for the host State) for Local Area Development Fund - regular revenue stream for welfare schemes, creation of additional infrastructure and common facilities.
- The State Governments to contribute a matching 1% from their share of 12% free power.

7.6.3 Tariff Policy, 2016 (Portions relevant to Hydropower)

- Intent of Govt. for promotion of HEP emphasized in the objective of the Policy - "To promote HEP generation including PSP to provide adequate peaking reserves, reliable grid operation and integration of variable RE sources".
- Renewable Purchase Obligation – Hydropower excluded from RPO (8% of the total consumption excluding Hydro power).
- As notified in Revised Tariff Policy, 2016, Cost plus Tariff regime (in which tariff is to be determined by the regulator under section 62 of Electricity Act, 2003) has been extended for public & private sector hydro power projects up to 15.08.2022.
- Certainty of long term PPA for min. 60% of capacity, balance through merchant sale - Provision for extension of PPA beyond 35 years for a further period of 15 years.
- Enabling provision for suitable regulatory framework incentivizing HEPs for using long term financial instruments - in order to reduce tariff burden in the initial years.
- Depreciation – Developer shall have the option of charging lower rate of depreciation vis-à-vis the ceiling determined by CERC.

7.6.4 Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013

Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 has been notified by the Govt. of India on 27.09.2013 which have more participation of local people in terms of Land acquisition and Rehabilitation & Resettlement. The main objectives of the Act are given below:

- To ensure a humane, participative, informed and transparent process for land acquisition with the least disturbance to the owners of the land and other affected families
- Provide just and fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition
- Make adequate provisions for such affected persons for their rehabilitation and resettlement
- Ensure that affected persons become partners in development leading to an improvement in their post-acquisition social and economic status.

7.6.5 Other Measures Taken for Increasing the Hydro Capacity

- A Consultation Process has been evolved for Fast Tracking of S&I activities and preparation of Quality DPRs wherein appraising agencies advise Developer in carrying out various investigations and firming up the project layout etc.
- Time bound appraisal norms have been evolved in CEA for examination of DPRs.
- A number of projects have been prioritized which are being monitored regularly at highest levels by the Govt. of India for their expeditious implementation.
- Central Electricity Authority (CEA) is monitoring the progress of each project regularly through frequent site visits, interaction with the developers and critical study of monthly progress reports.
- A Power Project Monitoring Panel (PPMP) has been set up by the Ministry of Power to independently follow up and monitor the progress of the hydro projects.

- Regular review meetings are taken by Ministry of Power/ CEA with equipment manufacturers, State Utilities/ CPSUs/ Project developers, etc. to sort out the critical issues.
- Review meetings are taken by MoP/ CEA with Border Road Organization, Ministry of Road Transport and Highways etc. to sort out the infrastructure issues.

7.7. CONCLUSIONS

- Most hydro facilities have the ability to manage net-load variability and uncertainty. Hydro plants would be able to provide a more valued service to the grid than the manner in which they have historically been used , in view of high penetration of solar and wind energy.
- Hydro plants shall be considered for compensation for balancing the grid by implementing differential tariff for peak and off-peak power. Pumped storage plants should be encouraged to operate in pump mode by providing incentive for its operation.
- Infrastructure cost from the Hydro project may be excluded for determining tariff. As the need for generation resources that can provide system flexibility increases with an increased proportional penetration of variable renewables, the value of hydropower and pumped storage will become more significant.
- At Present, Central Financial Assistance/ Support in the form of grant/ assistance/ subsidy is being provided by the Govt. to the renewable small Hydro Projects up to 25MW capacity. Extension of this Financial Assistance/ Support to all hydro projects (irrespective of the size/ capacity) is likely to give a boost to the development of hydro power in the country.

CHAPTER 8
GAS BASED POWER PLANTS

8.0 INTRODUCTION

Natural Gas is one of the cleanest fuels with less carbon dioxide per joule delivered than either by coal or oil and contains far fewer pollutants than other hydrocarbon fuels and therefore the Natural gas has emerged as the most preferred fuel due to its inherent environmentally benign nature, easy transportability, ease of use, greater efficiency and cost effectiveness. The development of Natural Gas industry in the country started in 1960s with discovery of gas fields in Assam and Gujarat. After discovery of South Basin fields by ONGC in 1970s, Natural Gas assumed importance. The Exploration activities in India were earlier carried out only by the National Oil Companies (ONGC & OIL) under nomination regime. Later private companies were allowed to enter into exploration through JV with National Oil Companies (NOCs) under Pre-NELP (New Exploration Licensing Policy) regime. Subsequently, 100% foreign participation in exploration was allowed in the current NELP regime. Later discoveries were made in Gujarat, Krishna Godavari (KG) basin, Cauvery basin, Tripura, Assam etc. Hydrocarbon Exploration and Licensing Policy (HELP) is introduced in March, 2016 for a uniform licensing system to cover all hydrocarbons such as oil, gas, coal bed methane etc. under a single licensing framework coupled with open acreage policy.

The demand of natural gas has sharply increased in the last two decades at the global level. In India, the natural gas sector has gained importance, particularly over the last decade. However, the supply is not keeping pace with the demand. There is shortage of natural gas for the fertilizer plants, power plants and petrochemical complexes. The power and fertilizer industries emerged as the key demand drivers for natural gas due to the scale of their operations, policy intervention and social impact. In an agrarian economy such as India, the priority has been the production of fertilizers.

8.1 BACKGROUND

In India, Natural gas produced from domestic sources is being allocated to different sectors by Central Government as per policy guidelines issued from time to time. In case of imported gas, the marketers are free to import Re-gasified Liquid Natural Gas (RLNG) and sell the RLNG to customers.

Gas based generation in India got the impetus when HVJ (Hajira- Vijaypur-Jagdishpur) gas pipeline was commissioned by GAIL in the 80's after discovery of gas in the west coast of India. This led to commissioning of a number of Gas based Combined Cycle Gas Turbines (CCGTs) along the HVJ pipe line in the Western and Northern part of India. Prior to that, very little gas based generation was present in the North East. Apart from the major HVJ trunk pipeline, certain regional gas grids like in KG basin and Kaveri basin also helped in development of some gas based power generation capacities. Isolated fields are located mainly in parts of Rajasthan, Tamil Nadu and North-Eastern Region.

With the New Exploration Licensing Policy (NELP), gas exploration in India got an impetus and the discovery of gas in Krishna Godavari Dhirubhai 6 (KGD6) field by Reliance Industries Limited in 2002, was expected to be a turning point in gas production in the country. With the commissioning of East West pipeline by Reliance Gas Infrastructure India Limited, KGD6 gas got infused into the system in early 2009.

With the commencement of production from KGD6 field and the expectation of considerable increase in the volume of production from this field, number of gas based plants were taken up for implementation in the country even without firm allocation of gas. The peak flow of the gas in KGD6 fields was expected to be about 80 MMSCMD, by the end of the year 2009, and was to increase further in subsequent years. Before the commencement of production from KGD6 fields, gas based power plants were operating primarily with the allocated Administrative Price Mechanism(APM) /Non APM/Panna-Mukta-Tapi- Ravva basin gas from nominated fields, but these supplies were short of their requirement. When KGD6 gas production was about to start in 2009, Empowered Group of Ministers (EGoM) on pricing and utilization for natural gas under New Exploration and Licensing Programme (NELP) made allocation of 63.17 MMSCMD of KGD6 gas to power sector in May 2008 and October 2009. The EGoM in its meeting held on 23rd August,2013 decided that the entire additional NELP gas production, available during the years 2013-14, 2014-15 & 2015-16 after meeting the supply level of 31.5 MMSCMD to fertilizer sector, be supplied to the power sector.

Supply of KGD6 gas was started in 2009-10 with 39.67 MMSCMD and reached a peak of 55.35 MMSCMD in 2010-11. The gas from KGD6 started gradually declining to 42.33 MMSCMD in 2011-12 ,25.74 MMSCMD in 2012-13 and only 14 MMSCMD in June, 2013. Contrary to the projections, the gradual reduction in production from KGD6 upset the gas based capacity addition programme in the country. When the production from KGD6 field fell to 16 MMSCMD in March, 2013, the supplies to power sector got reduced to zero.

Table 8.1 below shows the availability of KGD6 Gas to all sectors in various years starting from 2009-10.

Table 8.1
Availability of KG-D6 gas to all Sectors

Year	2009-10	2010-11	2011-12	2012-13
Supply in MMSCMD	39.67	55.35	42.33	25.74

8.2 PRESENT STATUS

Out of total installed capacity of 3,26,833 MW as on 31st March,2017, a capacity of 25,330 MW (about 7.75%) is from gas based power plants. However, capacity of 24,037MW is being monitored by CEA. Out of the total monitored capacity, a capacity of 21,048 MW is connected with Main Pipeline/Gas grid and 2989 MW is connected with isolated gas fields. Of the grid connected gas based capacity of 21,048 MW, 8,042 MW is predominantly APM gas based and 6,897 MW is predominantly on KG D6 gas. Besides this a capacity of 6,110 MW has been commissioned without any gas allocation. In addition, a capacity of 406 MW is under construction and is likely to be commissioned by 2021-22.

Normative Gas requirement to operate the existing Power plants of capacity of 24,037 MW at 90% Plant Load Factor (PLF) is about 117 MMSCMD. However, the total domestic gas allocated to power projects is 87.05 MMSCMD and average gas supplied to these gas based power plants during the year 2016-17 was only 29.59 MMSCMD. The gas grid connected capacity had received 20.22 MMSCMD gas during the year 2016-17 and achieved average PLF of around 19% only and gas based capacity connected with isolated gas field had received 9.37 MMSCMD gas and achieved a PLF of 50.43 %. Therefore, the average Plant Load Factor of gas based generation capacity in the country during 2016-17 is about 22.86%.

Details of gas based capacity with gas supply position for the year 2016-17 is given in Annexure **8.1**. Supply of Natural gas to gas based power plants during last few years is shown in **Table 8.2**.

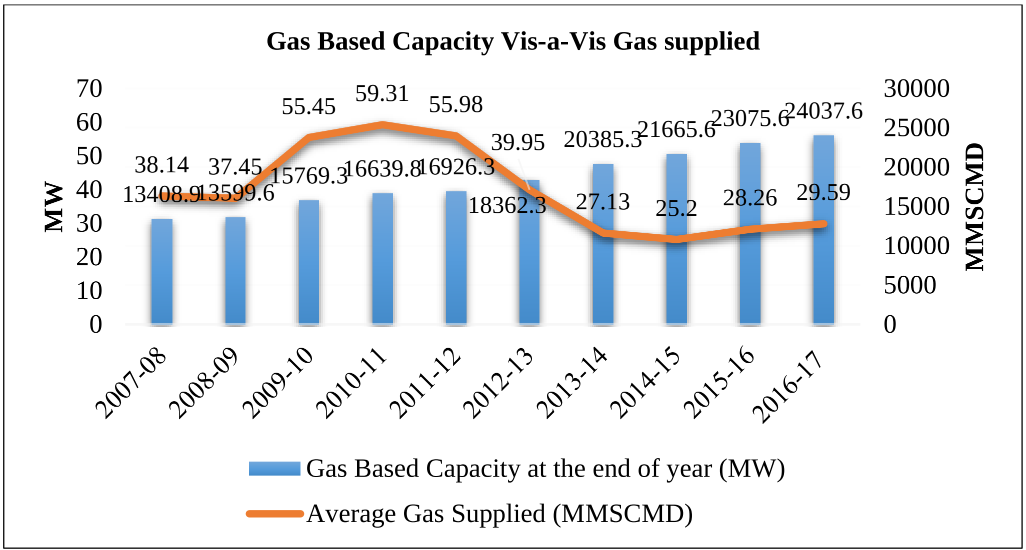
Table 8.2
Average Gas Supply and Shortfall

Sl.	Years	Gas Based Capacity at the end of year (MW)	Gas Required* (MMSCMD)	Average Gas Supplied (MMSCMD)	Shortfall (MMSCMD)
1	**2**	**3**	**4**	**5**	**(6)=(4)-(5)**
1	2007-08	13408.92	65.67	38.14	27.53
2	2008-09	13599.62	66.61	37.45	29.16
3	2009-10	15769.27	78.09	55.45	22.64
4	2010-11	16639.77	81.42	59.31	22.11
5	2011-12	16926.27	81.78	55.98	25.80
6	2012-13	18362.27	90.70	39.95	50.75
7	2013-14	20385.27	97.90	27.13	70.77
8	2014-15	21665.57	104.00	25.20	78.80
9	2015-16	23075.57	113.63	28.26	85.37
10	2016-17	24037.57	117.45	29.59	87.86

*normative gas requirement at 90% PLF.

Supply of gas-to-gas based power plants during last few years has been shown in **Exhibit 8.1**.

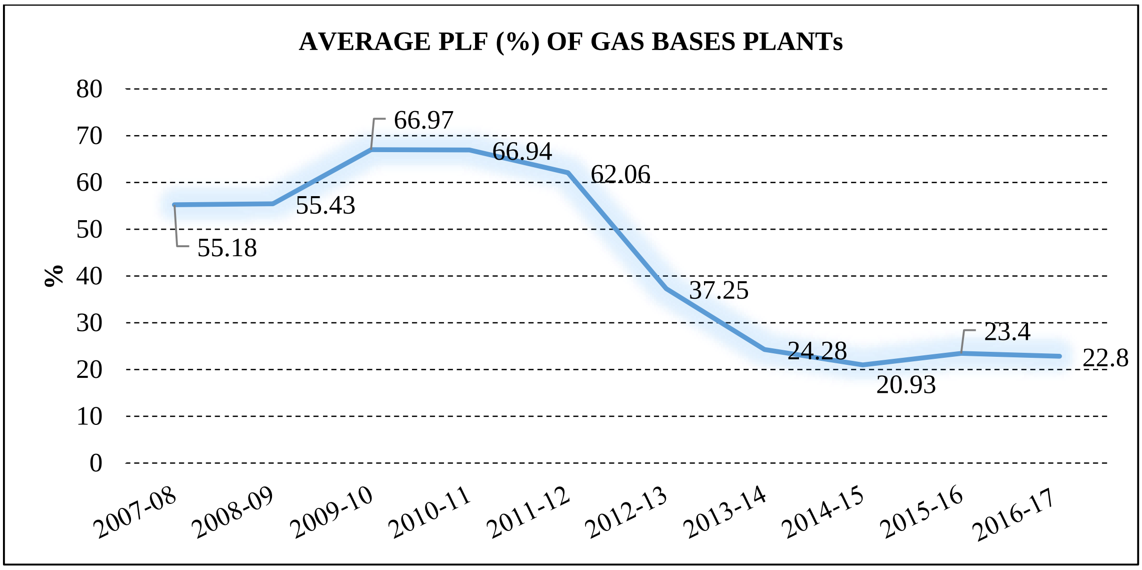
Exhibit 8.1



As can be seen from the **Exhibit 8.1**, domestic gas supply to gas based power plants had reached a peak of 59.31 MMSCMD during 2010-11, thereafter, due to unprecedented reduction in gas supply, the gas supply to gas based power plants had reduced sharply. During the year 2016-17, total gas supplied to gas based power plants was only 29.59 MMSCMD, which is even less than gas supply during 2007-08.

Average PLF of gas based capacity for the last few years is shown in **Exhibit 8.2**. It can be seen from **Exhibit 8.2** that average PLF of gas based capacity during 2007-08 was around 55% and had increased to 67% in the year 2009-10, thereafter average PLF started declining and for the year 2016-17 (Apr-Dec,2016) average PLF came down to around 22% only.

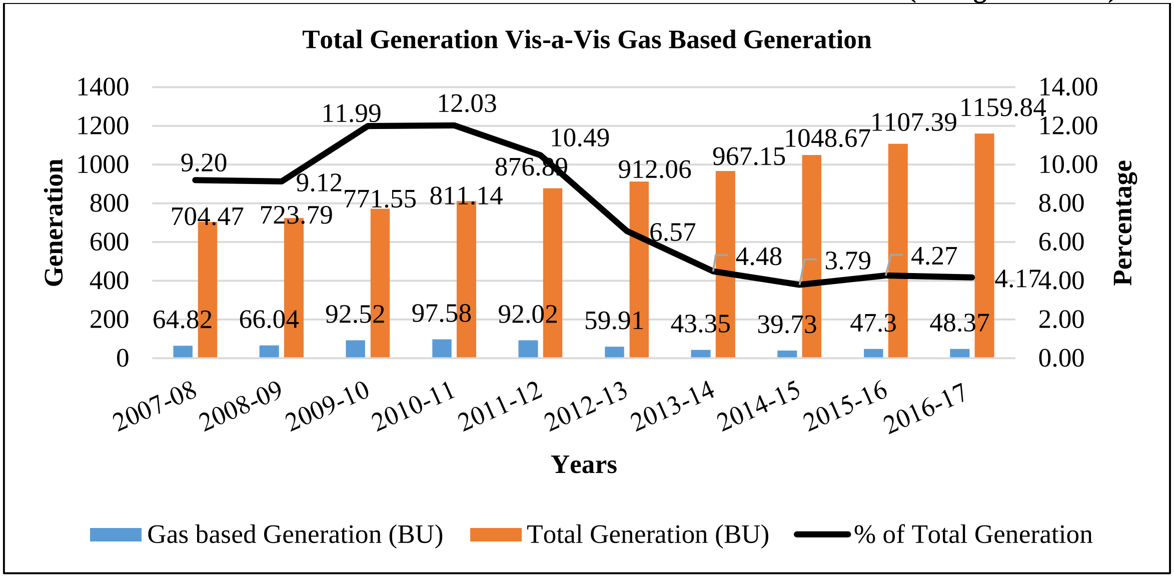
Exhibit 8.2



Share of gas based power generation in total generation from 2007-08 to 2016-17 is shown in **Exhibit 8.3**.

Exhibit 8.3

(All figures in BU)



8.3 ADVANTAGES OF GAS BASED POWER PLANTS

Natural gas based power generation has many advantages over other conventional energy sources mainly on account of its lesser impact on the environment and better economics. However, despite these advantages, due to shortage of domestic gas, India's energy mix is skewed towards coal compared to other countries, with gas based power share in India only 8% against the world average of around 22%[1].

Gas based power plants require significantly less land and water in comparison to coal based power plant of the same capacity. In addition, gas based plants with quick ramping can support the renewable balancing power requirements. This gains importance especially in the context of India's aspiration to rapidly scale up renewable generation. Besides, gas based capacity will minimize the need for other alternative modes of power generation during peak hours of power shortage such as using diesel generators etc., which are not only costlier but also result in more environmental pollution. It may also be noted that gas based power generation would reduce carbon emissions, as emissions from gas based power generation is less as compared to Diesel or coal based generation. Details are shown in the **Table 8.3**.

Table 8.3
CO_2 emission from various fuels

Particulars of the Plant	Gas based	Coal based	Diesel based
Capacity (MW)	1000	1000	1000
Gross Station Heat Rate Kcal/kWh	1850	2350	1975
Auxiliary Power Consumption (%)	3%	8.5%	3.5%
Net Station Heat Rate (Kcal/kWh)	1900	2568	2047
Fuel emission factor (g CO2/KJ)	49.4	99.6	69
Specific CO2 emission (tCO2/MWH)	0.30	0.98	0.59

However, due to acute shortage of domestic gas and higher price of imported natural gas, gas based power plants are not in a position to run their plants efficiently.

8.4 CAPACITY ADDITION DURING 2017-22 AND GAS REQUIREMENT

In view of the shortage of gas, Ministry of Power had issued an advisory in March, 2012 for the developers not to plan power projects based on domestic gas till 2015-16, as projections for 2014-15 and 2015-16 given by MoP & NG could not support any new capacity.

[1] World Bank – World Development Indicators data

Due to uncertainty in availability of domestic gas, though there was a capacity of about 3,500 MW are at advanced stage of construction, only a capacity of 406 MW is likely to be commissioned during the period 2017-22.

8.5 GAS BASED POWER PLANTS AS PEAKING PLANTS

Government of India has chalked out a program of massive capacity addition from RES by 2022. The total RES capacity by March, 2022 is planned to be 175 GW. The generation from RES shall be treated as must-run. Therefore, at any instant, the net system demand after absorbing the generation from RES (i.e. Net Demand = Total Demand -generation from RES) needs to be met through conventional generation sources. The solar generation would be maximum during the day time when the system demand is quite low and would be "NIL" during evening peak hours. This would make the Net Demand Curve very steep and would require generation from conventional sources which can ramp up very fast. This necessitates dedicated peaking plants.

Further, infusion of significant quantum of RES into the grid will also need availability of adequate balancing power to take care of the variability and uncertainty associated with RES generation. Balancing requirement as well as ramping requirement of the grid can be sourced in order of priority from Hydro plants, Pumped Storage Plants and Open Cycle Gas Turbine Plants followed by Closed Cycle Gas Turbine Plants. Now, out of the total hydro capacity of **44,478.42 MW** as on 31st March,2017, **25,727.75 MW** are storage type, **3611.67 MW** are run-of the river type and **15,139 MW** are run-of the river with pondage type. Irrigational requirement, failure of monsoon etc. limit the availability of hydro power. Again, capacity addition from hydro plants are taking place at a very limited pace due to a host of reasons like delay in environmental and forest clearance, R&R problems etc. Adequate Pumped Storage Plants are also not available. Therefore, for balancing, gas based plants has to be utilised. Gas based plants are of two types namely open cycle gas plants and combined cycle gas plants. Open cycle gas plants are very suitable for balancing and ramping requirement of the grid because of its quick start and stop time. But open cycle gas based plants are less efficient than the closed cycle ones. Now, of the total monitored gas based capacity of 24,037 MW, 350 MW is only open cycle and the balance are closed cycle plants. However, the new gas-based combined cycle power plants offer higher efficiency and can go from start to full load quicker. The total start-up time is just 30 minutes (from warm start) and shutdown time is 30 minutes. These are single shaft machines, can operate at a minimum load of 20%, and therefore are best suited to cater the variability of RES.

Presently, there is acute shortage of domestic gas for the Gas Based Power Plants. During the year 2016-17, Gas Based Plants were running at a PLF of around 22.86%. To run gas plant at a PLF of 85%, normative gas requirement would be about 110 MMSCMD. This is significantly more than the present availability of 29.88 MMSCMD. The role of gas based plants during evening to meet the balancing power and ramping requirement is vital for the Indian grid.

Optimisation studies showed that for integrating renewables of 175 GW by 2021-22 and to meet the peaking and ramping requirement of the system, PLF of gas based capacity during 2021-22 is likely to be around 37% compared to around 22% at present. The gas requirement is of the order of about 45.27 MMSCMD. It has been observed from the studies that the gas based capacities are utilised maximum during the peak hours to meet the peak and the ramping requirement. The actual gas requirement may substantially get reduced in the event of any or all of the followings:

- Maximisation of utilisation of domestic gas during peak hours to meet the peaking and the ramping requirement.
- Utilisation of full peaking potential of the hydro plants.
- Operation of some of the coal based thermal power plants in two shift.

Efforts should be made for exploring the modalities of implementation of the above keeping in view the grid stability, and commercial issues involved threin.

8.6 STEPS TAKEN BY GOVERNMENT TO OVERCOME SHORTAGE OF GAS

Government of India has adopted a multi-pronged strategy to augment gas supplies and bridge the gap between supply and demand for the domestic market. These include: -

- Policy to grant relaxation, extension & classifications at development & production stage for early monetization of hydrocarbon discoveries.
- Discovered Small Field Policy.
- Formulation of Hydrocarbon Exploration and Licensing Policy (HELP) in March, 2016.

  Four main facets of this policy are:
  a) Uniform license for exploration and production of all forms of hydrocarbon. The uniform licence will enable the contractor to explore conventional as well as unconventional oil and gas resources including CBM, shale gas/oil, tight gas and gas hydrates under a single license. The concept of Open Acreage Policy will enable E&P companies choose the blocks from the designated area.
  b) an open acreage policy,
  c) easy to administer revenue sharing model and
  d) marketing and pricing freedom for the crude oil and natural gas produced.

The decision will enhance domestic oil & gas production, bring substantial investment in the sector and generate sizable employment. The policy is also aimed at enhancing transparency and reducing administrative discretion.

- Policy for marketing freedom for gas produced from Deepwater & Ultra Deepwater areas.
- MOP&NG is taking necessary steps to augment production of natural gas from the gas fields/wells by awarding gas blocks for Exploration & Production activities in various sedimentary basins of the country under the New Exploration Licensing Policy (NELP).
- Encouraging import of gas in the form of Liquefied Natural Gas (LNG) and also making efforts for import of gas through international pipelines projects.
- Implementation of Natural Gas Hydrate Programme (NGHP) for evaluation of hydrate resources and their possible commercial exploitation.
- Introduction of scheme for utilisation of gas based generation capacity.

8.7 SCHEME FOR UTILIZATION OF GAS BASED GENERATION CAPACITY

In order to optimally utilize gas based generation capacity and to meet the gas requirement of grid connected gas based capacity, Government of India has sanctioned a scheme which envisages supply of imported spot Liquefied Natural Gas (LNG) to the stranded gas based power plants as well as plants receiving domestic gas to revive and improve utilization of the stranded gas based power generation capacity in the country. The mechanism also envisages sacrifices to be made collectively by all stakeholders, including the Central and State Governments by way of exemptions from certain applicable taxes and levies on the incremental LNG being imported for the purpose. The scheme envisages supply of imported spot Liquefied Natural Gas to the stranded gas based power plants through a reverse e-bidding process. The scheme is to be implemented for the years 2015-16 and 2016-17. The scheme envisages financial support from PSDF (Power System Development Fund). The outlay for the support from PSDF has been fixed at ₹ 7,500 crores (₹ 3,500 crores and ₹ 4,000 crores for the year 2015-16 and 2016-17 respectively).

A gas based capacity of 14,305 MW, comprising 5,194 MW of gas based plants having predominantly allocation from KGD6 fields, 3,762 MW of gas based capacity commissioned without any gas allocation and 5,349 MW of new gas based capacity which are ready for commissioning (if gas is made available) were considered as stranded.

The following interventions/ sacrifices are envisaged in the scheme, to be made by the Central Government, State Governments, power developers and gas transporters collectively.

a) Streamlining the procedure for availing Customs duty waiver on imported LNG for the gas based power plants
b) Waiver of Value Added Tax (VAT) on the e-bid RLNG
c) Waiver of Central Sales Tax (CST), Octroi and Entry Tax on the e-bid RLNG
d) Waiver of Service Tax on regasification and transportation of the e-bid RLNG
e) Reduction in pipeline tariff charges by 50%, reduction in marketing margin by 75% on incremental volumes by GAIL / other transporters on the e-bid RLNG
f) Capping of fixed cost to be recovered by the promoters: Power developers to forgo return on their equity.
g) Provision for co-mingling and swapping of gas

h) Exemption from transmission charges and losses for such stranded gas based power projects on lines of solar power on generation from the e-bid RLNG
i) Support from Power System Development Fund (PSDF)

8.8 RECOMMENDATIONS

1. The scheme for utilisation of gas based generation capacity introduced by Government of India is for two years only. But it is felt that a long term policy intervention is required for optimal utilization of gas based capacity in the country.

2. In view of massive capacity addition target of 175 GW from RES, Gas Based Power plants in the country need to play a vital role in balancing and ramping requirements of the grid. Availability of at least 45.27 MMSCMD of gas to Gas Based Plants in the country needs to be ensured for this purpose. The actual gas requirement may reduce if full peaking potential of the hydro plants can be utilised and if the coal based thermal power plants can operated in a two shift.

3. The regasification capacity in the country is also a matter of concern for gas based power plants, particularly those who are connected with RGTIL East-West pipeline. Due to technical constraints like directional flows etc., imported RLNG from west coast cannot be transported to power plants located in the East Coast. Therefore, facility of re-gasification capacity may be suitably created at East coast also.

Annexure-8.1

CUMULATIVE REPORT ON FUEL SUPPLY/CONSUMPTION FOR GAS BASED POWER STATIONS IN THE COUNTRY FOR THE PERIOD APRIL'16-MARCH'17

S. No	Name of Power Station	Installed Capacity (MW)	State	Gas Allotted (MMSCMD)	Gas Consumed (MMSCMD)
(A) CENTRAL SECTOR					
1	NTPC, FARIDABAD CCPP	431.59	HARYANA	**2.32**	**0.63**
2	NTPC, ANTA CCPP	419.33	RAJASTHAN	**2.32**	**0.43**
3	NTPC, AURAIYA CCPP	663.36	UTTAR PRADESH	**3.85**	**0.34**
4	NTPC, DADRI CCPP	829.78	UTTAR PRADESH	**4.01**	**1.32**
	Sub Total (NR)	**2344.06**		**12.50**	**2.72**
5	NTPC, GANDHAR(JHANORE) CCPP	657.39	GUJARAT	**3.19**	**1.44**
6	NTPC, KAWAS CCPP	656.2	GUJARAT	**6.07**	**1.00**
7	RATNAGIRI (RGPPL-DHABHOL)	1967	MAHARASHTRA	**10.63**	**2.37**
	Sub Total (WR)	**3280.59**		**19.89**	**4.81**
8	KATHALGURI (NEEPCO)	291	ASSAM	**1.4**	**1.17**
9	MONARCHAK (NEEPCO)	101	TRIPURA	**0.5**	**0.15**
10	AGARTALA GT+ST (NEEPCO)	135	TRIPURA	**0.75**	**0.67**
11	TRIPURA CCPP (ONGC)	726.6	TRIPURA	**2.65**	**2.24**
	Sub Total (NER)	**1253.6**		**5.3**	**4.23**
	Total (CS)=A	**6878.25**		**37.69**	**11.76**
(B) STATE SECTOR					
12	I.P.CCPP	270	DELHI	**1.55**	**0.50**
13	PRAGATI CCGT-III	1500	DELHI	**2.49**	**1.13**
14	PRAGATI CCPP	330.4	DELHI	**2.25**	**1.00**
15	DHOLPUR CCPP	330	RAJASTHAN	**1.60**	**0.09**
16	RAMGARH (RRVUNL,Jaisalmer)	273.8	RAJASTHAN	**1.45**	**1.40**
	Sub Total (NR)	**2704.2**		**9.34**	**4.12**
17	PIPAVAV CCPP	702	GUJARAT	**0.00**	**0.02**
18	DHUVARAN CCPP(GSECL)	594.72	GUJARAT	**0.94**	**0.18**
19	HAZIRA CCPP(GSEG)	156.1	GUJARAT	**0.81**	**0.01**
20	HAZIRA CCPP EXT	351	GUJARAT	**0.00**	**0.09**
21	UTRAN CCPP(GSECL)	518	GUJARAT	**1.69**	**0.08**
22	URAN CCPP (MAHAGENCO)	672	MAHARASHTRA	**4.90**	**2.19**

	Sub Total (WR)	**2993.82**		**8.34**	**2.57**
23	KARAIKAL CCPP (PPCL)	32.5	PUDUCHERRY	**0.20**	**0.18**
24	KOVIKALPAL (THIRUMAKOTTAI)	107	TAMIL NADU	**0.45**	**0.24**
25	KUTTALAM (TANGEDCO)	100	TAMIL NADU	**0.45**	**0.24**
26	VALUTHUR CCPP(Ramanand)	186.2	TAMIL NADU	**0.89**	**0.55**
27	GODAVARI (JEGURUPADU)***	216	ANDHRA PRADESH	**1.31**	**0.54**
	Sub Total (SR)	**641.7**		**3.30**	**1.75**
28	LAKWA GT (ASEB,Maibella)	157.2	ASSAM	**0.90**	**0.73**
29	NAMRUP CCPP + ST (APGCL)	181.5	ASSAM	**0.66**	**0.48**
30	BARAMURA GT (TSECL)	58.5	TRIPURA	**0.60**	**0.23**
31	ROKHIA GT (TSECL)	111	TRIPURA	**0.30**	**0.52**
	Sub Total (NER)	**508.2**		**2.46**	**1.96**
	Total (SS)=B	**6847.92**		**23.44**	**10.4**
(D) PVT/IPP SECTOR					
32	RITHALA CCPP (NDPL)	108	DELHI	**0.40**	**0.00**
33	GAMA CCPP	225	UTTARAKHAND	**0.48**	**0.23**
34	KASHIPUR CCPP(SRAVANTHI)	225	UTTARAKHAND	**0.80**	**0.36**
	Sub Total (NR)	**558**		**1.68**	**0.59**
35	TROMBAY CCPP (TPC)	180	MAHARASHTRA	**2.50**	**0.84**
36	MANGAON CCPP	388	MAHARASHTRA	**1.09**	**0.09**
37	BARODA CCPP (GIPCL)	160	GUJARAT	**0.75**	**0.03**
38	ESSAR CCPP **	300	GUJARAT	**1.17**	**0.00**
39	PAGUTHAN CCPP (GPEC)	655	GUJARAT	**1.43**	**0.19**
40	SUGEN CCPP (TORRENT)	1147.5	GUJARAT	**5.35**	**2.32**
41	UNOSUGEN CCPP	382.5	GUJARAT	**0.00**	**0.00**
42	DGEN Mega CCPP	1200	GUJARAT	**0.00**	**0.00**
	Sub Total (WR)	**4413**		**12.29**	**3.47**
43	GAUTAMI CCPP	464	ANDHRA PRADESH	**3.82**	**0.00**
44	GMR - KAKINADA (Tanirvavi)	220	ANDHRA PRADESH	**0.88**	**0.00**
45	GMR- Rajamundry Energy Ltd.	768	ANDHRA PRADESH	0.00	**0.39**
46	GODAVARI (SPECTRUM)	208	ANDHRA PRADESH	**1.43**	**0.57**

47	JEGURUPADU CCPP (GVK) PHASE- II*	239.4	ANDHRA PRADESH	**2.85**	**0.06**
48	KONASEEMA CCPP	445	ANDHRA PRADESH	**1.78**	**0.00**
49	KONDAPALLI EXTN CCPP .	366	ANDHRA PRADESH	**4.57**	**0.09**
50	KONDAPALLI ST-3 CCPP (LANCO)	742	ANDHRA PRADESH		**0.66**
51	KONDAPALLI CCPP (LANCO)	350	ANDHRA PRADESH	**2.32**	**0.51**
52	PEDDAPURAM (BSES)	220	ANDHRA PRADESH	**1.09**	**0.00**
53	VEMAGIRI CCPP	370	ANDHRA PRADESH	**4.16**	**0.11**
54	VIJESWARAN CCPP	272	ANDHRA PRADESH	**1.32**	**0.41**
55	PENNA CEMENT INDUSTRIES*	30	ANDHRA PRADESH	**0.12**	DNR
56	RVK ENERGY*	28	ANDHRA PRADESH	**0.11**	DNR
57	SILK ROAD SUGAR*	35	ANDHRA PRADESH	**0.10**	DNR
58	LVS POWER*	55	ANDHRA PRADESH	**0.22**	DNR
59	KARUPPUR CCPP (ABAN)	119.8	TAMIL NADU	**0.50**	**0.30**
60	P.NALLUR CCPP (PPN)	330.5	TAMIL NADU	**1.50**	**0.00**
61	VALANTARVY CCPP	52.8	TAMIL NADU	**0.38**	**0.26**
	Sub Total (SR)	**5315.5**		**27.15**	**3.36**
62	DLF ASSAM GT	24.5	ASSAM	0.10	DNR
	Sub Total (NER)	**24.5**		**0.10**	**0.00**
	Total(PVT/IPP)=C	**10311**		**41.22**	**7.42**
	GRAND TOTAL=A+B+C	**24037.17**		**102.35**	**29.58**

*** Gas Allocation includes Long-term RLNG contracts and allocation of e-bid RLNG**
MMSCMD – Million Metric Standard cubic meter per day

Annexure-8.2

LIST OF UNDER CONSTRUCTION GAS BASED POWER PLANTS

(All figures in MW)

State	Project Name	Implementing Agency	Unit No	Capacity (MW)
AP	Panduranga CCPP	Panduranga Power Ltd	Module-1	116
AP	RVK Gas Engine	RVK (Rajahmundry) Pvt.Ltd	GE: 5-8	38
			GE:1-4	38
AP	RVKCCPP	RVK (Rajahmundry) PVT.Ltd	Module-1	120
			Module-2	120
			Module-3	120
AP	Samalkot CCPP-II	Reliance Power	Module-1	400
			Module-2	400
			Module-3	400
			Module-4	400
			Module-5	400
			Module-6	400
Telangana	Astha Gas Engines	Astha	4 Engines	34.88
TN	Ind Barath Gas Project	Ind Barath	Block-I	65
Uttarakhand	Beta CCPP	BIPL	GT+ST	225
Uttarakhand	Kashipur CCPP-II	Sravanthi Energy Pvt. Ltd	GT+ST	225
Total (Private Sector)				**3,501.88**

CHAPTER 9

COAL REQUIREMENT

9.0 INTRODUCTION

Fuel is the key input required to be tied up before implementation and proper operation of the thermal power plants. In the changed scenario with growing concern on environment, Government has given emphasis on Renewable Energy projects. However, Country's reliance on coal based generation cannot be overlooked. An important aspect which, therefore, needs to be addressed is the availability of adequate coal to fuel the generation of power. In order to optimize coal usage, Government is committed for super critical/ ultra-super critical technology which are much more efficient and results into reduction in usage of coal. The timely availability of all the key inputs including fuel would ensure timely completion of the project and therefore avert detrimental implications of cost and time overruns in case the power project is delayed.

This Chapter broadly deals with a review of coal availability during the 12th Plan, an assessment of requirement of fuel for the period 2017-22 & indicative requirement of the coal for the period 2022-27 as well as critical issues which need to be addressed and constraints being experienced in the coal sector. This would give a broad scenario to all the associated stakeholders to enable them to take advance action and plan their production targets etc.

9.1 COAL SUPPLY SCENARIO

9.1.1 Background

Coal is the mainstay of India's energy sector. The All India Installed Capacity of the country is about 326,848 MW as on 31.03.2017, out of which about 192,163 MW (58.8%) is coal based. Once the power station is commissioned, the biggest challenge is to operate the station at a high plant load factor (PLF), which is a measure of the output of a power plant compared to the maximum output it could produce. Higher load factor usually means more output and a lower cost per unit of electricity generation. Performance of the power plant is measured on the basis of PLF and Station Heat Rate. However, the Plant Load Factor (PLF) of the coal based power stations in the country has been decreasing steadily over the years. The PLF has decreased from 78.9 % in 2007-08 to 59.64 % in 2016-17.

9.1.2 New Coal Distribution Policy

The Government has introduced the New Coal Distribution Policy (NCDP), effective from 1st April 2009, which assures supplies at pre-determined prices to some categories of consumers and reintroduces e-auctions to encourage a vibrant market for the commodity. The Main Features of the Policy are as follows:

- 100% Normative Requirement of coal would be considered for supply to Power Utilities.
- Supply of coal through commercially enforceable Fuel Supply Agreements (FSAs) at notified prices by CIL.
- 10% of annual production of CIL to be offered through e-auction for consumers who are not able to source coal through available institutional mechanism.
- FSAs to indicate Annual Contracted Quantities (ACQ) of coal to Power Utilities by coal companies during entire year. Incentive and penalty clauses incorporated in FSAs.

Signing of Fuel Supply Agreement (FSA)

Thermal power plants commissioned before 31st March 2009, FSAs were signed with a trigger value of 90% of the Annual Contracted Quantity (ACQ). Subsequently, CCEA in 2013 directed CIL to sign FSAs for a total capacity of about 78,000 MW, which were likely to be commissioned by 31.03.2015. Out of 78000 MW, around 9,840 MW were having tapering linkages. Taking into account the overall domestic availability and the likely actual requirements of these power plants, FSA's were signed for domestic coal quantity of 65%,65%,67%,75% of ACQ for the years 2013-14,2014-15,2015-16 & 2016-17 respectively for power plants having normal coal linkages. However, actual coal supplies would be commensurate to long term PPA's.

9.1.3 Coal stocking norms

The norms for number of days of coal stock for power stations is fixed depending on the distance of the power plant from the mine-head as given in **Table 9.1**.

Table 9.1
Coal stocking norms for power stations

Distance of Power Plant	Number of Days of Stock
Pit-head Station	15
Upto 500 kms away from Coal Mine	20
Upto 1,000 kms away from Coal Mine	25
Beyond 1,000 kms away from Coal Mine	30

9.1.4 Import of coal

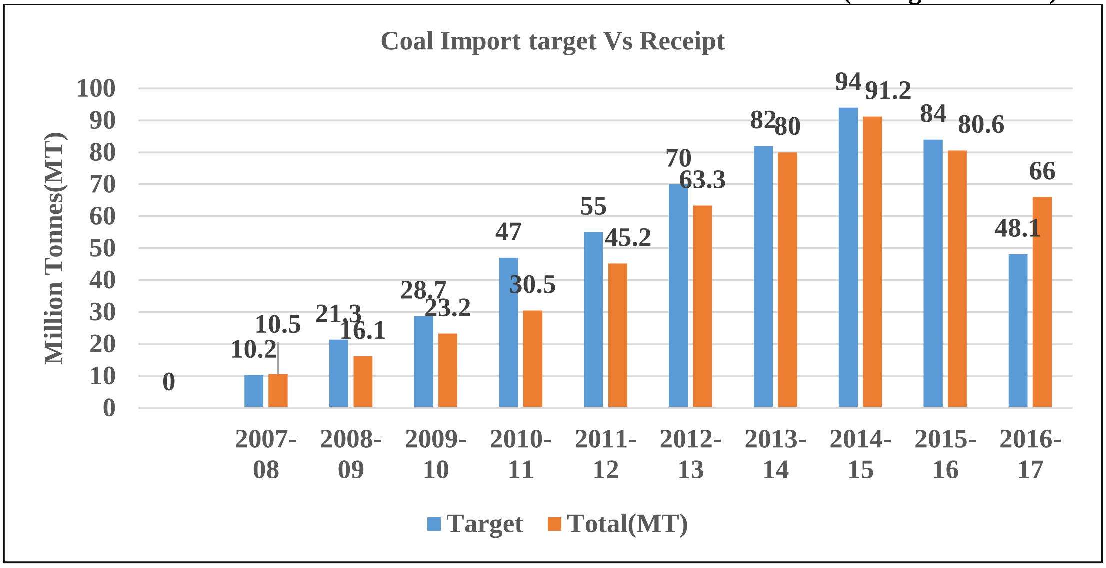
In the past, Power Utilities were advised to import coal to maintain the stipulations of Ministry of Environment and Forest regarding use of coal of less than 34% ash content and to occasionally supplement the coal from indigenous sources. However, due to inadequate availability of domestic coal, power utilities were advised to import coal for blending. Further, with the commissioning of power plants designed for use of imported coal as fuel, power utilities imported coal to meet the requirement of fuel for these power plants. The details of coal imported by power utilities to meet the shortfall in the availability of domestic coal and to meet the requirement of power plants on imported coal during 11th Plan & 12th Plan are furnished in **Table 9.2 and Exhibit 9.1**.

Table 9.2
Details of coal imported by power utilities

Year	Target (MT)	Coal Import for		
		Blending to meet shortfall in domestic coal (MT)	Meeting requirement of imported based power plants (MT)	Total(MT)
2007-08	10.2	8.4	2.1	10.5
2008-09	21.3	13.9	2.2	16.1
2009-10	28.7	18.8	4.4	23.2
2010-11	47.0	21.1	9.4	30.5
2011-12	55.0	27.5	17.7	45.2
2012-13	70.0	31.6	31.7	63.3
2013-14	82.0	37.8	42.2	80.0
2014-15	94.0	48.5	42.7	91.2
2015-16	84.0	37.1	43.5	80.6
2016-17	48.0	19.8	46.3	66.1

Exhibit 9.1

(All figures in MT)



9.1.5 Critical /super critical stock at power plants

Coal stock position at the power plants is being monitored on daily basis. The low coal stock at power plants is categorised as critical and super critical so that coal supply to such power plants could be augmented on priority. The criteria, given in **Table 9.3** below**,** is being adopted for classifying critical / super critical coal stock at the power plants.

Table 9.3

Criteria for classifying critical / super critical coal stock

Criticality	Plants	Criteria
Critical stock at Power plant	Pit-head Plants	coal stock less than 5 days
	Non Pit-head Plants	coal stock less than 7 days
Super critical stock at Power plant	Pit-head Plants	coal stock less than 3 days
	Non Pit-head Plants	coal stock less than 4 days

The details of critical/ super critical coal stock at the power plants during 12th Plan period (upto 2016-17) are given in **Table 9.4, Exhibit 9.2 and Exhibit 9.3.**

Table 9.4

Details of critical/ super critical coal stock at the power plants during 12th Plan period

Year	No. of plants monitored by CEA	No. of Power plants with Critical Coal stock	No. of Power plants with Super Critical Coal stock	Stock in Million Tonnes
2012-13 (As on 31.03.2013)	93	21	14	19.6
2013-14 (As on 31.03.2014)	100	20	9	20.3
2014-15 (As on 31.03.2015)	100	12	6	26.1
2015-16 (As on 31.03.2016)	101	0	0	38.9
2016-17 (As on 31.03.2017)	112	1	0	27.73

Exhibit 9.2

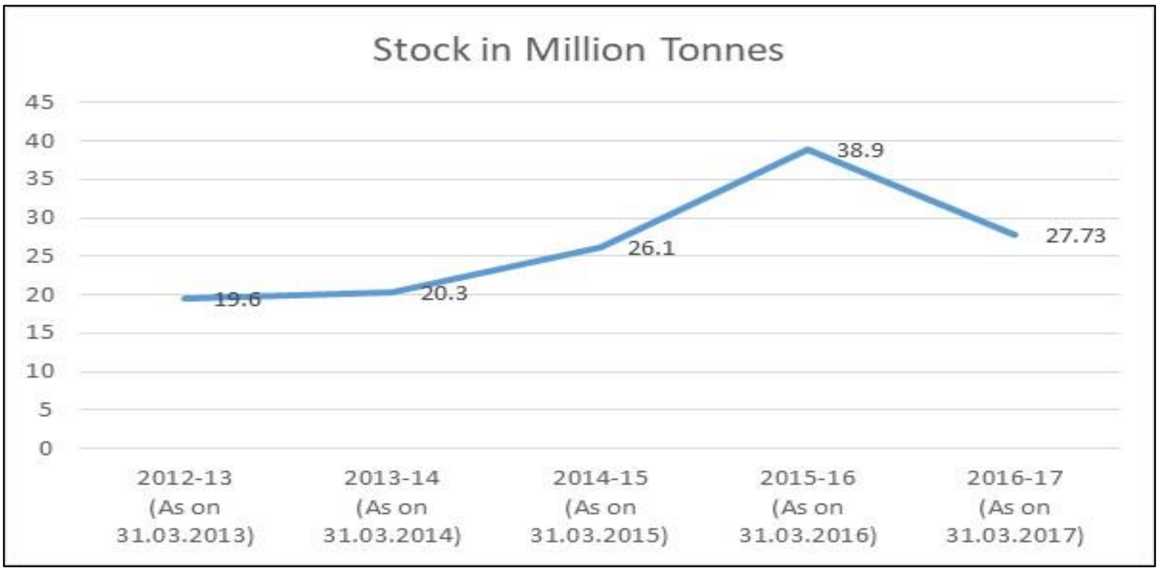
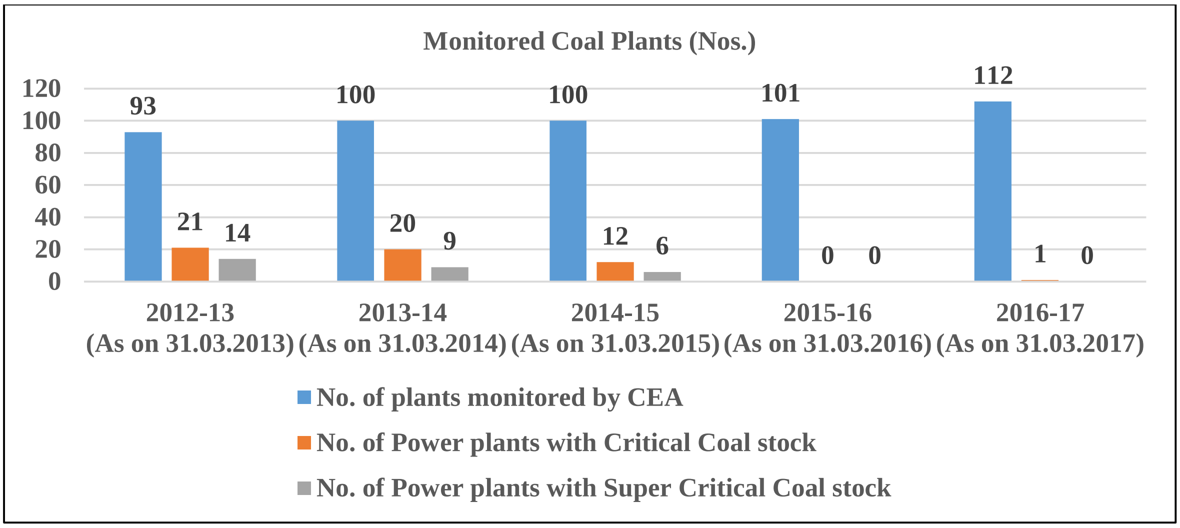


Exhibit 9.3



Note: CEA is monitoring the coal based plants above 100 MW where coal is being supplied by CIL/SCCL and involves Rail transportation.

During the year 2015-16, the coal stock at the power plants has reached an all-time high of about 39 MT.

9.1.6 Generation loss due to coal shortage

With the enhanced availability of domestic coal and comfortable coal stock during 2015-16, none of the power plants have reported generation loss due to coal shortage and negligible during 2016-17. The details of generation loss reported by power utilities during 12th Plan (up to 2016-17) are given in **Table 9.5 and Exhibit 9.4**.

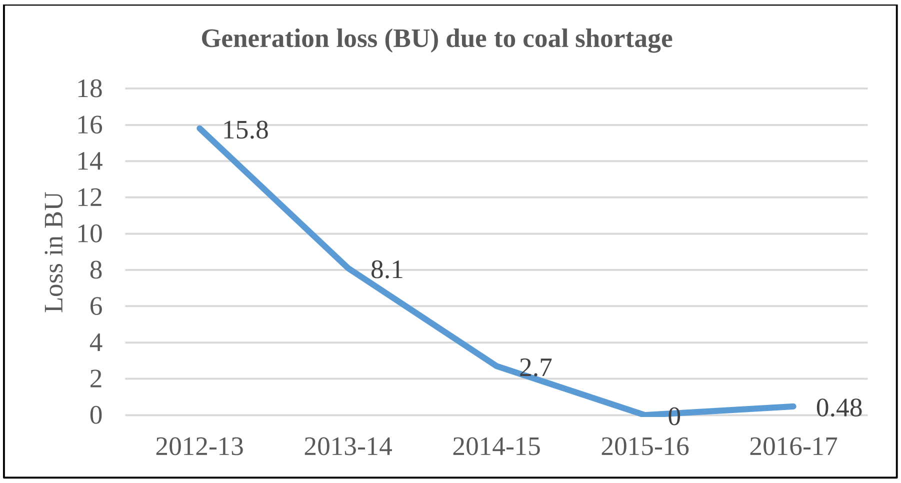
Table 9.5

Generation loss due to coal shortage

(All figures in BU)

Year	Generation loss due to coal shortage
2012-13	15.8
2013-14	8.1
2014-15	2.7
2015-16	0
2016-17	0.48

Exhibit 9.4



9.2 COAL DEMAND AND SUPPLY

9.2.1 Coal Supply Position during 2015-16 and 2016-17

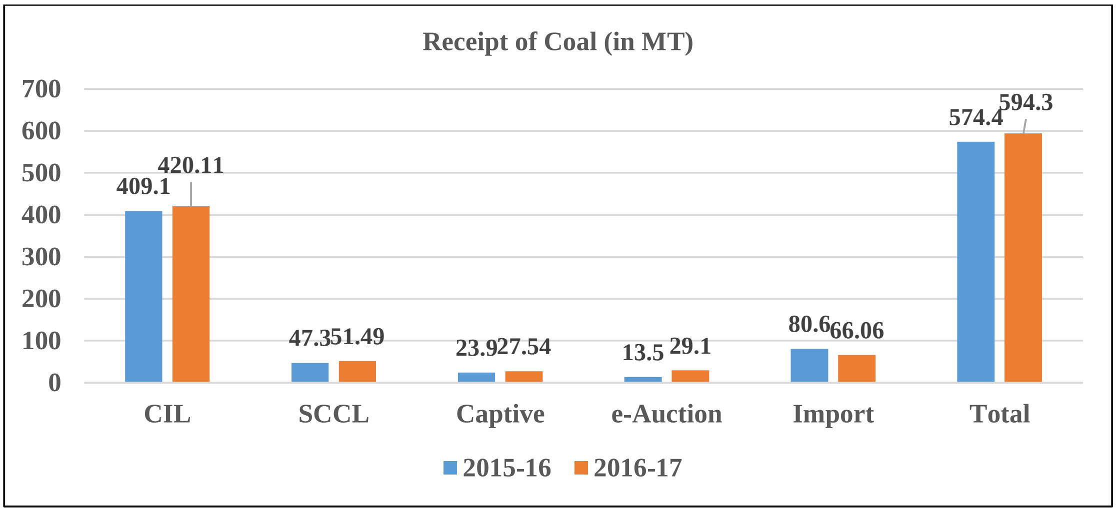
The coal stock at the power plants in the beginning of 2016-17 (as on 1st April, 2016) was more than 38 MT which was sufficient for operation of power plants for 27 days. The details of source-wise program and despatch/receipt of coal by power plants during 2015-16 and 2016-17 are given in **Table 9.6 and Exhibit 9.5**.

Table 9.6
Source-wise program and receipt of coal by power plants

(In Million Tonnes)

	April, 2015- March 2016			April 2016- March,2017			Growth in
Source	**Program**	**Receipt**	**%**	**Program**	**Receipt**	**%**	**Receipt (%)**
CIL	435.0	409.1	94.0	487.5	420.1	86.2	2.7
SCCL	38.0	47.3	124.5	64.25	51.5	80.1	8.9
CAPTIVE	32.0	23.9	74.7	40.00	27.5	68.9	15.2
e-Auction	10.0	13.5	135.0	12.00	29.1	242.5	115.6
IMPORT	84.0	80.6	95.9	48.00	66.1	137.6	-18.0
TOTAL	**599.0**	**574.4**	**95.9**	**651.75**	**594.3**	**91.2**	**3.5**

Exhibit 9.5



9.2.2 Coal Demand and Availability Position during the Year 2017-18

For the year 2017-18, coal based generation programme of 958 BU has been estimated in consultation of the power utilities. The total coal requirement of 630 MT for the power plants has been estimated considering normal monsoon year. The details of coal requirement vis-à-vis coal availability during the year 2017-18 are given in **Table 9.7**.

Table 9.7
Assessment of Coal Requirement for the Year 2017-18

S.No.	Description	Units	
1	**Coal based generation**		
1.1	Coal based generation programme during 2017-18	BU	958
2	**Coal Requirement**		
2.1	For plants designed on domestic Coal	MT	584
2.2	For plants designed on imported coal	MT	46
2.3	**Total Coal Requirement**	MT	630
3	**Coal Availability from Indigenous Sources**		
3.1	From CIL	MT	450
3.2	From SCCL	MT	60
3.3	From Captive Mines	MT	35
3.4	From e-auction/Stock	MT	39
3.5	Total domestic coal availability	MT	584
3.6	Shortfall in domestic coal availability	MT	0
3.7	Requirement of imported coal for blending	MT	0

It is seen from the above that power plants on domestic coal would meet their requirement of coal from indigenous sources and may not require import of coal for blending. However, some power utilities / power plants may plan for import of coal for blending for their coastal power plants considering economics in import of coal vis-à-vis domestic coal and Railway logistic constraints etc. Power plants designed on imported coal would continue to import coal to meet their coal requirement.

9.3 COAL DEMAND AND AVAILABILITY DURING THE YEARS 2021-22 & 2026-27

With the 19th EPS demand projections and likely Renewable Energy Sources (RES) capacity addition, the coal based generation has been estimated and accordingly provisional coal requirement has been worked out. The likely capacity of RES has been as 175GW by the terminal year 2021-22. Accordingly, in the year 2021-22, the estimated gross generation from coal based power plants would be around 1072 BU. The details of coal requirement for the year 2021-22 have been worked out considering 30% reduction in Hydro generation due to failure of monsoon and being supplemented by coal based generation.

During 2026-27, the total capacity of RES has been estimated to be 275 GW capacity, considering 175 GW of total capacity at the end of the year 2021-22 and 100 GW capacity addition of RES during 2022-27. The generation from coal-based power plants is estimated as 1259 BU for the year 2026-27. The coal requirement for the year 2026-27 has been worked out considering 30% reduction in hydro generation due to failure of monsoon and is being supplemented by coal-based generation and details are given in **Table 9.8**.

Table 9.8
Coal requirement in the year 2021-22 and 2026-27

S.No	Description		2021-22	2026-27
			RES:175 GW	RES:275 GW
1	**Coal Requirement**			
1.1	Coal based generation (gross)	BU	1072	1259
1.2	Hydro based generation (gross)	BU	156	257
1.3	30% reduction in Hydro Generation assuming failure of monsoon	BU	46.8	77.1
1.4	Total coal based generation (1.1+1.3)	BU	1118.8	1336.1
1.6	**Coal Requirement @0.65kg/kwh+1% transportation loss**	**MT**	**735**	**877**
1.7	Imports by plants designed on imported coal	MT	50	50
2	**Domestic coal Requirement (1.6-1.7)**	**MT**	**685**	**827**

Exhibit 9.6

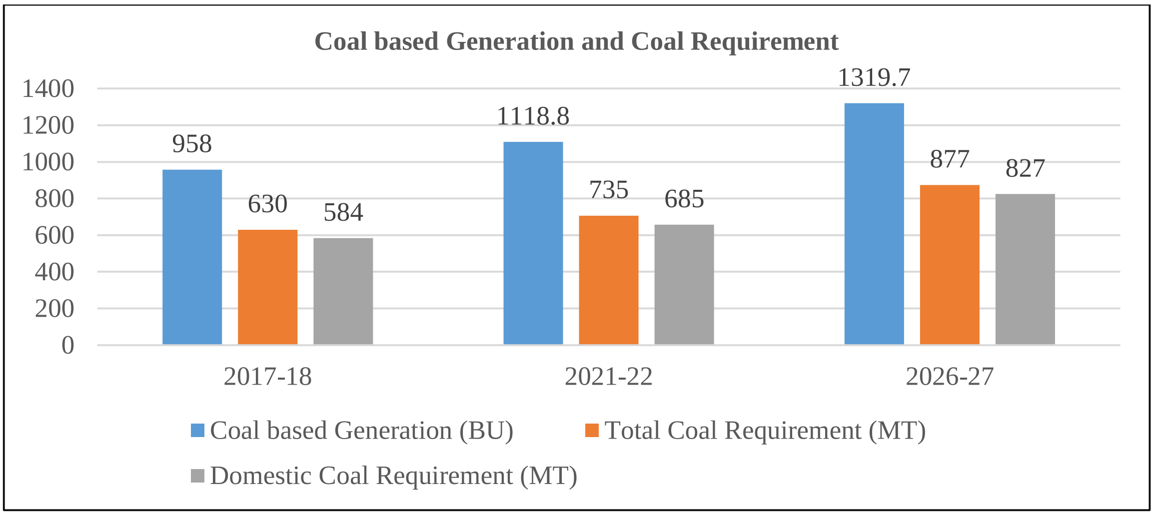
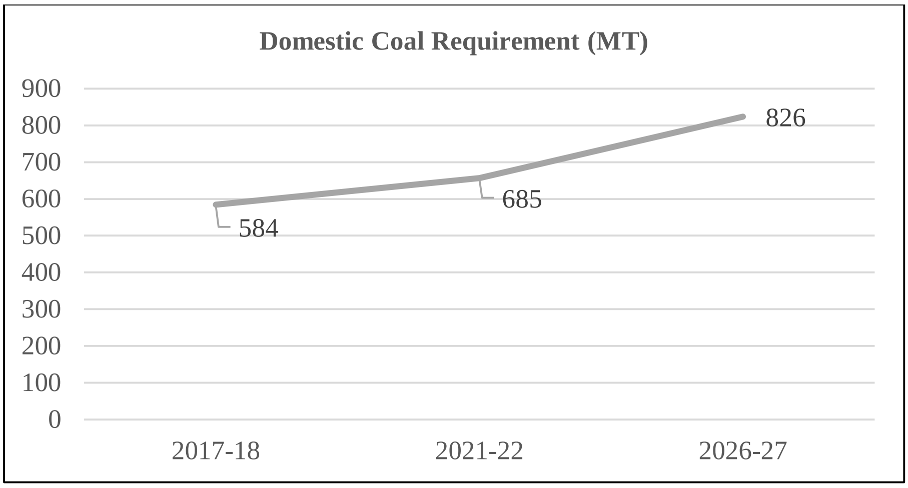


Exhibit 9.7



In order to enhance coal availability, multi-dimensional efforts are underway by Coal India Ltd to enhance production of domestic coal. A road map has been prepared by CIL to substantially enhance coal production level to 1 Billion Tonnes (BT) by the year 2019-20. With this programme there would be no shortage in the availability of coal for the power plants during 2021-22 and 2026-27. In addition, coal production from the captive coal blocks allotted to power utilities would also supplement the availability of domestic coal.

9.3.1 Issues/constraints in making coal available to power stations

Timely availability of adequate coal is extremely crucial for maximizing generation from the power plants. In addition to tapping fuel source or organizing its availability, it is also essential to create the infrastructure to facilitate fuel to reach the intended destination. Therefore, development of mines/ ports and requisite transportation facilities commensurate with the completion of the projects is very necessary. The gestation period in the development of mines and even transport facilities are in some cases longer than the gestation period for setting up of thermal power stations. It is, therefore, imperative for the Power Sector to make its prospective coal requirement, over a long time horizon, known to the Ministry of Coal, Railways and port authorities to enable them to undertake co-ordinated development of coal mines and transport infrastructure with the coming up of thermal power stations.

9.4 NEW INITIATIVES FOR ADDRESSING ISSUES RELATED TO COAL SUPPLY TO THE POWER PLANTS

9.4.1 Rationalization of Coal Linkages

In order to undertake a comprehensive review of existing sources of coal and considering the feasibility of rationalization of these sources to optimize cost of coal transportation, a new Inter-Ministerial Task Force (IMTF) was constituted by Ministry of Coal in June, 2014. Also CIL engaged M/s KPMG Advisory Services Private Ltd to assist the Task Force in optimization exercise. Report of Inter-Ministerial Task Force (IMTF) and Part-I of KPMG report was discussed with the power utilities on 2nd December, 2014. IMTF report was agreed by the concerned power utilities. As per KPMG, total benefit by way of logistic savings was expected in the range of ₹ 3500 to ₹ 6000 crores. The new Inter-Ministerial Task Force (IMTF) had recommended a three step approach for implementation.

i. The recommendations inter-alia included rationalization of linkage sources for 19 power utilities in Stage-I by swapping linkage coal between different coal companies to optimize distances and maximizing dispatches of coal. As per status of implementation of recommendations of IMTF, Coal India Ltd. executed revised Fuel Supply Agreement (FSA) with 17 power plants in respect of Stage-I rationalization. This had resulted in movement rationalization of 24.6 MT coal with annual savings of ₹ 913 crores (approximately) of recurring transportation cost.

ii. The Task Force recommended rationalization of 6 swap sets among power utilities in Stage-II which envisaged swapping of coal between 'imported coal and domestic coal' and 'domestic coal of different power stations among 6 States involving 11 power utilities in Centre /State/ Private Sector.

iii. Among the participating companies, 19 swaps were envisaged. Out of these swaps, only 6 swaps (saving 952 Crores) were agreed for implementation. However, with the improved availability of coal for pit head power plants, the swaps agreed for swapping of imported coal with domestic coal for pit head plants was not feasible. Thus, at present, only 4 swaps (saving ₹ 687 Crores) are under implementation/consideration and out of which, only one set of swap has been implemented result in movement of rationalization of 1.3 MT coal and potential annual savings of ₹ 458 crores of transportation cost.

With the implementation of Stage-I and Stage-II of recommendations of the IMTF, movement rationalization of 25.9 MT coal has been taken is with potential annual saving of ₹ 1371 crores of transportation cost.

9.4.2 Third Party Sampling

In order to address quality concern of the coal supply to power plants, it was decided in the meeting held in Ministry of Power on 28.10.2015 that coal samples shall be collected and prepared by a Single Third Party Agency appointed by power utilities and coal companies. It was suggested that CIMFR may undertake bidding process for appointment of Third Party Sampling Agencies on behalf of power utilities and coal companies. Necessary funding arrangement shall be made by coal companies and power utilities on equal sharing basis.

A committee constituted with Director (Operations), NTPC and Director (Marketing), Coal India Ltd. as Co- Chairman with representatives from CEA, NTPC, CIL, DVC, APP, State of Gujarat, Madhya Pradesh, Rajasthan, Haryana, Karnataka and Railways to look into the issues of Third Party Sampling has been constituted and prepared a road map for implementation of decisions on Third Party Sampling. The terms of reference for the committee was as under:

i. The committee to look into issues of third party sampling for coal supplies for power sector including e- auction.

ii. The issue of re-grading of mines in case there is persistence variation of mine declared grades with results of third party sampling.

iii. Issue of coal shortfall on account of energy shortage due to grade slippage as per third party report at loading end.

iv. Issue of non-materialization of quantity of coal due to non-placement of Railway rakes against indents of CIL.

v. Issue of adjustment of quantity of coal due to variation in actual delivered quantity vs normative wagon carrying capacity.

vi. Involvement of Railways to ensure transportation of coal as per billed quality and quantity.

vii. Feasibility of the following aspects:

- Use of IT in GPS tracking of coal supply
- On-line coal analysers/auto samplers to address issues at loading end
- Online submission of analysis results of coal samples for speedy settlement of bills

It has been decided that CIMFR will undertake the work of third party sampling at unloading point, i.e., at the power plant end. Therefore, with the sampling of coal at loading and at unloading point will address the issues of quality and grade slippage of the coal supplied to power utilities in their power plants.

9.4.3 Flexibility in Utilization of Domestic Coal

In order to achieve flexibility in utilization of domestic coal for reducing the cost of power generation, the proposal for allowing flexibility in utilization of domestic coal was approved by the Cabinet on 4.05.2016. Under the scheme, the Annual Contracted Quantity (ACQ) of each individual coal linkage as per Fuel Supply Agreement is to be aggregated as consolidated ACQ for each State and Company owning Central Generating Stations instead of individual generating station. The State/Central Gencos would have flexibility to utilize their coal in most efficient and cost effective manner in their own power plants as well as by transferring coal to other State/Central Gencos Power plants for generation of cheaper power. The States may also transfer coal to efficient IPPs selected through e-Bidding process. Ministry of Power/Central Electricity Authority in consultation with all the Stake holders has prepared and issued the methodology for flexibility in utilization of domestic coal. Supplementary agreements have been signed by power utilities for aggregation of ACQ with coal subsidiaries/CIL. The flexibility in utilization of domestic coal will result in reduction of cost of electricity to the consumers.

9.5 COAL WASHERIES IN INDIA

In India, 20 percent of coal produced is washed as against a global average of 50 percent. Coking coal preparation has long been in operation in India but recently, the trend has been shifted to washing of non-coking coal due to environmental and efficiency concerns. The long distance transportation of coal via land routes offer an ideal opportunity for coal washing in India because of economic benefits. Though coal washery increases the overall cost of coal, but the benefits accrued in terms of saving in transportation, O&M cost and efficiency are sustained.

Ministry of Environment & Forests vide Notification G.S.R. 02(E), dated January 02, 2014, has amended Rules in respect of use of washed/ blended or beneficiated coal with ash content not exceeding thirty-four percent on quarterly average basis in Thermal Power Plants. As per the amended rules, power plants located beyond 500 kms from the pithead shall be supplied with and shall use raw or blended or beneficiated coal with ash content not exceeding thirty-four percent on quarterly average basis w.e.f. 5th June 2016. Ministry of Coal/CIL is required to take necessary action for compliance of the above.

9.6 LIGNITE

Lignite reserves in the country have been estimated at around 40.9 Billion tonnes, most of which is found in the State of Tamil Nadu. About 82 % of the Lignite reserves are located in the State of Tamil Nadu & Pondicherry. At present only a small percentage of the total reserves of lignite have been exploited. Considerable scope remains for the exploitation of the lignite reserves and use of lignite in thermal power stations subject to cost-economics. State-wise distribution of Lignite resources is shown in **Table- 9.9**.

Table 9.9
State-wise Lignite Reserves

State	Total[MT]
Tamil Nadu	33,309.53
Rajasthan	4,835.29
Gujarat	2,722.05
Jammu & Kashmir	27.55
Others (Kerala, West Bengal)	11.44
Total	**40,905.86**

The anticipated requirement of Lignite by NLC Ltd, plants in Rajasthan & Gujarat and IPP at Neyveli during 2017-22 & 2022-27 are shown in **Table 9.10**.

Table 9.10
Lignite Requirement during 2017-22 & 2022-27

State/Year	Total (2017-22) (MT)	Total (2022-27) (MT)
NLC Ltd.	131.64	186.83
IPP at Neyveli	9.51	9.51
Rajasthan	50.50	50.50
Gujarat	56.66	56.66
Total	**248.31**	**303.50**

Source NLC

9.7 CONCLUSIONS

The coal requirement for the year 2021-22 and 2026-27 have been worked out considering 30% reduction in Hydro generation due to failure of monsoon and being supplemented by coal based generation. The domestic coal requirement in the year 2021-22 has been estimated as 685 Million Tonnes and 827 Million Tonnes in the year 2026-2027 while imports by plants designed on imported coal to be 50 Million tonnes in the year 2021-22 as well as in 2026-27.

CHAPTER-10
KEY INPUTS

10.0 INTRODUCTION

Timely availability of all key inputs - as per the schedule of requirement of the individual power projects, is vital for successful implementation of any Power Plant. Infrastructural support such as port facility, construction & manufacturing capabilities specifically erection machinery and erection agencies including civil and BOP contractors are also of utmost importance. This Chapter therefore examines the availability of following key inputs –

- Manufacturing capacity for equipment
- Major Materials – Cement, Steel, Castings, Forgings, Tubes & Pipes
- Transport – Railways and Ports
- Gas pipelines including regasification facilities
- Land and Water for Thermal stations

Availability of other inputs like Fuel, Funds and Man-power have been dealt in separate chapters.

The estimation of materials has been made based on the estimates already available for the past plan (NEP-2012) with suitable changes/modifications for large supercritical units and latest manufacturing trends indicated by the manufacturers. Inputs for Cement and other materials for nuclear projects have been considered at 130% of the requirement of coal based projects based on the assessment of Nuclear Power Corporation (NPCIL) for NEP-2012. Inputs for hydro projects have been retained from the NEP-2012.

Availability of transportation has been estimated based on the issues/constraints identified in the previous Plan and the developments and policy initiatives brought out by various Ministries during the deliberations. Suggestions for further improvements have also been indicated based on the inputs received during the deliberations from the manufacturers and utilities.

Major share of capacity addition during the coming years is planned through renewable sources like solar and wind. As the inputs required for the renewables stations are substantially different from those for conventional stations, these have been covered as a separate sub-section.

10.1 CAPACITY ADDITION PLAN

Based on the review of 12th Plan, the targeted and anticipated capacity addition during the 12th Plan (2012-17) is given in **Table 10.1**.

Table- 10.1
Targeted Capacity addition – 12th Plan (2012-17)

(All Figures in MW)

Source	**Capacity (MW)**
Coal + Lignite	69,800
Gas based	2,540
Hydro	10,897
Nuclear	5,300
Total	**88,537**

Table- 10.2

Capacity addition Achieved– 12th Plan

(All Figures in MW)

A	**12th Plan Capacity Addition Target**	**88,537**
B	**Capacity addition as per target(88,537 MW) during 12th Plan as on 31.03.2017**	**63,912.9**
C	**Capacity slipped from the capacity addition target of 12th Plan**	**24,613.8**
D	**Additional Capacity commissioned during 12th Plan as on 31.03.2017 outside the capacity addition target**	**35,296.6**
Total Capacity addition achieved during 12th Plan (B+D)		**99,209.5**

As may be seen the 12th Plan witnessed a total capacity addition of over 99 GW (**Table 10.2**) as against targeted capacity addition of 88.5 GW. This, coupled with large scale renewables planned have led to sharp reduction in the thermal capacity addition requirements during 2017-22. Accordingly, the capacity addition required during 2017-22 given in **Table 10.3**.

Table- 10.3

Capacity addition required for the period 2017-22 (figures in MW)

Period	**RES Capacity addition (GW)**	**Conventional Capacity**					**Renewables capacity in March-2022**
		Thermal		**Hydro**	**Nuclear**	**Total**	
		Coal	**Gas**				
2017-22	117.75	6445*	406	6,823	3300	16,974	175,000

Note: *Coal based capacity of 47,855 MW are in different stages of construction and are expected to be available during 2017-22.

The capacity addition requirements for the period 2022-27 are estimated and are given in **Table 10.4**.

Table- 10.4

Capacity addition required for the period 2022-27 (figures in MW)

Conventional Capacity				**Total**	**Renewables capacity addition**
Thermal		**Hydro**	**Nuclear**		
Coal Capacity addition Required	**Gas**				
46,420	0	12,000	6,800	65,220	100,000

Note: **Since 47,855 MW of coal based plant are expected to come during 2017-22 and will be partially utilized during 2017-22, therefore, this coal based capacity addition of 47,855 MW may be utilized during 2022-27. Hence, **ONLY 46,420 MW** additional coal based capacity addition may be required during 2022-27

10.2 AVAILABILITY OF EQUIPMENT

10.2.1 Main plant equipment

As has been decided by the Ministry of Power that entire coal based capacity addition during the years 2017-22 and subsequent Plan periods shall be through supercritical units. Requisite indigenous manufacturing capacity for manufacture of super-critical units is considered vital to ensure lifetime support for services and spares, specific problem solving and customization for trouble free operation of these units in the Indian conditions. As a result of the efforts made by the Government over the last decade for creating indigenous manufacturing capacity for supercritical units, BHEL entered into technology collaborations and several joint ventures by the International manufacturers were set up for indigenous manufacturing of supercritical main plant equipment.

Encouraged by the bulk orders awarded by the Government with mandatory Phased Manufacturing Programme provisions, most joint ventures are under advanced stage of completion of the manufacturing facilities and have also started rolling out components/sub-assemblies etc. from their manufacturing facilities. The indigenous manufacturing capacity for supercritical main plant equipment likely to be available from BHEL and the JVs are given in **Table 10.5**.

Table- 10.5

Indigenous manufacturing capacity for Supercritical equipment

(Capacity MW/year)

Manufacturers	Boilers	Turbine-generator
BHEL	13,500	13,500
L&T-MHPS	4,000	4,000
Alstom -Bharat Forge	-	4,000
TJPS (Toshiba-JSW Power System)	-	3,000
Thermax-Babcock & Wilcox	3,000	-
Doosan Power Systems India Pvt Ltd	2,200	-
Total	**22,700**	**24,500**

Thus, adequate indigenous manufacturing capacity of supercritical main plant equipment is available in the country. Most manufacturers do not have requisite orders and have expressed concerns on lack of orders. Indigenous manufacturing capacity for hydro and nuclear stations also exists in the country.

Indigenous manufacturing capacity for Gas Turbines/combined cycle stations is also available in the country and large sized Gas Turbines including advanced class are being manufactured by BHEL.

10.2.2 Balance of Plant (BoP) equipment

Balance of Plant systems such as Coal Handling Plant, Ash Handling Plant, Water Treatment / DM Plant, Cooling Towers, CW System, Chimney, electrical systems and switchyard etc. were identified as critical items for timely commissioning of thermal power projects in the 12th Plan and several measures like standardisation of BoP systems, reviewing the qualifying requirements to ensure quality vendors and large vendors for faster execution of projects, mandating a central organization to maintain a dynamic data base with regard to BOP orders were suggested.

The above issues have been largely addressed and in the 12th Plan generally no constraints/delays on account of BoP have been faced. However, off-late, constraints in availability of good BoP systems vendors are being felt as many of the good Coal Handling Plant/Ash handling plant vendors are not in good financial health. Even in the EPC contracts, the EPC agency normally sub-contracts BoP systems or procures these as bought out items and thus availability of good BoP vendors is vital for all projects. NTPC brought out that, due to lack of good contracting agencies in Coal Handling Plants(CHP) & Ash handling Plants (AHP) with good financial health, works get affected in these areas and NTPC is required to make lot of efforts in making available supplies and making these systems ready to match with the commissioning requirement. In several cases, NTPC had to terminate the contracts awarded due to non-performance of the vendors – like Ash handling plant system at Solapur, VSTPP-IV and Barh-I projects and coal handling plant at Kanti TPS.

The major reasons identified for poor performance of the agencies are as under:

- Agencies have taken works beyond their capacities and are not able to mobilize the resources to meet the commissioning targets

- Cash flow problems / financial crunch of agencies
- Many a times, works taken at lower prices but not able to sustain during execution

In such cases where constraints are felt by BoP vendors or where contract have been terminated, NTPC has adopted the following action Plan for completing the projects: -

- Taking materials through sub-vendors by giving comfort letters and making direct payments to sub-vendors.
- Direct payments to sub-agencies working at sites to ensure that regular payments to the labourers working at site.
- Hiring cranes and other T&Ps. and providing these, to the agencies on chargeable basis.

BoP systems in power stations are generally material handling systems which are common to several other large industries like cement, steel etc. and vendors are operating across number of such industries. Some main plant equipment/EPC contractors have also reported that BoP vendors and civil contractors prefer "Non-Power" works. Thus, a long term solution for ensuring requisite availability of good BoP vendors needs to be found.

The NEP-2012 had suggested mandating a central organization to maintain a dynamic data base with regard to BOP orders and their liquidation. Considering the constraints being faced by the power sector, it is felt that such an organizational mechanism for information sharing on BoP vendors across industries needs to be considered. Such a mechanism could provide the following salient details: -

- A web based portal for sharing all information relating to BoP vendors viz. orders at hand, their implementation status etc. orders completed, feedback of the customers so that project developers can take informed decisions.
- Availability of T&P and trained Skilled/Semi-skilled man power available with the vendor.
- In second phase the BoP vendors and Construction agencies could be rated based on their performance.

It is also felt that new advanced technologies BoP systems like High Concentration Slurry Disposal (HCSD) type ash disposal systems, closed pipe type conveyers for coal handling plants (CHP), large size R.O systems would be required, and requisite capacity for implementation of these systems and also indigenous manufacturing of key equipment for such systems should be developed.

10.3 AVAILABILITY OF KEY MATERIALS

Availability of the following key materials has been assessed for thermal, hydro and Nuclear capacity addition planned: -

- Steel - Structural Steel and Reinforcement steel
- Cement
- Aluminum
- Boiler Tubes & Pipes
- Thicker Boiler Quality Plates
- Castings & Forgings for Turbo-Generators (TG) Sets

As has been brought out, the estimation of materials for thermal projects has been made based on the inputs received from the equipment manufacturers - the norms adopted for estimation of material in the past plan (NEP-2012) were reviewed by the manufacturers and modifications indicated have been suitably incorporated. Inputs for Cement and other materials for nuclear projects have been considered at 130% of the requirement of coal based projects.

10.3.1 Norms Adopted for Estimation

The norms adopted for estimation of materials are given in **Table 10.6** and **Table 10.7**.

Table- 10.6
Norms for estimation of key materials for projects

(All figures tonnes/MW)

Materials	Thermal		Hydro
	Coal/Lignite	Gas	
Cement	150	60	956
Structural steel	85	29	34
Reinforcement steel	45	24	93
Stainless steel	2	1	-
Aluminium*	0.5	0.5	0.1

*Used in windows, metal cladding walls, control rooms

Table- 10.7
Norms for estimation of Castings and Forgings for Coal based projects

(Figures in MT per set*)

Equipment	Weight of Castings	Weight of Forgings
Turbine	384	234
Generator	3	130
Total	**387**	**364**

*Supercritical 660/800 MW unit

The above norms for castings and forgings have been considered for estimation of materials. While the weight of castings and forgings indicated by different manufacturers varies, the total weight of castings and forgings indicated by them do not vary significantly. Some manufacturers have also indicated lower requirements of castings/forgings, however for estimation purposes, the higher values have been considered.

Table- 10.8
Norms for estimation of Tubes, Pipes & Thick Boiler Plates

Figures in Tons/MW

Material	Subcritical Units	Supercritical Units
Tubes & Pipes	10.15	10.62
Thicker Boiler Quality Plates	1.20	1.61

10.3.2 Material Estimates

Based on the above norms, the estimates for various key materials for the generation capacity requirements for the period 2017-22 and 2022-27 are given in **Table 10.9** and **Table 10.10.**

Table- 10.9

Estimates of key materials for projects

(All figures in Million tonnes)

	2017-22#					2022-27				
	Coal/ Lignite 6445 MW	Gas 406 MW	Hydro 6,823 MW	Nuclear 3,300 MW	Total 16,974 MW	Coal/Lignite** Net Capacity addition 46,420 MW	Gas 0 MW	Hydro 12000 MW	Nuclear 6800 MW	Total** 65,220 MW
Cement	#Since the capacity Shown during 2017-22 are all under construction and it is presumed that orders have already been placed, therefore the material requirement is considered as NIL.					6.963	0.00	11.472	1.3260	19.761
Structural steel						3.946	0.00	0.408	0.7514	5.105
Reinforcement steel						2.089	0.00	1.116	0.3978	3.603
Stainless steel						0.093	0.00	-	--	0.093
Aluminium*						0.023	0.000	0.001	0.0044	0.029

Note: * Used in windows, metal cladding walls, control rooms

Since 47,855 MW of coal based plants are expected to come during 2017-22 and will not be required during 2017-22, therefore, this coal based capacity addition of 47,855 MW may be utilized during 2022-27. Hence,** **ONLY 46,420 MW** additional coal based capacity addition may be required during 2022-27

Table- 10.10

Estimates of Castings/Forgings, Tubes/pipes and Plates

(All figures in Million tons)

Description	Coal/lignite	
	2017-22	2022-27
	6,445 MW	Net Capacity addition 46,420 MW
Castings	It is presumed that orders have already been placed, therefore the material requirement is considered as NIL.	0.0271
Forgings		0.0255
Tubes & Pipes		0.493
Thick Boiler Quality Plates		0.0748

Note: Additional coal based capacity of 46,420 MW during 2022-27 is over and above 47,855 MW coal based capacity under construction and likely to yield benefits during 2017-22, for which it is presumed that orders have already been placed, therefore the material requirement is considered as NIL.

As may be seen from above, based on demand projections, the coal based capacity addition requirements during 2017-22 comes out to be 6,445 MW. However, coal based projects to the tune of about 47855 MW are already under construction and are likely to get commissioned during 2017-22.

Indigenous manufacturing facilities for castings and forgings is available at BHEL Hardwar and with other manufacturers like L&T and Bharat forge. BHEL central forge and foundry plant (CFFP) Haridwar have considerably augmented their capacity and are now manufacturing castings and forgings for 660/800 MW units except for some special castings. The total capacity of castings and forgings for BHEL CFFP Haridwar is 10,000 tons per annum. L&T and Bharat forge also have world class casting and forging capability. L&T forge plant has capacity to produce large casting of up to 54 tons – suitable for 660/800 MW units. Thus BHEL and other indigenous manufacturers have adequate indigenous capacity for castings and forgings. However, the designs of castings/forgings are specific to each manufacturer and manufacturers adopt different designs, material composition etc. based on their OEMs standard practice. Thus most manufacturers presently use imported castings/forgings.

The equipment manufacturers have brought out that most of the tubes and plates are required to be imported. Tubes up to grade T 20 are indigenously available and beyond that tubes are imported. Similarly, Carbon Steel pipes up to 8" (200 Normal Bore) size are available indigenously but beyond that are imported. Alloy steel pipes to ASTM grade A 335 P91/P92 and thick walled carbon steel pipes to ASTM grade A106 Gr C are imported due to lack of domestic availability. Special fittings, Critical valves like Control valves are not available indigenously. There is no indigenous capacity for manufacturing of thick boiler plates and they are entirely imported. SAIL has brought out that they are manufacturing only electric resistance welded (ERW) tubes and are not manufacturing seamless tubes required for boilers. Besides, there is no indigenous capacity for manufacturing of CRGO/CRNGO steels at present and these steels are imported.
During the deliberations held with the manufacturers and ministry of steel in the meetings of NEP sub-committee for key inputs, it was agreed by all that indigenous manufacturing of critical steels and tubes and plates needs to be created. Ministry of steel/SAIL agreed to undertake R&D for indigenous development of various special steels used in manufacturing of boilers and Turbine generators. It is suggested that a joint mechanism may be created under Ministry of Steel with participation of power equipment manufacturers and steel manufacturers for more information sharing on compositions/properties of various steels and steel products required and their indigenous development by the steel industry.

10.4 RAIL TRANSPORTATION

Rail transportation is critical for movement of equipment as well as coal to power stations. The NEP-2012 and the 12th Plan working group on power by the planning commission had stressed on

- Creation of dedicated freight corridors (DFC),
- Augmentation of capacity to evacuate coal from major coal fields namely North Karanpura, Ib Valley, Talcher and Mand Raigarh.
- Rail connectivity to all ports having coal unloading facilities especially the minor ports.
- Gauge conversion, new railway lines, electrification of new routes

Railways have indicated that, while Dedicated Freight Corridors (DFCs) are being pursued, parallel efforts are also being made for augmentation of Railway lines; so as to overcome any constraints being felt in transportation. Major railway projects have been undertaken in Central & Eastern railway. Also, a coordination mechanism between Ministry of Power and Ministry of Railways exists for identifying bottlenecks/priorities for transportation and based on the assessment/discussions therein the Raipur - Titlagarh line has already been advanced for commissioning in 2018 as against 2020 planned earlier. Railways have also been requested to ensure that no constraints are faced in North Karanpura area where Coal India Ltd is coming with new mines and Coal from these mines as well as from NTPC coal blocks in that area would be required to move to Central region.
Regarding rail line connectivity for minor ports, Railways have brought out that Ministry of Railways have taken a policy decision not to undertake any fresh projects for connectivity to new/minor ports and all such projects for port connectivity will be undertaken on PPP model where JVs would be formed by the port developers; with Railways as 26 % equity partner. Such an arrangement would facilitate land acquisition for the lines by the Railways while also ensuring requisite participation by the port developers. Such a mechanism lowers the financial burden of new projects on Railways, ensures commitment of the other stakeholders (port developers etc.) and also leads to benefits of Revenue sharing to the Stakeholders.

The white paper[2] brought out by Railways in Feb-2015, envisages a shelf of 154 New Line projects with total length of 17105 km at a projected cost of ₹ 173,448 crores and 208 nos. gauge conversion and doubling projects covering 18,976 km at a cost of ₹ 94,937 crores. The shelf of projects has been categorised with a view to providing focused attention and assured funding to various categories. With the present levels of funding, the prioritized projects may take anywhere from 3 to 13 years to complete. Thus many projects have been taken on cost sharing basis with the industry – two such projects have been taken up with Coal India and one with NTPC.

The Railways policy on participation of the private sector in providing last mile connectivity to ports, large mines, cluster of industries for building rail connectivity and capacity augmentation has proposed the following five models:

i) Non-Government private line model
ii) Joint Venture
iii) Capacity augmentation through funding by customer
iv) BOT
v) Capacity augmentation through annuity model.

All the models provide a clear revenue stream to the investor for making the connectivity projects bankable**.** Three Model Concession Agreements for private line model, joint venture and BOT have been approved and put in public domain. The agreements for the other two models are under approval process.

10.5 ROAD TRANSPORTATION

Road transportation provides last mile connectivity to the power projects in conjunction with other modes of transportation like Railways and ports; while it is the sole mode for transportation for large over dimension consignment (ODC). The NEP-2012 and the 12th Plan working group on power by the planning commission had stressed on: -

- Augmentation of Roads and Highways for transportation of Over Dimensioned Consignments (ODC) for higher size units.
- Amendment in Motor Vehicle Act to accommodate heavy consignments above 49 MT and inclusion of hydraulic axle trailers.
- Review of load classification for Roads & Bridges by IRC/ MoRTH to accommodate ODCs beyond 100 MT.
- Single window clearance and onetime payment for ODC movement.
- Proper design of Toll Plazas built on highways.
- Changes in Road design in North Eastern & Hill states to minimise sharp curves/gradients in roads and have sufficient vertical clearance in underpasses.
- Proper Approach Roads for Hydro Projects

The issue of ODC movement is the most critical for power projects. However, the equipment manufacturers have indicated that despite constant follow up for the last several years there has been no satisfactory solution to the above mentioned issues. With substantial number of state specific clearances required at present, turn over time for lorries/demurrage goes up considerably; and with limited availability of agencies for large ODC movements, this leads to delays in transportation of critical items, leading to delays in project execution. Thus the issue needs to be addressed on priority. Manufacturers have given several suggestions like – adoption of standardized maximum axle weight of around 16 MT/axle and no approvals should be required thereafter, single window clearance system for ODCs as against case to case basis by individual state authorities at present. It has also been suggested that a National Bridge Up-gradation

[2] Indian Railways – A white paper - http://www.indianrailways.gov.in/railwayboard/uploads/directorate/finance_budget/Budget_2015-16/White_Paper-_English.pdf

Programme may be taken up by Ministry of Road Transport and Highways (MoRTH) in partnership with Central & State authorities for upgradation of all bridges to minimum strength facilitating ODC movements.

MoRTH have indicated that approval of ODC on national highways has been made online. It is seen from MoRTH website that a system for online clearance for ODC movements is operational[3]. However, it is seen that the online clearance pertains to only the bridges on National Highways (NH) and there also it excludes bridges with span greater than 50 metre. Quote - *The movement has been allowed on NHs and for bridges having span length less than 50 metres except distress bridges (bridges which are unsafe for carrying IRC loads as per Ministry's Circular no. RWNH35072/1/2010S& R(B) dated 20th May ,2014. The movement of bridges having span length >50 metres or bridges not covered in Ministry's Circular no.RWNH35072/1/2010S& R(B) dated 24/01/2013 shall be allowed only after checking adequacy as per IRC:SP:37:2010 and completing the procedure as per Circular dated 20th May,2014.*

From a typical approval for BHEL Hyderabad to Wanakbori TPS available on the MoRTH website, it is seen that there are 8 distressed bridges and 10 other bridges involved where no ODC movement is permitted. Also there are 11 bridges (10 special bridges and 1 bridge of span greater than 50 metres) where ODC movement shall be allowed only after checking adequacy and completing the procedure thereby implying specific clearance to be sought. Thus as has been brought out by the manufacturers such a system has little utility as substantial specific clearances are required in spite of this online system. Thus the suggestion of manufacturers towards adoption of standardized maximum axle weight of around 16 MT/axle and no approvals should be required thereafter, single window clearance system for ODCs as against case to case basis by individual state authorities at present or undertaking a National Bridge Up-gradation Programme by Ministry of Road Transport and Highways (MoRTH) in partnership with Central & State authorities for upgradation of all bridges to minimum strength facilitating ODC movements need to be seriously considered to remove the constraints prevailing in ODC movements.

10.6 PORTS

Ports are vital for transportation of imported coal as well as equipment for the projects. The NEP-2012 and the 12th Plan working group on power by the planning commission had stressed on the following for ports development: -

- Adequate coal unloading arrangement at Ports to handle imported and domestic coal.
- On the East Coast, coal handling facilities to be augmented at Paradip and Vizag Ports to evacuate coal from mines in Orissa as rail routes are congested.
- Mechanisation of all major and important minor ports by augmenting crane capacities, silos, conveyors & wagon tipplers.
- Increasing draft at various ports to handle Panamax or capsize vessels.
- Creation of RO-RO berths in at least two major ports namely Kandla on the west coast and Paradip on the east coast for unloading ODCs.
- Road connectivity to ports to handle ODCs has to be ensured.

Ministry of Shipping have brought out that out of the 12 major ports in the country, six ports namely Haldia, Paradip, Tuticorin, New Manglore are handling Coal and the present capacity of these ports to handle the coal is 75 million tons/annum. Also, Ministry of Shipping has taken a policy decision that further augmentation of capacity at the major ports would be done through PPP mode only.

The Ministry of Shipping, Government of India has 12 Major Ports under the administrative control of the Ministry viz. Kolkata, Paradip, Visakhapatnam, Chennai, Kamarajar Port (Ennore), V O Chidambarnar (Tuticorin), New Mangalore, Mormugao, Cochin, Mumbai, Kandla and Jawaharlal Nehru Port. There are 6 Major Ports on the West Coast of India

[3] https://morth-owc.nic.in/auth/users/index.asp

and 6 Major Ports on East Coast on India. Besides, there are several minor Ports which are not in the Scope of the Ministry and they come under the purview of the State Governments.
The Major Ports have a total capacity of 871.52 million tonnes as on 31st March, 2015. The Major Ports at Haldia Dock (Kolkata Port), Paradip, Ennore, V O Chidambarnar, New Mangalore and Mormugao have dedicated coal handling facilities. Further, the Port of Visakhapatnam also handles coal at multipurpose berth. The capacity of dedicated coal handling facilities is 74.56 million tonnes as on 31.3.2015.

The capacity augmentation projects at Major Ports are undertaken on Public Private Partnership model (PPP) only where the private developers develop their own jetties and handling, navigation and other facilities are provided by the port authorities. The Request for qualification process is initiated based on the demand for cargo capacity for different category of cargo. The qualified bidders at RFQ stage are entitled to participate in RFP (Request for Proposal) with revenue sharing model with the concerned Major Ports. The model Concession Agreement between PPP operator and the Port is signed with conditions for the Project thereof.

Ministry of shipping has brought out that it may be necessary for the Power Companies to enter into Memorandum of Understanding (MOU) for logistic Plan for evacuation of Thermal Coal. Based on the MoU, the capacity with development of berth is taken up by the concerned Port. A copy of the procedure to be followed for appraisal/approval of PPP projects in ports, notified by the Central Government is placed at **Annexure-10.1**.

10.7 INLAND WATERWAYS

The following five major river/canal systems have been declared as National Waterways[4]:-

- Ganga - Bhagirathi - Hooghly river system between Haldia (Sagar) & Allahabad (total 1620 km) - declared as National Waterway No.1 (NW-1) in 1986.
- Brahmaputra river between Bangladesh Border and Sadiya (891 Km) - declared as National Waterway no. 2 (NW-2) in 1988
- West coast canal (Kottapuram - Kollam), Udyogmandal canal (Kochi- Pathalam bridge) and Champakara canal (Kochi - Ambalamugal) (total 205 km) – declared as National Waterway No.3 (NW-3) in 1993
- Kakinada-Puducherry stretch of Canals, River Godavari (Kaluvelly Tank, Bhadrachalam – Rajahmundry) and River Krishna (Wazirabad – Vijayawada) (total 1095 km) declared as National Waterway No.4 (NW-4) in 2008.
- Talcher- Dhamra stretch of river Brahmani, Geonkhali- Charbatia stretch of East Coast Canal, Charbatia-Dhamra stretch of Matai river and Mangalgadi-Paradip stretch of Mahanadi delta rivers (total 623 km) declared as National Waterway No.5 (NW-5) in 2008

In addition, Lakhipur to Bhanga stretch of river Barak (121 km) in Assam **is proposed as National Waterway -6**
Some of the waterways like NW-1 and NW-2 are well developed.

i. On NW-1, Inland Waterways Authority of India (IWAI) is carrying out various developmental works for improvement in navigability and development & maintenance of other infrastructure such as terminals and navigation aids. IWAI had been maintaining a Least Available Depth (LAD) of 3.0 meters between Haldia (Sagar) & Farakka (560 km), 2.5 meters in Farakka - Barh (400 km), 2.0 meters in Barh - Ghazipur (290 km) and 1.2 to 1.5 meters in Chunar - Allahabad sector (370 km) on this waterway (NW-1).
ii. Several large cargo movements have already been carried out on this waterway – like trial movements of 2600 tonnes fertilizer of M/s Tata Chemicals from Haldia to Fatuha (Patna), 2500 tonnes fertilizer of M/s IFFCO Phulpur from Fatuha (Patna) to Kolkata was done successfully during 2013-

[4] http://iwai.nic.in/index1.php?lang=1&level=2&sublinkid=145&lid=164

14. Further, several Inland tourist vessels made successful voyages in Kolkata - Semaria - Kolkata and Kolkata - Patna - Kolkata sections during 2013-14.

iii. On NW-2, IWAI is maintaining a navigable depth of 2.5m in Bangladesh Border- Neamati (629 Km), 2.0 m in Neamati – Dibrugarh (139 Km) and 1.5m in Dibrugarh – Sadiya (Oriumghat) stretch. At present the waterway is being used by vessels of Government of Assam, CIWTC, Border Security Forces, Tourism organization and other private operators. Long cruise tourist vessels are making voyages between Sivsagar near Dibrugarh and Manas wild life sanctuary near Jogighopa regularly. Over dimensional cargo (ODC) is also transported through the waterway from time to time. Transportation of POL (petroleum, oil and lubricants) was also made through this waterway from Silghat to Budge-Budge (West Bengal) and Baghmari (Bangladesh).

Inland waterways can be effectively used for Coal transportation as it is exerting a lot of pressure on Indian Railways network; thus wherever feasible, transportation of coal (particularly imported coal) using Inland Waterways can be looked into.

A beginning has already been made by NTPC for transportation of imported coal to Farakka station through National Waterway-1. The transportation has already started in Nov'13 and till 31.12.2015, a total of about 1.2 MMT imported coal has been supplied to Farakka through this mode. The salient details of the mechanism/process employed are as under: -

a. NTPC executed a Tripartite Agreement with Inland Waterways Authority of India (IWAI) and selected the Operator. As per agreement, the Operator is required to: -
   i. Unload and transport 3 MMTPA imported coal from high seas (Sandheads/Kanika Sands – about 140 kms from Haldia) to Farakka power plant.
   ii. Create the infrastructure from transfer point in mid sea to NTPC coal stock yard including Transhipper, Barges, Unloading arrangement at Farakka waterfront, Conveyor (about 2.5 km) from jetty to Farakka coal stockyard
   iii. Operate and maintain the project for 7 years from COD
   iv. NTPC had given commitment for transport of 3 MMTPA coal through inland waterway for 7 years from COD.
   v. Entire investment for the project is to be made by the operator. Payments for the coal transported by the Operator is made by the Imported Coal Supplier (ICS) appointed by NTPC time to time.
   vi. Material handling system at Farakka shall be transferred to NTPC after 7 years of operation.
b. IWAI is required to ensure Least Available Depth (LAD) of 2.5 m for minimum 330 days in a year and navigational aids for round the clock operation.
c. The project commenced its operation on 28.10.2013 and first set of 03 barges reached Farakka on 13.11.2013, carrying approx. 1500 MT each of imported coal.

Several thermal power stations are operational on the banks of Ganga in the States of West Bengal and Bihar. Also several more Thermal Power Stations are proposed/under construction in Bihar and Uttar Pradesh. Their coal requirement can be met through IWT. Railways & Waterways can jointly develop routes/ strategies for easing out movement of coal & power equipment to the power projects.

10.8 LNG REGASIFICATION & PIPELINES FOR TRANSPORTATION OF NATURAL GAS

The prevailing regasification capacity for LNG in the country stands at about 21 Million metric tons per annum (MMTPA). However, only a part of this capacity is available for power sector. PLL is planning to expand its Dahej terminal capacity to 17.5 MMTPA from present 15 MMTPA by 2019. M/s Shell is also planning to expand its capacity and increase to 5 MMTPA with the construction of break water facility. Though Kochi Terminal has been commissioned in September -2013, at present, the terminal is running at about 3.41% of its capacity.

ONGC have signed a Memorandum of Understanding (MoU) with New Mangalore Port Trust (NMPT), Mitsui and BPCL for carrying out feasibility study for setting up LNG regasification terminal at Mangalore. IOCL is setting up 5 MMTPA LNG regasification terminal at Ennore. GAIL and IOCL have signed separate MoUs with Dhamra LNG Terminal Pvt. Ltd. for booking of capacity in their proposed LNG terminal in Orissa. Andhra Pradesh Gas Distribution Corporation (APGDC), an affiliate company of GAIL in collaboration with the Government of Andhra Pradesh is promoting setting up of a 3.5 MMTPA Floating Storage Regasification Unit (FSRU) based LNG terminal in Kakinada.

At present, the country is having about 15,000 km of natural gas pipeline infrastructure and an additional 15,000 km of pipeline is required for completion of National Gas Grid. Out of this additional 15,000 km, PNGRB/Government of India has authorized entities for laying of about 11,900 km of pipelines. About 1175 km of pipeline in respect of Ennore-Bengaluru-Puducherry-Nagapattinam-Madurai-Tuticorin was pending for award due to court case pending before the Hon'ble Supreme Court. The said court case has been recently cleared paving the way for award of this section also.

10.9 INPUTS FOR RENEWABLE ENERGY PROJECTS

As brought out in Para-10.1 above, substantial capacity addition is envisaged from renewables during 2017-22 and 2022-27. MNRE was requested for working out the norms for estimation of various inputs for renewables projects based on solar, wind etc., their indigenous availability and issues involved in transportation of equipment etc. in consultation with the manufacturers of these equipment and would be made available by MNRE separately.

10.10 LAND AND WATER FOR THERMAL STATIONS

10.10.1 Land

The land requirement for various configurations of thermal plants is being considered as per CEA Report "Review of Land Requirement for Thermal Power Station-2010" - the typical value for 2-unit combination of coal based station based on domestic coal varies from 1.11 to 0.929 Acres/ MW for 500MW unit to 800MW unit size and is approx. 0.55 Acres/ MW for Coastal Stations based on Imported Coal. The same has been concurred by the members.

The 12th Plan working group on Power by the Planning Commission had identified the following major Issues of concern regarding land acquisition: -

- Lack of land Records, Issues related to compensation -Lack of clarity about the status of occupiers who are not owners,
- Right of Way (ROW) for Ash/Water pipelines, coal conveyors and transmission lines, Resistance from local people,
- MOEF clearance and acquisition of forest land and Resettlement and rehabilitation of the Project Affected People (PAP).

The working group had recommended the following for Land use and acquisition:

- Minimizing land requirement pressure for new projects by use of spare land within existing plants.
- Review of MoEF procedures for expeditious project clearances.
- Higher capacity units in place of older small size units & Adoption of higher size units.
- Shelf of sites for projects i.e. land bank needs to be created.
- New technology options to be adopted for minimizing land requirement.
- Land acquisition by States need to be done expeditiously in a time bound manner, considering that a large percentage of power is allocated / committed to the Home State from the power project.

As no additional capacity addition is envisaged from thermal projects during 2017-22, and also large thermal capacity is under construction, no major constraints are anticipated for thermal generation on account of land availability. Land for projects under construction and recently awarded would already have been tied up.

However, issues faced in general by the utilities for land acquisition were discussed by the Sub-Committee and the major points emerged out of the discussions are as under: -

- Different types of land acquisitions are involved in Power plant construction viz. Land acquisition in contiguous land for Main Plant, Township, Ash dyke, Reservoir etc. (Pvt/ Govt/Forest), Linear land acquisition mainly for Railway corridor. Approach roads etc (Pvt/ Govt/Forest) and Right of Use/Right of Way (RoU/RoW) for Municipal water pipeline/Ash pipe/Transmission line corridors.
- With the enactment of new LARR act, apart from increase in input costs, **the process is getting more complicated and lengthy now**. Theoretically, almost 5 years are required for completion of LA process that includes Social Impact Assessment process/ consent of owners. The problem is more in linear acquisitions wherein number of PAPs and villages are more.
- For NTPC's Greenfield projects, viz. Gadarwara, Kudgi, Khargone, Lara, Meja, NPGCL, BRBCL, etc., **problems are being faced in acquisition of land for Railway Siding**. The reasons include rate difference in the land acquired under old act / new act as awards for certain patches were declared under old act, finalization of R&R Plan, incomplete land records resulting to left out land in critical areas, etc. Active support of the state administration is essential for resolving such issues. A possible solution brought out by the members could be formation of JVs with Railways and land acquisition by Railways under the Railway Act.
- While in general, acquisition of forest land is avoided by the utilities/NTPC, difficulties are being faced in transfer of forest land mainly in linear acquisitions – Rail line corridor at Lara, Darlipalli projects of NTPC.
- The major problem faced in transfer of Govt land is GMK & GMA land and absence of pre-defined process of agreeable solution for eviction of Raiyatis. At times transfer of Govt land is becoming more difficult than acquisition of Private land.
- RoU (Right of Use) Act is available in MP, Chattisgarh, Bihar, Gujarat and Haryana. Due to absence of such act in Maharashtra, Karnataka, UP and Odisha difficulties have been faced in availability of land for laying of MuW pipelines in NTPC projects in respective states. – Solapur, Kudgi, Meja and Darlipalli. Even in the states where RoU act is available difficulties have been faced in availability of land (mostly on account of owners' demand of higher compensation) in BRBCL/ NPGCPL/Kanti/ Gadarwara projects of NTPC.

10.10.2 Water

As per Environment (Protection) Rules, 1986 (Amendment 1998) issued by MOE&F, all thermal power plants, using water from rivers/lakes reservoirs, are required to install cooling towers irrespective of location and capacity. Thus all thermal stations are being provided by closed cycle cooling water (CCW) systems.

Over the years, considerable technology improvements have been made to reduce water consumption in the stations - the consumptive water requirement which used to be about 7m3/MWh in the past, has been optimized by various technological interventions & water conservation practices and has been brought down to 3m3/MWh.

As per the new environmental Regulations issued by MOE&F in Dec-2015, all new plants to be installed after 1st January, 2017 shall be required to meet specific water consumption upto maximum of 2.5 m3/MWh. In view of the necessity to install FGD system in the stations due to SOx emission limits prescribed in the new MOE&F Regulations, higher consumption water requirement of about 3 m3/MWh is estimated.

The 12th Plan working group on Power by the Planning Commission had suggested for **creation of large reservoirs/ dams on potential rivers to retain flood waters** by the state Govts./Ministry of water resources to ease water availability for the projects.

10.11 CONSTRUCTION MACHINERY

The availability of construction machinery for project execution is generally considered adequate. However, as brought out earlier, contractors at times take works beyond their capacities and are not able to mobilize the resources and deploy adequate T&P items to meet the commissioning targets. In the above context, a suggestion has been made for creation of a mechanism for sharing information on orders/work load on various contractors and availability of T&P items/construction machinery with them.

Suggestions were also sought from the equipment manufacturers on improvements in construction machinery and construction practices to improve the pace of project execution. The salient issues emerged from the information provided by the manufacturers and deliberations held in the Sub-Committee are as under: -

- Better infrastructure for transportation and ODC movement could facilitate larger size sub-assemblies at shop, leading to reduction in execution time at sites. This would also require deployment of larger size cranes and handling equipment at site. For bigger modules, higher size cranes of about 1000 tons may be required at site.
- Better site infrastructure by the customer comprising of: -
  - ✓ Pre-assembly yards at site with dedicated T&P – permitting boiler contractor for fabrication at site could provide considerable reduction in the time of Construction. For this, an additional area of 70,000 sq.m. would be required by the Contractor
  - ✓ Well compacted and motorable area for storage of material.
  - ✓ Hard crusting of Boiler cavity and surrounding area for Crane Marching
  - ✓ Advancement of underground portion of civil foundations in boiler area, depending upon Engineering and interface input
- Adoption of improved Construction Practices in Civil works like: -
  - ✓ Using concrete batching plants instead of concrete mixers
  - ✓ Tower Cranes and placer booms for concreting for standalone high rise buildings instead of concrete pumps
  - ✓ Automatic plastering machines
  - ✓ Rebar Processing Unit for Fabrication of Reinforcement Steel
  - ✓ Pre Engineered Buildings with tubular sections with pocketed foundations

It is suggested that a Task Force may be created under NTPC with participation from equipment manufacturers/EPC contractors to examine the issue in detail and work out an optimized framework of site preparation, T&P requirements etc. for overall improvement in project execution.

10.12 CONCLUSIONS & RECOMMENDATIONS

The broad conclusions/recommendations for key inputs are as under: -

- Adequate manufacturing facilities exist for main plant equipment– Lack or orders is a concern of all manufacturers.

- Presently there are large imports of raw materials, castings/forgings, tubes/pipes of alloy steels, CRGO steel etc. for Boiler and Turbine generators. It is suggested that a joint mechanism may be created under Ministry of Steel with participation from power equipment manufacturers and steel manufacturers for more information sharing on compositions/properties of various steels and steel products required and their indigenous development by the steel industry.

- Constraints in availability of good BoP systems vendors are being felt as many of the good Coal Handling Plant/Ash handling plant vendors are not in good financial health. Even the EPC agency normally sub-contracts BoP systems and thus availability of good BoP vendors is vital for all projects – both, EPC or separate package basis. In several cases BoP contract had to be terminated due to non-performance of the vendors. As BoP vendors cater to material handling systems in other industries also, it is suggested that an organizational mechanism for information sharing on BoP vendors across industries needs to be considered. Such a mechanism could provide the salient details on orders in hand, T&P available, past performance etc. This could be a web based portal under DHI or Ministry of commerce.

- New advanced technologies BoP systems like High Concentration Slurry Disposal (HCSD) type ash disposal systems, closed pipe type conveyors for coal handling plants (CHP), large size R.O systems also need to be indigenized. The equipment manufacturers may back integrate as some of them also have their BoP or EPC setups or may undertake vendor developments.

- ODC movement Continues to be a major constraint; though MoRTH have placed an online system for ODC approval, it is seen that substantial specific clearances are required in spite of this online system as large number of bridges – special bridges, bridges with span >50 m, distress bridges are not covered under online approval. Thus the suggestion of manufacturers towards adoption of standardized maximum axle weight of around 16 MT/axle with no approvals required thereafter, single window clearance system for ODCs or undertaking a National Bridge Up-gradation Programme for upgradation of all bridges to minimum strength facilitating ODC movements need to be considered to remove the constraints prevailing in ODC movements.

- Inland waterways can become an attractive mode of transportation in conjunction with Railways. The success of NTPC coal transportation to Farakka could be replicated across numerous other stations.

- The prevailing regasification capacity for LNG in the country stands at about 21 Million metric tons per annum (MMTPA) – further expansions are being planned by several players. Also additional 15,000 km, of gas pipelines are under construction for completion of national Gas grid.

- Future Infrastructure Project in Railway line, Port development will be done through PPP mode.

- Suggestions were sought from the equipment manufacturers on improvements in construction machinery and construction practices to improve the pace of project execution. Several improved construction practices and pre-requisites and corresponding infrastructural issues have been brought out by the manufacturers. It is suggested that a Task Force may be created under NTPC with participation from equipment manufacturers/EPC contractors and utilities to examine the issue in detail and work out an optimized framework of site preparation, T&P requirements etc. for overall improvement in project execution.

Annexure – 10.1

PPP IN PORT PROJECTS

1. INTRODUCTION

The Central Government has notified a system for appraisal/approval of projects to be undertaken through Public Private Partnership (PPP). Detailed procedure to be followed for this purpose is specified below.

2. INSTITUTIONAL STRUCTURE

The institutional structure for the appraisal/approval mechanism is specified.

3. APPLICABILITY

1) These guidelines will apply to all PPP projects sponsored by Central Government Ministries or Central Public Sector Undertakings (CPSUs), statutory authorities or other entities under their administrative control.

2) The procedure specified herein will apply to all PPP projects with capital costs exceeding ₹ 100 crore or where the underlying assets are valued at a sum greater than ₹ 100 crore. For appraisal/approval of PPP projects involving a lower capital cost/value, detailed instructions will be issued by the Department of Expenditure.

4. PROJECT IDENTIFICATION

The sponsoring Ministry will identify the projects to be taken up through PPPs and undertake preparation of feasibility studies, project agreements etc. with the assistance of legal, financial and technical experts as necessary. Guidelines for Formulation, Appraisal and Approval of Public Private Partnership Projects The guidelines and procedures will apply to all PPP projects sponsored by central government, CPSUs, statutory authorities or entities under their administrative control Note: The Guidelines for Formulation, Appraisal and Approval of Public Private Partnership Projects were notified by Ministry of Finance, Department of Economic Affairs, vide 0M No. 1/5/2005 - PPP, dated January 12, 2006. * In accordance with procedure approved by CCEA in the meetings of October 27, 2005 and March 22, 2007. Projects of all sectors costing ₹ 250 crore or more or under NHDP costing ₹ 500 crore or more Projects of all sectors costing ₹ 250 crore or more or under NHDP costing ₹ 500 crore or more* Guidelines for Formulation, Appraisal and Approval of Central Sector Public Private Partnership Projects.

5. INTER-MINISTERIAL CONSULTATIONS

1) The Administrative Ministry may, if deemed necessary, discuss the details of the project and the terms of concession agreement in an inter-ministerial consultative committee and comments, if any, may be incorporated or annexed to the proposal for consideration of PPPAC.
2) There could be projects, which involve more than one Ministry/ Department. While considering such projects, PPPAC may seek participation of such Ministries/Departments.

6. 'IN PRINCIPLE' APPROVAL OF PPPAC

1) While seeking 'in principle' clearance of PPPAC, the Administrative Ministry shall submit its proposal (in six copies, both in hard and soft form) to the PPPAC Secretariat in the format specified at Annex-Il and accompanied by the pre-feasibility/feasibility report and a term-sheet containing the salient features of the proposed project agreements.
2) PPPAC Secretariat will circulate the copies of PPPAC memo and associated documents to all concerned. A meeting of the PPPAC will be convened within three weeks to consider the proposal for 'in principle' approval.

3) In cases where the PPP project is based on a duly approved Model Concession Agreement (MCA), 'in principle' clearance by the PPPAC would not be necessary. In such cases, approval of the PPPAC may be obtained before inviting the financial bids as detailed below.

7. EXPRESSION OF INTEREST

Following the 'in principle' clearance of PPPAC, the Administrative Ministry may invite expressions of interest in the form of Request for Qualification (RFQ) to be followed by shortlisting of pre-qualified bidders.

8. FORMULATION OF PROJECT DOCUMENTS

The documents that would need to be prepared would, inter alia, include the various agreements to be entered into with the concessionaire detailing the terms of the concession and the rights and obligations of the various parties. These project documents would vary depending on the sector and type of project. Typically, a PPP will involve the concession agreement that will specify the terms of the concession granted to the private party and will include the rights and obligations of all parties. There could be associated agreements based on specific requirements.

9. APPRAISAL/APPROVAL OF PPPAC

1) RFP (Request for Proposals), i.e. invitation to submit financial bids, should normally include a copy of all the agreements that are proposed to be In cases where the PPP project is based on a duly approved Model Concession Agreement, 'in principle' clearance by the PPPAC would not be necessary. In such cases, approval of the PPPAC may be obtained before inviting the financial bids entered into with the successful bidder. After formulating the draft RFP, the Administrative Ministry would seek clearance of the PPPAC before inviting the financial bids.

2) The proposal for seeking clearance of PPPAC shall be sent (in six copies) to the PPPAC Secretariat in the format specified along with copies of all draft project agreements and the Project Report. The proposal will be circulated by PPPAC Secretariat to all members of the PPPAC.

3) Planning Commission will appraise the project proposal and forward its Appraisal Note to the PPPAC Secretariat. Ministry of Law and any other Ministry/Department involved will also forward written comments to the PPPAC Secretariat within the stipulated time period. The PPPAC Secretariat will forward all the comments to the Administrative Ministry for submitting a written response to each of the comments.

4) The concession agreement and any supporting agreements/documents thereof, along with the PPPAC Memo, will be submitted for consideration of PPPAC, The PPPAC will take a view on the Appraisal Note and on the comments of different Ministries, along with the response from the Administrative Ministry.

5) PPPAC will either recommend the proposal for approval of the competent authority (with or without modifications) or request the Administrative Ministry to make necessary changes for further consideration of PPPAC.

6) Once cleared by the PPPAC, the project would be put up to the competent authority for final approval. The competent authority for each project will be the same as applicable for projects approval by PIB.

10. INVITATION OF BIDS

Financial bids may be invited after final approval of the competent authority has been obtained. However, pending approval of the competent authority, financial bids could be invited after clearance of PPPAC has been conveyed.

11. EXEMPTION FROM THE ABOVE PROCEDURE

Ministry of Defence, Department of Atomic Energy and Department of Space will not be covered under the purview of these guidelines. PPPAC will either recommend the proposal for approval of the competent authority (with or without modifications) or request the Administrative Ministry to make necessary changes for further consideration of PPPAC Projects of all sectors costing ₹ 250 crore or more or under NHDP costing ₹ 500 crore or more.

CHAPTER 11

FUND REQUIREMENT

11.0 INTRODUCTION

The generation capacity addition for the period 2017-22 and 2022-27 has been assessed in the Chapters 5. This chapter estimates total fund requirement for this capacity addition. The requirement of funds assessed in this chapter does not include the funds required for captive power plants and for R&M of existing power plants. The requirement of funds for transmission have been included in Volume-II of the National Electricity Plan

11.1 FUND REQUIREMENT FOR THE PERIOD 2017-2022

A total capacity addition of 58,384 MW from conventional sources has been envisaged for the period 2017-2022, consisting of 47,855 MW of coal based power stations, 406 MW of gas based power stations, 6,823 MW of hydro power stations and 3,300 MW of nuclear stations. Besides this, there has been a big thrust by the Government of India for setting up renewable power generation capacity of 1,75,000 MW by the year 2022, out of which 1,17,756 MW is expected to be set up during the period 2017-2022. The requirement of funds for generation projects for the period 2017-2022 has been assessed, based on the above mentioned capacity addition. However, it may be mentioned that no additional fund will be required for gas based generation capacity as the construction of these plants has already been completed and could not be commissioned so far due to non-availability of domestic gas.

To assess the fund requirement for various types of generation projects, the year-wise phasing of expenditure has been considered in accordance with the normal scenario. The cost per MW for the year 2017-18 has been estimated based on present day cost and this has further been escalated thereafter @4% per annum. However, in view of the recent trend, the capital cost per MW in case of solar, wind and biomass based power projects has been pegged at present day level without any escalation in subsequent years. The details of assumptions of capital cost per MW and year-wise phasing of expenditure of different categories of generation projects are given in **Annexure 11.1** and **Annexure 11.2** respectively.

Based on the above, the total fund requirement for the period 2017-2022 is estimated to be Rs.11,55,652 Crores, which also includes the likely expenditure during the period for the projects coming up in the year 2022-2027. **Table 11.1** below captures the year-wise details of total estimated fund requirement.

Table 11.1
Total fund requirement for Generation projects during 2017-2022

(₹Crores)

	2017-18	2018-19	2019-20	2020-21	2021-22	Total
For projects likely to be commissioned during 2017-22	2,19,509	2,22,030	1,92,582	1,71,208	47,475	8,52,804
Advance action for projects likely to be commissioned during 2022-27	2,304	18,757	35,303	67,198	1,79,286	3,02,848
Total	2,21,813	2,40,787	2,27,885	2,38,406	2,26,761	11,55,652

The mode-wise estimated fund requirement for the period 2017-2022 (including the likely expenditure during this period for the projects coming up in the year 2022-2027) is given in **Table 11.2**.

Table 11.2

Fund requirement for Generation projects (Mode-wise) during 2017-2022

(₹Crores)

Year	Thermal	Hydro	Nuclear	Renewables	Total
2017-18	76,781	15,622	9,479	1,19,931	2,21,813
2018-19	73,376	19,465	9,728	1,38,218	2,40,787
2019-20	52,915	23,461	8,088	1,43,422	2,27,885
2020-21	55,846	26,431	11,912	1,44,218	2,38,406
2021-22	63,991	29,546	16,127	1,17,096	2,26,761
TOTAL	**3,22,908**	**1,14,524**	**55,334**	**6,62,885**	**11,55,652**

Out of the fund requirement of ₹ 8,52,804 Crores for the projects likely to be commissioned during 2017-22, it is estimated that ₹ 1,42,566 Crores would be required for Central sector projects, ₹ 92,889 Crores would be required for State sector projects and ₹ 6,17,349 Crores for Private sector projects. In this estimation, it is assumed that all the Renewable projects will be implemented by private developers.

11.2 FUND REQUIREMENT FOR THE PERIOD 2022-27

The fund requirement for the period 2022-27 has been estimated based on total capacity addition of 1,65,220 MW, consisting of 46,420 MW of thermal projects, 12,000 MW of hydro projects, 6,800 MW of nuclear projects and 1,00,000 MW of renewable energy projects.

The fund requirement for the period of 2022-27 has been assessed using same principles as that for 2017-22 viz. based on year wise phasing of expenditure under normal scenario and estimated capital cost per MW. The latter has been arrived at based on estimated capital cost per MW for the year 2017-18 with annual escalation @4%. Nuclear units of 1000 MW each based on Light Water Reactor (LWR) technology are expected during 2022-23 & 2023-24 and 2 units of 1000 MW on LWR in 2026-27. For these nuclear units, the cost per MW have been considered as ₹ 20 Crores for the year 2022-23 with an annual escalation @4% thereafter. As for the period 2017-22, the capital cost per MW for solar, wind and biomass based power projects in the period 2022-27 has been maintained at present day level without any escalation in the coming years. The details of assumptions of capital cost per MW and year-wise phasing of expenditure of different categories of generation projects are given in **Annexure 11.1** and **Annexure 11.2** respectively.

Based on the above, the total fund requirement for the period 2022-2027 has been estimated to be ₹ 9,56,214 Crores**.** In the absence of information about specific years of commissioning except nuclear projects, it is assumed that the capacity addition is equally spread out over each of the five years. In case of nuclear projects, units of 1000 MW each based on LWR technology have been considered during 2022-23 & 2023-24, 2 units of 700MW of PHWR have been considered in the year 2024-25, one unit of 700 MW PHWR in the year 2025-26 and one unit of 700 MW PHWR & 2 units of 1000 MW LWR in 2026-27. This fund requirement does not include advance action for projects coming up during the period 2027-2032.

The mode-wise fund requirement for the period 2022-2027 (excluding the expenditure likely to incurred during this period for the projects coming up in the year 2027-2032) is given in **Table 11.3**.

Table 11.3

Fund requirement for Generation projects (mode-wise) during 2022-2027

(₹Crores)

Year	Thermal	Hydro	Nuclear	Renewables	Total
2022-23	77,663	31,932	19,390	1,15,917	2,44,902
2023-24	71,837	26,105	18,435	1,16,179	2,32,556
2024-25	65,778	18,267	17,173	1,16,320	2,17,538
2025-26	50,544	10,116	16,194	1,12,408	1,89,262
2026-27	25,767	3,416	8,514	34,259	71,956
TOTAL	**2,91,589**	**89,837**	**79,706**	**4,95,082**	**9,56,214**

11.3 SOURCES OF FUNDS

In case of Central Sector projects, generally developers make an equity contribution of 30%. In case of projects developed in State Sector and Private sector, the equity contribution is generally 20% and 25% respectively.

Based on the estimation of fund requirement for the period 2017-22 and considering sector-wise equity contribution mentioned in section 11.1, it is estimated that developers will be required to infuse equity amount totaling to ₹ 2,98,435 Crores. Further, they will have to arrange for total debt of ₹ 8,57,216 Crores.

Similarly, the equity and debt requirement (excluding fund requirement for advance action for projects during the period 2027-2032) for the period 2022-2027 have been estimated as ₹ 2,62,110 Crores and ₹ 6,94,104 Crores respectively.

The sources, available for debt funding are scheduled commercial banks, financial institutions like Power Finance Corporation (PFC), Rural Electrification Corporation (REC), Life Insurance Corporation (LIC), Bonds - domestic as well as oversees, foreign currency loan from World Bank, ADB, KfW, EXIM Bank and also from foreign equipment manufacturers. It is also expected that funds including foreign funds from private players would also be invested through Infrastructure Investment Trusts (InvIT). The Subordinate Debt/grant from Government may also be available to some projects to be developed by PSU/States.

In respect of nuclear power generation, Government budgetary support may be required for funding equity requirement for future power projects. Further, to promote the Renewable energy, Govt. of India is providing Viability Gap Funding (VGF) from National Clean Energy and Environment Fund (NCEEF) and is also arranging low cost funds from International Agencies like World Bank, ADB etc. Apart from this, IREDA is financing renewable energy projects under various schemes.

Annexure 11.1

ASSUMPTIONS FOR ESTIMATING CAPITAL COST OF POWER PROJECTS

1. For the period 2017-2022

Sl.No.	Project type	Capital cost per MW (₹ Crores)				
		2017-18	2018-19	2019-20	2020-21	2021-22
1	Coal	6.5	6.76	7.03	7.31	7.60
2	Hydro	10	10.4	10.8	11.2	11.7
3	Solar	5.5	5.5	5.5	5.5	5.5
4	Wind	6	6	6	6	6
5	Biomass	5.7	5.7	5.7	5.7	5.7
6	SHP	6.5	6.76	7.03	7.31	7.60
7	Nuclear (PHWR)	10	10.4	10.8	11.2	11.7

2. For the period 2022-2027

Sl.No.	Project type	Capital cost per MW (₹ Crores)				
		2022-23	2023-24	2024-25	2025-26	2026-27
1	Coal	7.9	8.2	8.5	8.9	9.25
2	Hydro	12.2	12.7	13.2	13.7	14.2
3	Solar	5.5	5.5	5.5	5.5	5.5
4	Wind	6	6	6	6	6
5	Biomass	5.7	5.7	5.7	5.7	5.7
6	SHP	7.9	8.2	8.5	8.9	9.25
7	Nuclear (PHWR)	12.2	12.7	13.2	13.7	14.2
8	Nuclear (LWR)	20.0	20.8	21.6	22.5	23.4

Annexure 11.2

ASSUMPTIONS FOR ESTIMATING CAPITAL COST OF POWER PROJECTS

PHASING OF EXPENDITURE OF GENERATION PROJECTS, FOR THE PERIODS 2017-22 AND 2022-27

Type of Project	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Total
Coal	10%	10%	20%	30%	30%	-	-	-	-	100%
Hydro	20%	25%	25%	20%	10%	-	-	-	-	100%
Solar	80%	20%	-	-	-	-	-	-	-	100%
Wind	60%	40%	-	-	-	-	-	-	-	100%
Biomass	30%	40%	30%	-	-	-	-	-	-	100%
SHP	30%	40%	30%	-	-	-	-	-	-	100%
Nuclear	3%	1%	4%	5%	10%	15%	21%	26%	15%	100%

CHAPTER 12
EMISSIONS FROM POWER SECTOR

12.0 INTRODUCTION

The phenomenal growth in demand for energy is increasingly affecting the natural environment. Human activities now occur on a scale that has started to interfere with complex natural systems. Anthropogenic activities such as energy generation from fossil fuels, industrialization and deforestation have been increasing the atmospheric concentration of Green House Gases (GHGs) above their natural levels resulting in Global climatic change. Excessive concentration of Green House Gases like Carbon di-oxide (CO_2) and Methane (CH_4) and other harmful emissions in the atmosphere has become one of the most critical global environment issues by which human life is gravely threatened.

In most of the developing countries, the major requirement of power is met through thermal power plants. India also depends largely on coal as a major source of energy for producing power and coal will continue to play a major role in producing power in near future. As on 31.03.2017, coal based power generation capacity is around 58.08 % of the total installed capacity but generates almost 76.08 % of total power generation in country.

Generation of power by use of fossil fuel like coal, oil and gas pollutes the atmosphere in many ways. Emission of particulate matter and generation of fly ash from coal based power stations are local health hazard. Gaseous emissions from fossil fuel based power generation like CO_2, SO_x, NO_x and Mercury etc. affect the local as well as global climate.

12.1 EMISSION FROM THERMAL POWER STATIONS

Fossil fuel-fired power plants burn fossil fuels like coal, lignite, natural gas, diesel etc. to generate steam/ hot air to run turbines generating electricity. The generation of power from combustion of fossil fuels has an impact on Air, Water and Land resulting in degradation of local as well as global environment.
The major types of pollutants emitted from thermal power stations are as follows:

12.1.1 Air Pollution

The following major air pollutants are generated from combustion of fossil fuels by thermal power stations: i) Nitrogen oxide(NO_2) ii) Sulphur di-oxide (SO_2) iii) Green House Gases like CO_2 iv) Suspended Particulate Matter (SPM) v) Mercury Emissions. Traces of Carbon monoxide (CO) is also produced during the process of combustion. The brief description of major pollutants and their effects are detailed below:

12.1.1.1 Nitrogen Oxide

Most of the NOx is emitted as NO which is oxidised to NO_2 in the atmosphere. All combustion processes at high temperature are sources of NOx emission. Formation of NO_X may be due to thermal NO_X which is the result of oxidation of nitrogen in the air or due to fuel NO_X which is due to nitrogen present in the fuel. In general, higher the combustion temperature the higher NOx is produced. Some of NOx is oxidised to NO_3, an essential ingredient of acid precipitation and fog. There were no existing norms for control of NO_x. However, new norms notified by Ministry of Environment, Forest and Climate Change has stipulated norms for NOx control, which are discussed later in the chapter.

12.1.1.2 Sulphur Oxide

The combustion of sulphur contained in the fossil fuels, especially coal and oil is the primary source of SO_X. About 97% to 99% of SO_X emitted from combustion sources is in the form of Sulphur Di-oxide which is a critical pollutant, the remainder is mostly SO_3, which in the presence of atmospheric water is transformed into Sulphuric Acid at higher concentrations, produce delirious effects on the respiratory system. The SOx emissions are controlled by providing tall height stack for dispersion. Higher size units of 500 MW and above were also required to keep space provisions for future installation of Flue Gas de-sulphurisation (FGD) system when required. In specific cases, installation of FGD system has been stipulated by MOE&F while granting environmental clearance. The new norms notified by Ministry of Environment, Forest and Climate Change has stipulated emission norms for SOx which are discussed later in the chapter.

12.1.1.3 Green House Gases

A number of gases like CO_2, Methane, nitrous oxide(N_2O), Chlorofluorocarbons and water vapour are called Green House Gases. Carbon dioxide is released primarily through the burning of fossil fuels. It is generated by combustion of coal and hydrocarbons. Methane is released through the decomposition of organic matter (marshes, cattle raising, rice flakes etc.) and the use of fossil fuels.

12.1.1.4 Particulate Matter

The terms particulate matter, particulates, particles are used interchangeably and all refer to finely divided solids dispersed in the air through chimney or stack of power stations. Norms have been stipulated by Ministry of Environment, Forest and Climate Change for control of Suspended Particulate Matter and are more stringent for new power plants.

12.1.1.5 Carbon Monoxide

It is a colorless, odorless flammable and toxic gas. It has ability to react with hemoglobin in the blood and reduce the oxygen absorbing capacity of the blood. It is generated by incomplete combustion of coal and hydrocarbons. The most significant source of CO is automobiles.

12.1.1.6 Mercury Emissions

Emissions of mercury from thermal power stations are a subject of increasing concern because of its toxicity, volatility, persistence, long range transport in the atmosphere. Once released into the environment, mercury contaminates soil, air, surface and ground water. The mercury emitted from coal-fired power plants originates from the mercury present in the coal. Typically, mercury is present in the coal in the tens of parts-per-billion range. Burning of enormous quantity of coal for power generation makes it the largest anthropogenic source of mercury emissions.

12.1.2 Water Pollution

Water pollution refers to contamination of natural water, whereby its further use is impaired. The contamination could be caused by the introduction of organic or inorganic substances in the water or due to change in the temperature of the water.

In thermal power stations the source of water is river, lake, pond or sea from where water is usually taken. There is possibility of water being contaminated from the source itself. Further contamination or pollution could be added by the pollutants of thermal power plant waste as inorganic or organic compounds.

The types of water pollution & its sources are given in **Table 12.1**.

Table 12.1
Types of Water Pollution & its Sources

	Type		Sources
(i)	Thermal pollution	-	Discharges from condenser
(ii)	Carryover of ash to water bodies	-	Ash pond overflow, ash handling area drainage
(iii)	Acid or alkaline effluents	-	DM water treatment plant, chemical storage area & lab
(iv)	Leaching and water percolation	-	Ash dumps, ash ponds
(v)	Heavy metals	-	Air heater wash, wash water from boiler fire side clearing
(vi)	Toxic substances, high total dissolved solids (TDS) , Phosphates high alkaline, ammonia	-	Boiler blowdown
(vii)	sludge and oil	-	Drains from fuel oil area, tube oil area, transformer oil off
(viii)	Cyanide and other chemicals	-	Radio graphic lab
(ix)	Bacteriological pollution	-	Sanitary & domestic waste

The effects of water pollutants are manifold and depend on the type and concentration. Some of these are given below in **Table 12.2**.

Table 12.2
Effects of Water Pollution

	Pollutants		Effects
a	Soluble organic as represented by BOD(Biological Oxygen Demand)		Deplete oxygen in surface water, Fish killing, the growth of undesirable aquatic life and odours Certain organics can be bio-magnified in the aquatic food chain
b	Suspended solid		Decrease water clarity and hinder photosynthesis, form sludge deposits which changes eco-system results.
c	Chloride		Salty taste in water
d	Acidic, alkaline and toxic substances		Cause fish killing also can cause imbalance in stream eco-system
e	Disinfectants Cl_2, H_2O_2		Killing of micro-organisms
f	Ionic forms Fe, Ca, Mg, Mn, Cl and SO_4		Changed water characteristics, staining hardness, salinity

All discharge from thermal power stations to water bodies is made after treatment as per the environmental standards prescribed by MOE&F. Further, ash ponds are High Density Polyethylene (HDPE) lined to prevent leaching etc. Also zero discharge system with no discharge to water body are envisaged at many stations.

12.1.3 Fly Ash Generation

Indian coal is of low grade with ash content of the order of 30%-50 % in comparison to imported coals which have low ash content of the order of 10%-15%. Large quantity of ash is thus being generated at coal/lignite based Thermal Power Stations in the country, which not only requires large area of precious land for its disposal but is also one of the sources of pollution of both air and water. To reduce the requirement of land for disposal of fly ash in ash ponds and to address the problem of pollution caused by fly ash, Ministry of Environment, Forests and Climate Change has issued various Notifications on fly ash utilization, first Notification was issued on 14th September, 1999 which was subsequently amended in 2003, 2009 and 2016 vide Notifications dated 27th August, 2003, 3rd November, 2009 and 25th January, 2016 respectively. The Notification of 3rd November, 2009 prescribes targets of Fly Ash utilization in a phased manner for all Coal/Lignite based Thermal Power Stations in the country so as to achieve 100% utilization of fly ash.

The latest MoEF&CC's Notification of 25th January, 2016 stipulates mandatory use of fly ash based products in all Government schemes or programmes e.g. Pradhan Mantri Gramin Sadak Yojana, Mahatma Gandhi National Rural Employment Guarantee Act, 2005, Swachh Bharat Abhiyan, etc.

12.1.4 Land Degradation

The thermal power stations are generally located on the non-forest land and do not involve much Resettlement and Rehabilitation problems. However, it's effects due to stack emission etc., on flora and fauna, wild life sanctuaries and human life etc. have to be studied for any adverse effects. One of the serious effects of thermal power stations is land requirement for ash disposal and hazardous elements' percolation to ground water through ash disposal in ash ponds.

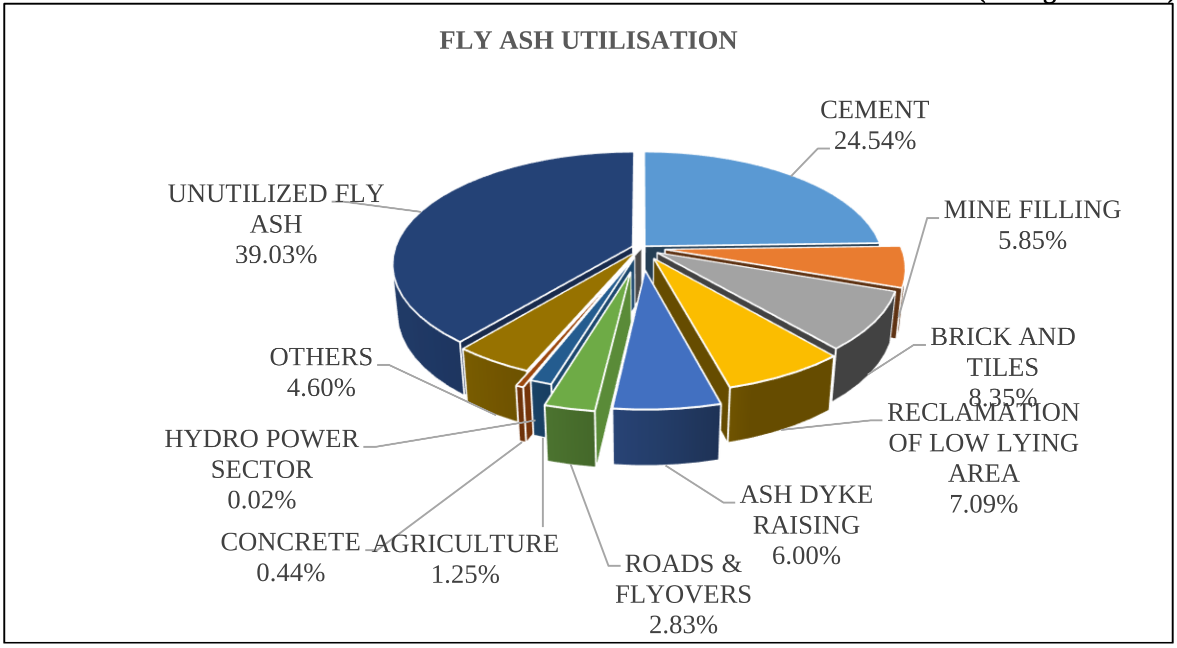
12.2 STEPS TAKEN BY THERMAL POWER STATIONS TO REDUCE EMISSIONS FROM POWER PLANTS

Following steps are presently being taken by power utilities to reduce the pollution from thermal power stations: -

- **SPM Emissions:** - High Efficiency Electrostatics Precipitators (ESP) are installed in the power station to arrest fly ash and reduce suspended particulate matter within the prescribed emissions norms. A SPM norm stipulated by MOEF& CC are generally adhered to by coal based power stations. However, depending upon the local condition, Pollution Control Board or other implementing agencies within the provision of Environment Protection Act has stiputed more stringent norms.
- **NOx Control**.:- Low NO_X burners are being used in the power station for NOx control through primary combustion control. The existing NOx emissions from coal based power station without having any secondary NOx control system is in the range of 600-1000mg/Nm3.
- **SOx control** – Indian coal used in the thermal power station generally has low sulphur content about 0.3% to 0.5% and SOx control is being achieved through dispersion from tall stacks provided as per the Regulations prescribed. In coal based units of 500MW and above and also at stations with capacity of 1500 to 2000MW, space provisions are required to be kept for installation of Flue Gas Desulfurization (FGD), if required, in future. In sensitive areas, the installation of FGD plants may be insisted upon by MOEF&CC even for station with smaller capacity. Flue gas desulphurization systems have been installed in few stations; wherever prescribed by the MOEF&CC.
- **Liquid Effluent Discharge**: - Effluent Treatment Plant is being installed to control parameters like pH, Free available Chlorine Suspended solids, Oil & Grease, Copper, Iron, Zinc, TDS & Total Suspended Solids. Many power stations have achieved zero liquid discharge. Most of the power plants are adhering to the norms stiputed.
- **Fly Ash Utilization: -** The steps have been taken by Thermal Power Stations to ensure 100% utilization of ash generated by them. The Fly ash collected in the dry form is being used for brick making, coal mines backfilling, road construction and cement manufacturing. Data of 151 coal based thermal stations, with an Installed capacity of 145044.80 MW, consuming coal of 536.64 Million tonnes and generating Fly Ash of 176.74 Million tonnes were analysed in 2015-16 by CEA. The analysis shows that country has achieved Fly Ash Utilization of 107.77 Million tonnes with percentage utilization of 60.97 % (However, the actual utilization of fly ash may vary from station to station). Fly ash utilisation in various sectors are shown in **Exhibit 12.1**.

Exhibit 12.1

(All figures in %)



- **Mercury emissions:**

  India has signed Minimata convention on legally binding instrument to protect human health & environment from adverse effects of Mercury in September 2014. Article 8 of the Minimata convention pertains to reducing mercury emissions to the atmosphere through measures to control mercury emissions from coal based power stations. The studies carried out by CIMFR, Dhanbad on mercury content in Indian coal has estimated mercury emission factor of coal as 0.14 g/tonne or 14ppm. Control systems provided for NOx and SOx (SCR and FGD) along with ESP also offer the co-benefit of mercury emissions control.

12.3 NEW EMISSION STANDARDS FOR THERMAL POWER PLANTS

MOEF&CC has notified new Environment norms for Thermal power station including Emission and Effluent discharge on 7th December,2015. The **Table 12.3 and 12.4** show the new environmental norms for thermal power stations which are to be complied at different time schedule.

Table 12.3

New Environmental Norms for Thermal Power Stations*

Emission parameter	TPPs (units) installed before 31st December, 2003	TPPs (units) installed after 31st December 2003 and up to 31st December 2016	TPPs (units) to be installed from 1st January 2017
Particulate Matter	100 mg/Nm3	50 mg/Nm3	30 mg/Nm3
Sulphur Dioxide (SO2)	600 mg/Nm3 for units less than 500MW capacity 200 mg/Nm3 for units 500MW and above capacity	600 mg/Nm3 for units less than 500MW capacity 200 mg/Nm3 for units 500MW and above capacity	100 mg/Nm3
Oxides of Nitrogen (NOx)	600 mg/Nm3	300 mg/Nm3	100 mg/Nm3

*To be complied within 2 years by existing stations and w.e.f 1st January,2017 for plants under construction.

Table 12.4

MoEF &CC WATER NORMS FOR THERMAL POWER PLANTS

S No.	MoEF &CC WATER NORMS FOR THERMAL POWER PLANTS
1.	All plants with Once Through Cooling (OTC) shall install Cooling Tower (CT) and achieve specific water consumption of 3.5 m3/MWh within 2 years of notification.
2	All existing CT based plants shall reduce specific water consumption up-to maximum of 3.5 m3/MWh within a period of 2 years of notification.
3.	New plants to be installed after 1st January 2017 shall have to meet specific water consumption of 2.5 m3/MWh and achieve zero water discharge.

12.4 IMPLICATIONS OF NEW EMISSION STANDARDS ON POWER SECTOR

The new norms stipulated by MOEF & CC cannot be met until new technologies like Flue Gas Desulfurization (FGDs) for SOx reduction and Selective Catalyst Reduction (SCRs) for NOx reductions are introduced.

The following technologies are available to reduce SOx emissions from coal based power stations:

1) Wet /Lime Stone Flue Gas Desulfurization
2) Spray Dry Scrubber
3) Sea Water Scrubbing

The following technologies are available to reduce NOx emissions from coal based power stations:

1) Combustion control
2) Selective Catalyst Reduction (SCR)
3) Selective Non Catalyst Reduction (SNCR)

To meet the new norms for SOx and NO_X reduction, coal based power stations will face lot of challenges. Some of the issues and challenges are discussed below.

For implementing SOx reduction, coal based power stations have to install flue gas desulfurization plants. It is estimated that around 16,789 MW of the coal based capacity will be affected due to non-availability of space for installing FGD plant. A land of 7 acres is required to install FGD plant for a plant of 2×500 MW. Also where space is available, FGD installation may require 2- 3 years for installation and involve a shutdown of at least 1-2 months. In addition to this, for an installed capacity of around 2 lakh MW, a large amount of limestone will be needed for operating FGD plants. The by-product of FGD plants is Gypsum. So the disposal of such large quantity of Gypsum will be an added problem. Installing of FGD plant shall increase the Auxiliary Power Consumption (APC) by at least 1% – 1.5 % affecting the overall Efficiency of the power plant.

For implementing NOx control, coal based power stations have to install Selective Catalytic Reduction (SCR) as combustion control system may reduce the NOx emissions to around 600-700 mg/NM3 only. However, in view of the new norms of 300 mg/NM^3, installation of SCR becomes must. The main challenge with SCR is that they have not been proven for high ash Indian Coal. Also space constraint/layout constraints is also expected to be a major challenge for installation of SCR. Also for operating SCR, large amount of Ammonia will be required involving challenges in transportation and storage of Ammonia due its toxic nature.

Apart from all the issues and challenges, availability of vendors to supply FGD and SCR in such a large quantity will be the main constraint.

12.5 CARBON EMISSIONS FROM POWER SECTOR

The world over consumption of fossil fuel is the primary contributing factor in the build-up of atmospheric concentration of GHGs like carbon dioxide resulting in Global warming. As per UN Human Development Report 2015, the per capita carbon dioxide emission in India is among the lowest and is estimated to be around 1.7 metric tonnes as compared to the world average of 4.6 tonnes per capita and 17.0 tonnes per capita for USA (**Table 12.5**).

Table 12.5

Per capita emission of CO_2 of different countries

Country	Per capita CO_2 emission in the 2011 (tonnes of CO_2)
India	1.7
USA	17.0
Australia	16.5
U.K	7.1
Japan	9.3
China	6.7
World	4.5

Source: UNDP Human Development report 2015

About half of total carbon dioxide from India is estimated to be generated from power sector. The other major contributors of CO_2 emission in our country are transport and industrial sector. CEA is annually estimating the amount of CO_2 emissions from grid connected power stations. The total amount of CO_2 emission from grid connected power stations in the year 2015-16 has been estimated at 846.3 million tonnes. Year wise carbon di-oxide emissions from Indian power sector during the last 5 years are given in **Table 12.6**.

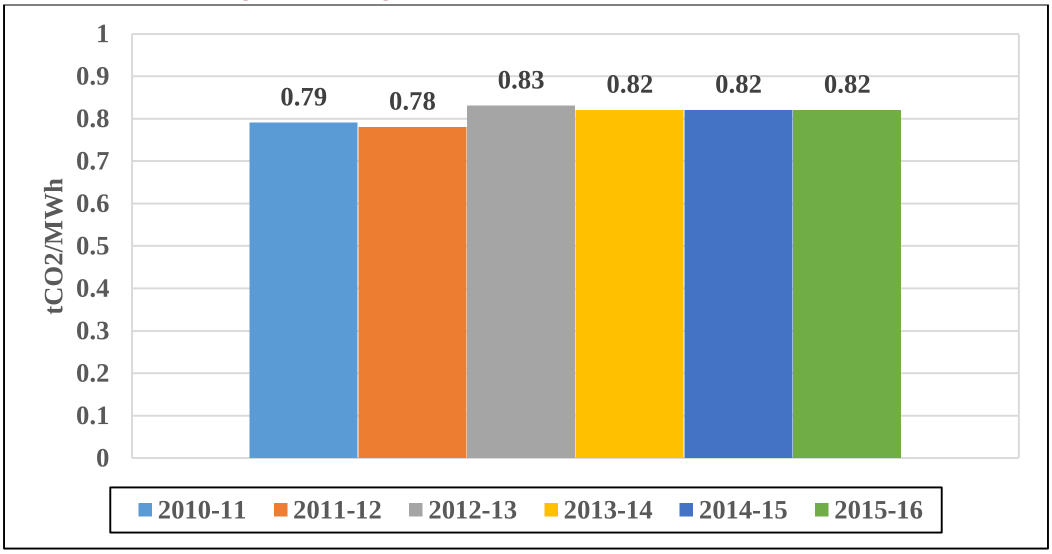
Table 12.6
Total Absolute Carbon Di-oxide Emissions of the power sector (2010-11 to 2014-15) in Mtonnes CO_2

	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
India	598.35	637.8	696.5	727.4	805.4	846.3

Source: CEA CO_2 baseline database for the Indian power sector version 11.0 March 2016)

In the year 2015-16, the weighted average CO_2 emission rate from grid connected power stations (excluding captive power stations and stations on islands and from Renewables) is 0.82 $kgCO2/kWh_{net}$. During the year 2015-16, the weighted average has increased marginally due to the increase in percentage of coal-based generation and decrease in hydro and gas based generation. Year wise weightage average emission factors are shown in **Exhibit 12.2**.

Exhibit 12.2
Weighted Average Emission factor in $tCO_2/MWh(net)$



Source: CO2 baseline database for power sector

The CO_2 emission from gas based power stations is almost half of that is generated by coal based power stations. The weighted average CO_2 emissions for various fossil fuels used in Indian power stations are shown in **Table 12.7**.

Table 12.7
Weighted average specific emissions for fossil fuel-fired stations in FY 2015-16, in tCO_2/MWh_{net}

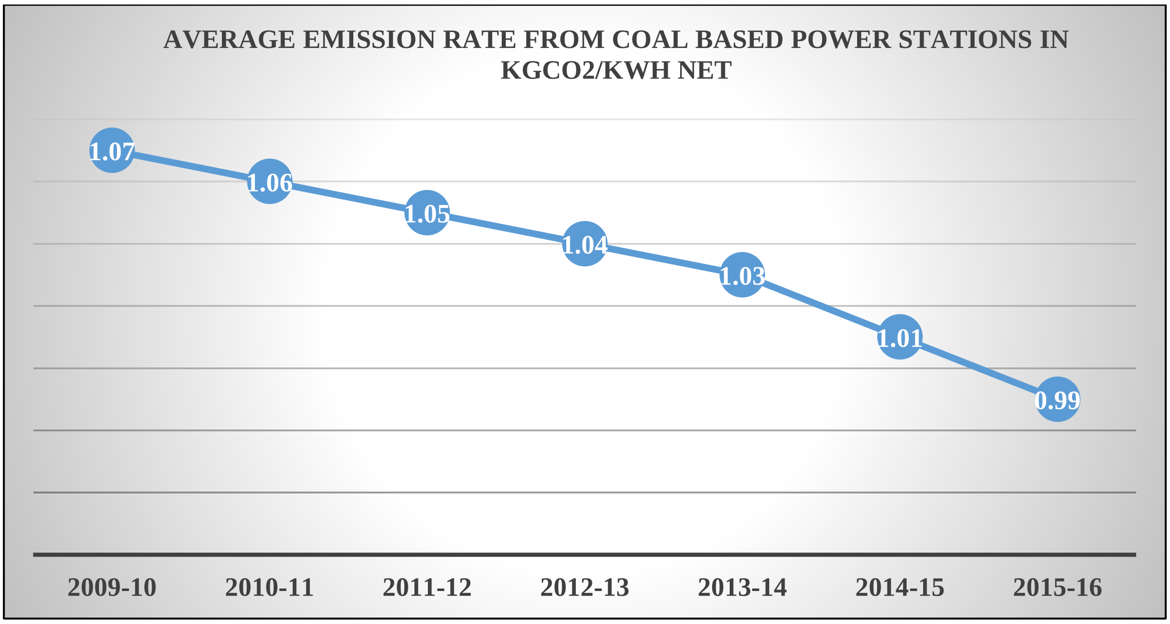
Coal	Diesel	Gas*	Lignite
0.99	0.57	0.46	1.36

* Only gas-fired stations that do not use any other fuel. Stations that use naphtha, diesel or oil as a second fuel are excluded from the weighted average.

The weighted average emission rate of coal and lignite based generation is 0.99 kg CO_2/ kWh_{net} and 1.36 kg CO_2/ kWh_{net} respectively during the year 2015-16. However, the average emission rate from coal based stations has been on declining trend due to the fact that more number of efficient supercritical technology based units are getting commissioned and also due to introduction of Perform Achieve and Trade (PAT) scheme which aims at improving the efficiency of power plants.

The **Exhibit 12.3** shows the declining trend of average CO_2 emission rate from coal based power stations.

Exhibit 12.3



12.6 IMPACT ON CO_2 EMISSIONS DUE TO CAPACITY ADDITION FROM SUPERCRITICAL TECHNOLOGY BASED COAL POWER STATIONS.

With the rapidly expanding thermal generation capacity, installation of large size supercritical units is being encouraged to enhance efficiency of power generation, reduce coal consumption and GHG emissions. Supercritical technology based units have about 2% more efficiency than sub critical technology based power plants. The country is going ahead with installing Supercritical technology based units in recent time. As on 31st March, 2017, 60 No. of units based on Supercritical technology have already been commissioned.

An Analysis has been carried out to estimate reduction of quantum of amount of CO_2 emissions by installing supercritical units in the country by 31st March,2017. It shows that about 20.69 Million tonnes of CO_2 emissions have been avoided due to commissioning of Supercritical technology based units assuming that business as usual scenario would have been commissioning of sub critical technology based units.

Details of the analysis is given in **Table 12.8.**

Table 12.8

Impact of Supercritical technology based units on CO_2 emissions

A	Total Generation capacity added from Supercritical units as on 31.3.2017	**41,310 MW**
B	Total actual gross generation from Supercritical units during 2016-17 in Million Units	**559,314.6 MU**
C	Business as usual :500 MW subcritical: estimated CO_2 emission (Kg CO_2/kwh Gross) [based on designed heat rate]	**0.853**
D	Super Critical Units: Estimated CO_2 emissions (Kg CO_2/kwh Gross) [based on designed heat rate]	**0.816**
E	CO_2 emission reduction {(C-D)/1000 x B in Million Tonnes	**(0.037*/1000) x 559,314.6= 20.69 Million Tonnes**

12.7 IMPACT ON CO_2 EMISSIONS DUE TO HUGE CAPACITY ADDITION FROM RENEWABLE ENERGY SOURCES.

Government of India has announced a huge capacity addition from renewable energy sources by the year 2021-22. Target installed capacity of renewable energy sources is set at 1,75,000 MW by the end of the year 2021-22 which includes 1,00,000 MW capacity from solar and 60,000 MW from wind, 15,000 MW from small hydro and biomass based power generation.

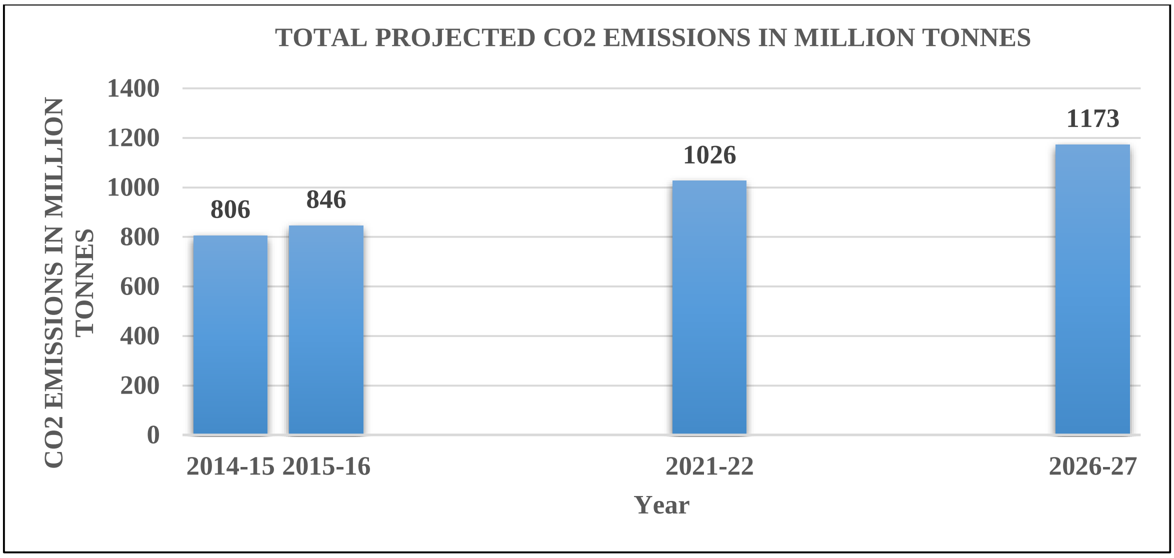
Based on the projections of capacity addition by 2021-22 given by Ministry of New and Renewable Energy, it is estimated that a generation of about 327 BU will be available from renewable energy sources. Assuming the present weighted average emission rate of 0.82 kgCO_2/KWh of Indian Grid, it is estimated that about 268 Million tonnes of CO_2 will be avoided annually by the end of 2021-22 from renewable energy sources. However, the net reduction of CO_2 emissions will be less as emissions from thermal power stations will increase due to frequent cycling and ramping of the plants than during steady state operation.

12.8 PROJECTIONS OF CARBON EMISSIONS IN 2021-22 AND 2026-27

On the basis of generation from each fuel source including renewables, carbon footprint i.e. projected carbon emissions and the emission factors considering base year of 2015-16 have been worked out.
Emissions factors (gCO2/MJ) as given for Indian Coal/Lignite in the Initial National Communication and for Imported Coal Gas/Oil/Diesel/Naphtha as given by Inter Government Panel on Climate Change (IPCC 2006) have been considered for estimating Carbon emissions from various fuels. The methodology as given in CO2 Baseline Database for the Indian Power Sector User Guide published annually by CEA has been followed in arriving the carbon emissions. Also, it is assumed that 75% of the coal generation will come from subcritical units and remaining from supercritical units in the year 2021-22. Further in the year 2026-27, it is assumed that 60% of the coal generation will come from subcritical units and remaining from supercritical units.

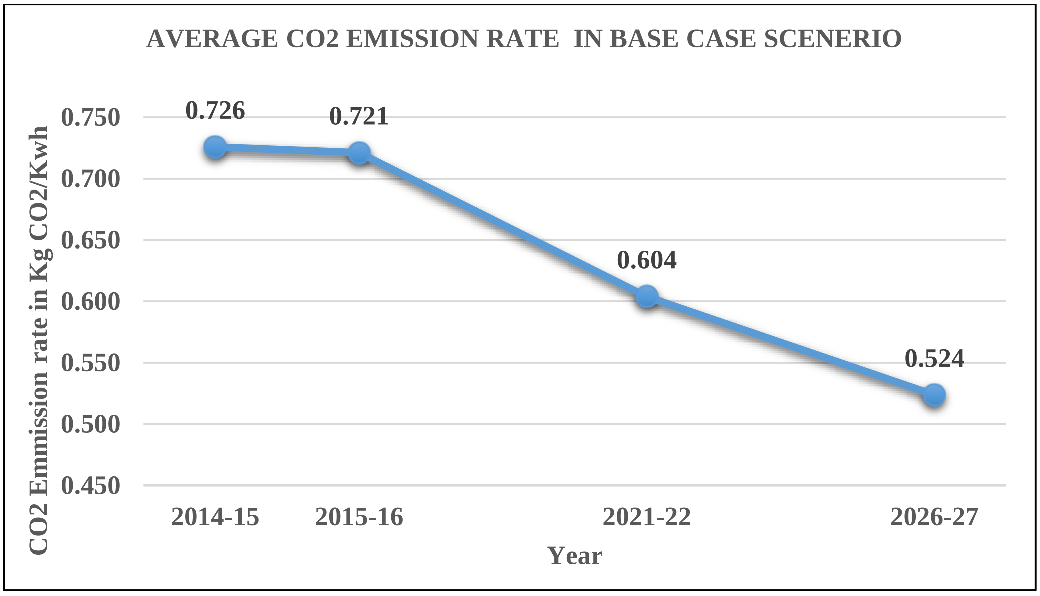
The total CO_2 emissions projected will increase from 846 Million tonnes in 2015-16 to 1026 Million tonnes in the year 2021-22 and 1173 Million tonnes in 2026-27 and are shown in **Exhibit 12.4.**

Exhibit 12.4



The average emission factor kgCO_2/kwh from the total generation including renewable energy sources in base case scenario has been estimated and are shown in **Exhibit 12.5**.

Exhibit 12.5



It may be seen that the average emission factor is expected to reduce to 0.604 kg CO_2/kWh in the year 2021-22 and to 0.524 kg CO_2/kWh by the end of 2026-27.

12.9 INITIATIVE OF GOVERNMENT OF INDIA TO REDUCE CARBON EMISSIONS

Mitigation of CO_2 emission is an important agenda on international level. Improving efficiency of thermal power stations is one of the effective methods to reduce CO2 emissions which is being achieved by various schemes introduced by Government of India like Perform Achieve and Trade Scheme under National Mission on Energy Efficiency and adopting super critical/ultra-super critical technology for coal based generation. Also efficiency improvement measures through Renovation and Modernization (R&M) of old and inefficient units is undertaken and units in which R&M is not possible are being considered for retirement. Thrust is being given for increasing the share of non-fossil fuel (renewable, hydro etc.) based generation in the energy-mix to reduce the CO_2 emissions from power sector.

12.10 COUNTRY'S STAND ON CLIMATE CHANGE- INDCs

Under the Copenhagen Accord, India had pledged to reduce its CO_2 intensity (emissions per GDP) by 20 to 25 percent by 2020 compared to 2005 levels. Also in October,2015, India had submitted its Intended Nationally Determined Contribution (INDC) to UNFCCC. The key elements are:

- To reduce the emissions intensity of its GDP by 33% to 35 % by 2030 from 2005 level.
- To achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030, with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

The studies show that the proposed trajectory of capacity addition programme for 2017-22 and 2022-27 is in line with India's submissions under INDCs. An analysis has been carried out and details are shown below.

12.10.1 Installed Capacity

As on 31st March,2017, share of non-fossil fuel based capacity (Hydro + Nuclear + RES) in the total installed capacity of the country is around 33 %. It is expected that the share of non-fossil based capacity will increase to 49.3% by the end of 2021-22 and will further increase to 57.4 % by the end of 2026-27. Details of expected installed capacity and % share is shown in **Table 12.9**.

Table 12.9

Installed capacity and share of non-fossil fuel

Year	Installed Capacity (MW)	Installed Capacity of Fossil fuel (MW)	Installed Capacity of Non-Fossil** fuel (MW)	%of Non-fossil fuel in Installed Capacity
March,2016	3,26,833	2,18,330	1,08,503	33.20%
March,2022	4,79,419	2,43,038	2,36,381	49.31%
March,2027	6,19,066	2,63,885	3,55,181	57.37%

** Non Fossil Fuel – Hydro, Nuclear and Renewable Energy Sources

Note: 1. Including 47,855 MW of Coal based capacity addition currently under construction and likely to yield benefits in 2017-22 and an additional 46,420 MW coal based capacity addition required during 2022-27 & a coal based capacity considered for retirement being 22,716 MW during 2017-22 and 25,572 MW during 2022-27.
2. The actual % may change to the extent of thermal capacity materialising and actual retirement taking place during 2017-22 and 2022-27.

12.10.2 Emission Intensity from power sector

The total CO_2 emissions from grid connected power stations in the country in the year 2005 was estimated as 462 million tonnes. The CO_2 emissions from power sector is estimated to increase to 1026 million tonnes by the end of 2021-22 and to 1173 million tonnes by the end of year 2026-27.

Table 12.10 shows the emission intensity (kg CO_2/₹ GDP) in the year 2005 and expected emission intensity (kg CO_2/₹ GDP) in the year 2021-22 and 2026-27 from Grid connected power stations. It can be seen that emission intensity is likely to reduce by 40.51 % by the end of 2021-22 and 53.65 % by the end of 2026-27 from the year 2005 level.

Table 12.10

CO_2 emissions Intensity from Power Sector

	Years		
	2005	**2022**	**2027**
Emission intensity kg/₹ GDP	0.015548	0.009249	0.007207
% Reduction in emission intensity base 2005		40.51	53.65

12.11 CONCLUSIONS

- Government of India has taken various measures to reduce environmental emissions from thermal power stations. This includes improving efficiency of power generation, notification of stricter environment norms and retiring old and inefficient plants, Perform Achieve and Trade scheme etc.
- The average CO_2 emission rate from coal based stations in the country has been on declining trend indicating improvement in efficiency of power generation from coal based power plants.
- About 20.69 Million tonnes of CO_2 emissions have been saved due to commissioning of Supercritical technology based units.
- It is estimated that about 268 Million tonnes of CO_2 will be avoided annually by the end of 2021-22 due to renewable energy sources.
- During 2015-16, the country has achieved Fly Ash Utilization of 107.77 Million tonnes with percentage utilization of 60.97%.

CHAPTER 13
R&D ACTIVITIES IN POWER SECTOR

13.0 INTRODUCTION

Research and Development in power sector of India is managed under Ministry of Power through three schemes namely In-house Research and Development (IHRD) of CPRI, Research Scheme on Power (RSoP) and R&D under National Perspective Plan (NPP). R&D is also undertaken by various ministries like MNRE, Department of Science & Technology, R&D laboratories of CSIR , Academia (IITs, NITs and Engineering Colleges) and by CPSU's BHEL, NTPC, NHPC, SJVNL, POWERGRID. Private sector companies, global R&D centers, etc also pursue it significantly. Many technological aspects, which are proposed for adoption in the country, are new from the perspective of Indian Power Sector. This includes the large capacities of superconducting generators, High Temperature Superconducting (HTS) power apparatus, Ultra/Extra high voltage transmission lines and its connected equipment, Gas Insulated Substation (GIS) as well as smart metering in distribution systems.

R&D activities and infrastructure developed by CPSUs, CPRI and MNRE during 12th plan were reviewed and projects which are important but could not be taken up under 12th plan are proposed for consideration during the year 2017-22. The following new developments have taken place in the last decade:

- Adoption of Supercritical technologies for thermal generation with large units of 660 MW and 800 MW capacity.
- Technology for Ultra High Voltage transmission of 800 kV DC, 1200 kV AC have been adopted. Some of the transmission lines of 1200 kV AC are in the process of being commissioned.
- There has been a greater emphasis on renewable sources of energy and Government of India has set a target of 175 GW generation capacity by 2022 consist of 100 GW from solar 60 GW from wind and 15 GW from small hydro and other renewable sources of energy. These developments have given rise to new challenges and issues in the power sector. Some of these include:
    - Integration of renewable energy generating sources with the Grid.
    - Impact of renewable energy generation on the existing and new coal fed generating stations.
    - Transmission corridor for evacuation of power generated from renewable sources
    - Microgrid and electricity solutions for remote isolated areas.
    - Adoption of micro grids and smart grids particularly in relation to efficiency of operation as well as to deal with the consumer related issues is very crucial for further development of Indian Power Sector. The adoption of large capacity generating units and high voltage transmission lines necessitated the adoption of state-of-the-art technology of high capacity transformers as well as grid safety, security and energy conservation.

13.1 R&D CHALLENGES DURING 2017-22 AND BEYOND

It is a known fact that technology can help in enhancing supply of energy at affordable price and deliver it efficiently, sustainably and reliably. The supply should be reliable with high degree of availability. However, the real challenge lies in creation of a conducive environment for R&D to flourish. The country so far has been in the fore front of technology deployment but not in development. Hence, a proactive policy approach for technology induction must be in place.

The in-house R&D arms of major CPSUs like NTPC, NHPC and POWERGRID aim at introduction and absorption of new technology by applied research primarily through project routes. Major manufacturers like BHEL, ABB, GE etc., have their own R&D set up, focusing on product development. Central Power Research Institute (CPRI) is provided with capital funds from the Ministry of Power for in-house research as well as funds to coordinate and manage MoP's research schemes. Central Electricity Authority (CEA) has to promote research in matters affecting the generation, transmission, distribution and trading of electricity. The policy of the Government is to promote R&D projects which would help the nation to become self-reliant in technology.

Funds are also earmarked under different schemes including the Deendayal Upadhyay Gram Jyothi Yojana (DDUGJY) for enabling investigations and technology development.

Research and Development in power sector and consequent changes have resulted in the development of a sound generation base, a reliable grid and a modern distribution system. Continued and sustained efforts are required through involvement of various science and technology laboratories like that of CPRI, CSIR, DRDO, BARC and cooperation from Government bodies like DST, DSIR and MNRE, for promoting technology in India.

In the present scenario, it is proposed to categorize R&D initiatives into five different conventional sectors, viz. Generation, Transmission, Distribution, Environment and Renewables including Microgrid.

R&D is a continuous activity. Integration of several technologies with techno-economic, statutory compliance and environmental considerations to be achieved over a long term scenario also plays role in deployment of a particular technology. Utilities work in competitive and regulated environment and adoption of technology depends on that also.

13.2 R&D INITIATIVES OF GENERATION SECTOR

The major challenge to the energy and power sector is to reduce and ultimately eliminate generation shortfall, to provide a reliable and cost-effective power supply to the customers, and to achieve it in a sustainable manner with minimum impact on the environment.

Generation sector is in the midst of a paradigm shift – one which has never been seen before in India. Moreover, the renewable energy plants have been classified as ‘must run’ plants. Also, most of the fossil fired plants are forced to operate at part load for sustained period. We have also moved progressively from coal shortage era to imported coal regime and now to coal surplus period. All these indicate that we are at the cusp of a new age where India will have to devise technologies and strategies to extract maximum benefit from renewable as well as conventional plants in a sustainable manner.

Though solar, wind and other sources of renewable energy have recently received much publicity; still the role of conventional generation continues to be critical. Solar and wind power are distributed sources which cannot be built at very high capacity levels or be centrally controlled. Moreover, they are dependent on weather conditions like wind levels and solar insolation, and so they may be unavailable for certain periods at a stretch and during this period, dependence would be exclusively on conventional power generating sources. Hence, huge opportunities to improve the generation system, including the aspects like better plant design, increasing efficiency, improvement in fuel quality and waste heat recovery system exist. The following are different technologies with proposed prototypes and pilot plant demonstration for implementation:

13.2.1 Thermal Generation

Some of the important areas of R&D in Thermal generation are identified for collaborative R&D.

13.2.1.1 Ultra Super Critical (USC) and Advanced- USC Plants

Ultra super-critical plants operate at higher temperature and pressure (approximately 600°C and 32 MPa) resulting in higher efficiency. These plants require low coal usage per kWh of electricity generated and have less CO_2 emissions. A few such plants have been built in Europe and Japan. The efficiency of these plants goes up to 44%. However, the extreme operating parameters impose stringent requirements on materials.

Considering that coal shall remain as the mainstay of India's power industry and the inevitability of global pressure, India should seriously focus to reduce emissions due to its own as well as global climate concerns. Development of Advanced Ultra Supercritical (Adv-USC) Technology for power plants has been taken as one of the four Sub-Missions as part of the National Mission under the guidance of the Principal Scientific Adviser to the Government of India. Under this initiative, it is proposed to develop and establish 800 MW Adv-USC Power Plant on a Mission Mode, as a collaborative project involving Indira Gandhi Centre for Atomic Research (IGCAR), NTPC, BHEL and CPRI. Material degradation issues and condition assessment programmes are also to be investigated.

Research to increase the steam parameter to 700°C from the level of 600°C and to increase the efficiency levels beyond 40% needs to be explored. The research in this area for the development of suitable materials to handle high temperature is already being coordinated by Government of India with the participation from BHEL, Nuclear Power Corporation Limited (NPCIL) and few experts in the country.

13.2.1.2 IGCC Technology

Integrated Gasification Combined Cycle (IGCC) integrates a coal gasifier, a gas clean up system and gas turbine in a combined cycle mode where coal is gasified with either oxygen or air. The resulting synthesized gas (or syngas) consisting of primarily hydrogen and carbon monoxide is cooled, cleaned and fired in a gas turbine. The technology has shown capability of power generation at higher efficiency and lower emission levels with respect to pulverized coal combustion technologies as demonstrated in the USA, Netherland and Spain.

The other important aspect of IGCC where technological advances are continuously made is the syngas cleaning especially at higher temperature. This removes the efficiency penalty of cooling the syngas to ~90ºC and again heating it to the required temperature for the gas turbine. These demonstration plants should have sufficient slip stream facilities where the upcoming warm gas cleaning technologies can be tested at actual operating condition.

Furthermore, IGCC technology opens up new product area along with electricity generation like liquid fuel generation, hydrogen production, pre-combustion CO_2 capture and integration of fuel cell which may provide future options of zero emission coal technologies with higher efficiency. There is a need to continue funding of such research with active participation of NTPC, BHEL and the leading State generation utilities.

13.2.1.3 Waste Heat Recovery Systems for enhancing the power plant efficiency.

The thermal power plants operating on Rankine power cycle normally achieve power generation efficiency in the range of 35–40% depending on various site conditions, turbine inlet steam conditions and design of equipment etc. Balance of the heat input is essentially lost as condenser losses (about 48–50%) and boiler exhaust gas losses (about 6–7%) besides other nominal losses viz. radiation losses, un-burnt carbon losses etc. In a 500 MW unit, about 25 MW of thermal heat would be available if the flue gas temperature is dropped, say, from 140°C to 110°C. The major challenge in low temperature heat recovery system is the requirement of large heat transfer area and thus additional pressure drops, which increases the cost of the system. Use of waste heat recovery system, though desired for obvious cost benefits, is equally important for environmental protection since lower quantity of fossil fuels shall be burnt for same quantum of useful energy.

Efforts are being made in developing technologies where waste heat can be gainfully recovered and applied to: (i) Produce refrigeration / air-conditioning using Vapor Absorption/Adsorption Machines based on Li–Br, Ammonia absorption system. (ii) Plant cycle efficiency improvement using condensate pre-heating and fuel oil heating (iii) Produce electric power independent of the main plant Turbine – Generator (TG) set using Aqua-Ammonia Cycle or Organic Rankine Cycle. (iv) Flue Gas Desalination of sea water (v) Flue Gas Cooling Tower Blow down recovery.

13.2.1.4 Bulk ash utilization

Coal-based thermal power plants have been a major source of power generation in India where about 61% of the total power obtained is from coal-based thermal power plants (on installed capacity basis). Fly Ash is a by-product material being generated by thermal power plants from combustion of Pulverized coal. High ash content is found to be in range of 30% to 50% in Indian coal. So far several uses of fly ash have been developed viz. substitute of cement in concrete, land filling, mine filling, agriculture, etc. Practically fly ash consists of all the elements present in soil except organic carbon and nitrogen. Thus, it has a great potential material with manifold advantages in agriculture. Research needs to be carried out in developing technologies for bulk utilizations of fly ash in other areas such as construction of roads, bricks etc.

13.2.1.5 Advanced surface engineering technologies for higher life expectancy of Thermal plant components

The surface engineering technologies are becoming essential in critical applications of power plants involving erosion as well as corrosion. Thus the immediate technological requirements to be addressed in respect of damage tolerance capacity of materials are:

(i) High temperature wear and erosion resistance of thermal components (Burner, liner, and shield).
(ii) Silt erosion resistance of hydro parts.
(iii) Cavitation problem in hydro turbines.

The other important investigations needed include the following:

- Design & Development of Last Stage Steam Turbine Blades and balancing of flue gas flow inside boiler for Improved Performance
- Identifying the impact of cyclic loading on power plant components due to increased renewable penetration in the grid
- Formulation of the methodologies for better plant performance under low load conditions
- Preparation of coal directory and develop software tools for helping operator for maximizing generation at lower ECRs with optimum blending of Imported and Indian coals
- Study of coal characterization and combustion characteristics using Drop Tube Reactors.
- Boiler combustion Computational Fluid Dynamics (CFD), CFD modelling of sub and Supercritical boilers
- Development of Nano particles for application in high thermal coefficient lubricants, additives in water to reduce evaporation losses.
- Automatic Voltage Regulator (AVR)- Power system Stabliser (PSS) Tuning of Generators through Modelling and Simulation Studies
- Application of Synchro phasors for Monitoring and enhancing power system stability
- Advanced Non-destructive Testing (NDT)/ Non-destructive Examination (NDE) based diagnostics and inspection tools for condition assessment of plant components such as in-situ inspection of low pressure (LP) Turbine Blades by Ultrasonic Phased Array method
- Design & development of Low Pressure Steam Turbine last stage blades through Computer Aided Design (CAD) modelling and CFD based analysis for determination of efficiency
- Modelling of utility boiler (250/500 MW) with simulated imbalance conditions and assessment on plant performance and control measures for achieving uniform flow conditions
- Development of proto-type new turbine blades
- Performance evaluation of new blades.
- Establishment of better coal storage facility
- Establishment of Advanced facilities for coal combustion / blended coal combustion evaluation studies
- Application of technologies for on-line measurements of coal flow, fineness, heating value, and balancing for combustion optimization in utility boilers
- Development of Hot Gas Clean-up Systems for Integrated Gasification Combined Cycle (IGCC).
- Optimization of boiler and turbine steam cycles and balance of plant for improved energy efficiency

Following are the areas of scientific support required by the Generating Stations:

- Quantitative and Qualitative analysis of deposit, solvent selection and post operational chemical cleaning recommendations for boilers.
- Robotic Inspection of Low Temperature Super Heater (LTSH) tubes without lifting tube panels.
- Alloy analysis for identification of material mix-up in boiler, turbine auxiliary, GT etc.
- Condition assessment of super heater / re-heater tubes of ageing boilers through accelerated creep testing.
- Metallurgical Failure analysis of pressure parts components etc.
- Wear Debris analysis – lubricating oils of rotating components.
- Deposits of boiler, condenser, Effluents, Ash, cooling waters, Coal, etc. using equipment like Atomic Absorption Spectroscopy (AAS), X-Ray Diffraction (XRD), Ion Chromatograph (IC), Total Organic Carbon (TOC) , Energy Dispersive X-Ray Analysis (EDAX) analyzer, etc.
- Monitoring of ion exchange resins & activated carbon for capacity and kinetics from stations
- Diagnosis of vibration problems of rotating machines
- NDE of boilers, steam turbine, Gas turbines and generator components, Health assessment and life enhancement using advanced Non-destructive analysis tools such as Dye penetration (DP), Ultrasonic tests, eddy current testing, video imaging, phased array testing, Time of Flight Diffraction (TOFD) etc.
- Condition Monitoring and life assessment of high voltage transformers through dissolved gas analysis (DGA), polarization and depolarization current (PDC), Recovery voltage measurement (RVM) and Furfural content & degree of polymerization.
- Specialized analytical support for characterizing the turbine deposits, corrosion products, heavy metals in effluents, etc.
- Switchyard condition assessment by early detection of incipient faults through Corona & Thermal scanning.

13.2.2 R&D in Hydro Generation Sector

The following are the R&D areas identified:

1) Vortex rope mitigation
2) Renovation, Modernization and upgradation (RMU)
3) Silt erosion: "Hard Coating (HP_HVOF- High Velocity Oxygen Fuel) on underwater parts is employed to mitigate erosion in underwater parts due to high silt and to increase the life of underwater parts". Improvement in this regards need to made.
4) Transient operation
5) Turbine assembly

Following key points are identified which can be addressed by further R&D:

- Effective technique for draft tube vortex rope breakdown, structural dynamic when vortex rope strikes to draft tube wall and causes damage due to cavitation.
- The causes of pressure recovery loss near the best efficiency point in draft tube.
- Dynamic pressure distribution and comparison between conventional and splitter blade runner.
- Correlation between pressure, stress, and strain to estimate the life cycle of runner blade.
- Fluid-structure interaction of guide vanes, vibration, and magnitude of forces on guide vane spindle of Francis turbine.
- Fluctuations in vane less space during turbine runner acceleration or deceleration and optimization of movement of guide vanes during turbine start-up after emergency shutdown of the Francis turbine.
- Transient dynamic behaviour and runner blade loading during no-load run/ runway, load rejection, and start-up as well as shutdown of the Francis turbine. A strategic start-up and shutdown technique of the Francis turbine may be developed.
- Integrated operation of cascade hydro power plants
- Optimization studies for exploitation of hydro potential
- Studies on benefits of pumped storage schemes in the Indian context for hybridization with the Renewable Schemes
- Use of Global Positioning Systems and Geographic Information Systems (GPS/GIS) in hydro potential studies and other areas.
- Numerical Flow Simulation using Computational Fluid Dynamics (CFD)
- Technology for Split Runners/ Site Fabrication of Runners
- Development of facilities for large size/weight casting and forging facilities
- Development of Shaft Seal for Silty Water
- Modernization of generators to increase efficiency
- Variable speed drive for pumped storage schemes
- Monitoring System for on-line measurement of Turbine Efficiency and Silt
- Monitoring cavitation causing Erosion
- Development of Poly Tetra Fluoro Ethylene (PTFE) material
- Measures to tackle corrosion/erosion problems in acidic water
- Construction Methodology for Arch Dams
- Reinforced Cement Concrete (RCC) Dams - construction techniques and construction material
- Measures to increase service life for silt flushing gates
- Excavation of large size cavern with stabilization technology and soft rock tunneling
- Measures to tackle bad geology in dam foundation and cut-off wall
- Power generation technology assessment and development
- Performance optimization of hydro plant components through Computational Fluid Dynamics approach.
- Design and development of model test facilities should be conducted for all unit sizes above 25 MW.

13.3 R&D IN TRANSMISSION

13.3.1 Adoption of Advanced technologies

Transmission towers and conductors play major role in power transfer. To meet the growing demand for power in urban and industrial areas requires transfer of huge quantum of power. Due to the constraints in getting environmental clearances, and acquiring Right of Way (RoW), introduction of compact transmission lines is an alternative choice. The compact transmission lines have the advantage of reduced RoW and reduced tower dimensions. The compact lines invariably require polymer or long rod insulators for effecting reduced dimensions of tower. Reconductoring of existing lines with High temperature Low sag (HTLS) conductor is a viable option to increase the power transfer capacity. Design aspects of compact towers and feasibility study of different types of HTLS conductors are to be explored for implementation.

Compact transmission line support using FRP is gaining importance and adopting compact transmission lines in Indian power network has become essential due to increase in load growth and difficulty in building new lines due to RoW issues. The main features of compact lines are reduced RoW and tower dimensions. The compact lines have reduced clearances and require polymer or long rod insulators for effecting tower dimensions. The aspects need to be addressed are: design, development and testing of 220 kV and 400 kV towers and implementation in a utility as a pilot project.

Keeping in view the bulk power transfer requirement development of high temperature electrical conductors for transmission lines is essential. The major challenges are to overcome the transmission losses, increase the power transmission on the existing lines and the development of more efficient power conductors for new lines. The development of efficient power transmission system seems to have the major stake in the future of transmission system and will become the national priority. One of the major requirements of conductors is to have high ampacity and low sag properties. In this direction, high temperature conductors which can withstand temperatures well above 250 °C are required to meet the growing demand to transfer power.

Recent developments have demonstrated that '6201' and 'Al59' are the two major alloy conductors in use. However, further enhancement is possible by designing new alloys and economically viable processing techniques. The present alloy conductors use alloying elements such as Zirconium (Zr) to restrict the re-crystallization temperatures of the alloy conductors so that the conductor can withstand high temperatures. The strength and conductivity of conductors need to have a best compromise so as to get the maximizing benefit during power transmission. Research in developing high temperature All Aluminium Alloy Conductors (AAAC) for transmission and distribution line applications is needed specially for developing new materials for this purpose. The high temperature conductor should have an allowable temperature of 300°C in emergency condition and 250-260 °C in continuous operation.

Design and development of seismic resistant substation is necessary to maintain reliability and safety of electrical equipment after an earthquake. This depends on the seismic response of individual substation components such as transformer, bushings, switchgear etc. The use of seismic qualification of electric equipment is one of the most cost effective methods for reducing the damage and disruptions from earthquake. Thus, equipment and supporting structures for power generating stations, and substations located in seismically sensitive regions / zones have to be designed and standardized to withstand possible earthquakes.

13.3.2 UHV DC +/- 800 kV

Considering the implementation of next High Voltage Direct Current (HVDC) transmission at +/- 800 kV, indigenous manufacture of equipment is required. The research focus will cover the following aspects: (1) DC electric field, corona studies on equipment and electrodes; (2) Effect of pollution on insulator surface; selection of insulator profile, configuration to withstand DC stress under normal and polluted conditions. (3) Performance of bushings under DC electric stress. (4) Effects of DC stress on transformer insulation, ageing studies, diagnostic tools (5) Overhead transmission Lines (6) Bushings and transformers.

Some of the other potential areas of research are as follows:

Voltage Source Converter (VSC) based HVDC transmission has become an attractive option for bulk power transfer between meshed grids. The advantages of VSC based HVDC transmission is: high controllability of active and reactive power at the converters terminal and the ability to improve the system stability. The project envisages design, development and deployment of 50 MW VSC based back-to-back HVDC system, as a pilot project study.

High Speed Grounding Switches (HSGS) for HVDC systems are required to connect the station neutral to the station ground in case the ground electrode path becomes isolated. The development of indigenous HSGS will be carried out as a pilot project study for installation at HVDC substation.

The concept of transformer less HVDC transmission is under active research at various institutions. A pilot project study is proposed to evaluate various aspects.

To adopt the VSC based HVDC transmission technology, High Speed Grounding Switches for HVDC systems and to absorb the concept of transformer less HVDC transmission system in power sector, pilot project study is required to be undertaken to gain the experience for wider acceptability and implementation.

13.3.3 Design and development of equipment for 1200 kV UHV AC System

Power sector growth necessitates development of indigenous technology for absorption in to the network at higher voltage levels, mainly to strengthen the system and power evacuation. The key equipment proposed for indigenous development are: 1200 kV sub-station, circuit breakers, shunt reactors and controlled shunt reactors for dynamic reactive power compensation. Development of High Energy ZnO blocks for lightning arrestor is required for dissipation of high energy. Development of operating mechanism for 1200 kV disconnector is essential in the light of UHV transmission system technology.

13.3.4 HVDC and FACTS

Efforts are needed for better utilization of the facilities that have been installed in recent years. System studies will be useful to evaluate the cost-benefit trade-offs for further use of these devices.

The key technologies that are being considered for development of controls, for EHV and UHV AC and DC transmission systems are, compact towers that significantly reduce RoW requirements, application of High Temperature Superconducting technology in developing transformers, cables, fault current limiters, motors etc., Gas Insulated Substations that require about 80% less area than conventional substations, substation automation and remote operation systems.

The technical developments in communication technology and measurement synchronization for reliable voltage Phasor measurements have made the design of system wide protection solution possible. The introduction of Phasor Measurement Units (PMU) has greatly improved the observability of power system dynamics. Based on PMU’s input, different kinds of Wide Area Protection, emergency control and optimization systems can be designed.

Additionally, Smart Grids to support utilities in making optimal usage of the transmission grid capacity and to prevent the spreading of disturbances are also being considered. By providing on-line information on stability and safety margins for dynamic condition monitoring, Smart Grids would serve as an early warning system in case of potential power system disturbances.

13.3.5 Development of controllers for FACTS devices

Application of Flexible Alternating Current Transmission System (FACTS) devices in Indian power system is proposed, extensively supported through system studies. Research in the direction of developing indigenous development of FACTS devices and its controls are essential and the objective is to design & develop controls for FACTS devices such as: Static Compensator, HVDC, multi-terminal HVDC, switchable shunt reactors, series and shunt HVDC taps, Unified Power Flow Controller (UPFC), Interline-Power-Flow-Controller (IPFC) & Static Synchronous Compensator (STATCOM) and deployment in network. The controller performance is to be studied in real time.

There is a need to develop controller for controlled switching of circuit breakers, which is used to close or open the contacts of circuit breaker by time dependent control of trip coils, to eliminate undesirable transients. Substantial research in this direction is required.

13.3.6 Automation

A pilot project may be taken up considering the advantages of process bus technology over the conventional station bus technology. Process bus technology has the advantage of reduced copper wiring, integration of any number of Intelligent Electronic Devices (IEDs) at bay level etc. Integration of optical current transformers (CTs) in place of conventional current transformer is also to be considered.

13.3.7 Innovative visualization with sustainable self-awareness feature

The perspective of the real time data set at different levels is required for different aspects. It is required to have customized and intended data set to be visualized for particular user/ Energy management systems (EMS) operator. The objective of innovative visualization with sustainable self-awareness feature is to serve real time data for different level of users with the specified authorization and based on their usability which leads visualization to self-awareness. The system will depict the required real time data efficiently with the expert system/intelligent system.

13.3.8 Next Generation Data Analytics in Energy Domain

Data Analytics for power system analysis could be efficiently implemented on Cloud Infrastructure. Project shall include the design and development of an application framework with Software Sub Modules for energy trading, billing, pricing and tools for load forecasting in the form of Software as a Service (SaaS). Data Analytics assist in analyzing specific consumer benefits, support efficient delivery and investment in the electric system, facilitate customer choice etc., on which exhaustive and heuristic analysis can be done.

Using Data Analytics, it is becoming possible to run simulations or models to predict the future outcome, rather than to simply provide backward looking data about past interactions, and to do these predictions in real-time to support each individual business action. While this may require significant changes to existing operational and Business Intelligence (BI) infrastructure, the potential exists to unlock significant improvements in business results and other success rates. Next-generation Analytics can support BI search tools that can find reports and generate Structured Query Language (SQL) queries, visual discovery tools to slice/dice data intuitively at the speed of thought.

Data analytics and tools can also be used for monitoring and improving the performance of utilities and generating stations. Some of the important topics for study should include the following:

Application & Features:

1) Advanced forecasting techniques for sustainable operations
   - Novel Forecasting Techniques
   - Advanced modelling tools
2) Architectures & tools for operations
   - Self- Healing Grids
   - Control Methodologies for Sustainable self-aware services
3) Simulators and training for operation of smart grids
4) Transmission system, real time security assessment
   - Innovative solutions to demands of real time security analysis
5) Prognostic Health Management in the Smart Grid.

Other major areas of focus are mentioned below:

- Real-time Power System Simulator
- Use of Space Technology in power system
- Forecasting Grid Congestion in Power System network
- Transmission Towers with reduced Right of Way
- System Security and Operator Training
- Calculation of Total Transfer Capacity, Available Transfer Capability

- Expansion Planning
- Transmission cost estimation
- Phasor Measurement Units (PMUs)
- Nitrogen Injection Fire Prevention & Extinguishing System (NIFPES) and fire prevention system
- Gas Insulated Transmission Lines (GITL)
- EHV Cables and submarine cables for bulk power transmission
- High Temperature Superconductor (HTS) cable system
- Superconducting Fault Current Limiter (SFCL)
- Superconducting Magnetic Energy Storage System (SMES)
- Composite insulators
- Synthetic and Natural esters for Transformer Oil
- Development of Cold-Rolled Grain-Oriented (CRGO) Silicon Steel for Transformer core
- High Quality Pressboard Insulation for transformers
- Resin Impregnated Paper (RIP) bushing
- SF_6 filled large capacity power transformer technology

13.4 R&D IN DISTRIBUTION

Distribution system has direct impact on the consumers. It is also an area in which there are significant challenges. A large share of system losses occurs in distribution circuits and a significant amount of power system investment goes in the purchase and installation of distribution hardware. Recently, the development of smart grid concepts and the use of solar power have changed the way in which distribution networks function.

The distribution sector requires most significant priority since the efficiency, financial viability and losses effect the viability of the total power sector as a whole. Various privatization models including franchising, Public Private Model, and others would need to be studied and comprehensive recommendations may be made State wise. The issues regarding refinancing of the debt to save on the interest burden on the utilities, bringing down the cost of procurement of power from outside the State need consideration. Hence R&D in distribution system needs impetus.

Distribution system needs careful attention in the areas such as reduction in losses, metering, distribution automation, planning, harmonic pollution, custom power devices, Demand Side Management (DSM) etc. High Voltage Distribution System (HVDS) is an effective method for reduction of technical losses and improved voltage profile. Application of IT has great potential in reducing technical and commercial losses. Integrated resource planning and demand side management also needs special attention and implementation. Substantial efforts are required for capacity building, so that the present day distribution system would be transformed into a modern day distribution system. Smart grid represents a vision for a digital upgrade of power distribution system to both optimize present operation as well as to open up new avenues for alternative energy production. Improvement in reliability of distribution network can be achieved with deployment of Supervisory Control and Data Acquisition/Distribution Management System (SCADA/DMS) for remote monitoring and control of various network elements, obviating need for manned substations. Distribution Management System (DMS) extends the monitoring and control functionality of SCADA to distribution transformers. Remote Terminal Units (RTUs) and Fault Passage Indicators (FPIs) are installed at substations.

Design Automation: Expertise is available for manual design of distribution networks. But it is a labor-intensive activity and often results in non-standard and sub-optimal designs. There is a strong need to standardize and promote design automation techniques which would reduce costs and improve performance.

Feeder Load Characteristics: Individual feeder loads differ widely in their behavior. A methodology needs to be evolved for studying feeders in order to characterize them. The technique should be relatively simple and trade off accuracy against efforts involved, since any distribution entity has a large number of feeders, and needs to accurately predict their contributions to the total load curve for the next day, so as to contract for energy supplies from generation companies.

Appropriate tariff models: Along with the usual charges based on monthly energy charges, it is possible to factor in charges based on time-of-day (TOD) and the ratio of peak time energy to average energy consumption. This can have the effect of reducing the overhead of the power sector infrastructure. But detailed studies are needed to evaluate the effectiveness of the scheme under typical Indian conditions, and to come up with the most effective tariff structures.

Load Shedding: Currently load shedding is generally carried out at the feeder level, with an entire feeder being disconnected as a single entity. With the facilities offered by smart grid, it is possible to be more selective, and enable the system operator to shed non-essential loads, while maintaining service to critical loads. With this flexibility, the system can be run more effectively, while critical loads having assured supply, less dependency on stand by genets. Detailed studies on this aspect will be useful.

Security and Protection: In conventional distribution schemes, loads are protected mainly through over-current relays and fuses. A smart grid has the facility to provide more sophisticated protection. In addition, the ability to operate the feeder through remote control opens up the possibility of load control in response to under-frequency and voltage collapse conditions.

13.4.1 R&D in Solar Organic Polymer based Light Emitting Devices

High power Silicon based Light Emitting Diodes (LEDs) are gradually making large in-roads as common light sources. However, huge capital investment needed to manufacture LED and huge breakeven point is a serious deterrent in this competitive world. It is important to note that incandescent, fluorescent and Compact Fluorescent Light (CFL) sources have been popular for decades at lower wattages and metal halide and sodium vapour lamps at higher wattages for large area lighting.

However, there is scope for development of organic polymer based electroluminescent light sources, which could compete with High power silicon based light emitting devices. The concept has been used and commercialized in some ways by leading manufacturers for backlit lighting of mobile phones.

13.4.2 Distribution Automation

The research work should be aimed at developing indigenous know-how of full scale Distribution Automation system, which can cover from primary substations to consumer level intelligent automation. The future research initiatives for power distribution automation are:

- Customer Level Intelligent Automation System
- Computer Aided Monitoring and Control of Distribution Transformers
- Substation and Feeder Level Automation
- Data communication system for Distribution Automation
- Development and Standardization of Distribution Automation software

13.5 R&D IN RENEWABLE ENERGY

Hydrocarbon resource limits are bound to force the world away from fossil fuels in coming decades. In addition, the environmental and health burdens arising out of the use of hydrocarbons may force mankind towards clean energy systems. Therefore, there is a need for electric power industry to look at other technologies of power generation through solar, wind, biomass, small hydro, fuel cells, geothermal, tidal etc.

Technologies related to wind, biomass, solar, small hydro, geothermal, fuel cells, Waste to Energy (WtE) need to be identified. Research focus is on grid connectivity of large wind mills, self-healing wind generation connected micro-grids, distributed generation and large use of ethanol and hydrogen for energy products. Development of micro and mini grids and larger penetration of renewable energy is an important area of research

The R&D activities in the field of New and Renewable energy includes the following:

1) Development of micro grids and suitable control mechanism.
2) Energy storage: electrical and thermal storage with enhanced charge-discharge efficiencies and new technology routes.
3) Indigenous development of floating Solar Photo-Voltaic (SPV) stations.
4) Development and demonstration of lead redox flow battery system for solar energy storage and retrieval
5) PV degradation studies and identification of best suited technology for maximum solar PV generation
6) Indigenous development of wet and dry robotic cleaning system for PV modules.
7) Development of super hydro phobic coatings for PV modules.
8) Utilization of Unmanned Aerial Vehicles (UAVs e.g. DRONE) and Light Detection and Ranging (LIDAR) for PV Plant inspection
9) Utilization of concentrated solar thermal energy for Cooking systems, desalination and cooling systems
10) Development of solar thermal and fossil hybrid power plants. Development of the hybrid technology as combination of conventional and any of the renewable sources (solar/wind/biomass etc)
11) Development of Centralized Solar PV Forecasting Solution
12) Development of new technologies like Quantum dots, multi junction cells and third generation technology like solar panels which utilizes ultra-violet (UV) and infrared-spectrum which ultimately increases the efficiencies of cells.
13) Distinct Focus on both small wind and large wind systems as the technologies and their deployment are vastly different
14) Low wind speed turbine development (India has very few locations with high wind speeds)
15) Development of low cost material for small wind turbine blades and tower

R&D in renewable energy includes different technologies which are listed below:

1) Integration of renewable energy with the power grid
2) Cost of storage in case of solar energy and wind power
3) Bringing down the cost of solar PV cells and wind power generation
4) O&M issues of renewable energy generation
5) Tackling with the End of Life of Solar PV modules

The main areas of R & D in renewable generation are:

- Primary converter: developments for enhancement of efficiency, cost reduction and new technology routes.
- Electrical energy distribution and grid connectivity: conventional grid-renewable grid ties, micro grids, domestic grid tied systems, etc.
- End use equipment for efficient interface to renewable power.
- Research to bring down the cost of solar PV cells as well as the storage batteries applicable for distributed generation system especially in rural areas.
- Develop design principles of deciding on to the capacity of battery systems.
- Recommendations regarding most appropriate technology for hybridization of solar and wind power for meeting out the demand uniformly for all the 24 hours in accordance with demand profile.
- Design and Development of Solar PV based Super- Efficient Agricultural Pumps and Hybrid Multidimensional Inverters
- Grid safety and security considerations.
- Development of suitable and efficient energy converter from source to load that may involve prime movers, generators, and power electronic controllers.
- Effect on the conventional thermal power generator and any design modifications required to cope up with the variable nature of solar and wind power and take lessons from other developed countries like Germany/Japan.

These studies would make recommendations for the following:

- Extent of backing down on the conventional coal fired thermal generators and total number of such operations during the life time of plant.
- Any changes required on the generator in electrical insulation to cope up with such operations.
- Any changes required of the materials of construction of turbine rotor blades, generator rotor, insulation, etc., for future applications with greater induction of solar and wind power.

13.6 R&D IN MICROGRIDS

A Microgrid is a local energy grid with controlled capability which means it can disconnect from the main grid and operate autonomously. The grid connects homes; business and other building to central power resources which allow the use of appliances, heating/cooling systems and electronics devices. But this interconnectedness means that when part of the grid needs to be repaired everyone is affected. A Microgrid generally operates while connected to the grid, but importantly it can break off and operate on its own using local energy generation in time of crisis like storms or power outages or for other reasons. Microgrid can be powered by distributed generators, batteries and renewable resources like solar panels. Depending on how it is fueled and how its requirements are managed, a Microgrid might run indefinitely. Microgrid connected to the grid at a Point of Common Coupling (PCC) that maintains voltage at the same level as the main grid unless there is some sort of problem on the grid or other reasons to disconnect. A Microgrid not only provides backup for the grid in case of emergencies but can also be used to cut energy costs or connected to local resources that is too small or unreliable for traditional grid use. The microgrid allows communities to be more energy independent and environmental friendly.

Microgrids can be described by one of four categories:

- Off grid Microgrids including islands, remote sites and other microgrid systems not connected to local utility network.
- Campus Microgrids-That are fully interconnected with a local utility grid but can also maintain some level of service in isolation from the grid.
- Community Microgrids-Integrated into utility network.
- Nanogrids- Comprise of smallest discrete network units with the capability to operate independently.

13.6.1 Impedance Emulator

Switched impedances are needed to correct power factor in Micro-grid systems. In the case of switched systems many inductors or capacitors are connected. A solid-state equivalent of a motor generator (MG) set to test battery powered inverters is developed. These inverters (Equipment Under Test - EUT) are to be loaded with variable inductor, capacitor, or even resistors. However, to reduce the resistive losses and yet maintain high power factor and low Total Harmonic Distortion (THD) on the EUT, a novel system need to be developed, which is similar to an electronic Motor Generator set. This can also be deployed as a Pulse Width Modulated Power (PWMP) factor correction system in micro grids.

It is well known that renewable energy resources are distributed throughout the country. Wind power is available in southern and western parts, whereas solar power is available in north western, central and northern parts of India. Similarly, small hydel potential is identified in the Himalayan and North-Eastern parts of the country. Apart from these renewable energy resources, biomass potential is also identified in few Indian metro cities.

To meet the power demand of the country, in particular the un-electrified rural Indian population from the sustainable energy resources in a reliable manner, the hybrid combination of conventional and non-conventional resources in off grid and grid connected mode are potential power solution in Indian context. Tapping power from these resources and integration with the national grid is a very challenging issue. It involves delicate operation and control, interfacing, storage, generation/load forecasting and regulatory issues. Even though in India, we have few simple micro-grid (having only one or two resources) in operation, their application is mainly focused only on power production and lacks research and development activities. Therefore, there is immediate requirement for renewable energy based micro grid as a reliable solution for electrification of power isolated area.Govt. of India has an extensive plan to generate more green power from sustainable renewable energy resources. Therefore, a modern state of art micro grid research infra-structure is highly required in India for carrying out extensive research in this area.

13.7 R&D IN COMMUNICATION SYSTEM

Though the telecommunication sector initially started with transmitting voice over wired lines the telecom companies have diversified into multimedia, wireless communication etc. in a big way. Electrical utilities have started finding benefits from advances in communication technology. People did try to develop Power Line Carrier Communication (PLCC) separately riding purely on power lines itself. But it failed due to impedance offered by power network. Power Grid is already planning to deploy fiber optic cable network along the entire transmission system across the country. It must be noted that electrical network is one of the most widely dispersed networks along the length and breadth of the country.

Alternatively, it is suggested that the electrical utilities (transmission and distribution together) run fiber optic cables along HT lines down to the ultimate consumers. These cables could be laid alongside HT cables and even on 11 kV lines and down to 3 phase LT lines along the same cable, in the same trench, on the same pole and maintained by the utility. The utility uses it for its own data communication and could lease it to cable operators for a fixed extra monthly income. The Telecom Regulatory Authority of India (TRAI) regulates bandwidth for wireless radio frequency and not for fiber optic lines. Utility can plan for laying underground pipes to carry both power lines and also draw about 10 fiber optic lines in all new trenches. TV, computer network terminations should have fiber optic modem or set top box interface modules- if not available, it should be developed indigenously. This will make the city/ town free from hanging wires, reduce road digging by multiple entities and bring in discipline among utilities.

Microwave towers are considered to pose health risks also by some. Also many companies are working on Light Based Field Interface (LIFI) as alternative to Wi-Fi. LEDs can also be used to carry signal information superimposed on its powering current. Fluctuations in lumen output will not be noticeable. This is not possible with incandescent bulb or metal halide or sodium vapour lamps as bandwidth is low.

13.8 R&D IN ENVIRONMENT

The need for electricity generation to be clean and safe has never been more obvious. Environmental and health consequences of electricity generation are important issues, alongside the affordability of the power which is produced. Production of electricity from any form of primary energy has some environmental effect. The power sector in India is one of the largest emitters of CO_2. The share of the power sector CO_2 emissions in the total CO_2 emissions in India is higher than the global average. The main reason for such a high share is the power sector’s heavy reliance still on coal.

There are various technologies and processes that have substantial potential to reduce Green House Gas (GHG) emission. Clean coal technologies and renewable energy usage have been adopted by India as methods of best approach to tackle climate change issues.

Along with all these methods, further steps can be implemented for reduction of CO_2 emissions. These are research and development; information and education (for awareness); economic measures; regulatory measures; and voluntary agreements. Each step offers advantages and drawbacks and has different effects on CO_2 reduction. Low carbon generation options, nuclear and renewable technologies, are needed to substantially reduce emissions. Due to the high ash content of Indian coal, oxy-fueling and post combustion CO_2 capture would be suitable options for India. Pre combustion capture in a coal fired IGCC plant would require the adaptation of the technology to the Indian coal quality. Retrofitting coal power plants with CO_2 capture technologies could be an option to achieve clean coal technology.

Developments of following technology ready methods are being tried:

1) Use of CO_2 for reduction in pH of ash water
2) CO_2 capture by Modified Amine Solution
3) Development of Pressure Swing Adsorption (PSA) process for CO_2 capture and conversion of CO_2 into useful products

PSA is a technology used for separation of some gas species from a mixture of gases under pressure according to the species' molecular characteristics and affinity for an adsorbent material. Special adsorptive materials (e.g. Zeolite) are used as a molecular sieve, preferentially adsorbing the target gas species at high pressure. The process then swings to low pressure to desorb the adsorbent material.

Clean environment mechanism at thermal power stations, creating data base for ash quality, advanced ash management schemes, sustaining coal based power generation considering new and emerging environmental issues, effects of electromagnetic (EM) waves on human beings with specific reference to up-gradation of transmission voltages, eco-design and energy efficient power transformers, development of waste water treatment & recycling technologies, emission control technologies for NOx, SOx and mercury are some of the areas where R&D activities are required for improvement of environment and for sustainable development.

13.9 INFRASTRUCTURE FOR TESTING AND CERTIFICATION

In order to support the ambitious schemes of Government of India like "Make in India", "Start-up India" etc., and the need for maintaining quality and reliability of products manufactured in India, there is a need for infrastructure development and setting up of regional testing laboratories to help small scale and medium entrepreneurs for producing quality power products in India. CPRI is well equipped for testing and certification of electrical product and Government of India has been supporting the infrastructure development for testing. However, there are certain test requirements for which facilities are not presently available either at CPRI or in private laboratories in India. Based on the discussion with manufacturers and Power utilities, the following have been identified as new areas for which testing facilities are to be established in a phased manner during the years 2017-27.

A) Testing of Power Equipment/Apparatus/Systems
Testing of Capacitor Voltage Transformer

- Pressure test for the enclosure (cl.7.2.9 of IEC 61869-5:2011)
- Type tests for carrier frequency accessories (cl.7.2.505 of IEC 61869-5:2011)
- Type tests for carrier frequency accessories (cl.7.3.502 of IEC 61869-5:2011)
- Mechanical test (cl.7.4.5 of IEC 61869-5:2011 std) - To be augmented
- Enclosure tightness test at low and high temperatures (cl.7.4.7 of IEC 61869-5:2011) Gas dew point (cl.7.4.8 of IEC 61869-5:2011 std)

There is also a need to upgrade the following facilities in the next five years.

- Upgradation of temperature rise test facility on Voltage Transformers
- Augmentation of electrical endurance and overload test facilities up to 2000A, 660V for LV Switchgear and mechanical endurance test facility for LT & HT Switchgear as per IEC Standards.
- Multiple current injection set for temperature rise test for LT Switchboards as per IEC 61439-1 & 2
- Impulse analyzing system for 800 kV, 20kJ impulse generator
- Mobile test facility for conducting routine test and special test on transformers up to 5 MVA, 33/11 kV rating
- DC test facility for MCCBs, MCBs, switches and contactors
- Transient recorder for short circuit test
- Test facility for low current interruption test on load break switches, disconnector, HT/LT contactors etc.
- Test facility for capacitor switching test for back to back capacitor bank breaking current and in rush breaking and making current as per IEC 62271-100
- High voltage station testing transformers 245 kV, single phase – 3 Nos.
- Make switch 17.5 kV, 265 kApk.
- Automatic power factor controller on 33 kV side at 33 kV substation

B) Evaluation of Insulators

- Ageing test on polymeric insulator –
- Solid layer test facility for up to 400 kV insulators
- Flashover test on 220 kV & 400 kV insulators

C) Testing of composite insulator Steep front impulse test

D) PMU Testing and Certification

Extensive research work in the field of PMU technology is required for the Nation. The important areas of research are State Estimation, development of algorithm for optimal placement of Phasor Measurement Unit (PMU), calibration of PMU under steady state and dynamic conditions, voltage stability monitoring, phase angle monitoring, frequency monitoring, inter area oscillation monitoring, fault location, development of controller, development of wide area protection schemes, Remedial Action Schemes (RAS)/System Integrated Protection Schemes (SIPS).

There is a need to gear up for performance tests as per IEEE C37.118.1, 2011, IEEE C37.118.1a, 2014, IEEE C37.242, 2013.

E) Substation Automation

In the area of substation automation, the following facilities require consideration.

- Conformance test facility for process bus devices and IEC 61850 for switches used in the substations.
- Communication protocol conformance test facilities for Distributed Energy Resources (DER) system, Substation to Substation and Substation to Control Centre systems and devices.
- Test facility for cyber security conformance and assessment.

This includes Optical CTs and PTs, Sample devices (Merging units) and software based conformance test tools as per IEC 61850 requirements for merging units, switches, substations and control centres.

F) Electric Power Cables

- Establishment of Power cables laboratory for test facilities up to 765 kV.
- Up gradation of reactor module to 900 kV
- Setting up of Partial discharge laboratory for testing equipment rated up to 765 kV with accessories like coupling capacitor, divider, etc.
- Development of suitable insulation materials for DC cables
- Setting up of test facilities like super imposition test and polar reversal test.

G) Setting up of Superconducting Electrical apparatus laboratory for testing of transformers, motors, fault limiters etc.

H) Creation of facilities for testing and evaluation of Cryogenic systems for high temperature superconducting based power apparatus like, Superconducting Magnetic Energy Storage (SMES) devices, motors, transformers etc.

I) Evaluation of Conductors

- Creep test (elevated temperature)
- Sag Tension Performance.
- Temperature Cycle test
- Stress-Strain test on Stranded Conductor and Core at elevated temperature.
- High Temperature Endurance & Creep test on Stranded Conductor.

In addition to the above test facilities, in order to support the ambitious Government of India schemes like “Make in India”, “Startup India”, there is a need to establish more regional testing and Research Laboratories and incubation centers under the Central Power Research Institute. The regional laboratories can also help in setting up of many Microgrid projects to exploit the opportunities presented by renewable sources of energy. These Centres can supplement government programmes which are intended to provide 24 X 7 electric power to all, especially in the rural sector.

Sufficient funds should be made available for setting up of new Regional testing and Research laboratories for speedy implementation of projects envisaged for the growth of Indian Power sector.

13.10 CHALLENGES IN TECHNOLOGY MANAGEMENT

There are certain key considerations for administration of an effective and commercially viable R&D programme to compliment the Government of India schemes. Some of these aspects are as follows.

13.10.1 Role of CPRI in the management of R&D in Electrical Power Sector

CPRI plays a crucial role to promote and execute R&D activities in power & energy sector for the country. R&D component of CPRI activities must be considerably enhanced with added inputs and emphasis. This requires appropriate modifications of policies. Proper demarcation of activities under R&D, Test & Certification, and Quality assurance is needed internally. The task ahead is to create and consolidate suitable R&D infrastructure and effectively execute relevant activities suited to the country. There should be a distinct and separate R&D structure at CPRI with specialized infrastructure and expert manpower to work exclusively on critical and futuristic technologies as needed by the stake-holders.

CPRI's interaction with Academia and R&D Organizations and premier institutions like ISRO, BARC and CSIR needs to be further strengthened to generate synergy and avoid duplication of expensive infrastructure. CPRI has to be strengthened for consortium mode of R&D involving Academia, Industry and Utilities.

CPRI scheme of involving expert consultants and visiting professors should be effectively leveraged further to form an expert base to guide the academic and research programs undertaken through R&D projects. Leveraging National Knowledge Network (NKN), a National Data base of Power & Energy Experts drawn from CEA, IITs, NITs, PSUs, MNCs, PIOs and Private sector has to be created to tap core expertise for R&D.

International collaboration on R&D activities must be pursued vigorously by CPRI to achieve 'Vision of Excellence' to reach global standards. This includes collaboration arrangements with centres of excellence of advanced countries.

13.11 INITIATIVES FOR IMPROVING R&D IN THE POWER SECTOR

13.11.1 Reliability & Asset management of existing T&D system components

As India plans for 1200 kV transmission system, an authentic database of the reliability of the existing systems and apparatus up to 400 kV class will be the basic need. We have apparatus in the power system which are as old as 50 years and more but are performing satisfactorily. A national diagnostic and reliability assessment plan of the Indian systems as a joint study plan between the various utilities and the manufacturers will give tremendous knowledge base and learnings as we migrate to higher and higher voltage levels of transmission and associated apparatus. A 'national classified registry' could be created about the reliability of the Indian power network based on the diagnostic studies.

13.11.2 Need for creation of globally recognized 'Centres of Excellence' under national mission

There is a need to identify the 'R&D needs' of various sectors and various stake holders, and create 'Centres of Excellence' across the nation at various selected organizations in identified technical areas. This should be a national R&D priority. The competence level of the experts, the sophistication of the infrastructure, the quality of research programme undertaken, the quality of outputs, the Intellectual Property Right (IPR), etc. must be nurtured incentivized and promoted.

CPRI being the prime R&D organization for the electrical power sector should convert and create 'Centres of Excellence' in many areas such as 'Advanced Polymers for Electrical Applications', 'Electrical Insulation Materials & Processes', 'Power System Analysis', and 'Advanced Diagnostics for Power System Components'.

13.11.3 National R&D programmes

The two national R&D programs of the Ministry of Power, RSOP and NPP, administered through CPRI in consultation with CEA have given a good boost to the R&D efforts of the Utilities, Academia, R&D organizations, and the Manufacturers. They have helped in building R&D infrastructure in many organizations over a period of time.

The guidelines and the methodology of selection, monitoring, and reviewing of the funded R&D projects need to be online and through IT enabled R&D management system. Further a national level 'R&D project digital data base' of all nationally funded major projects will help in realization of the R&D objectives. A suitable online R&D management system needs to be in place, primarily at CPRI, and also across the other national R&D centres of importance.

13.11.4 Competence mapping and competence nurturing

India has one of the largest scientific and technology pool in the world. Many of them are national and international level experts. There is a need to scientifically measure the competence level and competence areas of the experts and the organization to classify the country's expertise level on various areas. This would help in deploying the right scientific input to a given R&D project. The 'measurement matrix for competence mapping' has to be created and the experts and expert organizations are to be evaluated against the norms stipulated. This will help in creating a 'knowledge bank of country's expert resources', rather than arbitrarily rating the country's expertise and the experts in various areas. The upgradation of knowledge level through training could thus be more structured and measured. India's key technical competence areas, the competence level of various R&D organizations, the competence level of the experts, etc. can be documented for improvement purpose.

CPRI, CSIR, DRDO laboratories who are involved in many R&D programmes, may benefit substantially by evaluating the core competencies of the organization in various areas, and could be a scientific basis for creation and monitoring of 'Centres of Excellence' in their identified core competence areas. This could be a national R&D mission project.

13.11.5 'Knowledge Academy' in the area of Electrical Power

There is a great need to provide a 'reservoir and a continuous pipeline' of qualified and competent technical and scientific workforce in the area of electrical power. There is urgency to create a 'CPRI Academy' to provide structured courses on electrical power to fresh and experienced engineers who will contribute to the technology base of the country. It may be like an autonomous University, providing basic level and advanced level theoretical and practical courses to engineers. With more and more engineers opting to software related career, there is a great dearth of skilled and practical electrical engineers in the country with adequate domain knowledge.

13.11.6 Intellectual Property Right (IPR) Management Cells in National Level Laboratories

There is an urgent need to promote awareness related to IPRs amongst the scientists and technologists. An 'IPR cell' with IPR policies and procedures need to be formulated to suit the need and purpose of the national R&D organizations. The IPR cell should be manned by experts who are skilled in training the scientists of the organization, setting IPR targets, and facilitating the innovation management of the organization.

13.11.7 Initiation of Mega projects of disruptive technologies

Disruptive technologies provide quantum jump in the technology advancement. All the breakthrough developments have happened essentially through material / system developments. There are very few R&D projects of this category in the electrical power sector. Mega projects like super conductor based fault current limiters, and transformers have been in the research mode for quite long, as also research in the field of combustion process, gasification process, nano-technology, high temperature steels etc. CPRI could coordinate a well-planned mega research scheme in many of these areas under NPP scheme of larger dimensions. 'Wireless power transmission' is another disruptive breakthrough. R&D project to be initiated as collaborative project with huge impact in the electrical power sector.

13.11.8 Easing the Market entry for newly / indigenously developed power products

In the context of Power Sector, many indigenously developed products, especially those involving substantial developmental investment, face entry barrier in the form of qualification requirements pertaining to equipment performance over a minimum period specified by end users. Though this has arisen out of genuine reliability concerns of new products, this provides some inertia for indigenous development. Users' interests can be safeguarded by the product developers by way of recourse to deferred payments, extended guarantees or insurance cover to indemnify them against the risk of failure. Further, development of indigenous products must be encouraged by providing an opportunity to the developers to carryout field trials on no cost basis. This has to be considered to promote national R&D efforts.

There is a need for enunciation of a clear policy / guideline to provide incentives for the commercialization of products developed through indigenous R&D efforts. The incentive could be among others, in the form of excise duty exemption at least for a period of five years from the date of commercialization.

13.11.9 Strengthening of the R&D Infrastructure

R&D Infrastructure at National Level needs strengthening in terms of facilities especially for type testing of prototypes with a view to minimize development / commercialization cycle. Many cases exist where the customers prefer overseas test reports as sufficient facilities do not exist in the country. A national audit may be conducted through Industry and utility forums to identify the gaps and efforts should be made to bridge the gaps.

13.11.10 R&D Mechanism

Research and Development towards innovative technologies has always been crucial for meeting future energy challenges. The requirement and capacity to apply sound tools in developing effective Research and Development (R&D) strategies and programs is becoming increasingly important. The need to promote development and refinement of analytical approaches to energy technology analysis, R&D priority setting and assessment of benefits from R&D activities has become need of the hour.

Management of modern R&D is complex and it requires discreet but multiple interface with academia, R&D institutions, government etc., besides leveraging core strength of the organization. Also, the R&D management should be well structured. In line with the aforesaid, following R&D strategy is proposed to be adopted:

13.11.11 R&D Platforms

Platforms to support international cooperation and collaboration could increase the effectiveness of R&D investments. These include:

- Technology transfer mechanisms;
- Information sharing on both technology and best practice;
- International support for demonstration projects to improve the outlook for R&D;
- Opening internships and researcher exchanges with other countries;
- International exhibition of R&D equipment, instruments, and materials; and
- Information sharing systems to collect and disseminate information on renewable energy technologies.
- International collaboration can provide opportunities for information exchange, multiply the benefits from R&D programs, including communicating best practices and lessons learned.

13.11.12 Policies for R&D

- Developing integrated R&D plans based on a multi-disciplinary approach. A well-integrated R&D plan would ensure that proposed programs are culturally appropriate, reflect current and planned resource endowments, and involve communities in discussions of energy policy;
- Removing fossil fuel subsidies to balance the energy pricing mechanism in order to attract or drive private capital to the energy industry;

- Developing skills and capacities to create a knowledge workforce leads to success of energy efficiency programs, proper operation and maintenance of clean technologies;
- Providing as much certainty as possible concerning long-term (e.g. 5 to 10 years) funding for R&D
- Monitoring and evaluating R&D programs results to enable timely adjustments to funding levels and strategies where necessary
- In addition to subsidizing electricity through low tariffs, policy should support and subsidize purchase of energy efficient appliances

13.11.13 Institutional and funding framework for R&D

Government should fund the R&D programme through schemes such as National Perspective Plan (NPP) and Research Scheme on Power (RSoP). Some of them can be in collaborative mode with participation from CPSUs, Industry and academic institutes and utilities.

CPRI, NTPC, NHPC, SJVNL, Powergrid, DISCOMs, BHEL, CSIR, CSIR laboratories, Government funded R&D Institutions, IITs, NITs may execute the projects identified, which shall be coordinated and managed by CEA and CPRI on behalf of MoP.

With a view to create R&D infrastructure and to establish new facilities, augmentation of existing facilities and establishment of regional testing laboratories in different parts of India is essential.

Government should continue to support CPRI through capital grants. The regional laboratories of CPRI can help India's small and medium Entrepreneurs to produce globally competitive electrical products. This will be a major initiative to boost our "Make in India" programme. Further Government should provide test and evaluation facilities at subsidized and affordable rates to Indian Manufacturers through Central Power Research Institute.

Policy to earmark a larger percentage of profit after tax by PSUs as part of Corporate Social Responsibility (CSR) should be considered to provide the much needed impetus to R&D in Power sector.

13.12 RECOMMENDATIONS

Followings are the important recommendations of this sub-group:

- Preparation of a well-defined R&D Vision and Policy document clearly highlighting the R&D plan for the next decade and providing incentives for the commercialization of products developed by indigenous R&D efforts of start-up organizations based in India
- Enhance Delegation of Power to R&D division to improve the performance and delivery of the system.
- Development of a platform for collaborative research involving Industries, Utilities, R&D organizations and Academia both national and international levels to bridge the technology gaps, strengthen expertise, and build synergy.
- Consideration of R&D projects of national importance that require serious intellectual and financial resource as National Mission projects with funding from Government.
- Creation of ecosystems where MNCs, industry associations and professional societies may work in tandem in different R&D Programs of the nation to compliment schemes like "Make in India", Start up India", "Power for all" and help in creation of more jobs.
- Creation of 'National Registry of experts & expertise' in various areas by competence mapping.
- Creation of Centers of Excellence (CoE) in identified areas to take up application oriented research projects.
- Establishment of 'Power Academy' or 'CPRI Academy' to enhance the knowledge base of fresh and experienced engineers which will also serve as a 'finishing school' for young engineers and as 'refresher training centre' for middle level management.
- Formulation of an effective IPR policy for the national R&D organizations to protect the innovations of R&D engineers and also to avoid possible infringements.

- Need for preparation of a well-defined Policy to provide incentives for the commercialization of products developed through indigenous R&D efforts and by Start-Up Organizations based in India. This should be aimed at easing the Market entry for newly / indigenously developed power products and solutions. Incentives could be excise duty exemption for a period of at least five years from the date of commercialization and Qualifying requirement (QR) relaxation (prior experience, financials).

CHAPTER 14
HUMAN RESOURCE REQUIRMENT

14.0 INTRODUCTION

Trained Manpower is an essential prerequisite for the rapid development of all areas of the power sector. The trained manpower comprises of skilled engineers, supervisors, managers, technicians and operators. Power sector is poised for massive growth in generation and commensurate growth in transmission and distribution infrastructure.

Manpower development including training facilities shall be proportional to this capacity addition requirement. The technical knowledge acquired needs to be supplemented with applied engineering in various fields of power generation, transmission and distribution. All these skills need to be regularly updated to cope with rapidly advancing technology.

14.1 MANPOWER ASSESSMENT

14.1.1 Manpower availability in 2012-17

The Capacity addition for 12th Plan (2012-17) is expected at about 1,31,950 MW (Conventional of 99,209 MW + Renewable of 32,741 MW). The total manpower by the end of 12th Plan (2012-17) shall be of the order of 1558.81 thousands out of which 1186.33 thousands will be technical and 372.48 thousands will be non-technical.
(As per norms considered in Sub-Group-9 of Working Group on Power for 12th & 13th Plans on Human Resources Development, August 2011).

Table 14.1
Total Manpower Available at the end of 2012-17 {Beginning of 2017-22 Plan, considering a capacity addition of 1,31,950 MW (including 32,741 MW from RES) during the 12th Plan}

(Figures in Thousands)

S No	Particulars	Technical	Non-Technical	Total
1	Thermal Generation*	174.82	57.98	232.80
2	Hydro Generation	49.37	19.30	68.67
3	Nuclear	10.03	4.56	14.59
4	Power System			
	Transmission	27.36	8.74	36.10
	Distribution	924.75	281.90	1206.65
	Total	**1186.33**	**372.48**	**1558.81**

* including Renewable Energy Sources

14.1.2 Manpower requirement during the years 2017-22

For a capacity addition of 1,76,140 MW **(Table 14.2)** considered (including renewables of 1,17,756 MW and 48,261MW thermal (coal & gas) plants already under construction) in 2017-22, the additional manpower requirement shall be of the order of 253.76 thousands out of which 194.91 thousands will be technical and 58.85 thousands will be non-technical. The total manpower by the end of 2017-22 shall be 1617.72 thousands, out of which 1232.95 thousands will be technical and 384.77 thousands will be non-technical. Details are given below:

Table 14.2
Targeted Capacity addition during 2017-22

Particulars	**Total (MW)**
Thermal (Coal under construction – 47,855 MW + Gas plant 406MW)	48261
Hydro	6823
Nuclear	3300
Sub-Total Conventional	**58384**
Renewable (Solar-87711.17, Wind-27720.23, Biomass-1704.22, SHP-620.14)	**117756**
Total	**176140**
Transmission System Capacity Addition Circuit Kilometers MVA capacity Addition	**62,800 ckm 1,28,000 MVA**
Distribution Capacity Addition (33/11kV S/S)	**110,000 MVA**

Table 14.3
Norms for Manpower

(Man/MW)

S No	**Particulars**	**Technical***	**Non-Technical***
1	Thermal Generation	0.486	0.144
2	Renewable		
	Solar	0.550	0.165
	Wind	0.321	0.096
	Biomass	0.486	0.144
	Small Hydro	1.341	0.405
3	Hydro Generation	1.341	0.405
4	Nuclear	1.098	0.468
5	Power System		
	Transmission	1 Employee for 18.30 Ckt Km	30% of the Technical Manpower
	Distribution	12 persons per 10MVA(of 33/11kV S/S)	

*Norm for manpower considered is including regular as well as contractual employment. These norms are average of all sizes of generation capacity. However, value changes with plant site and size, higher the plant size lower is the Man/MW ratio. Further Man/MW ratio may further get reduced with increase in level of automation.

Table 14.4

Additional Manpower required for Capacity Addition of 1,76,140 MW envisaged in 2017-22 Plan and HV, EHV & UHV Transmission network of length of about 62,800 Ct.kms.

(Figures in Thousands)

S No	Particulars	Technical	Non-Technical	Total
1	Thermal Generation	23.45	6.95	30.40
	Solar*	48.24	14.47	62.71
	Wind	8.90	2.66	11.56
	Biomass	0.83	0.25	1.08
2	Small Hydro	0.83	0.25	1.08
3	Hydro Generation	9.15	2.76	11.91
4	Nuclear	3.62	1.54	5.16
5	Power System			
	Transmission	3.43	1.03	4.46
	Distribution	96.46	28.94	125.40
	Total	**194.91**	**58.85**	**253.76**

*** As per MNRE estimates, an additional 91114 semi-skilled persons (below ITI/Technician level) are also required in Solar, which are not accounted for in the norms.**

Table 14.5

Manpower available at the beginning of the period 2017-22 after considering retirement of 20% of manpower and recoupment of 7.5% of existing manpower

		Manpower available as on 31.03.2017 after 20% reduction (due to retirement, death, change of profession etc.)		Recoupment of manpower at the rate of 7.5% in five years		Total
S No	Particulars	Technical	Non-Technical	Technical	Non-Technical	Total
1	Thermal Generation	139.86	46.38	13.11	4.35	203.70
2	Hydro Generation	39.50	15.44	3.70	1.45	60.09
3	Nuclear	8.02	3.65	0.75	0.34	12.76
	Power System					
	Transmission	21.89	6.99	2.05	0.66	31.59
	Distribution	739.80	225.52	69.36	21.14	1055.82
	Total	**949.07**	**297.98**	**88.97**	**27.94**	**1363.96**

Table 14.6
(Table 14.4+Table 14.5)
Total Manpower Available at the end of 2017-22 & Beginning of 2022-27

(Figures in Thousands)

S No	Particulars	Technical	Non-Technical	Total
1	Thermal Generation*	235.22	75.31	310.53.
2	Hydro Generation	52.35	19.65	72.00
3	Nuclear	12.39	5.53	17.92
4	Power System			
	Transmission	27.37	8.68	36.05
	Distribution	905.62	275.60	1181.21
	Total	**1232.95**	**384.77**	**1617.72**

***Thermal Generation includes generation from Solar, Wind and Biomass.**
The above manpower is inclusive of Technical manpower of 58.80 thousand and Non-Technical of 17.63 thousand for O&M of RES envisaged for addition in the period 2017-22.

14.1.3 Manpower requirement during the period 2022-27

For a capacity addition of 1,65,220 MW (including renewables of 100,000 MW) during 2022-27 **(Table 14.7**), the additional manpower requirement shall be of the order of 252.78 thousands out of which 193.77 thousands will be technical and 59.01 thousands will be non-technical. The total manpower by the end of 2022-27 shall be 1668.67 thousands, out of which 1272.90 thousands will be technical and 395.77 thousands will be non-technical. Details are given below:

Table 14.7
Targeted Capacity Addition during the period 2022-27

Particulars	Total (MW)
Thermal	46420
Hydro	12000
Nuclear	6800
Sub-Total Conventional	**65220**
Renewable (Solar- 50000, Wind-40000, Biomass-7000, SHP- 3000 MW)	**100000**
Total	**165220**
Transmission System Capacity Addition Circuit Kilometers MVA capacity Addition	**62,800 Ckm** **1,28,000 MVA**
Distribution Capacity Addition (33/11kV S/S)	**110,000 MVA**

Table 14.8

Additional Manpower required for the Capacity Addition of 1,65,220 MW envisaged in 2022-27 and for HV, EHV & UHV Transmission Lines of length of 62,800 Ckt.kms.

(Figures in Thousands)

S No	Particulars	Technical	Non-Technical	Total
1	Thermal Generation[#]	22.56	6.68	29.24
	Solar	27.50	8.25	35.75
	Wind	12.84	3.84	16.68
	Biomass	3.40	1.01	4.41
2	Small Hydro	4.02	1.22	5.24
3	Hydro Generation	16.09	4.86	20.95
4	Nuclear	7.47	3.18	10.65
5	Power System			
	Transmission	3.43	1.03	4.46
	Distribution	96.46	28.94	125.40
	Total	**193.77**	**59.01**	**252.78**

[#]Manpower required for operationalizing 47,855 MW Thermal in 2017-22 would be utilized in 2022-27.
The above manpower is after taking into account 20% additional manpower in down stream/ allied/ automation and 25% reduction in manpower due to expected automation atleast in urban centres and some smart cities.

Table 14.9

Manpower available at the beginning of period 2022-27 after considering retirement of 20% and recoupment of 7.5% of manpower

(Figures in Thousands)

		Manpower available as on 31.03.2022 after 20% reduction (due to retirement, death, change of profession etc.)		Recoupment of manpower at the rate of 7.5% in five years		Total
S No	**Particulars**	**Technical**	**Non-Technical**	**Technical**	**Non-Technical**	**Total**
1	Thermal Generation	188.18	60.25	17.64	5.65	**271.72**
2	Hydro Generation	41.88	15.72	3.93	1.47	**63.00**
3	Nuclear	9.91	4.42	0.93	0.41	**15.67**
	Power System	0.00	0.00	0.00	0.00	
	Transmission	21.90	6.94	2.05	0.65	**31.54**
	Distribution	724.50	220.48	67.92	20.67	**1033.57**
	Total	**986.37**	**307.81**	**92.47**	**28.85**	**1415.50**

Table 14.10
Table 14.8+ Table 14.9
Total Manpower available at the end of 2022-27

(Figures in Thousands)

S No	Particulars	Technical	Non-Technical	Total
1	Thermal Generation*	276.14	86.90	**363.04**
2	Hydro Generation	61.90	22.05	**83.95**
3	Nuclear	18.31	8.01	**26.32**
4	Power System			
	Transmission	27.38	8.62	**36.00**
	Distribution	888.88	270.09	**1158.97**
	Total	**1272.90**	**395.77**	**1668.67**

***Thermal Generation includes generation from Solar, Wind and Biomass.**
Inclusive of manpower for O&M of RES added for the period 2022-27 for Technical is 47.76 thousands and Non-Technical is 14.32 thousands

14.1.4 Manpower engaged in the plants proposed for retirement

It is proposed that thermal capacity of 22,716 MW may be retired in the period of 2017-22 and 25,572 MW in 2022-27. The units proposed for retirement are old ones and generally having the unit capacity of 250 MW and below have higher Man/ MW norms i.e. in the tune of 1.5 Persons/ MW than required for new units to be set up which are mostly of size 660 MW and higher. Further, the manpower to get retired at the rate of 20% per year have already been considered. Therefore, the manpower required for the O&M of the capacity to be added in 2017-27 will be even less than the manpower engaged in the capacity proposed for retirement. Thus in thermal areas, theoretically, there will be no net addition of manpower during 2017-27. Thus the manpower engaged in the plants to be retired needs to be reoriented / retrained in the modern thermal technology for engaging them in new power plants planned to be commissioned in 2017-27.
Manpower Norms and the order of manpower de-engaged in the thermal capacity proposed for retirement is as tabulated below-

Table 14.11
Man/MW norms for de-engagement of manpower due to retirement in generation, transmission, distribution in 2017-27

(In Man/MW)

S No	Particulars	Technical	Non-Technical
1	Thermal Generation	1.08	0.42
2	Renewable		
	Solar	0.55	0.165
	Wind	0.321	0.096
	Biomass	0.486	0.144
	Small Hydro	1.341	0.405
3	Hydro Generation	1.341	0.405
4	Nuclear	1.098	0.468
5	Power System		
	Transmission	1 Employee for 18.30 Ckt Km	30% of the Technical Manpower
	Distribution	12 persons per 10MVA(of 33/11kV S/S)	

*Norm for manpower considered is including regular as well as contractual employment. These norms are average of all sizes of generation capacity. However, value changes with plant site and size, higher the plant size lower is the Man/MW ratio. Further Man/MW ratio may further get reduced with increase in level of automation.

Table 14.12
Capacity proposed for retirement in 2017-27

(In MW)

Particulars	2017-22	2022-27	Total
Thermal	22,716	25,572	48,288

Table 14.13
Manpower likely to be de-engaged in plants proposed for retirement in 2017-27

Particulars	Technical	Non-Technical	Total
Thermal Generation	52.15	20.28	72.43

The re-engagement of the manpower from the plants proposed for retirement would pose a challenge in that the plants retiring and the plants coming up may be under different organisations and also the plants retiring and the plants commissioning owned by the same organisation may be at different geographical locations. The complete manpower going to be de-engaged may not be suitable for re-engagement. Therefore, it will require a great deal of strategy and planning for smoothening the transition of manpower.

14.2 MANPOWER AVAILABILITY

On the basis of the total number of technical institutions operational, it can be seen that at all the three levels, graduation, diploma and ITI there are sufficient number of students passing out each year. They are given the specific skill sets required to perform the duties by organising Induction level training.

Table 14.14
Manpower Availability Vs Requirement

Colleges	Total Colleges	Annual Intake in lakhs	Total for 5 years (lakhs)	Manpower Requirement for 2017-22 (lakhs)*	Manpower Requirement for 2022-27 (lakhs)*
Engineering	3384	16.34	81.70	0.29	0.30
Management	3364	3.54	17.70	-	-
Polytechnics	3436	11.35	56.75	0.22	0.22
ITI	11964	16.92	84.60	0.79	0.79
Total	**22148**	**48.15**	**240.75**	**1.30**	**1.31**

From the **Table 14.14** it is observed that sufficient number of Engineers, Managers and Diploma holders are available. However, in respect of lower level skills like that of ITI, there are certain gaps in numbers of skills as explained below.

Our ITIs and other vocational training institutions have to be augmented for providing certain skill sets like High Pressure Welders, Fabricators, Fitters, Binders, Drillers, Plumbers, Electricians, Linemen, Heavy Machine Operators, Operators-Crane, Dozer, Dumper, Excavation, Bar Benders, Piling Rig Operators etc. who would be required in huge number for the Erection & Commissioning Activities for the Thermal, Hydro, Nuclear Plants and Transmission & Distribution areas. The quality and range of their training will keep pace with the changing needs of the economy and opportunities for self-development.

14.3 TRAINING NEED ASSESSMENT

14.3.1 Training Strategy

To fulfil the above needs, training to the power sector personnel is provided in the following categories:

i) O&M Training to all existing employees engaged in O&M of generating projects (Thermal, Hydel, Gas) and Transmission & Distribution System as per statutory requirements under the Gazette Notification of September 2010 issued by CEA ranging from 4 Weeks to 30 Weeks.

   This inter-alia includes the following:
   - Classroom Training
   - Simulator Training for Thermal and Hydel
   - On-Job Training

ii) Induction level training for new recruits Technical & Non-Technical is considered a must in the power sector

iii) Refresher/Advanced training of 5 Days in a year to all existing personnel of varying degrees in various specializations in line with National Training Policy for Power Sector.

iv) Management training of 5 Days in a year to the Senior Executives/Managers in India/Abroad in line with National Training Policy for Power Sector.

v) Training for personnel from retiring units found suitable for re-engagement.

The most important component of the strategy should be “Training for All” irrespective of the level in the hierarchy. At least one-week of training in a year must be provided to every individual. Five days training per annum per technical person based on National Training Policy is being implemented selectively at some utilities. This needs to be strictly implemented.

14.3.2 Recommendations for Capacity Building

- **O&M Training**

As per the Gazette Notification No. CEI/1/59/CEA/EI (Measures relating to Safety and Electric Supply) Regulations, 2010 and amendment thereof, if any, issued by CEA, Engineers, Supervisors and Technicians engaged for O &M of Power Projects (Thermal, Hydel, Gas) and T&D have to mandatorily undergo training ranging from 4 weeks to 30 weeks.

- **On-Job Training Facility**

On-Job training is also now mandatory for all trainees who are being given training in O & M of Generation Projects (Thermal, Hydel, Gas) and Transmission & Distribution. This training varies from 2 weeks to 16 weeks.

- **Induction Training**

Induction training to all technical personnel is a must.

- **Refresher/Advanced Training**

Refresher/Advanced Training must be arranged for each individual on promotion, which calls for performing new/different roles and working conditions.

A mix of Technical, Commercial and Management capabilities of 1 week is proposed.

- **Training of Personnel engaged in the thermal plants to retire for their re-engagement in new power plants**

Manpower engaged in the plants to be retired needs to be reoriented / retrained in the modern thermal technology for engaging them in new power plants planned to be commissioned in 2017-27.

- **Management Training**

Continuous development of Executives/Managers, especially at the transition period of their career and in the context of constantly changing business environment and the Regulatory aspects is of utmost importance. Aspects of Commercial and Regulatory affairs of the power sector should be taught to the executives. Also, Executives in Finance and Management with non-technical background should be provided technical orientation through suitable training programs. For this a training of 1 week is proposed.

- **Simulator Training**

As per the Gazette Notification No. CEI/1/59/CEA/EI (Measures relating to Safety and Electric Supply) Regulations, 2010, Simulator training of 2 weeks & 1 Week is a must for operation and maintenance personnel of Thermal and Hydro plants respectively. This is included in O&M training above. For safe and efficient functioning of manual and automatic equipment, personnel have to be trained on Simulators. Load Despatch System Operators may also be imparted training on Simulators.

- **Training in Renewable Sources of Energy**

Since it is envisaged that about 32,741 MW of Renewable Energy is added in 2012-17 and 1,17,756 MW in 2017-22 and 1,00,000MW in 2022-27, it is proposed that specialized training of at least 1-2 months should be given in various renewable energy technologies like solar, wind, bio-mass, small hydel etc. Grid connectivity of Renewable energy sources may also be given importance in training.

- **Training in Demand Side Management, Energy Efficiency and Energy Conservation**

Training for Energy Managers and Energy Auditors, Industry personnel, Operators, Farmers should also be provided in respect of DSM, Energy Conservation & Energy Efficiency. Energy Conservation should also be a part of course curriculum for students.

- **Power System Operators Training**

System Planners, Operators & Engineers should be given regular refresher training and the new entrants should be given exhaustive training of 3 months. This training shall be required to be given to about 250 – 300 trainees every year during the years 2017-22.

- **Capacity Building under DDUGJY & IPDS**

Capacity Building of various GOI schemes such as DDUGJY and IPDS scheme is recommended for the employees of Power Distribution Utilities.

- **HRD and Technical Competence building due to Technology Advancement and R&D**

There is a need to match the growth rate, Technology Advancement and R&D needs of both skilled manpower as well as highly qualified research personnel to sustain a steady growth in technology development. Thus, emphasis needs to be laid upon skill development of such Manpower.

- **Introduction of Training on Attitudinal Changes / Behavioural Sciences**

It is highly recommended to introduce training on Attitudinal Changes / Behavioural Sciences in the curriculum of induction level training as well as re-training programs. After undergoing such training, the personnel develop a sense of belongingness to the organization.

In addition to Technical Skills, Power Professionals need to have Life Skills like Communication Skills, Time Management, Team Work, Technical Writing, Morals & Ethics etc.

- **Training in Information Technology & Cyber Security**

Information technology has pervaded all facets of life. Adequate training according to the job requirement should be provided in the field of information technology & cyber security. Use of IT should be promoted and maximum number of personnel should be made computer literate.

- **Training of Non-Technical Officers and Staff**

Training of non-technical officers and staff should be done in regular intervals in the functional skills/management areas in association with the concerned Institutes as per needs.

- **HRD and Capacity Building for Power Generating Stations**

It is proposed to have a capacity building program for the Executives, Engineers, and Operators of Power Stations in both State and Central Sectors in the areas of DSM, Energy Management and Energy Audit during the years 2017-22 and 2022-27.

- **Training for Nuclear Power Personnel**

Due to stringent safety requirements and other national and international regulations, every person working in Nuclear Power Sector is exposed to specialized training. To meet the multi-disciplinary needs, the Department of Atomic Energy (DAE) has built in-house training facilities both for professionals and non-professionals.

- **Training Abroad**

Live liaison should be made with the concerned authorities to depute the eligible personnel for training in the developed countries to keep them abreast of the latest global developments.

- **Hot Line Maintenance Training**

There is a great demand from various Utilities for Hot Line Maintenance Training. There is an urgent need for augmentation of Training Capacity as this type of Training is presently being imparted by only two institutes in the country.

- **Training through Distance learning education, E-Learning & Web based Training**

Since it may not be possible for all the persons engaged in Construction and O&M of Power Projects, knowledge upgradation & training is suggested through correspondence and also by way of Web based Training and also through e-learning.

- **Need for written Training Policy by every Utility**

Every Utility of Central Sector, State Sector & Private Sector should have a written Training Policy indicating how the organisation proposes to meet its Training needs.

❖ **Adoption of ITIs**

More than sixty (60) nos. of ITIs have been adopted by CPSUs wherein about 18,000 technicians pass out every year from these institutions. Such initiatives by CPSUs under their CSR activities may be encouraged.

❖ **Provision for Training budget**

In line with the National Training Policy for the Power Sector, every organisation should have a training budget starting at least equal to 5% of the annual salary budget.

14.3.3 Training Infrastructure Requirements vis-a-vis Availability

14.3.3.1 Training Load

Training requirement for 2017-22 & 2022-27 have been worked out with the following assumptions and are given in **Table 14.15** and **Table 14.16.** Details of simulator training infrastructure requirement are given in **Table 14.17** and **Table 14.18**.

i) O&M Training to the manpower added and engaged in O&M of generating projects (Thermal, Hydel, Gas) and Transmission & Distribution System as per statutory requirements under the Gazette Notification No. CEI/1/59/CEA/EI (Measures relating to Safety and Electric Supply) Regulations, 2010 issued by CEA.
This inter-alia includes the following:
- Classroom Training
- Simulator Training for Thermal and Hydel
- On-Job Training

ii) Induction level training for new recruits is considered a must in the power sector.

iii) Minimum one-week training (Refresher/Managerial) every year for all technical personnel in line with National Training Policy for Power Sector.

14.3.3.2 Classroom Training Infrastructure Requirement vs. Availability for 2017-22 (For O&M of Generating Projects and T&D system as per CEA norms)

Training load considering 1-week training annually for all existing technical personnel and induction training of duration specified in CEA regulations to all technical personnel to be inducted for capacity addition with associated T&D system during 2017-22 period is given in **Table 14.15.**

Table 14.15

Classroom infrastructure Requirement vs. Availability in 2017-22

(in Thousand-man-week)

	Training Infrastructure Available			**Annual Requirement**	**Deficit(-)/Surplus(+)**
Sub-Sector	**At the CEA Recognised Training Institutes**	**At Other Training Centres**	**Total availability**		
Distribution	22	1	23	927.15	-904.15
Hydro	20.8	13	33.8	56.16	-22.36
Thermal	234.97	61	295.97	216.29	79.68
Transmission	46	36	82	28.87	53.13
Total	**323.77**	**111**	**434.77**	**1228.47**	**-793.70**
Nuclear				16.16	
Solar				19.30	
Wind				3.56	
Total				**1267.49**	**-816.56 (excluding nuclear)**

From the **Table 14.15**, it is evident that there is no deficit in training infrastructure in Thermal and Transmission areas. However, there is need for creation of infrastructure in Hydro and Distribution areas considering that all existing employees are imparted 1-week training annually and new inductees are imparted induction training of duration mentioned in the CEA Regulations. Actual deficit in Hydro and Distribution would be marginally less as almost all NPTI institutes also conduct training in Hydro areas except HLTC, Bangalore and in distribution areas while predominantly they conduct training in thermal areas except in case of PSTI and HLTC at Bangalore and HPTC at Nangal, Punjab. Further, some infrastructure available with training cells, which also impart training, at the power companies would also reduce the infrastructure deficit.

The existing infrastructure itself is grossly under-utilised. The under-utilisation is mainly due to organisations under state government particularly Discoms giving almost no attention to training. Thus, efforts should be made to optimally utilise the existing infrastructure.

All the organisation under state/pvt/ central sector are required to impart training to their personnel at Government recognised institutes as mandated in CEA's Safety Regulations 2010.

There is a need for creation of infrastructure by way of setting up new institutes or augmenting the infrastructure in the existing institutes i.e. in CEA recognized institutes and other training institutes. However, priority be given on utilization of existing input structure. More infrastructure can be created in phased manner. Same approach may be adopted in case of simulator training infrastructure.

14.3.3.3 Classroom infrastructure Requirement in 2022-27

Table 14.16
Classroom infrastructure Requirement in 2022-27

Sub-Sector	Training Load (thousand-man-week)
Distribution	909.16
Hydro	75.70
Thermal	280.28
Transmission	28.88
Sub-Total	**1294.02**
Nuclear	24.53
Solar	11
wind	5.14
Total	**1334.69**

Total annual training load during 2022-27 will be about 1335 thousand-man-weeks. In the areas of Nuclear, solar and wind power, the training load requirement is also depicted in **Table 14.22**. Training of personnel engaged is Nuclear power is not controlled by the Ministry of Power. The concerned Ministry may take stock of the training infrastructure in Nuclear power. Similarly, the area of Solar and Wind power comes under MNRE. The training infrastructure available for training in solar and wind power is not well organised and low in comparison to the requirement. The existing power sector institutes need to start training/ augment training capacity for RE areas. Training in solar and wind areas may be made statutory on the line of training specified for those engaged in the O&M of Thermal, and Hydro power plants, thereby the infrastructure creation will gain momentum and training could be provided in more fruitful and productive manner.

14.3.3.4 Simulator Training Load

Training infrastructure to meet mandatory simulator training has very little shortage in thermal which would be bridged once 6 planned simulators at different NPTIs are installed. Requirement of hydro simulator would also be met once these multi-mode simulators are installed at NPTI. The simulator training load requirement and existing availability are indicated in **Table 14.17** which **depicts the simulator training to supervisors and engineers comprising about 36% of total new technical inductees in 2017-22.**

Table 14.17
Simulator Training Infrastructure Requirement Vs Availability 2017-22

S No	Area	Simulator Training required (Thousand-Man-Weeks/Year)	Simulator Infrastructure available (Thousand-Man-Weeks/Year)	Deficit (-) (Thousand-Man-Weeks/Year)
1	Thermal	5.26	5.50	0.24
2	Hydro	1.32	0.45	-0.87
	Total	**6.58**	**5.95**	**-0.63**

NPTI is already in the process of procuring multi-functional Simulators at six (6) of its institutes and therefore, this additional expenditure may not be required.

Table 14.18
Simulator Training Infrastructure Requirement Vs Availability 2022-27

S No	Area	Simulator Training required (Thousand-Man-Weeks/Year)	Simulator Infrastructure available (Thousand-Man-Weeks/Year)	Deficit (-) (Thousand-Man-Weeks/Year)
1	Thermal	5.79	4.80	-0.99
2	Hydro	2.88	3.09	+0.21
	Total	**8.67**	**7.89**	**-0.78**

(Considering 6 additional Hydro /Thermal Simulators at NPTI)

There would be 46,420 MW new capacity addition in Thermal category in 2022-27. The existing simulator capacity could be utilised to impart training in refresher courses to existing employees in the Thermal area.

NPTI is already in the process of procuring multi-functional Simulators at six (6) of its institutes and, thus no additional expenditure may be required.

14.4 FUNDING

14.4.1 Funding for Classroom Training Infrastructure for Engineers, Supervisors and Operators

The maximum infrastructure requirement for class-room training for engineers, supervisors and operators has been calculated as 1267 thousand-man-weeks per year for 2017-22. The infrastructure available for class-room training for engineers, supervisors and operators has been estimated as 435 thousand-man-weeks per year for 2017-22. Therefore, there is a huge deficit of 794 thousand-man-week infrastructure in O&M training of technical personnel for 2017-22 in the field of conventional power. When training load for solar and wind is included the infrastructure shortage adds to 817 thousand-man-weeks. In terms of area specific break up, there is no shortage of infrastructure in Transmission and Thermal areas. However, In the distribution sector the infrastructure requirement for class-room training for engineers, supervisors and operators has been calculated as 927 thousand-man-weeks per year for 2017-22 while the infrastructure available for class-room training for engineers, supervisors and operators for distribution sector has been estimated as 23 thousand-man-weeks per year for 2017-22. In the Hydro area also, there is only 34 thousand-man-weeks infrastructure available as against the requirement of 56 thousand-man-week. Thus, there is deficit of 22 thousand-man-weeks per year for 2017-22 in Hydro area.

To bridge the infrastructure gap corresponding to 816 thousand-man-weeks and cater to training load in 2017-22, a huge fund would be required to be invested by the concerned organisations.

The training infrastructure required for the 2022-27 is to meet the training load of 1335 thousand-man-weeks per year, which is little more than that the requirement of 1267 thousand-man-weeks per year in 2017-22 period.

14.4.2 Funding for Thermal Simulator Infrastructure

As per the Gazette Notification No. CEI/1/59/CEA/EI (Measures relating to Safety and Electric Supply) Regulations, 2010 of CEA, persons working in the O&M of Thermal Power Plants have to undergo 2 weeks simulator training. The infrastructure available for simulator training has been calculated based on the existing simulators available in the country, which is 4.8 thousand-man-weeks per year. The infrastructure requirement has been calculated as 5.79 thousand-man-weeks per year for the 2022-27. Therefore, there is deficit of 0.99 in Thermal simulator infrastructure.

Considering a batch size of 16 and total number of 22 batches in a year, one training simulator can provide 0.704 of thousand man weeks in a year. Therefore, to create the simulator infrastructure required for deficit training requirement of 0.99 thousand-man-weeks per year during the 2022-27.

However, no funding is required in this respect as NPTI is already in the process of acquiring 6 multi-mode Simulators.

14.4.3 Funding for Hydro Simulator Infrastructure

As per the Gazette Notification No. CEI/1/59/CEA/EI (Measures relating to Safety and Electric Supply) Regulations, 2010 of CEA, persons working in the O&M of hydel power plants have to undergo 1 week simulator training. The infrastructure available for simulator training has been calculated based on the existing simulators available in the country, which is 0.45 thousand-man-weeks per year. The infrastructure requirement has been calculated as 1.32 thousand-man-weeks per year for the 2017-22 and 2.88 thousand-man-weeks per year for the 2022-27. Therefore, there is a deficit of 0.87 thousand-man-weeks per year for the 2017-22, which could be bridged with the setting up of simulators by 6 NPTIs at different locations. Thus, no more investment in hydro simulator would be required. While calculating the availability, a batch size of 10 and total number of 44 weeks has been considered in a year, thus one training simulator providing 0.44 thousand-man-weeks in a year.

14.4.4 Funding for Training

To create the infrastructure required to meet the annual training load in 2017-22, a huge investment shall be required. However, it is proposed that instead of creating new infrastructure, all NPTI institutes along with two upcoming institutes one each in Kerala and Madhya Pradesh may be fully utilized to accommodate the above mentioned training load.

14.5 RECOMMENDATIONS

- All the organisations under central/ state/private sector are required to impart training to their personnel at the institutes recognised by the Government(CEA/MoP) as mandated in Regulation 6 & 7 of CEA (measures relating to safety and electric supply) Regulations 2010.
- It is proposed that all Central Sector Utilities, State Sector Utilities and IPPs provide O&M and refresher training as per the norms stipulated in Regulation 6 & 7 of CEA (measures relating to safety and electric supply) Regulations 2010.
- NPTI has been entrusted with the role and responsibility as a National Apex Body for training by the Government of India (Gazette Notification July 3, 1993) and it runs the training programmes for the power sector personnel as mandated in the Regulations 6 & & of CEA Regulations 2010. NPTI's expertise in the training may be utilised by all Utilities / Industries of Power Sector to meet their mandatory requirement of Induction training to their new entrants as well as refresher training to their existing personnel which would, apart from meeting their training requirement, ensure effective utilisation of the huge infrastructure available with the NPTI.
- Power sector training in the areas of Smart Distribution, Smart Transmission and Smart Generation may also be strengthened in coordination with NPTI in order to accommodate emerging areas. This will help prepare competent man power for upcoming Renewable Installations of 175 GW in Solar, Wind, Small Hydro, etc.
- In compliance with the National Training Policy(NTP) of Ministry of Power, all organizations need to allocate training budget at least equal to 5% percent of the salary budget exclusively for funding training activities.

CHAPTER 15
CONCLUSIONS AND RECOMMENDATIONS

The National Electricity Plan includes a review of the 12th Plan, detailed capacity addition requirement during the years 2017-22 and Perspective Plan projections for the years 2022-27. After carrying out the detailed exercise towards formulation of National Electricity Plan, following conclusions and recommendations have emerged.

15.1 12TH PLAN CAPACITY ADDITION

i) In the 12th Plan, capacity addition from conventional sources is 99,209.6 MW (Coal 83,560 MW, Lignite 1,290 MW, Gas 6,880.5 MW, Hydro 5,479 MW, Nuclear 2,000 MW) against a target of 88,537 MW. This is about 112% of the target.

ii) Private players have started playing dominant role in capacity addition in power sector with 56 % of total capacity addition during 12th plan coming from private sector.

iii) There has been considerable slippage in achievement of capacity addition target of Hydro and Nuclear sources (Slippage: Hydro 5,451MW and Nuclear 3,300 MW) in the 12th Plan period. The factors affecting capacity addition in Hydro and Nuclear sectors need to be addressed urgently to arrest the further decline in generation mix.

iv) During 12th plan, capacity addition from supercritical technology based coal power plants has contributed around 42% of the total capacity addition from coal based plants.

v) R&M/LE works in respect of 37 Nos. thermal units with aggregate capacity of 7,202.6 MW have been completed during 12th Plan. Also about 4014.6 MW of Hydro capacity has been achieved through uprating, life extension and restoration activities for a total of 20 hydro R&M schemes as on 31st March,2017.

vi) A capacity addition of 32,741 MW from Renewable Energy Sources has been achieved during 12th Plan.

15.2 DEMAND SIDE MANAGEMENT

i) There would be reduction in electrical energy requirement through implementation of various programs of Demand Side Management, energy efficiency and conservation measures like S&L (Standards & Labelling), PAT (Perform-Achieve-Trade) Scheme in industries, LED domestic & Street lighting etc.

ii) Total energy savings during the year 2021-22 and 2026-27 has been estimated to be 249 BU and 337 BU respectively. This will result in reduction in both Electrical Energy Requirement (BU) and Peak Demand (MW).

iii) A uniform approach for formulation of DSM regulations (including demand response) throughout the country may be taken up in the Forum of Regulators. Regulators need to notify appropriate DSM regulations and direct the DISCOMs to prepare time bound DSM action plan. Regulators may direct Distribution Companies to take up energy efficiency measures in their areas. The DISCOMs may be suitably incentivized to implement DSM projects like lighting, air-conditioning, agricultural pumps, refrigerators and ceiling fans etc. for reduction in their peak demand.

15.3 DEMAND PROJECTIONS

i) Electricity demand of the country is periodically assessed by the Electric Power Survey Committee, taking into account the actual electricity demand incident on the system in the past years, planned and under implementation policies and programmes of the Government, various developmental activities projected in future, impact of energy conservation measures etc.

ii) The electrical energy requirement and peak electricity demand on all-India basis has been taken as per the 19th EPS to work out the generation capacity addition requirement. The EPS exercise involves all stakeholders and an extensive exercise has been done. Distribution company wise electricity demand projection has been carried out to arrive at the State / region and all- India electricity demand projection. Electrical energy requirement and peak demand on all-India basis adopted for generation expansion planning exercise is as under:

Year	Energy Requirement (BU)	Peak Demand (GW)
2021-22	1566	226
2026-27	2047	299

iii) CAGR of electrical energy requirement from 2016-17 to 2021-22 works out to 6.18 % and the CAGR of electrical energy requirement from 2021-22 to 2026-27 works out to 5.51 %. The CAGR of electrical energy requirement in the country from the year 2010-11 to 2015-16 has been 5.28 %.

iv) Load forecasting is undertaken by CEA once in five years through EPS committee. While making the load forecasting, a number of assumptions are made. In actual, these assumptions may deviate and need suitable modifications. It is therefore, suggested that **a Mid-term review of EPS Load Forecasting should be undertaken to help the stakeholders in the electricity sector to facilitate effective investment decisions.**

15.4 CAPACITY ADDITION REQUIREMENT

a) During the years 2017-22

(i) Priority has been accorded towards development of hydro, nuclear and gas based projects which are already committed for the year 2017-22. Committed Hydro capacity addition of 6,823 MW has been considered during 2017-22 based on assessment of progress of actual status of the projects. Nuclear capacity of 3,300 MW during 2017-22 has been considered for planning studies as per the information furnished by DOAE. Gas based capacity of 406 MW has been considered based on the projects that are in various stages of construction.

(ii) Considering the demand projections for the year 2021-22 as per the 19th EPS, committed capacity addition from Gas 406 MW, Hydro 6,823 MW, Nuclear 3,300 MW, RES 1,17,756 MW and likely retirement of 22,716 MW of coal based capacity during 2017-22, the study result reveals that coal based capacity addition of 6,445 MW is required during the period 2017-22. However, a total capacity of 47,855 MW coal based power projects are currently under different stages of construction and are likely to yield benefits during the period 2017-22. Thereby, the total capacity addition during 2017-22 is likely to be 1,76,140 MW.

(iii) An alternate scenario has also been constructed considering demand CAGR of 7.18% during the years 2017-22. It was found that 19,700 MW coal based capacity addition is required during the years 2017-22 in case of increased demand scenario. However, coal based capacity of 47,855 MW are at different stages of construction and are likely to yield benefits during 2017-22.

(iv) In view of a large capacity addition programme from Renewable Energy Sources, Hydro and Gas based power stations are required to play vital role by providing balancing power to cater to the variability and uncertainty associated with Renewable Energy Sources. Therefore, suitable measures to ensure timely completion of capacity addition from hydro and adequate supply of natural gas to stranded gas based power plants may be taken.

(v) As per Electricity Act, 2003, CEA has to prepare National Electricity Plan for Generation and Transmission. The basic objective of Generation Planning is to find out the ideal generation mix based on the demand projections. In view of this, an integrated approach for planning generation capacity addition involving various concerned ministries like MOP, MNRE, Department of Atomic Energy (DOAE) etc. needs to be adopted.

(vi) The rate of capacity addition particularly from coal based stations has outpaced the rate of increase in demand during the period from 2017-22. The PLF of the coal based stations is likely to come down to around 56.5% by 2021-22 with likely demand under CAGR of 6.18% and 175 GW of capacity addition from RES. In the event of increase in demand, without any deviation in other variables like RES or coal based retirements, the PLF of the coal based stations will invariably increase.

b) During the years 2022-27

(i) Priority has been accorded towards development of hydro and nuclear based projects which are already likely to get commissioned in the year 2022-27. Hydro capacity addition of 12,000 MW based on the projects concurred by CEA has been considered during 2022-27. Nuclear capacity of 6,800 MW during 2022-27 has been considered for planning studies as per the information furnished by DOAE. No new gas based power plants has been considered during 2022-27 in view of acute natural gas shortage in the country. Import from neighbouring countries to the tune 21,600 MW has been considered for the studies.

(ii) Considering the demand projections for the year 2026-27 as per the 19th EPS, coal based capacity addition of 47,855 MW already under construction for benefits during 2017-22, committed capacity addition of Nuclear 6,800 MW, Hydro 12,000 MW, RES 1,00,000 MW and likely retirement of 25,572 MW of coal based capacity during 2022-27, study results reveals that capacity addition of 46,420 MW is required during the period 2022-27. This capacity addition required during 2022-27 as shown in the results is in fact the peaking capacity requirement to be met in the grid. This capacity requirement can be met from any conventional source of energy but preferably from peaking power plants like hydro, gas or energy storage devices.

(iii) During the period from 2022-27, the PLF of the thermal plants shall progressively increase and would be hovering around 61% by 2026-27.

(iv) It is expected that the share of non-fossil based installed capacity (Nuclear + Hydro + Renewable Sources) will be increased to 49.3 % by the end of 2021-22 and will further increase to 57.4% by the end of 2026-27 considering capacity addition of 47,855 MW coal based capacity already under construction and likely to yield benefits during 2017-22 and 46,420 MW coal based capacity addition required during 2022-27.

15.5 THERMAL

i) India is now making a transition from power deficit to power surplus scenario.

ii) Avenues of exports of surplus power available in the Indian Grid to the SAARC countries need to be vigorously explored and pursued.

iii) A significant percentage of generating plants in the country is well past their useful life. They also contribute significantly to environmental pollution. CEA/MoP may undertake periodically a study to identify these units and draw up a time bound action plan for retirement of these inefficient and old units in consultation with the State Governments/ stakeholders.

iv) Retrofitting of the existing thermal plants for increased ramping capacity and backing down capacity must be explored in view of integration of RES.

v) Thermal plant in the vicinity of a city may explore the possibility of using treated sewage water from municipalities/corporations. Proper assessment of requirement of water by the power plants and availability of treated water from sewage need to be made for this purpose.

vi) India is now having manufacturing capability of power plants related equipment to the extent of 20,000 MW per year. With the infusion of high quantum of RES into the grid, this full capacity may not be utilized by meeting the internal demand of the country. To ensure full utilization of capacity, the manufacturing companies may explore the possibility of exporting the equipment to other countries. This shall be consistent with the "Make in India" policy of the Government of India.

vii) To accommodate high quantum of RES into the grid, thermal plants are likely to run at low PLF in future. Many plants may get partial/nil schedule of generation. Market mechanisms like ancillary services needs to be evolved through regulatory intervention so that the owners of thermal plants are able to use some of the stranded capacity.

viii) The electricity grid is undergoing rapid transformation in terms of net load characteristics after accommodating the variability of RES. Conventional power plants must have rapid ramping and backing down capability. It is proposed that the ramping and backing down characteristics of different categories of conventional generating units are spelt out in the CEA standard. A conventional unit should demonstrate its ramping and backing down capability before it is declared under commercial operation.

ix) To harness the balancing potential of the existing power plants, it is essential to develop market mechanism through regulatory intervention. The market must provide proper price signal to the potential stakeholders in the grid to willingly participate in the balancing market.

x) Gas based power stations are best suited after hydro power plants (including PSPs) for providing balancing requirements of the grid due to integration of RES. Therefore, adequate gas should be made available for effective utilization of existing gas based stations.

15.6 FUEL REQUIREMENTS

i) For the year 2017-18, coal based generation programme of 958 BU has been estimated in consultation of the power utilities. The total coal requirement of 630 MT for the power plants has been estimated considering normal monsoon year during the year 2017-18.

ii) The total coal requirement in the year 2021-22 and 2026-27 has been estimated as 735 MT (Base case) and 877 MT respectively including imported coal of 50 MT. The coal requirement for the year 2021-22 and 2026-27 has been worked out considering 30% reduction in Hydro generation due to failure of monsoon and being supplemented by coal based generation.

iii) Against a total domestic gas allocated to power projects of 87.05 MMSCMD, total gas supplied to these gas based power plants during the year 2016-17 was only 29.59 MMSCMD.

iv) It has been estimated that the gas based power stations shall need at least 45.27 MMSCMD of gas to meet the balancing and peaking requirement of the grid.

v) The scheme for utilisation of stranded gas based generation capacity introduced by Government of India is for two years only. However, a long term policy intervention is required for optimal utilization of gas based capacity in the country.

vi) The regasification capacity in the country is also a matter of concern for gas based power plants, particularly for those who are connected with RGTIL East-West pipeline. Due to technical constraints like directional flows etc., imported RLNG from west coast cannot be transported to power plants located in the East Coast.Therefore, facility of re-gasification capacity may be suitably created at East coast also.

15.7 HYDRO

i) Even though India is endowed with vast potential of hydro power, the development of hydro power has not taken place as per the planned capacity addition. In fact, the % of hydro capacity in the overall Installed capacity of the country has been registering a steady decline. The hydro development is plagued with many problems like land acquisition, R&R issues, environmental and forest clearance etc. Now, the need for capacity addition in hydro power is felt all the more with the rapid capacity addition in RES. Pumped storage and run of the river (with pondage) type of hydro power plants are ideal to meet the ramping and balancing requirement of the grid. In view of this, appropriate measures must be taken to address the problems associated with the hydro power development in the country.

ii) At present India is having 9 no. of PSPs with a total installed capacity of 4,786 MW. However, of these only 5 no. of PSP having IC of 2,600 MW are operational. Others hydro power plants are not working in pumping mode due to a variety of reasons. The swing available from generation mode to pumping mode and vice versa in a pumped storage plant is an effective tool in the hands of the grid operators for grid management. Installation of more number of PSPs and ensuring that the existing PSPs are capable of running as PSPs, is the need of the hour. Suitable policy may be framed for encouraging and exploiting pump storage potential of the country. It is proposed that, for the sake of grid stabilization, effective control of operation of these plants by RLDCs/SLDCs needs to be evolved in consultation with States/Developers/Regulators.

iii) Most hydro power plants have the ability to provide balancing power to manage variability associated with variable Renewable Energy (Solar and Wind). However, their participation in the above has been lukewarm as no financial incentive exists today on this account. There is no distinction between peak and off-peak tariff of a hydro plant. Therefore, suitable price signal needs to be generated to induce voluntary participation of the hydro plants in balancing requirement of the grid. Further, it is also proposed that infrastructure cost from the hydro project may be excluded for the purpose of determination of tariff.

15.8 RENEWABLE ENERGY

i) India has achieved a total installed capacity of 57,244.24 MW from Renewable Energy Sources as on 31.3.2017.

ii) The country has revised its Renewable Energy capacity target to 175 GW by 2022 in view of the significant renewable energy potential in the country.

iii) Accelerated development of RES requires adequate indigenous manufacturing facility for RES related equipment. Policy framework may be developed to encourage setting up of RES related equipment manufacturing facility in the country This would be consistent with the Government of India's "Make in India" policy.

15.9 KEY INPUTS

i) Adequate manufacturing facilities exist in India for main plant equipment. However, lack of orders is a concern of all equipment manufacturers.

ii) A joint mechanism may be created under Ministry of Steel with participation from power equipment manufacturers and steel manufacturers for more information sharing on compositions/properties of various steels and steel products required and their indigenous development by the steel industry.

iii) An organizational mechanism for information sharing on BoP vendors across industries needs to be considered. Such a mechanism could provide the details on orders in hand, T&P available, past performance etc. This could be a web based portal under DHI or Ministry of Commerce.

iv) New advanced technologies based BoP systems like High Concentration Slurry Disposal (HCSD) type ash disposal systems, closed pipe type conveyors for coal handling plants (CHP), large size Reverse Osmosis systems also need to be indigenized.

v) ODC movement continues to be a major constraint. Thus, the suggestion of manufacturers towards adoption of standardized maximum axle weight of around 16 MT/axle with no approvals required thereafter, single window clearance system for ODCs or undertaking a National Bridge Up-gradation Programme for upgradation of all bridges to minimum strength facilitating ODC movements need to be considered to remove the constraints prevailing in ODC movements.

vi) Inland waterways can become an attractive mode of transportation in conjunction with Railways. The success of NTPC coal transportation to Farakka could be replicated across numerous other stations.
vii) The prevailing regasification capacity for LNG in the country stands at about 21 Million metric tons per annum (MMTPA) – further expansions are being planned by several players. Also additional 15,000 km, of gas pipelines are under construction for completion of national Gas grid.
viii) Future Infrastructure Project in railway line, Port development will be done through PPP mode.
ix) Task Force may be created under NTPC with participation from equipment manufacturers/EPC contractors and utilities to examine the issue of pace of project execution in detail and work out an optimized framework of site preparation, T&P requirements etc. for overall improvement in project execution.

15.10 FUND REQUIREMENTS

i) The total fund requirement for capacity addition is estimated to be ₹ 11,55,652 crores during the period 2017-2022, which includes the RES capacity addition, as well as the expenditure done **during this period** for the projects coming up in the year 2022-27.
ii) The total fund requirement is estimated to be ₹ 9,56,214 crores for the period 2022-27 and **does not include advance action for projects coming up during the period 2027-2032**.

15.11 ENVIRONMENT

i) The total CO_2 emissions projected for the year 2021-22 and 2026-27 is 1026 Million Tonnes and 1173 Million Tonnes respectively.
ii) The average emission factor from grid connected power stations during 2015-16 was 0.721 kg CO_2/kWh. It is expected to reduce to 0.604 kg CO_2/kWh in the year 2021-22 and to 0.524 kg CO_2/kWh by the end of 2026-27.
iii) Emission intensity kgCO_2/GDP (₹) from grid connected power stations is likely to reduce by 40.51 % by the end of 2021-22 and 53.65 % by the end of 2026-27 from the year 2005 level.
iv) It is estimated that 20.69 Million Tonnes of CO_2 emissions have been avoided by 31.03.2017 due to commissioning of Super-critical technology based coal power plants vis-à-vis the scenario of only subcritical units had been commissioned.
v) It is estimated that about 268 Million Tonnes of CO_2 emission will be avoided annually by the end of the year 2021-22 from renewable energy sources.
vi) Country has achieved 60.97% of fly ash utilisation in the years 2015-16. In terms of absolute value, the same stands at 107.77 million tonnes.
vii) Detailed unit-wise feasibility study covering all factors like technology, investment, time frame, suitability in Indian context etc. may be carried out.

15.12 R & D in POWER SECTOR

There are many problems in Indian power sector which are specific to Indian conditions. Through promotion of R&D, these specific problem areas need to be addressed. It is suggested that CEA may act as an interface between Industry and academics for this purpose. An advisory group may be created for promotion of R&D activities in the country with a permanent cell at CEA. The advisory group may have members drawn from Government, Dominant players in the field of Generation, Transmission and Distribution sectors like NTPC, NHPC, BHEL, Powergrid, CESC etc., Research institutions like CPRI and Academic Institutions like IISc/IITs/ NITs.

15.13 HUMAN RESOURCE

i) Sufficient number of Engineers, Managers and Diploma holders are available in the country. However, there are gaps in respect of lower level skills like that of ITI.
ii) It is proposed that all Central Sector Utilities, all State Sector Utilities and all IPPs should create sufficient Training infrastructure as per the norms stipulated in notification of September 2010 issued by CEA.
iii) CEA has recognized about 74 Training Institutes spread all across the country. These institutes may be strengthened for Distribution/Lineman training along with training in renewable sector such as solar, wind etc.
iv) As per National Training Policy of MoP all organizations need to allocate training budget at least equal to 5% of salary budget exclusively for funding training activities.