सत्यमेव जयते

Draft National Electricity Plan

(Volume 1)

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

DECEMBER, 2016

CONTENTS

---++---

ACRONYMS

ACRONYMS	EXPANSION
AC	Alternating Current
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

ACRONYMS	EXPANSION
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
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
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

ACRONYMS	EXPANSION
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
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
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
FEED	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	Gas Insulated Substation
GPS	Geographic Positioning System
GR	General Review
GSPC	Gujarat State Petroleum Corporation
GT	Gas Turbine

ACRONYMS	EXPANSION
GW	Giga Watt
HBJ	Hazira-Bijapur-Jagdishpur (pipeline)
HFO	Heavy Fuel Oil
HEP	Hydro Electric Project
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
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
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
KKNPP	Kudankulam Nuclear Power Project
kW	kilo Watt

ACRONYMS	EXPANSION
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
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
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
NDT	Non Dispatchable Technologies
NECA	National Energy Conservation Awards
NEF	National Electricity Fund
NEP	National Electricity Plan
NETRA	NTPC Energy Technology Research Alliance
NHPC	National Hydroelectric Power Corporation

ACRONYMS	EXPANSION
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
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
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

ACRONYMS	EXPANSION
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
REDB	Rural Electricity Distribution Backbone
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	Re Gasified Liquefied Natural Gas
RM	Reserve Margin
ROM	Run Of Mines
ROR	Run Of River
ROW	Right Of Way
RPCs	Regional Power Committees
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

ACRONYMS	EXPANSION
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
SLR	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
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
UMPP	Ultra Mega Power Project
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

ACRONYMS	EXPANSION
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 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 10^{th} plan, detailed plan for 11^{th} plan and perspective Plan for 12^{th} Plan was notified in the Gazette in August, 2007.

The Second National Electricity Plan covering the review of 11^{th} plan, detailed plan for 12^{th} plan and perspective Plan for 13^{th} 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.
- **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)

4. 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

5. 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.

6. 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.

7. **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.

8. **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.

9. **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

10. 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 report is outcome of the inputs provided by various Sub Committees of the NEP.

MAJOR HIGHLIGHTS

1. In the 12th Plan, likely capacity addition from conventional sources as per review carried out as on 31.3.2016, will be 101,645 MW (Coal- 86,250 MW, Lignite – 1,290 MW, Gas – 6,080 MW, Hydro – 5,525 MW, Nuclear – 2,500 MW) against a target of 88,537 MW. This is about 115% of the target.
2. 56 % of total capacity addition during 12th plan is expected to come from private sector.
3. There is likely to be considerable slippage in capacity addition target in respect of Hydro (5,601 MW) and Nuclear (2,800 MW) in the 12th Plan period.
4. During 12th plan, capacity addition from supercritical technology based coal power plants is likely to contribute around 39% of the total capacity addition from coal based plants.
5. R&M/LE works in respect of 29 Nos. thermal units with aggregate capacity of 4,192 MW have been completed during 12th Plan upto 31.03.2016. During 12th Plan, a total of 22 hydro R&M schemes having an installed capacity of about 3042 MW is expected to accrue benefit of about 567 MW through uprating, life extension and restoration.
6. As on 31.03.2016, India has achieved a total installed capacity of 42,849 MW from Renewable Energy Sources.
7. The country has revised its Renewable Energy capacity target to 175 GW by the year 2021-2022.
8. A capacity addition of 17,930 MW from Renewable Energy Sources has been achieved during the first four years of 12th Plan.
9. Incremental energy savings due to implementation of various energy saving measures, during the year 2016-17, 2021-22 and 2026-27 are estimated to be 26 BU, 137 BU and 204 BU respectively over the year 2015-16.

10. The projected Peak Demand is 235 GW and Energy requirement is 1,611 BU (after considering DSM measures) at the end of year 2021-22 which is around 17% and 15.4 % lower than the corresponding projections made by 18th Electric Power Survey (EPS) report.
11. The projected Peak Demand is 317 GW and Energy requirement is 2132 BU at the end of year 2026-27 which is around 20.7% and 21.3% lower than the corresponding projections made by 18th EPS report.
12. Considering capacity addition from Gas – 4,340 MW, Hydro 15,330 MW, Nuclear -2800 MW and RES – 1,15,326 MW as committed capacity during 2017-22, the study reveals that no coal based capacity addition is required during the years 2017-22. However, a total capacity of 50,025 MW coal based power projects is 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 1,87,821 MW.
13. The study result for the period 2017-22 indicated that no coal based capacity addition is required. Considering this as input for the studies for the period 2022-27 and committed capacity addition of Nuclear - 4,800 MW, Hydro-12,000 MW and RES 100,000 MW during 2022-27 and demand projections for the year 2026-27, study for the period 2022-27 reveals that a coal based capacity addition of 44,085 MW is required. However, as coal based capacity of 50,025 MW is already under construction which is likely to yield benefits during 2017-22, this coal based capacity would fulfil the capacity requirement for the years 2022-27.
14. It is expected that the share of non-fossil based installed capacity (Nuclear + Hydro + Renewable Sources) will increase to 46.8 % by the end of 2021-22 and will further increase to 56.5 % by the end of 2026-27 considering capacity addition of 50,025 MW coal based capacity already under construction and likely to yield benefits during 2017-22 and no coal based capacity addition during 2022-27.

15. The Renewable Energy Generation will contribute about 20.3 % and 24.2 % of the total energy requirement in 2021-22 and 2026-27 respectively.
16. No power plant has reported generation loss due to coal shortage during 2015-16.
17. The total coal requirement in the year 2021-22 and 2026-27 has been estimated as 727 MT (Scenario – I with 175 GW installed capacity from RES by 2021-22) and 901 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. Adequate coal is expected to be available for the coal based power plants during 2021-22 and 2026-27.
19. Against a total domestic natural gas allocated to power projects of 87.46 MMSCMD, the average gas supplied to these gas based power plants during the year 2015-16 was only 28.26 MMSCMD.
20. It has been estimated that the gas based stations shall need at least 53.56 MMSCMD of gas to meet the balancing requirement of the grid arising due to RES integration.
21. Adequate manufacturing facilities exist in India for main plant equipment. However, lack of orders is a concern of all equipment manufacturers.
22. The total fund requirement for generation capacity addition is estimated to be Rs.10,33,375 crores during the period 2017-2022 which includes the funds required for RES capacity addition, as well as the expenditure done during this period on the projects coming up during the years 2022-27.
23. The total fund requirement for the period 2022-27 is estimated to be Rs. 6,05,965 crores but does not include advance action for projects coming up during the period 2027-2032.
24. The total CO_2 emissions for the year 2021-22 and 2026-27 is estimated at 983 million tonnes and 1165 Million tonnes respectively.

25. The current (2015-16) average CO_2 emission factor is estimated at 0.732 kg CO_2/kWh (including renewables). It is expected that this average CO_2 emission factor may reduce to 0.581 kg CO_2/kWh by the end year 2021-22 and to 0.522kg CO_2/kWh by the end of 2026-27.

26. Emission intensity kgCO2/GDP(Rs) from grid connected power stations is likely to reduce by 43 % by the end of 2021-22 and 53.96 % by the end of 2026-27 from the year 2005 level.

27. It is estimated that 6.073 Million tonnes of CO_2 emissions has been avoided during 2015-16 due to commissioning of Super-critical technology based coal power plants. The estimate is based on the assumption of commissioning of sub critical technology based units under BAU (Business as Usual) scenario.

28. 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.

29. Country has achieved 55.69% of fly ash utilisation in the years 2014-15. In terms of absolute value, the same stands at 102.54 million tons.

30. 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 about 3,02,088 MW as on 31.3.2016 from a meagre 1713 MW in 1950. Similarly, the electricity generation increased from about 5.1 Billion units in 1950 to 1,107 BU (including imports) in the year 2015-16. The per capita consumption of electricity in the country has also increased from 15 kWh in 1950 to about 1,010 kWh in the year 2014-15. Out of 5,97,464 census villages, 5,86,785 villages (98.2%) have been electrified as on 31.03.2016. Regional grids have been integrated into a single national grid with effect from 31.12.2012 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) as well as energy(MU) shortage have registered steady decline. The peak shortage and energy shortage were 3.2 % and 2.1 % respectively during the year 2015-16.

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 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 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 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.

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 need 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:

(a) Ensure availability of electricity to consumers at reasonable and competitive rates;
(b) Ensure financial viability of the sector and attract investments;
(c) Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimize perceptions of regulatory risks;
(d) Promote competition, efficiency in operations and improvement in quality of supply;
(e) Promote generation of electricity from Renewable sources;
(f) Promote Hydroelectric Power generation including Pumped Storage Projects (PSP) to provide adequate peaking reserves, reliable grid operation and integration of variable renewable energy sources;
(g) Evolve a dynamic and robust electricity infrastructure for better consumer services;
(h) Facilitate supply of adequate and uninterrupted power to all categories of consumers;
(i) Ensure creation of adequate capacity including reserves in generation, transmission and distribution in advance, for reliability of supply of electricity to consumers.

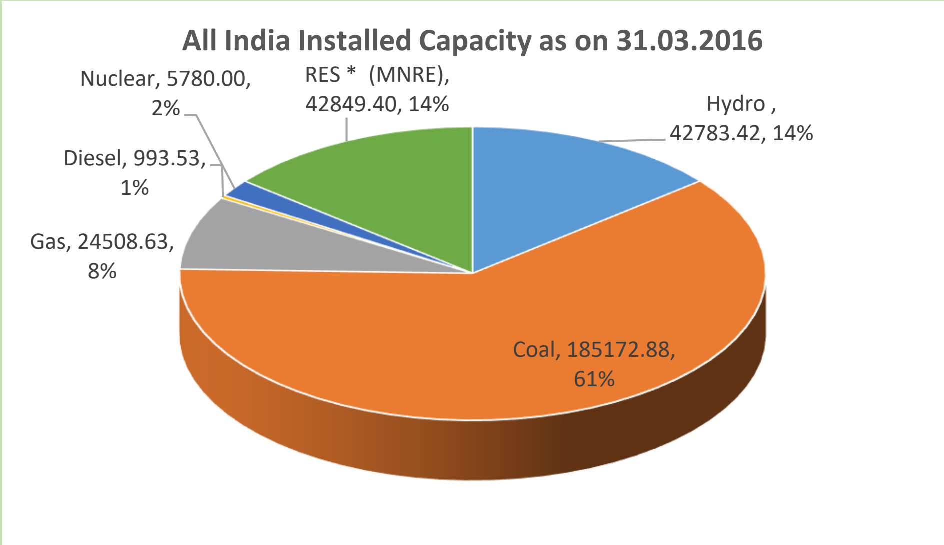
1.2 POWER SCENARIO IN THE COUNTRY

1.2.1 Installed Capacity

The Installed Capacity of the country as on 31.03.2016 was 3,02,088 MW comprising of 2,10,675 MW thermal, 5,780 MW Nuclear, 42,784 MW hydro and 42849 MW renewables and is depicted in the **Exhibit 1.1**.

Exhibit 1.1.

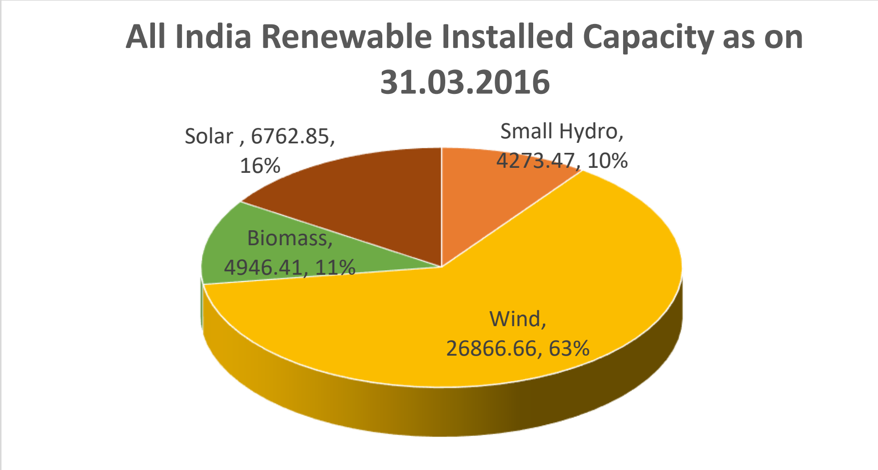
(All figures in MW)



The country has significant potential of generation from renewable energy sources. All efforts are being taken by Government of India to harness this potential. The Installed capacity as on 31st March, 2016 from renewable energy sources is 42,849 MW. The Total Renewable Installed Capacity comprises of 26,866.7 MW from Wind, 4,273.5 MW from Small Hydro Plants, 4,946.4 MW from Biomass Power & Biomass Gasifiers and 6,762.9 MW from Solar power & Urban & Industrial waste. 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)	Growth rate in (%)	Compound Growth (%)
10th Plan				
2002-03	107877	531.61	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	223344	**912.05**	**4.0**	**6.14**
2013-14	245259	**967.15**	**6.0**	
2014-15	271722	**1048.67**	**8.4**	
2015-16	302,088	**1107.38**	**5.6**	

Exhibit 1.3

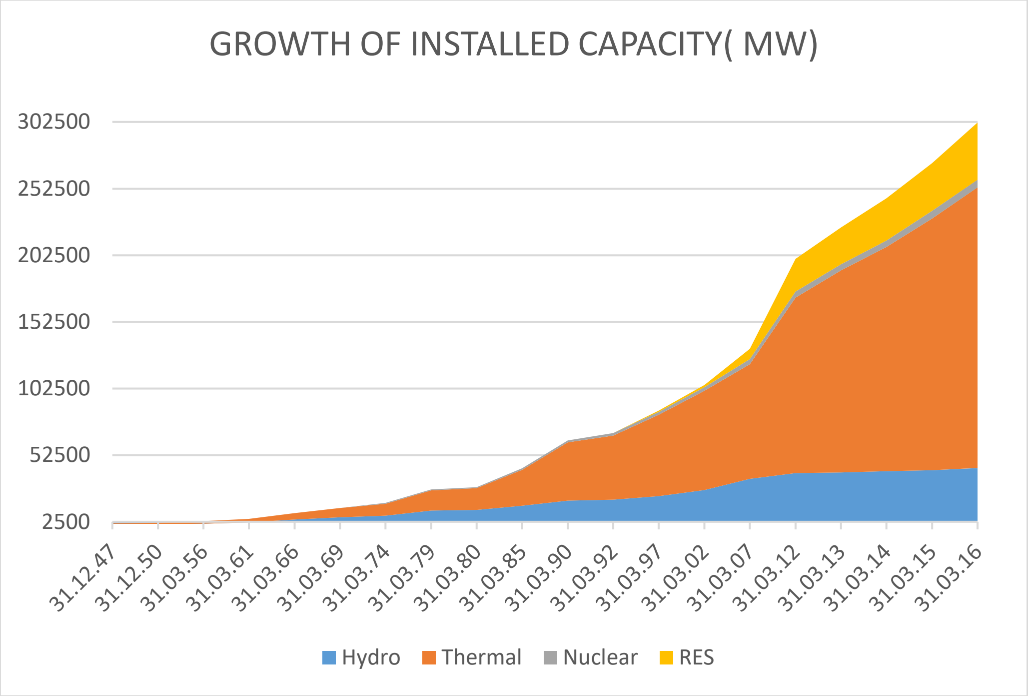
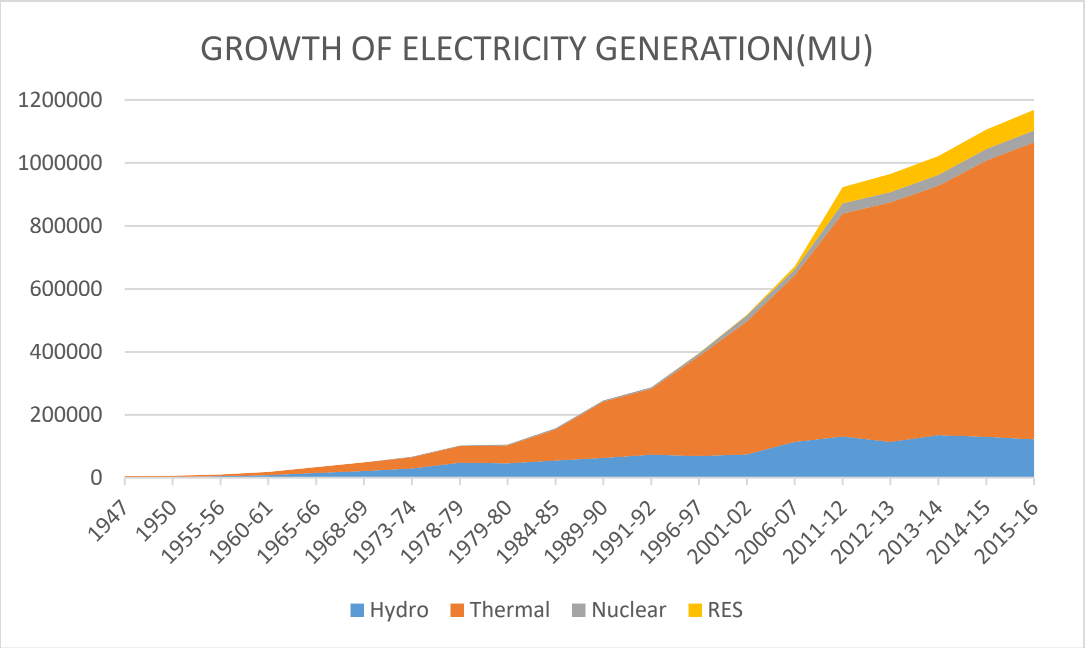


Exhibit 1.4



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 31.03.2015 the per capita electricity consumption has increased to 1010 kwh. The per capita electricity consumption target for the year 2015-16 was 1101 kwh. The per capita electricity consumption during four years of 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	1101.00 (provisional)

1.2.3 Actual Power Supply Position

The peak demand deficit was about 12,159 MW (9.0%) and the average energy shortage in the country was about 87 Billion kWh (8.7%) during the 1st year of 12th plan i.e. 2012-13. The peak deficit and energy shortage of the country has substantially declined to 4,903 MW (3.2%) and 23 Billion Units (2.1%) respectively during the fourth years of 12th Plan (2015-16). The power supply position in the country during four years of 12th Plan is summarized in **Table 1.3**.

Table 1.3

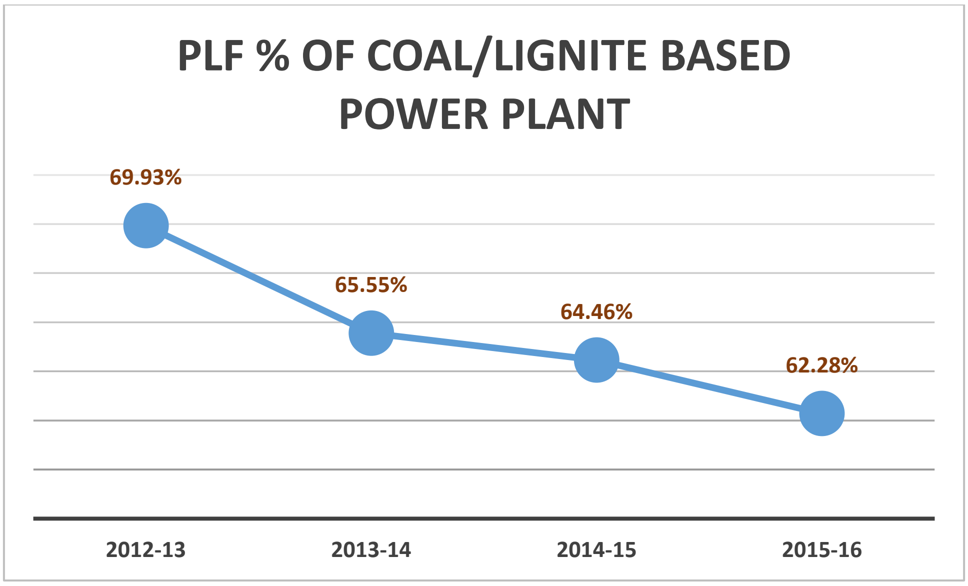
All-India Actual Power Supply Position (2012-16)

PERIOD	PEAK DEMAND (MW)	PEAK MET (MW)	PEAK DEFICIT/ SURPLUS (MW) (- / +)	PEAK DEFICIT/ SURPLUS(%) (- / +)	ENERGY REQUI-REMENT (MU)	ENERGY AVAIL-ABILITY (MU)	ENERGY DEFICIT/ SURPLUS (MU) (- / +)	ENERGY DEFICIT/ 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

1.2.4 Plant Load Factor of Coal/Lignite Based Power Plant

The national average Plant Load Factor (PLF) of Coal based power generating stations during last four years i.e. 2012-13, 2013-14,2014-15 and 2015-16 is 69.93% ,65.55%, 64.46% and 62.28% respectively. The year wise PLF is shown in **Exhibit 1.5**

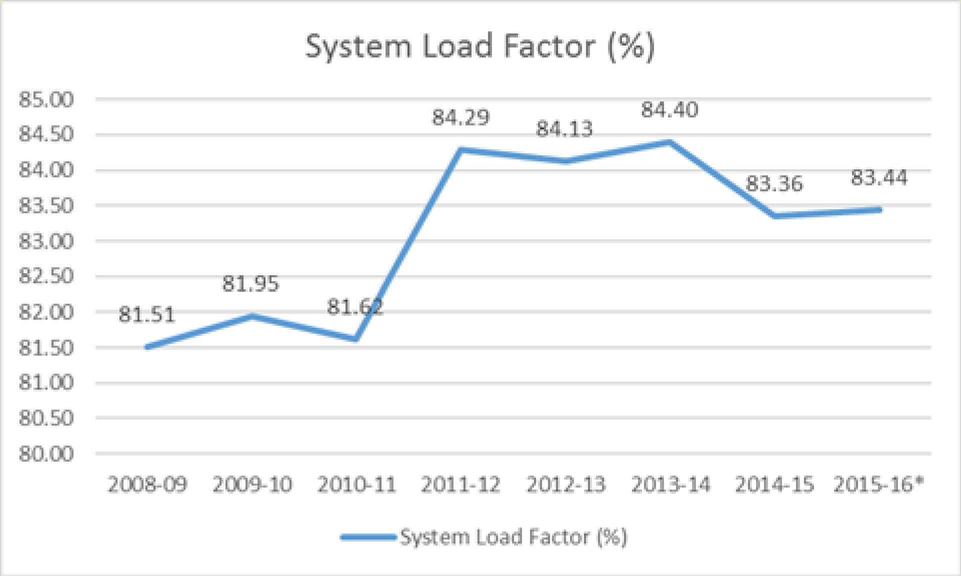
Exhibit 1.5



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, primarily because of prevailing energy shortages in the system and the load staggering measures adopted in the various states particularly in agriculture sector. Annual Electric Load Factor is as depicted in the **Exhibit 1.6.**

Exhibit 1.6

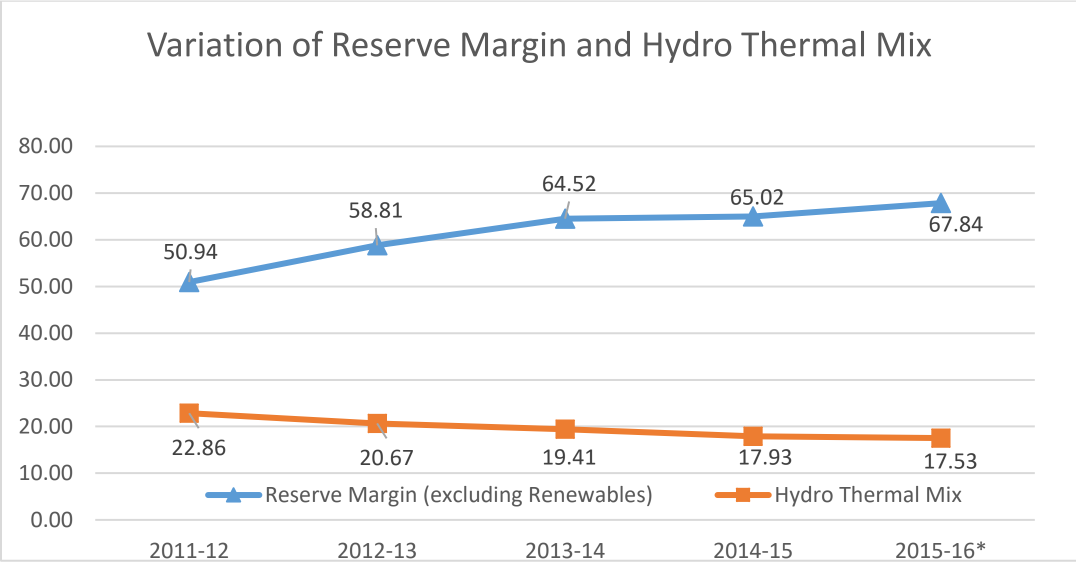


1.2.6 Reserve Margin and Hydro Thermal Mix

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 67.84% in January, 2016.

The Hydro-Thermal mix has been decreasing from 22.86% as on 31st March, 2012 to 17.53% in January,2016 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.**

Exhibit 1.7



This increase in Reserve Margin is on account of decrease in thermal PLF from 73.32 % in 2011-12 to 63.20 % in 2015-16 up to January, 2016. This is illustrated in the **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 27.03.09. 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 08.11.13 and 09.11.13 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 Projects

This Initiative was launched by the Central Government in 2005-06 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. 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 have 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 Krishnapattam 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 2.7.2012. 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 28.4.2015 citing non transfer of land to the developer by the Jharkhand Government

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

In addition, six other UMPPs, one in Chhattisgarh, two Additional UMPPs in Orissa, Second UMPP in Gujarat, Second UMPP in Tamilnadu, UMPP in Karnataka 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 25.08.2014 and Order dated 24.09.2014 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 24.09.2014, 9 nos. 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 nos. Coal Mines for linked End Used 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 31.3.2008. The salient features of the policy are given below:

- Transparent selection criteria for awarding sites to private developers.
- 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.
- 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 Government 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.

1.3.5 Augmentation of Indigenous Equipment Manufacturing Capacity

Indigenous manufacturing capacity for supercritical equipment has been created by BHEL and several Joint Ventures set up by the International equipment manufacturers in partnership with Indian companies. BHEL have entered into technology collaboration agreements with M/s. Alstom for supercritical boilers and M/s. Siemens for supercritical turbine generators. BHEL have achieved manufacturing capacity for power equipment of 20,000 MW/ year (around 13,500 MW for large thermal projects). Indigenous manufacturing capacity envisaged by JVs for Supercritical boilers is 16,200 MW and supercritical turbine generators are 14,000 MW.

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
Gammon- Ansaldo	4000 MW	-
Thermax-Babcock & Wilcox	3000 MW	-
BGR Hitachi	5 Boiler per annum (~3000) MW	5 Turbine generators per annum (~3000 MW)
Doosan Chennai Works Pvt. Ltd.	2200 MW (both subcritical and supercritical)	-
Total	16200 MW	14000 MW

Most of the Joint Ventures (JVs) companies are in the advanced stage of setting up of manufacturing facility

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 manufacturer. Accordingly, an advisory was issued by CEA vide its letter dated 2nd February, 2010 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. The period of advisory has expired in October, 2012. Accordingly, the matter has been considered by MoP and it was decided that the said advisory be extended for another period of two years i.e. upto October-2015. Further, extension of advisory for a period of three years is under consideration of Ministry of Power.

An assessment of requirement of Balance of Plant (BoP) equipment for power plants has also been carried out and efforts are being made to enhance the manufacturing capacity of existing vendors and encourage new vendors also.

It is necessary to sensitize the industry about the long term requirement of BoPs for the power sector to attract investment in BoP segment. Ministry of Power and CEA have already taken an initiative in coordination with Confederation of Indian Industry (CII) to sensitize the industry about the requirement of BoPs.

BoP is not a high technology area and a vendor having experience of executing other infrastructure projects could also develop BoP execution capabilities. This has been considered to avoid overburdening the existing BoP manufacturers. CEA has already reviewed the pre-qualification requirements for BoP vendors and the pre-qualification report for the various BoP packages has been finalised by CEA in consultation with the stakeholders. The recommendations of CEA have been forwarded to all State and Central Power Utilities for adoption.

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 100,000 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 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 Government 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.

As on 30.04.2016, State Specific Documents for the Twenty-one (21) States viz Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Punjab, Rajasthan, Sikkim, Telangana and Uttarakhand have been approved by the respective State Governments and signed by State & Central Government for implementation.

Preparation of documents in respect of other States/UTs is in progress and are at different stages of preparation.

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.

1.3.8 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 consumer's rests with the States. However, Government of India provides assistance to States through various Central Sector / centrally sponsored schemes for improving the distribution sector.

1.3.8.1 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 Rs. 51,577 Crore. 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 Dec 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 Rs. 32,612 crore including a budgetary support of Rs. 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 Rs. 44,011 crore including a budgetary support of Rs. 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.

1.3.8.2 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 Rs. 43,033 crore including a budgetary support of Rs. 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 Rs 39,275 crore including a budgetary support of Rs 35,447 crores. This outlay will be carried forward to the new scheme of DDUGJY in addition to the outlay of Rs. 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 6131 projects at an estimated cost of Rs 1,08,8826.8 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 30.04.2016.

Under the scheme electrification of 1,28,432 un-electrified villages, intensification of 6,56,015 partially electrified villages and electricity connections to 4.20 crore households have been approved. Out of which electrification of 1,16,585 un-electrified villages (91%), intensification of 3,54,959 partially electrified villages (54%) and electricity connections to 2.34 crore households (56%) have been achieved and an amount of Rs 41,061.49 Crores have been released to the states till 30-04-2016.

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

Ministry of Power vide OM dated 05.10.2012 had earlier notified, a Financial Restructuring Plan (FRP) of State owned Discoms to enable financial turnaround of State Discoms. Discoms of four States i.e. Tamil Nadu, Uttar Pradesh, Rajasthan and Haryana have participated in the scheme. Central Government vide notification dated December 13, 2013 has further extended the scheme to cover Andhra Pradesh / Telangana, Jharkhand and Bihar States. For these States, the notification has been amended by extending the cut-off date for reckoning the eligible amount of short term liabilities for bonds / re-scheduling, as 31.03.2013.

This scheme is now replaced by UDAY (Ujwal Discom Assurance Yojana) announced by Ministry of Power vide Office Memorandum No. 06/02/2015-NEF/FRP dated 20.11.2015, with an objective to improve the operation and financial efficiency of State owned Discoms. The UDAY scheme intends to achieve this through (a) improving operational efficiencies of Discoms, (b) reducing the cost of power procurement by Discoms, (c) financial turnaround of Discoms through State(s) takeover of Discoms debts, and (d) financing future losses and working capital of Discoms by State(s).

Salient features of the UDAY scheme

1. To improve operational efficiency, the UDAY scheme has identified specific areas for improvement (for example, compulsory feeder and distribution transformer metering, indexing and mapping of losses and quarterly tariff revisions) within a specified time frame, and measured against AT & C losses as per trajectory to be finalized by the Ministry of Power ("MoP") and participating State(s).

2. Recognising costly power as a primary reason for the systemic financial distress of Discoms, the UDAY scheme has proposed steps to be taken to reduce cost of power. For example, increased supply of domestic coal, coal linkage and coal price rationalization, supply of washed and crushed coal by Coal India Limited ("CIL") within specified dates, allowing coal swaps from inefficient plants to efficient plants, etc.

3. For the financial turnaround of Discoms, the UDAY scheme seeks:
    - Participating States to take over 75% of the debts of Discoms (by way of grant), as on September 30, 2015 over a period of two years: 50% of such debts will be taken over in the financial year 2015-16 and 25% in the financial year 2016-17;
    - Participating States to issue non-statutory liquidity ratio ("SLR") bonds, including State Development Loan ("SDL") bonds against Discoms' loans, for subscription firstly by pension funds, insurance companies and other institutional investors. The balance bonds (not taken up by pension funds, insurance companies, etc.) to be offered directly to lender banks/financial institutions in proportion to their current lending to Discoms. Proceeds of such issues of bonds will be transferred to Discoms for paying off their loans to lender banks/financial institutions;
    - Banks/financial institutions not to levy prepayment charge on Discoms' debts. Banks/FIs to also waive off unpaid overdue interest (including penal interest) on Discoms' debt, and to adjust such overdue/penal interest paid since October 1, 2013; and
    - 50% of Discoms' debt as on September 30, 2015 (after any waivers as aforesaid), which remain with Discoms, to be converted into loans or bonds with interest rate not exceeding the concerned Bank's base rate plus 0.1%. Alternatively, Discoms may issue State guaranteed bonds against the aforesaid debt at a rate not exceeding the bank's base rate plus 0.1%. The

State will take over 50% of the remaining 50% debt (i.e., 25%) in 2016-17 as aforesaid. The balance 25% remaining with Discoms will be dealt with through a mechanism to be developed by the MoP.

4. For financing future losses and working capital of Discoms, States will take over and fund future losses of Discoms in a graded manner until the financial year 2020-21. Also, lender banks/financial institutions are no longer to advance short term loans to Discoms for financing losses but may finance Discoms' working capital requirement by way of loans (or by letters of credit wherever possible), only upto 25% of the concerned Discom's previous year's annual revenue (or as per prudential norms).

5. States which achieve operational milestones of the UDAY scheme will be entitled to additional/priority funding through various funds/schemes of the MoP and Ministry of New and Renewable Energy.

18 States and one Union Territory have given their 'in-principle' approval to participate under UDAY. So far, 10 States namely Jharkhand, Chhattisgarh, Rajasthan, Uttar Pradesh, Gujarat, Bihar, Punjab, Jammu & Kashmir, Haryana and Uttarakhand have already signed the Memorandum of Understanding (MoUs) with Ministry of Power under UDAY.

1.3.8.4 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 Rs.980 crore including a budgetary support of Rs.338 crores. Under NSGM, 30% funding will be provided for development of Smart Grid in selected Smart Cities in the country along with development of micro grid in the Country. The 100% funding is also proposed for training & capacity building and consumer engagement etc.

As on 31.03.2016 two smart grid projects i.e. Chandigarh Electricity Department, Chandigarh and MSEDCL, Maharashtra has been approved with an approved project cost of Rs 28.58 Crores and Rs 90.05 Crores respectively.

1.3.8.5 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.

1.3.9 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 CO2 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 renewable 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 side, 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.

1.3.10 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 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 Rs. 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 Rs. 775 crores.

1.3.11 Domestic Efficient Lighting Programme

Domestic Efficient Lighting Programme (DELP) was launched by Government of India, replacing the Bachat Lamp Yojana. 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 Rs 310 for a 7 W bulb in January 2014 to Rs.54.90 for a 9 W bulb.

1.3.12 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.

1.3.13 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 Rs 7500 crores (Rs 3500 crores and Rs 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 NATIONAL ELECTRICITY PLAN FOR A PERIOD OF 2017- 2022

As mandated by the Act and the Policy, CEA has prepared the National Electricity Plan for the period 2017-22 and Perspective Plan for the period 2022-27 and a review of the Status of implementation of the 12th Plan projects. The draft NEP was circulated to all Stakeholders for their comments/suggestions.

---+++---

Annexure 1.1

STATUS OF ULTRA MEGA POWER PROJECTS

Sl. No.	Name of UMPP	Location	Levelised tariff (Rs/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. All units (6x660 MW) have been 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 non transfer of land to the developer by Jharkhand Government.

Projects identified for Bidding:

Sl. No	Name of UMPP	Location	Status
1.	Bedabahal	Bedabahal in Sundergarh District, Odisha.	The site for this UMPP is in village Bedabahal in Sundergarh district. RfQ and RfP issued in 2013 were withdrawn. Fresh RFQ and RFP are to be issued after finalization of standard bidding documents by expert committee.
2.	Tamil Nadu	Village Cheyyur, District Kancheepuram.	The site at Cheyyur in Kanchipuram district in Tamil Nadu has been identified along with captive port at Panaiyur village. Request for Qualification (RfQ) and Request for Proposal (RfP) issued in 2013 were withdrawn. Fresh RFQ and RFP are to be issued after finalization of Standard Bidding Documents.
3.	Bihar	Kakwara in Banka Distt	A site at Kakwara in Banka Distt 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.
4.	2nd Jharkhand UMPP	Husainabad, Deoghar Distt	A site at Husainabad, Deoghar Distt 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.

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, 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, the site near Narla and Kesinga subdivision of Kalahandi district was finalised. Consent from Government of Odisha is awaited.
3.	Chhattis garh	Near Salka in Khameria villages District Surguja.	In a meeting held on 21.7.2015, representative of Government of Chhattisgarh informed that due to surplus power in the State, the government is not keen on setting up the UMPP at present. The same would be confirmed by Government of Chhattisgarh to Ministry of Power.
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 which 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	---	On 12.01.2016, CEA & PFCCL team has visited site in Gir Somnath District, Gujarat identified by Government of Gujarat to explore the possibilities for setting up of UMPP. The matter is under process.
6.	Karnataka	State Government has identified a suitable site in Niddodi village of Mangalore taluka Dakshina Kannada District.	CEA sent Site visit report of Niddodi village of Mangalore taluka Dakshina Kannada District to Government of Karnataka in May 2013 highlighting issues with respect to the site and requested for quick resolution of the issues.

CHAPTER 2

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

2.0 INTRODUCTION

The capacity addition target set for the 12th Plan is 88,537 MW from conventional sources of energy. This Chapter includes details of likely capacity addition by the end of 12th plan and also the constraints faced in timely execution of the power projects. The review of capacity addition during the 12th Plan has been carried out as on 31.03.2016.

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 removing 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 **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)

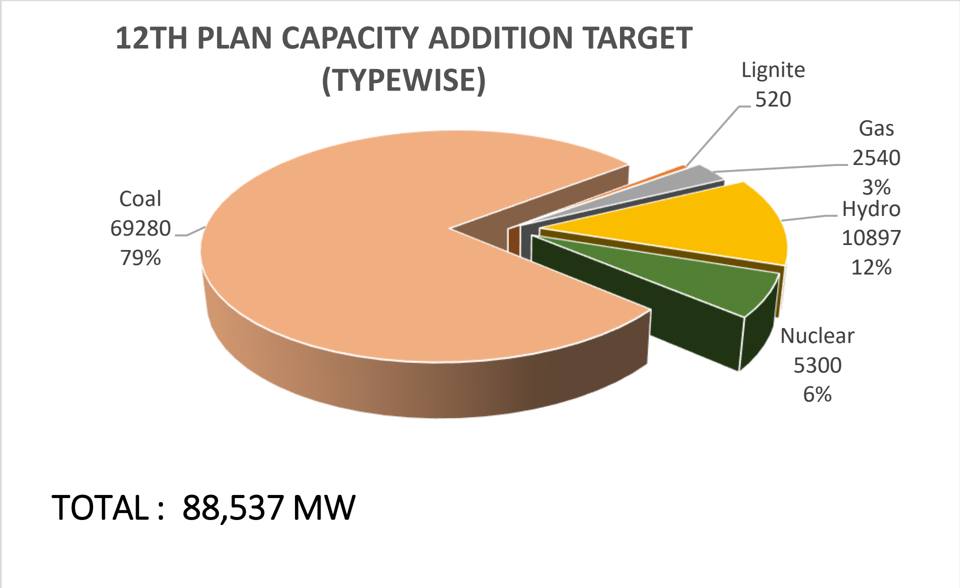
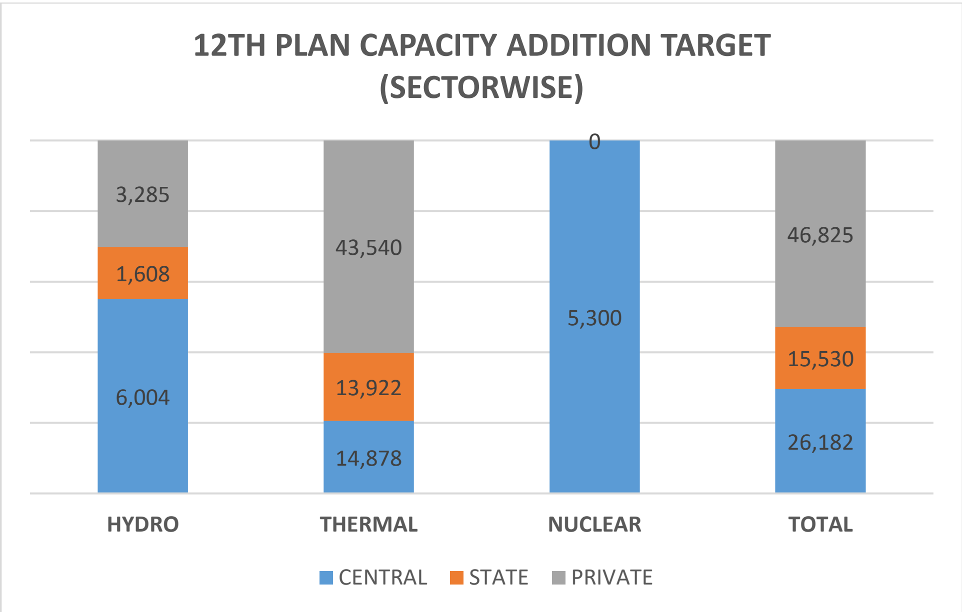


Exhibit 2.2

(Figures in MW)



2.2 REVIEW OF 12TH PLAN CAPACITY ADDITION FROM CONVENTIONAL SOURCES

The target set for capacity addition during the 12th Plan was 88,537 MW from conventional sources. As on 31st March 2016, capacity of 84,990 MW has been added during 12th five Year Plan comprising of 3,811 MW of Hydro, 80,179 of Thermal and 1,000 MW of Nuclear. The likely capacity addition to be achieved during 12th plan (by the end of 2016-17) is 1,01,645 MW.

Out of planned capacity addition target of 88,537 MW to be achieved by the end of 12th plan, a capacity addition of 67,141 MW is likely to be achieved as per target and Projects totalling to 21,386 MW are likely to slip from 12th Plan on account of various reasons viz. delay in placement of order for main plant, slow progress of civil work, poor geology etc. Further, additional projects totalling to 34,504 MW which were at various stages of construction and originally not included in the 12th Plan target are also likely to be commissioned during 12th Plan period. A summary of the likely capacity addition during 12th Plan is given in **Table 2.2.**

Table 2.2

Summary of likely capacity addition during 12th Plan

(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 31.03.2016**	**57,721***
C	**Capacity likely to be added as per target during balance period of 12th Plan**	**9,420**
D	**Capacity likely to be slipped from the capacity addition target of 12th Plan**	**21,386**
E	**Additional Capacity commissioned during 12th Plan as on 31.03.2016 outside the capacity addition target**	**27,270**
F	**Capacity Addition Likely during balance period of 12th plan outside the capacity addition target**	**7,234**
Total Capacity addition likely during 12th Plan as per target(B+C)		**67,141**
Additional Total Capacity addition likely during 12th Plan outside target(E+F)		**34,504**
Total Capacity Likely to yield benefit during 12th Plan (B+C+E+F)		**1,01,645**

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

The year wise capacity addition during 12th plan from conventional sources, achieved till 31st March ,2016 is shown in **Table 2.3**. Capacity addition achieved during 2015-16 was 23,976 MW, which is highest capacity addition ever achieved in a single year in the country. State wise capacity addition target and achievement till 31.3.2016 is given in **Annexure 2.1.** List of power projects commissioned /likely to be commissioned during 12th Plan period is given in **Annexure 2.2.**

Table 2.3

Year wise capacity addition achieved in first four years of 12th Plan

(Figures in MW)

Year	Sector	Central	State	Private	Total
2012-13	**Hydro**	374.00	57.00	70.00	**501.00**
	Thermal	5023.30	3911.00	11187.50	**20121.80**
	Nuclear	0	0	0	**0**
	Total	5397.30	3968.00	11257.50	**20622.80**
2013-14	**Hydro**	914.00	45.00	99.00	**1058.00**
	Thermal	1660.00	3322.00	11785.00	**16767.00**
	Nuclear	0	0	0	**0**
	Total	2574.00	3367.00	11884.00	**17825.00**
2014-15	**Hydro**	736.00	0	0	**736.00**
	Thermal	2659.20	4886.10	13285	**20830.30**
	Nuclear	1000.00	0	0	**1000.00**
	Total	4395.21	4886.10	13285	**22566.30**
2015-16	**Hydro**	480.00	610.00	426.00	**1516.00**
	Thermal	3295.60	6460	12710	**22460.60**
	Nuclear	0	0	0	**0**
	Total	3775.60	7070	13136	**23976.60**

The sector wise, mode wise capacity addition during 12th Plan achieved as on 31.03.2016 from conventional sources, is shown in **Table 2.4**.

Table 2.4

Capacity addition achieved during 12th Plan (as on 31.3.2016)

(Figures in MW)

Sector	Hydro	Thermal			Nuclear	Total
		Coal	Gas	Total		
State	712	16570	2009.1	18579.1	0	**19291.1**
Private	595	45870	3092.5	48962.5	0	**49557.5**
Central	2504.02	11785	853.1	12638.1	1000	**16142.1**
Total	**3811.02**	**74225**	**5954.7**	80179.7	**1000**	**84990.7**

A sector wise, mode wise summary of likely capacity addition during 12th Plan is furnished in **Table 2.5 and Exhibit 2.3**.

Table 2.5

Likely capacity addition during the 12th Plan (sector wise and type wise)

(Figures in MW)

SECTOR	HYDRO	THERMAL BREAKUP			NUCLEAR	Total
		COAL	GAS	TOTAL		
CENTRAL	2,994.0	14,490.0	878.6	15,368.6	2,500.0	20,862.6
STATE	1,107.0	20,380.0	2,109.1	22,489.1	0.0	23,596.1
PRIVATE	1,424.0	52,670.0	3,092.5	55,762.5	0.0	57,186.5
ALL-INDIA	5,525.0	87,540.0	6,080.2	93,620.2	2,500.0	1,01,645.2

Exhibit 2.3

(Figures in MW)

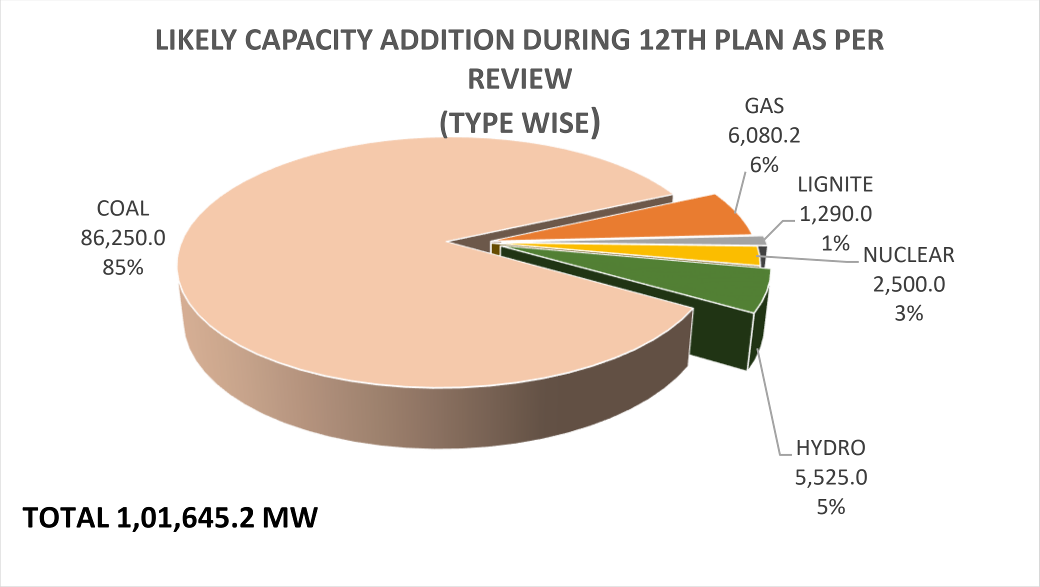


Exhibit 2.4

(Figures in MW)

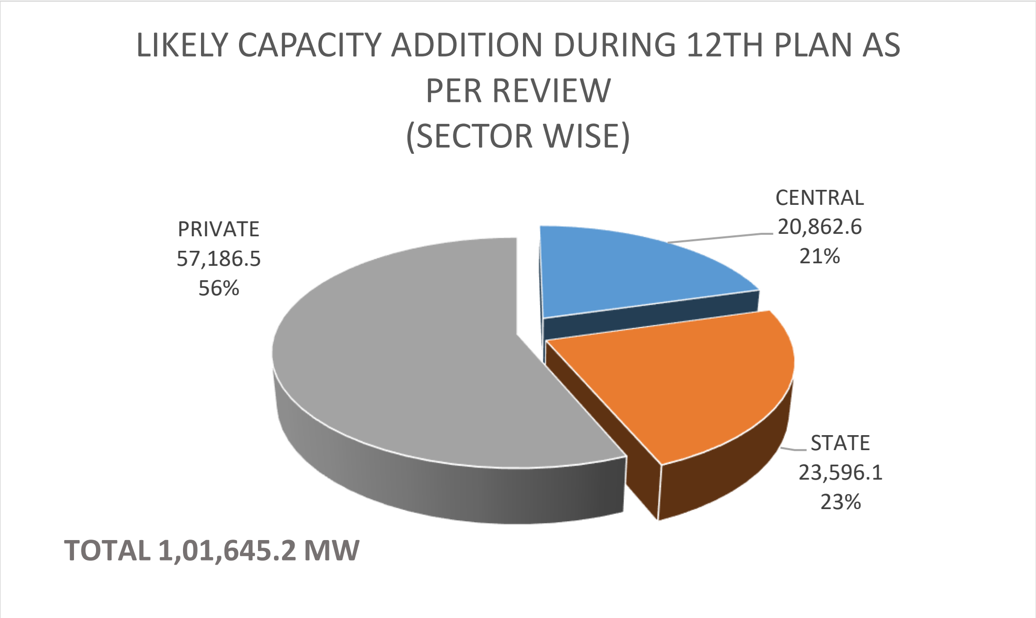
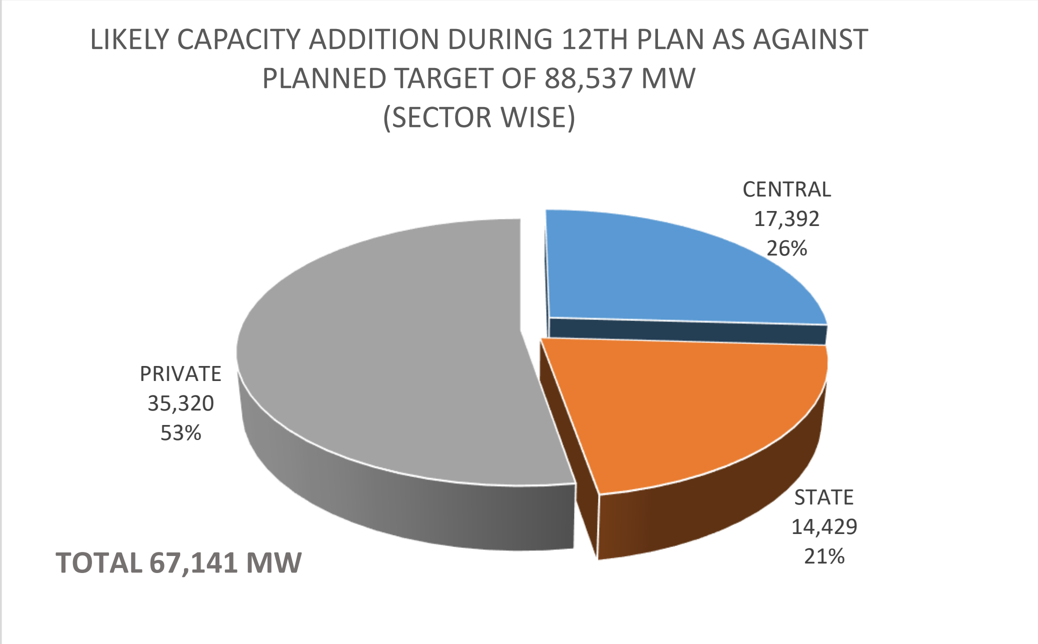


Exhibit 2.5

(Figures in MW)



2.3 ADDITIONAL CAPACITY LIKELY 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 34,504 MW not included in the 12th Plan target is likely to yield benefits during 12th Plan. Out of this, a capacity of 27,270 MW has already been commissioned till 31.03. 2016.The sector wise and mode wise details are shown in **Table 2.6 and Exhibit 2.6**. This includes Private sector contribution of 21,866 MW, amounting to around 63.4% of the total capacity addition which is outside the target.

Table 2.6

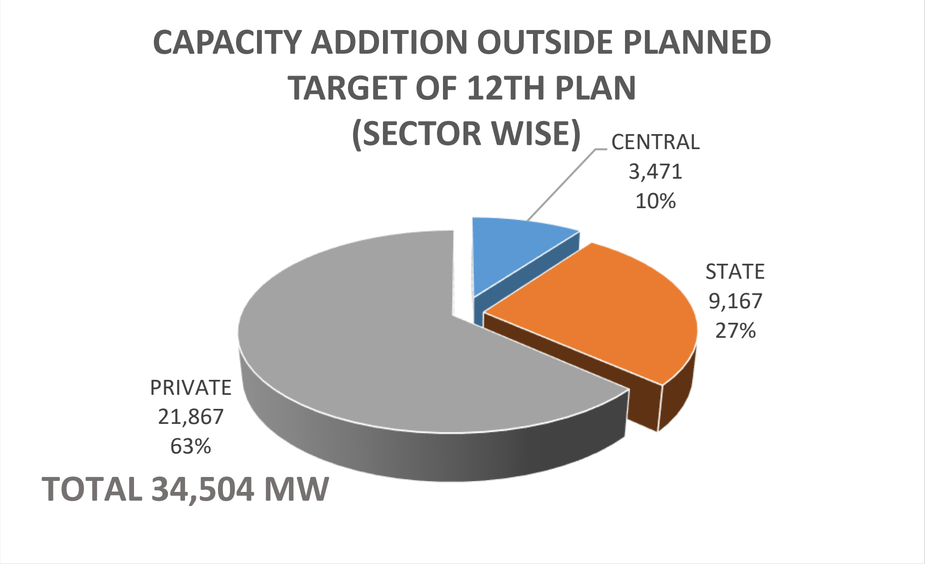
Additional Capacity Addition Likely during 12th Plan

(Figures in MW)

Sector	Hydro	Thermal			Nuclear	Total
		Coal	Gas/LNG	Total		
Central	0.0	3,420.0	51.0	3,471	0.0	3,471.0
State	0.0	8,770.0	397.1	9,167.1	0.0	9,167.1
Private	229.0	18,545.0	3,092.5	21,637.5	0.0	21,866.5
Total	229.0	30,735.0	3,540.6	34,275.6	0.0	34,504.6

Exhibit 2.6

(Figures in MW)



Majority of additional projects commissioned/likely to be 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 2.7.**

As can be seen from **Table 2.7**, capacity addition achievement for previous five year Plans was short of the target, but during 12th Plan, about 96% of capacity addition target has already been achieved till 31.03.2016 with one year still left of 12th Plan period. As per review of 12th Plan, it is expected that capacity addition achievement will surpass the target.

Table 2.7

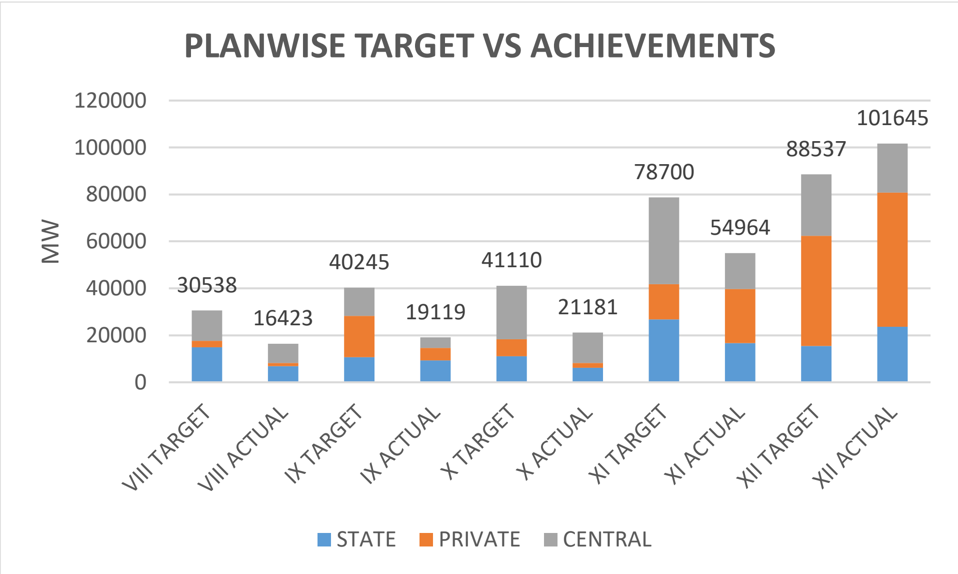
Capacity Addition Target vis-a-vis Achievement in previous five year Plans

(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 (likely)
State	14870	6835	10748	9353	11157	6245	26783	16732	15530	23596
Private	2810	1430	17589	5262	7121	1930	15043	23012	46825	57186
Central	12858	8157	11909	4504	22832	13005	36874	15220	26182	20863
Total	30538	16423	40245	19119	41110	21180	78700	54964	88537	101645
% Achievement		**53.7**		**47.5**		**51.5**		**69.84**		**114.8**

Exhibit 2.7(a)

(Figures in MW)

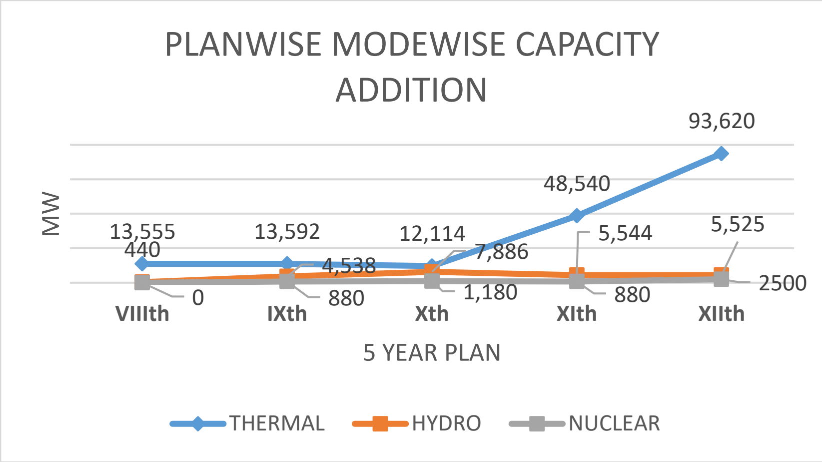


From the **Exhibit 2.7(a),** it can be seen that private sector contribution towards capacity addition has significantly increased during the 11th Plan period onwards contributing around 42% of the total capacity added during 11th Plan and about 56% of likely total capacity addition during 12th Plan will be from private sector.

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 targets.

2.5 GAS BASED POWER PLANTS READY FOR COMMISSIONING/UNDER CONSTRUCTION

A Gas based power generation capacity of 4,340 MW, in private sector, is ready for commissioning/under construction. However, due to unprecedented reduction in supply of domestic Natural Gas in the country, these power plants are yet to be commissioned. List of projects ready for commissioning/under construction but stranded due to non-availability of natural gas is enclosed at **Annexure 2.3.** This capacity has not been included in the likely capacity addition during 12th Plan.

2.6 COAL BASED THERMAL CAPACITY ADDITION

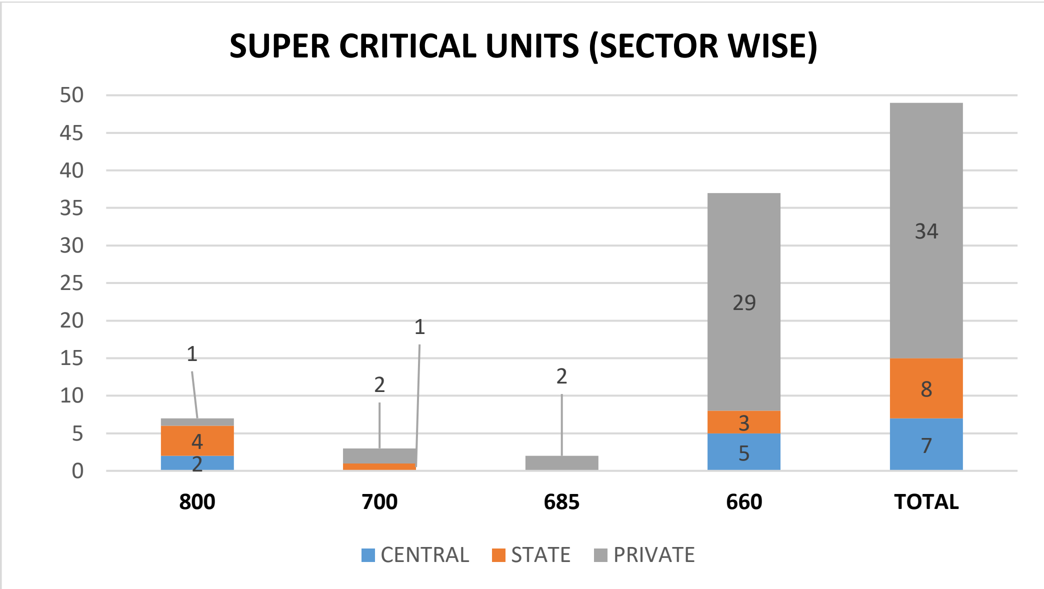
To follow low carbon growth strategy, Government of India is promoting Supercritical technology for coal based power plants, which has higher efficiency than conventional sub critical technology, thereby ensuring less CO_2 emissions. **Table 2.8** shows that around 33,490 MW (39%) of the total capacity addition from coal units (86,250 MW) are likely to be based on supercritical technology (660MW and above) during the 12th Plan period. It is expected that 34 No. of coal based units on supercritical technology are likely to be commissioned in private sector out of the total of 49 No of supercritical technology based units expected to be commissioned during 12th Plan.

Table: 2.8

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	1	7	5600	6.5
700	0	1	2	3	2100	2.43
685	0	0	2	2	1370	1.59
660	5	3	29	37	24420	28.31
Supercritical technology based capacity addition				**49**	**33490**	**38.83**
Less than 660 (Sub-critical)	22	32	80	134	52760	**61.17**
Total	**29**	**40**	**114**	**183**	**86250**	**100.00**

Exhibit: 2.8



2.7 PROJECTS SLIPPING FROM 12TH PLAN CAPACITY ADDITION TARGET

Out of targeted capacity addition of 88,537 MW, a capacity of 21,386 MW (24% of the target) is likely to slip from 12th Plan. Sector wise and mode wise details of capacity likely to slip are shown in **Table 2.9 and Exhibit 2.9.**

Table 2.9

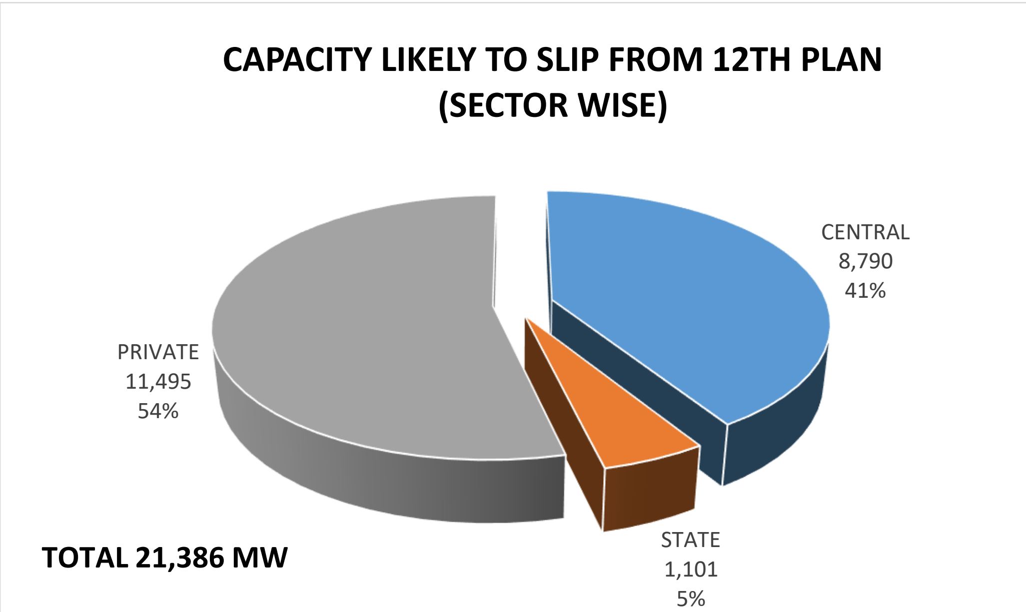
Capacity likely to Slip from capacity target of 88,537 MW during 12th Plan

(Figures in MW)

Sector	Hydro	Thermal			Nuclear	Total
		Coal	Gas/LNG	Total		
Central	3,010.0	2,980.0	0.0	2,980.0	2,800.0	8,790.0
State	501.0	600.0	0.0	600.0	0.0	1,101.0
Private	2,090.0	9,405.0	0.0	9405.0	0.0	11,495.0
Total	5,601.0	12,985.0	0.0	12,985	2,800.0	21,386.0

Exhibit 2.9

(Figures in MW)



State-wise list of capacity likely to slip from 12th Plan is given in **Annexure 2.4**. List of power projects likely to slip from 12th Plan capacity addition target is given at **Annexure 2.5**.

2.8 MAJOR REASONS FOR SLIPPAGE OF PROJECTS FROM 12TH PLAN.

2.8.1 Hydro Projects

- Slow progress of civil work
- Poor geology
- Unfavorable weather conditions like heavy monsoons, floods, cyclones etc.
- Law and order issues
- Funds Constraints
- Contractual issues
- Environmental issues
- Local issues

2.8.2 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.

2.9 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. The 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 to 15 to 20 years beyond the original designed economical life.

2.9.1 THERMAL

LE/R&M works to be taken up during 12th Plan are given in **Table 2.10.** R&M/LE works in respect of 29 Nos. thermal units with aggregate capacity of 4192MW have been completed during 12th Plan upto 31-03-2016. Details of the achievement of R & M and LE projects completed during 12th Plan till 31.3.2016 are shown in **Table 2.11.**

Table 2.10

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)
	State Sector	Central Sector	
LE	38 (6820)	32 (5246)	70 (12066)
R&M	20 (4150)	45 (13151)	65 (17301)
Total	58 (10970)	77 (18397)	135 (29367)

Table 2.11

Achievements of R&M and LE Projects during 12th Plan (upto 31.03.2016)

Sl. No.	Particulars	LE/R&M works completed during 12th Plan No. of units & capacity (MW)		Total (State Sector + Central Sector)
		State Sector	Central Sector	
1	**LE**	7(870)	11(1261.76)	18(2131.76)
2	**R&M**	5(850)	6(1210.5)	11(2060.5)
Total		**12(1720)**	**17(2472.26)**	**29(4192.26)**

Details of Achievements of LE and R&M Programme during 12th Plan upto 31.03.2016 are given in **Annexure 2.6**.

2.9.2 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 3042 MW and which will accrue benefit of about 567 MW through uprating, life extension and restoration are expected to be completed at an estimated cost of about Rs. 1353 Crores. Details are given in **Table 2.12**.

Table 2.12

Programme and Achievements of R&M and LE Projects during 12th Plan (upto 31.03.2016)

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	1352.67
Completed as on 31.3.2016	2	14	16	875.82

2.10 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.

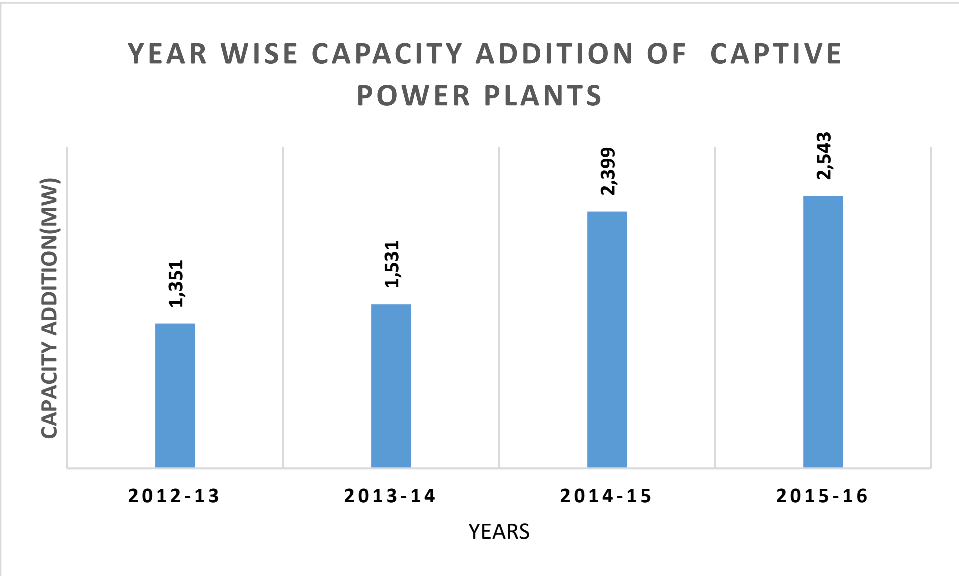
The installed capacity of captive Power Plants (1 MW and above) is about 47,200 MW as on 31.3.2016 registering a growth of 5.69 % over the year 2014-15. The total installed captive power plant capacity was 44,657 MW on 31.03.2015.

The energy generation from captive power plants during the year 2014-15 was about 162 BU registering a growth of about 8.7%. The generation from captive power plants was 148.9 BU during 2013-14.

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)



2.11 REVIEW OF 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 24,920 MW. During 11th Plan, a capacity addition of 14668 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 given shown in **Table 2.13**.

Table 2.13

Capacity addition target for Renewable Energy Sources during 12th Plan

(Figures in MW)

Source	Capacity
Solar	10000
Wind	15000
Other RES	5000
Total	**30,000**

However, in view of revised target of 1,75,000 MW of RES by 2022, the capacity addition target for the year 2015-16 and 2016-17 has been revised.

The installed capacity from renewable energy sources in the country is 42,849 MW as on 31.03.2016. Source wise installed capacity of renewable energy sources are shown in **Table 2.14 and Exhibit 2.11**.

Table 2.14

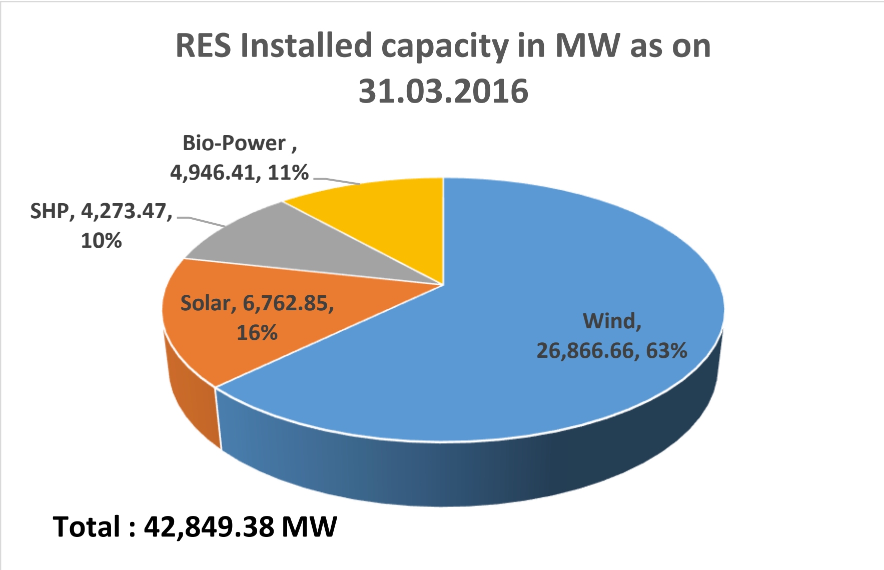
Installed capacity of Renewable energy sources as on 31.03.2016

(Figures in MW)

Source	Capacity
Solar	6762.85
Wind	26866.66
Bio-Power and waste power	4946.41
Small Hydro	4273.47
Total	**42849.38**

Exhibit 2.11

(Figures in MW)



As on 31.3.2016, a capacity addition of 17,930 MW from renewable energy sources has been achieved in first four years of 12th Plan. The details of capacity added source wise during 12th Plan as on 31.03.2016 is given in **Table 2.15**.

Table 2.15

Capacity addition achieved from Renewable Energy Sources during 12th Plan as on 31.03.2016

(Figures in MW)

Source	Capacity
Solar	5,823
Wind	9,509
Bio-Power and waste power	1,719
Small Hydro	879
Total	**17,930**

Note: As reported by MNRE

During the year 2015-16, a target of 4460 MW was set against which a capacity addition of 6,937 MW has been achieved. During the year 2016-17, a target of 16,825 MW has been set.

The likely capacity addition during 12th Plan from Renewable Energy Sources is 34,755 MW and is given in **Table 2.16 and Exhibit 2.12**.

Table 2.16

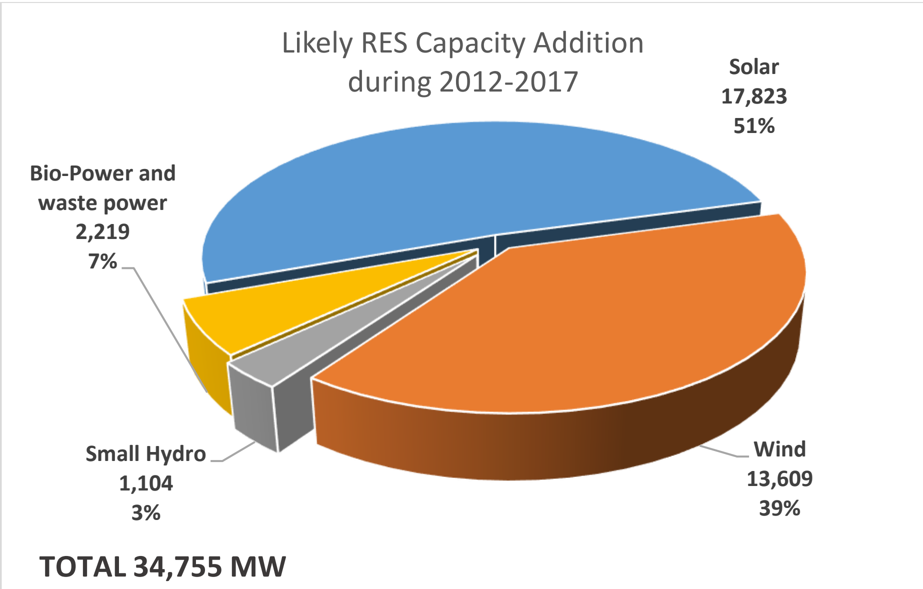
Likely capacity addition from Renewable energy sources during 12th Plan

(Figures in MW)

Source	Likely RES Capacity addition during 12th Plan
Solar	17,823
Wind	13,609
Bio-Power and waste power	2,219
Small Hydro	1,104
Total	**34,755**

Exhibit 2.12

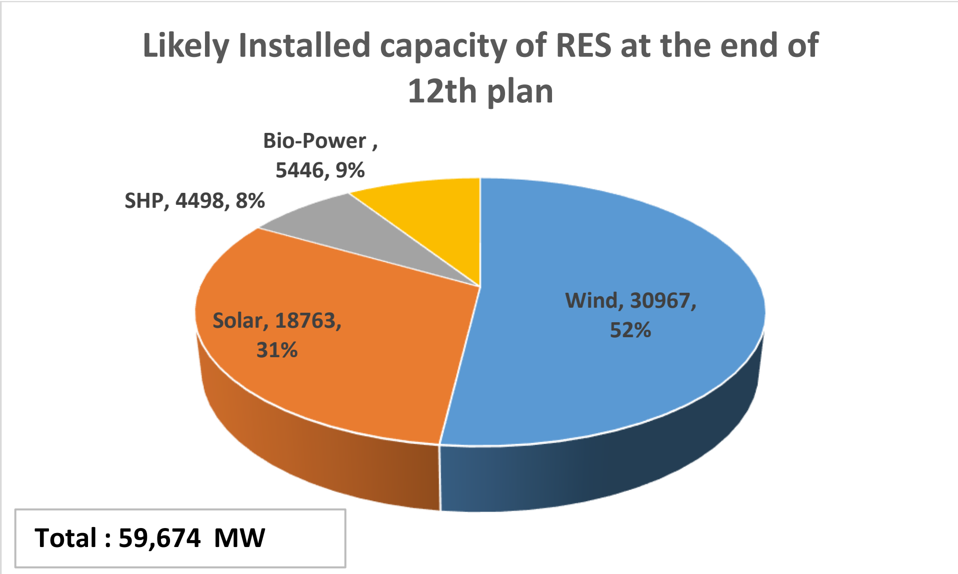
(Figures in MW)



The likely installed capacity of Renewable energy sources at the end of 12th Plan (31.3.2017) is 59,674 MW and is shown in **Exhibit 2.13**.

Exhibit 2.13

(Figures in MW)



2.12 CONCLUSIONS

i) In the 12th Plan, likely capacity addition from conventional sources as per review is going to exceed the target (88537 MW) significantly. The likely capacity addition during 12th Plan period will be of the order of 101,645 MW which is about 115% of the target.

ii) As envisaged in Electricity Act, 2003, private players have started playing dominant role in capacity addition in power sector with 56 % of total capacity addition during 12th Plan likely from private sector.

iii) There is likely to be 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 generation mix.

iv) Capacity addition from supercritical technology based coal power plants are likely to contribute around 39% of the total capacity addition from coal based plants likely to be commissioned during 12th Plan.

Annexure 2.1

STATE-WISE SECTOR-WISE CAPACITY ADDITION TARGET/LIKELY ACHIEVEMENT FOR 12th PLAN (2012-17)

		TARGET -88,537 MW				AS PER REVIEW on 31.3.2016				ACHIEVEMENT AS ON 31.03.2016			
SNo.	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	750	0	750
2	HARYANA	500	0	660	1160	500	0	660	1160	500	0	660	1160
3	HIMACHAL PRADESH	2763	506	314	3583	1963	165	106	2234	1963	0	70	2033
4	JAMMU & KASHMIR	659	450	0	1109	329	450	0	779	329	450	0	779
5	PUNJAB	0	0	3920	3920	0	0	3920	3920	0	0	3920	3920
6	RAJASTHAN	1400	1260	270	2930	0	1860	1860	3720	0	1860	1860	3720
7	UTTAR PRADESH	1000	1750	1980	4730	1000	1750	3300	6050	1000	1750	1980	4730
8	UTTARAKHAND	520	0	505	1025	0	0	330	330	0	0	330	330
9	CHANDIGARH	0	0	0	0	0	0	0	0	0	0	0	0
SUB TOTAL NORTHERN		**6842**	**4716**	**7649**	**19207**	**3792**	**4975**	**10176**	**18943**	**3792**	**4810**	**8820**	**17422**
10	CHHATTISGARH	660	1500	10680	12840	1460	1500	10625	13585	660	1000	8765	10425
11	GUJARAT	1400	1452	1400	4252	0	2578	5383	7961	0	2078.1	5382.5	7460.6
12	MAHARASHTRA	1000	1410	7890	10300	2320	3230	7650	13200	1660	2570	7110	11340
13	MADHYA PRADESH	1000	1700	4680	7380	1500	1700	8225	11425	1500	1700	8225	11425
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**	**5280**	**9008**	**31883**	**46171**	**3820**	**7348.1**	**29483**	**40651**
17	ANDHRA PRADESH	0	2250	6160	8410	0	1650	5940	7590	0	1600	4620	6220
18	TELANGANA	0	360	0	360	0	2100	0	2100	0	1360	0	1360
19	KARNATAKA	0	0	0	0	800	2300	0	3100	0	1500	0	1500
20	KERALA	0	100	0	100	0	0	0	0	0	0	0	0
21	TAMIL NADU	4750	1860	660	7270	4750	1860	2700	9310	3250	1860	2100	7210
22	PUDUCHERRY	0	0	0	0	0	0	0	0	0	0	0	0
SUB TOTAL SOUTHERN		**4750**	**4570**	**6820**	**16140**	**5550**	**7910**	**8640**	**22100**	**3250**	**6320**	**6720**	**16290**
23	BIHAR	4690	0	0	4690	2210	250	0	2460	1765	0	0	1765
24	JHARKHAND	1000	0	1080	2080	1000	0	540	1540	1000	0	540	1540
25	ORISSA	0	0	3960	3960	0	0	4210	4210	0	0	3200	3200
26	SIKKIM	0	0	2066	2066	0	0	988	988	0	0	195	195
27	WEST BENGAL	1492	0	600	2092	1492	1250	750	3492	1412	750	600	2762
SUB TOTAL EASTERN		**7182**	**0**	**7706**	**14888**	**4702**	**1500**	**6488**	**12690**	**4177**	**750**	**4535**	**9462**
28	ARUNACHAL PRADESH	1710	0	0	1710	410	0	0	410	0	0	0	0
29	ASSAM	750	100	0	850	250	100	0	350	250	0	0	250
30	MANIPUR	0	0	0	0	0	0	0	0	0	0	0	0
31	MIZORAM	60	0	0	60	0	0	0	0	0	0	0	0
32	MEGHALYA	0	82	0	82	0	82	0	82	0	42	0	42
33	NAGALAND	0	0	0	0	0	0	0	0	0	0	0	0
34	TRIPURA	828	0	0	828	878.6	21	0	899.6	853.1	21	0	874.1
SUB TOTAL N.EASTERN		**3348**	**182**	**0**	**3530**	**1538.6**	**203**	**0**	**1742**	**1103.1**	**63**	**0**	**1166.1**
35	A &N ISLANDS	0	0	0	0	0	0	0	0	0	0	0	0
36	LAKSHDWEEP	0	0	0	0	0	0	0	0	0	0	0	0
		26182	**15530**	**46825**	**88537**	**20863**	**23596**	**57187**	**101645**	**16142**	**19291**	**49558**	**84991**

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

Annexure 2.2

LIST OF PROJECTS COMMISSIONED/UNDER CONSTRUCTION FOR LIKELY BENEFITS DURING 12TH PLAN

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

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITION AL
23	Uri-II HEP U3	Hydro	JAMMU & KASHMIR	NHPC	Comm	60	Target
24	Uri-II HEP U4	Hydro	JAMMU & KASHMIR	NHPC	Comm	60	Target
25	Nimoo Bazgo HEP U1	Hydro	JAMMU & KASHMIR	NHPC	Comm	15	Target
26	Nimoo Bazgo HEP U2	Hydro	JAMMU & KASHMIR	NHPC	Comm	15	Target
27	Nimoo Bazgo HEP U3	Hydro	JAMMU & KASHMIR	NHPC	Comm	15	Target
28	Chutak HEP U1	Hydro	JAMMU & KASHMIR	NHPC	Comm	11	Target
29	Chutak HEP U2	Hydro	JAMMU & KASHMIR	NHPC	Comm	11	Target
30	Chutak HEP U3	Hydro	JAMMU & KASHMIR	NHPC	Comm	11	Target
31	Chutak HEP U4	Hydro	JAMMU & KASHMIR	NHPC	Comm	11	Target
32	Sipat-I TPP U 3	Coal	CHHATTISGARH	NTPC	Comm	660	Target
33	Lara TPP U-1	Coal	CHHATTISGARH	NTPC	UC	800	outside
34	Mauda TPP U1	Coal	MAHARASHTRA	NTPC	Comm	500	Target
35	Mauda TPP U2	Coal	MAHARASHTRA	NTPC	Comm	500	Target
36	Mouda STPP Ph-II U-3	Coal	MAHARASHTRA	NTPC	Comm	660	outside
37	Mouda STPP Ph-II U4	Coal	MAHARASHTRA	NTPC	UC	660	outside
38	Vindhyachal TPP St-IV U11	Coal	MADHYA PRADESH	NTPC	Comm	500	Target
39	Vindhyachal TPP St-IV U12	Coal	MADHYA PRADESH	NTPC	Comm	500	Target
40	Vindhyachal STPP St-V U13	Coal	MADHYA PRADESH	NTPC	Comm	500	outside
41	Vallur (Ennore) TPP U2	Coal	TAMIL NADU	NTPC/TNE B JV	Comm	500	Target
42	Vallur (Ennore) TPP U3	Coal	TAMIL NADU	NTPC/TNE B JV	Comm	500	Target
43	Tuticorin TPP JV U1	Coal	TAMIL NADU	NPTL (NLC JV)	Comm	500	Target
44	Tuticorin TPP JV U2	Coal	TAMIL NADU	NPTL (NLC JV)	Comm	500	Target
45	Neyveli II TPP U2	Lignite	TAMIL NADU	NLC	Comm	250	Target
46	Kudankulam U 1	Nuclea r	TAMIL NADU	NPC	Comm	1000	target
47	Kudankulam U 2	Nuclea r	TAMIL NADU	NPC	UC	1000	target
48	PFBR (Kalpakkam)	Nuclea r	TAMIL NADU	NPC	UC	500	target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITION AL
49	Kudgi STPP Ph-I , U-1	Coal	KARNATAKA	NTPC	UC	800	outside
50	Muzaffarpur (Kanti) TPP U3	Coal	BIHAR	NTPC JV	Comm	195	Target
51	Muzaffarpur (Kanti) TPP U4	Coal	BIHAR	NTPC JV	UC	195	Target
52	Barh STPP-II U1	Coal	BIHAR	NTPC	Comm	660	Target
53	Barh STPP-II U2	Coal	BIHAR	NTPC	Comm	660	Target
54	Nabinagar TPP U1	Coal	BIHAR	NTPC JV	Comm	250	Target
55	Nabinagar TPP U2	Coal	BIHAR	NTPC JV	UC	250	Target
56	Bokaro TPP A Exp U1	Coal	JHARKHAND	DVC	Comm	500	Target
57	Koderma TPP U2	Coal	JHARKHAND	DVC	Comm	500	Target
58	Raghunathpur TPP U1	Coal	WEST BENGAL	DVC	Comm	600	Target
59	Raghunathpur TPP U2	Coal	WEST BENGAL	DVC	Comm	600	Target
60	Teesta Low Dam-III HEP U1	Hydro	WEST BENGAL	NHPC	Comm	33	Target
61	Teesta Low Dam-III HEP U2	Hydro	WEST BENGAL	NHPC	Comm	33	Target
62	Teesta Low Dam-III HEP U3	Hydro	WEST BENGAL	NHPC	Comm	33	Target
63	Teesta Low Dam-III HEP U4	Hydro	WEST BENGAL	NHPC	Comm	33	Target
64	Teesta Low Dam-IV HEP U1	Hydro	WEST BENGAL	NHPC	Comm	40	Target
65	Teesta Low Dam-IV HEP U2	Hydro	WEST BENGAL	NHPC	Comm	40	Target
66	Teesta Low Dam-IV HEP U3	Hydro	WEST BENGAL	NHPC	UC	40	Target
67	Teesta Low Dam-IV HEP U4	Hydro	WEST BENGAL	NHPC	UC	40	Target
68	Bongaigaon TPP U1	Coal	ASSAM	NTPC	Comm	250	Target
69	Pare HEP U1	Hydro	ARUNACHAL PRADESH	NEEPCO	UC	55	Target
70	Pare HEP U2	Hydro	ARUNACHAL PRADESH	NEEPCO	UC	55	Target
71	Kameng HEP U1	Hydro	ARUNACHAL PRADESH	NEEPCO	UC	150	Target
72	Kameng HEP U2	Hydro	ARUNACHAL PRADESH	NEEPCO	UC	150	Target
73	Tripura CCGT Block-1	Gas	TRIPURA	ONGC JV	Comm	363.3	Target
74	Tripura CCGT Block-2	Gas	TRIPURA	ONGC JV	Comm	363.3	Target
75	Monarchak CCGT GT	Gas	TRIPURA	NEEPCO	Comm	65.4	Target
76	Monarchak CCGT	Gas	TRIPURA	NEEPCO	Comm	35.6	Target
77	Agartala CCPP ST-I	Gas	TRIPURA	NEEPCO	Comm	25.5	outside
78	Agartala CCPP ST-1	Gas	TRIPURA	NEEPCO	UC	25.5	outside
	SUB TOTAL(CENTRAL SECTOR)					**20862.6**	
	STATE SECTOR						
1	Pragati -III (BAWANA) CCGT (GT-3)	Gas	DELHI	PPCL	Comm	250	Target
2	Pragati -III (BAWANA) CCGT (GT-4)	Gas	DELHI	PPCL	Comm	250	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITION AL
3	Pragati -III (BAWANA) CCGT (ST-2)	Gas	DELHI	PPCL	Comm	250	Target
4	Kalisindh TPP U1	Coal	RAJASTHAN	RRVUNL	Comm	600	Target
5	Kalisindh TPP U2	Coal	RAJASTHAN	RRVUNL	Comm	600	outside
6	Chhabra TPP Ext U3	Coal	RAJASTHAN	RRVUNL	Comm	250	Target
7	Chhabra TPP Ext U4	Coal	RAJASTHAN	RRVUNL	Comm	250	Target
8	Ramgarh CCGT (GT)	Gas	RAJASTHAN	RRVUNL	Comm	110	Target
9	Ramgarh CCGT (ST)	Gas	RAJASTHAN	RRVUNL	Comm	50	Target
10	Anpara-D TPP U1	Coal	UTTAR PRADESH	UPRVUNL	Comm	500	Target
11	Anpara-D TPP U2	Coal	UTTAR PRADESH	UPRVUNL	Comm	500	Target
12	Parichha TPP EXT U5	Coal	UTTAR PRADESH	UPRVUNL	Comm	250	Target
13	Parichha TPP EXT U6	Coal	UTTAR PRADESH	UPRVUNL	Comm	250	Target
14	Harduaganj TPP EXT U9	Coal	UTTAR PRADESH	UPRVUNL	Comm	250	Target
15	Kashang - I HEP	Hydro	HIMACHAL PRADESH	HPPCL	UC	65	Target
16	Sainj HEP U1	Hydro	HIMACHAL PRADESH	HPPCL	UC	50	Target
17	Sainj HEP U2	Hydro	HIMACHAL PRADESH	HPPCL	UC	50	Target
18	Baglihar-II HEP U1	Hydro	JAMMU & KASHMIR	J&K State Power Developm ent Corp. Ltd.	Comm	150	Target
19	Baglihar-II HEP U2	Hydro	JAMMU & KASHMIR	J&K State Power Developm ent Corp. Ltd.	Comm	150	Target
20	Baglihar-II HEP U3	Hydro	JAMMU & KASHMIR	J&K State Power Developm ent Corp. Ltd.	Comm	150	Target
21	Korba West St.III TPP U5	Coal	CHHATTISGARH	CSEB	Comm	500	Target
22	Marwah TPP U1	Coal	CHHATTISGARH	CSEB	Comm	500	Target
23	Marwah TPP U2	Coal	CHHATTISGARH	CSEB	UC	500	Target
24	Sikka TPP Ext. U3	Coal	GUJARAT	GSECL	Comm	250	Target
25	Sikka TPS Extn., U-4	Coal	GUJARAT	GSECL	Comm	250	outside
26	Ukai TPP EXT U6	Coal	GUJARAT	GSECL	Comm	500	Target
27	Pipavav JV CCGT Block-1	Gas	GUJARAT	GSECL	Comm	351	Target
28	Pipavav JV CCGT Block-2	Gas	GUJARAT	GSECL	Comm	351	Target
29	Dhuvaran CCPP-III	Gas	GUJARAT	GSECL	Comm	376.1	outside

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITIONAL
30	Bhavnagar CFBC TPP, U-1	Lignite	GUJARAT	Bhavnagar Energy	UC	250	outside
31	Bhavnagar CFBC TPP, U-2	Lignite	GUJARAT	Bhavnagar Energy	UC	250	outside
32	Chandrapur TPP Ext. U8	Coal	MAHARASHTRA	MAHGENCO	Comm	500	Target
33	Chandrapur TPS, U-9	Coal	MAHARASHTRA	MSPGCL	Comm	500	outside
34	Koradi TPP Ext U8	Coal	MAHARASHTRA	MAHGENCO	Comm	660	Target
35	Koradi TPS Expn., U-9	Coal	MAHARASHTRA	MSPGCL	Comm	660	outside
36	Koradi TPS Expn., U-10	Coal	MAHARASHTRA	MSPGCL	UC	660	outside
37	Parli TPP U3	Coal	MAHARASHTRA	MAHGENCO	Comm	250	Target
38	Satpura TPP EXT U10	Coal	MADHYA PRADESH	MPGENCO	Comm	250	Target
39	Satpura TPP EXT U11	Coal	MADHYA PRADESH	MPGENCO	Comm	250	Target
40	Shree Singhaji TPP U1	Coal	MADHYA PRADESH	MPGENCO	Comm	600	Target
41	Shree Singhaji TPP U2	Coal	MADHYA PRADESH	MPGENCO	Comm	600	Target
42	Sri Damodaram Sanjeevaiah TPP (Krishnapattnam TPP) U1	Coal	ANDHRA PRADESH	APGENCO	Comm	800	Target
43	Sri Damodaram Sanjeevaiah TPP (Krishnapattnam TPP) U2	Coal	ANDHRA PRADESH	APGENCO	Comm	800	Target
44	Nagarjuna Sagar TR HEP U1	Hydro	ANDHRA PRADESH	APGENCO	UC	25	Target
45	Nagarjuna Sagar TR HEP U2	Hydro	ANDHRA PRADESH	APGENCO	UC	25	Target
46	Mettur TPP EXT U1	Coal	TAMIL NADU	TNEB	Comm	600	Target
47	North Chennai TPP Ext U1	Coal	TAMIL NADU	TNEB	Comm	600	Target
48	North Chennai TPP Ext U2	Coal	TAMIL NADU	TNEB	Comm	600	Target
49	Bhawani Barrage HEP II U1	Hydro	TAMIL NADU	TNEB	Comm	15	Target
50	Bhawani Barrage HEP II U2	Hydro	TAMIL NADU	TNEB	Comm	15	Target
51	Bhawani Barrage HEP III U1	Hydro	TAMIL NADU	TNEB	Comm	15	Target
52	Bhawani Barrage HEP III U2	Hydro	TAMIL NADU	TNEB	Comm	15	Target
53	Lower Jurala HEP U1	Hydro	TELANGANA	TSGENCO	Comm	40	Target
54	Lower Jurala HEP U2	Hydro	TELANGANA	TSGENCO	Comm	40	Target
55	Lower Jurala HEP U3	Hydro	TELANGANA	TSGENCO	Comm	40	Target
56	Lower Jurala HEP U4	Hydro	TELANGANA	TSGENCO	Comm	40	Target
57	Lower Jurala HEP U5	Hydro	TELANGANA	TSGENCO	UC	40	Target
58	Lower Jurala HEP U6	Hydro	TELANGANA	TSGENCO	UC	40	Target
59	Pulichintala HEP U1	Hydro	TELANGANA	TSGENCO	UC	30	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITIONAL
60	Pulichintala HEP U2	Hydro	TELANGANA	TSGENCO	UC	30	Target
61	Kakatiya TPS Extn., U-1	Coal	TELANGANA	T GENCO	Comm	600	outside
62	Singareni TPP, U-1	Coal	TELANGANA	Singareni Collieries Co. Ltd	Comm	600	outside
63	Singareni TPP, U-2	Coal	TELANGANA	Singareni Collieries Co. Ltd	UC	600	outside
64	Bellary TPP St-III, U-3	Coal	KARNATAKA	KPCL	Comm	700	outside
65	Yermarus TPP, U-1	Coal	KARNATAKA	KPCL	Comm	800	outside
66	Yermarus TPP, U-2	Coal	KARNATAKA	KPCL	UC	800	outside
67	Barauni TPS Extn. U-1	Coal	BIHAR	BSEB	UC	250	outside
68	Durgapur TPP Ext.	Coal	WEST BENGAL	Durgapur Projects Ltd	Comm	250	outside
69	Sagardighi TPS-II, U-3	Coal	WEST BENGAL	WBPDCL	Comm	500	outside
70	Sagardighi TPS-II, U-4	Coal	WEST BENGAL	WBPDCL	UC	500	outside
71	Namrup CCGT	Gas	ASSAM	APGCL	UC	100	Target
72	New Umtru HEP U1	Hydro	MEGHALYA	MeECL	UC	20	Target
73	New Umtru HEP U2	Hydro	MEGHALYA	MeECL	UC	20	Target
74	Myntdu St-I HEP ADDL UNIT	Hydro	MEGHALYA	MeSEB	Comm	42	Target
75	Rokhia GT	Gas	TRIPURA	Govt of Tripura	Comm	21	outside
	SUB TOTAL(STATE SECTOR)					**23596.1**	
	PRIVATE SECTOR						
1	Mahatma Gandhi Jhajjar TPP U2	Coal	HARYANA	China Light Power	Comm	660	Target
2	Talwandi Sabo TPP U1	Coal	PUNJAB	Vedanta	Comm	660	Target
3	Talwandi Sabo TPP U2	Coal	PUNJAB	Vedanta	Comm	660	Target
4	Talwandi Sabo TPP U3	Coal	PUNJAB	Vedanta	Comm	660	Target
5	Nabha TPP U1	Coal	PUNJAB	L&T Power Developm ent Ltd	Comm	700	Target
6	Nabha TPP U2	Coal	PUNJAB	L&T Power Developm ent Ltd	Comm	700	Target
7	Goindwal Sahib TPP U1	Coal	PUNJAB	GVK Industries	Comm	270	Target
8	Goindwal Sahib TPP U2	Coal	PUNJAB	GVK Industries	Comm	270	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITIONAL
9	Jallipa Kapurdi TPP U5	Lignite	RAJASTHAN	Raj West Power Ltd	Comm	135	Target
10	Jallipa Kapurdi TPP U6	Lignite	RAJASTHAN	Raj West Power Ltd	Comm	135	Target
11	Jallipa Kapurdi TPP U 7-8	Lignite	RAJASTHAN	Raj West Power Ltd	Comm	270	outside
12	Kawai TPP U1	Coal	RAJASTHAN	Adani Power Ltd	Comm	660	outside
13	Kawai TPP U2	Coal	RAJASTHAN	Adani Power Ltd	Comm	660	outside
14	Bara TPP U1	Coal	UTTAR PRADESH	Prayagraj Power Gen. Co. Ltd (Jaypee Group)	Comm	660	Target
15	Bara TPP U2	Coal	UTTAR PRADESH	Prayagraj Power Gen. Co. Ltd (Jaypee Group)	UC	660	Target
16	Lalitpur TPP, U-1	Coal	UTTAR PRADESH	Lalitpur power Generation Co. Ltd	Comm	660	outside
17	Lalitpur TPP, U-2	Coal	UTTAR PRADESH	Lalitpur power Generation Co. Ltd	Comm	660	outside
18	Lalitpur TPP, U-3	Coal	UTTAR PRADESH	Lalitpur power Generation Co. Ltd	UC	660	outside
19	Budhil HEP U1	Hydro	HIMACHAL PRADESH	LANCO Green Power Pvt Ltd	Comm	35	Target
20	Budhil HEP U2	Hydro	HIMACHAL PRADESH	LANCO Green Power Pvt Ltd	Comm	35	Target
21	Chanju-I HEP U1	Hydro	HIMACHAL PRADESH	IA Energy	UC	12	Outside
22	Chanju-I HEP U2	Hydro	HIMACHAL PRADESH	IA Energy	UC	12	Outside

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITION AL
23	Chanju-I HEP U3	Hydro	HIMACHAL PRADESH	IA Energy	UC	12	Outside
24	Srinagar HEP U1	Hydro	UTTARAKHAND	AHPCo. Ltd.	Comm	82.5	Target
25	Srinagar HEP U2	Hydro	UTTARAKHAND	AHPCo. Ltd.	Comm	82.5	Target
26	Srinagar HEP U3	Hydro	UTTARAKHAND	AHPCo. Ltd.	Comm	82.5	Target
27	Srinagar HEP U4	Hydro	UTTARAKHAND	AHPCo. Ltd.	Comm	82.5	Target
28	Avantha Bhandar TPP U1	Coal	CHHATTISGARH	Korba West Power Company Ltd.	Comm	600	Target
29	Maurti Clean Coal & Power Ltd.TPP U1	Coal	CHHATTISGARH	Maurti Clean Coal & Power Ltd.	Comm	300	Target
30	Uchpinda TPP U1	Coal	CHHATTISGARH	R.K.M. PowerGen Pvt Ltd	Comm	360	Target
31	Uchpinda TPP U2	Coal	CHHATTISGARH	R.K.M. PowerGen Pvt Ltd	Comm	360	Target
32	Uchpinda TPP U3	Coal	CHHATTISGARH	R.K.M. PowerGen Pvt Ltd	UC	360	Target
33	Vinjkote (Darrampura) TPP U1	Coal	CHHATTISGARH	SKS Ispat and Power Ltd.	UC	300	Target
34	Akaltara (Nariyara) TPP U1	Coal	CHHATTISGARH	KSK Mahanadi Power Company Limited	Comm	600	Target
35	Akaltara (Nariyara) TPP U2	Coal	CHHATTISGARH	KSK Mahanadi Power Company Limited	Comm	600	Target
36	Kasaipalli TPP U 2	Coal	CHHATTISGARH	ACB India	Comm	135	Target
37	Swastik Korba TPP U1	Coal	CHHATTISGARH	ACB India	Comm	25	Target
38	Vandana Vidyut TPP U1	Coal	CHHATTISGARH	Vandana Vidyut	Comm	135	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITIONAL
39	Balco TPP U1	Coal	CHHATTISGARH	Bharat Aluminium Co. Ltd	Comm	300	Target
40	Balco TPP U2	Coal	CHHATTISGARH	Bharat Aluminium Co. Ltd	Comm	300	Target
41	Athena Singhtarai TPP U1	Coal	CHHATTISGARH	Athena Chhattisgarh Power Ltd.	UC	600	Target
42	Baradhra (D B Power) TPP U1	Coal	CHHATTISGARH	DB Power Ltd	Comm	600	Target
43	Baradhra (D B Power) TPP U2	Coal	CHHATTISGARH	DB Power Ltd	Comm	600	Target
44	Newpara (TRN Energy) TPP U1	Coal	CHHATTISGARH	TRN Energy	UC	300	Target
45	Newpara (TRN Energy) TPP U2	Coal	CHHATTISGARH	TRN Energy	UC	300	Target
46	Ratija TPP	Coal	CHHATTISGARH	ACB India	Comm	50	Target
47	Tamnar TPP U1	Coal	CHHATTISGARH	Jindal Power Ltd	Comm	600	Target
48	Tamnar TPP U2	Coal	CHHATTISGARH	Jindal Power Ltd	Comm	600	Target
49	Tamnar TPP U3	Coal	CHHATTISGARH	Jindal Power Ltd	Comm	600	outside
50	Tamnar TPP U4	Coal	CHHATTISGARH	Jindal Power Ltd	Comm	600	outside
51	Chakabura TPP	Coal	CHHATTISGARH	ACB India Ltd.	Comm	30	outside
52	Raikheda TPP U1	Coal	CHHATTISGARH	GMR	Comm	685	outside
53	Raikheda TPP, U-2	Coal	CHHATTISGARH	GMR	Comm	685	outside
54	Mundra UMPP, U 2	Coal	GUJARAT	Tata Power Company Ltd	Comm	800	Target
55	Mundra UMPP U 3,4,5	Coal	GUJARAT	Tata Power Company Ltd	Comm	2400	outside
56	Salaya TPP U 2	Coal	GUJARAT	Essar Power Salaya Ltd	Comm	600	Target
57	Uno Sugen CCGT	Gas	GUJARAT	Torrent Power	Comm	382.5	outside
58	DGEN Mega CCPP Module 1	Gas	GUJARAT	Torrent Power	Comm	400	outside

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITIONAL
59	DGEN Mega CCPP Module 2	Gas	GUJARAT	Torrent Power	Comm	400	outside
60	DGEN Mega CCPP Module 3	Gas	GUJARAT	Torrent Power	Comm	400	outside
61	India Bulls- Amravati TPP Ph-I, U1	Coal	MAHARASHTRA	India Bulls Power Limited	Comm	270	Target
62	India Bulls- Amravati TPP Ph-I, U2	Coal	MAHARASHTRA	India Bulls Power Limited	Comm	270	Target
63	India Bulls- Amravati TPP Ph-I, U3	Coal	MAHARASHTRA	India Bulls Power Limited	Comm	270	Target
64	India Bulls- Amravati TPP Ph-I, U4	Coal	MAHARASHTRA	India Bulls Power Limited	Comm	270	Target
65	India Bulls- Amravati TPP Ph-I, U5	Coal	MAHARASHTRA	India Bulls Power Limited	Comm	270	Target
66	India Bulls - Nasik TPP Ph-I, U1	Coal	MAHARASHTRA	India Bulls Realtech Limited	Comm	270	Target
67	India Bulls - Nasik TPP Ph-I, U2	Coal	MAHARASHTRA	India Bulls Realtech Limited	UC	270	Target
68	India Bulls - Nasik TPP Ph-I, U3	Coal	MAHARASHTRA	India Bulls Realtech Limited	UC	270	Target
69	Dhariwal Infrastructure (P) Ltd TPP U1	Coal	MAHARASHTRA	Dhariwal Infrastructure (P) LTD	Comm	300	Target
70	Dhariwal Infrastructure (P) Ltd TPP U2	Coal	MAHARASHTRA	Dhariwal Infrastructure (P) LTD	Comm	300	Target
71	EMCO Warora TPP U1	Coal	MAHARASHTRA	GMR EMCO Energy Ltd	Comm	300	Target
72	EMCO Warora TPP U2	Coal	MAHARASHTRA	GMR EMCO Energy Ltd	Comm	300	Target
73	Butibori TPP Ph -II U 1	Coal	MAHARASHTRA	Vidarbha Industries Power Ltd	Comm	300	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITION AL
74	Butibori TPP Ph -II U2	Coal	MAHARASHTRA	Vidarbha Industries Power Ltd	Comm	300	outside
75	Tiroda TPP PH-I U1	Coal	MAHARASHTRA	Adani Power Ltd	Comm	660	Target
76	Tiroda TPP PH-I U2	Coal	MAHARASHTRA	Adani Power Ltd	Comm	660	Target
77	Tiroda TPP Ph-II U1	Coal	MAHARASHTRA	Adani Power Ltd	Comm	660	Target
78	Tiroda TPP Ph-II U2	Coal	MAHARASHTRA	Adani Power Ltd	Comm	660	outside
79	Tiroda TPP Ph-II U3	Coal	MAHARASHTRA	Adani Power Ltd	Comm	660	outside
80	GEPL TPP U1	Coal	MAHARASHTRA	Gupta Energy Pvt Ltd	Comm	60	Target
81	GEPL TPP U2	Coal	MAHARASHTRA	Gupta Energy Pvt Ltd	Comm	60	Target
82	Bela TPP U 1	Coal	MAHARASHTRA	Ideal Energy Projects Ltd	Comm	270	Target
83	Annupur TPP Ph-I U1	Coal	MADHYA PRADESH	MB Power (Madhya Pradesh) Ltd.	Comm	600	Target
84	Annupur TPP Ph-I U2	Coal	MADHYA PRADESH	MB Power (Madhya Pradesh) Ltd.	Comm	600	Target
85	Bina TPP U1	Coal	MADHYA PRADESH	Bina Power Supply Comp. Ltd (Jaypee Group)	Comm	250	Target
86	Bina TPP U2	Coal	MADHYA PRADESH	Bina Power Supply Comp. Ltd (Jaypee Group)	Comm	250	Target
87	Sasan UMPP U1	Coal	MADHYA PRADESH	Reliance Power Ltd.	Comm	660	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITION AL
88	Sasan UMPP U2	Coal	MADHYA PRADESH	Reliance Power Ltd.	Comm	660	Target
89	Sasan UMPP U3	Coal	MADHYA PRADESH	Reliance Power Ltd.	Comm	660	outside
90	Sasan UMPP U4	Coal	MADHYA PRADESH	Reliance Power Ltd.	Comm	660	outside
91	Sasan UMPP U5	Coal	MADHYA PRADESH	Reliance Power Ltd.	Comm	660	outside
92	Sasan UMPP U6	Coal	MADHYA PRADESH	Reliance Power Ltd.	Comm	660	outside
93	Seioni (Jhabua) TPP U1	Coal	MADHYA PRADESH	Jhabua Power Ltd	Comm	600	Target
94	Mahan TPP U1	Coal	MADHYA PRADESH	Essar Power	Comm	600	outside
95	Niwari TPP U1	Coal	MADHYA PRADESH	M/s BLA Pvt Ltd	Comm	45	outside
96	Nigri TPP U1	Coal	MADHYA PRADESH	JP Power Ventures Ltd.	Comm	660	outside
97	Nigri TPP U2	Coal	MADHYA PRADESH	JP Power Ventures Ltd.	Comm	660	outside
98	Thamminapatnam TPP U1	Coal	ANDHRA PRADESH	Meenaksh i Energy Pvt. Ltd.,	Comm	150	Target
99	Thamminapatnam TPP U2	Coal	ANDHRA PRADESH	Meenaksh i Energy Pvt. Ltd.,	Comm	150	Target
100	Nagarjuna Construction Company Ltd Ph-I U1	Coal	ANDHRA PRADESH	Ngarjuna Constructi on Company Ltd	UC	660	Target
101	Nagarjuna Construction Company Ltd Ph-I U2	Coal	ANDHRA PRADESH	Ngarjuna Constructi on Company Ltd	UC	660	Target
102	Painampuram TPP U1	Coal	ANDHRA PRADESH	Thermal Powertec h	Comm	660	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITIONAL
				Corporation Ltd.			
103	Painampuram TPP U2	Coal	ANDHRA PRADESH	Thermal Powertech Corporation Ltd.	Comm	660	Target
104	Simhapuri TPP Ph-I, U 2	Coal	ANDHRA PRADESH	Simhapuri Energy Pvt. Ltd.,	Comm	150	Target
105	Simhapuri TPP Ph-II, U1	Coal	ANDHRA PRADESH	Simhapuri Energy Pvt. Ltd.,	Comm	150	outside
106	Simhapuri TPP Ph-II, U2	Coal	ANDHRA PRADESH	Simhapuri Energy Pvt. Ltd.,	Comm	150	outside
107	Hinduja TPP, U1 (original capacity 525 MW)	Coal	ANDHRA PRADESH	Hinduja	Comm	520	Target
108	Hinduja TPP, U2 (original capacity 525 MW)	Coal	ANDHRA PRADESH	Hinduja	Comm	520	Target
109	Kondapalli CCGT St-III A	Gas	ANDHRA PRADESH	Lanco	Comm	371	outside
110	Kondapalli CCGT St-III B	Gas	ANDHRA PRADESH	Lanco	Comm	371	outside
111	Vemagiri CCPP-II Block-I	Gas	ANDHRA PRADESH	GMR Rajahmundry energy Ltd	Comm	384	outside
112	Vemagiri CCPP-II Block-II	Gas	ANDHRA PRADESH	GMR Rajahmundry energy Ltd	Comm	384	outside
113	Ind Barath (Tuticorin) TPP U1	Coal	TAMIL NADU	Ind. Barath Power Ltd.	Comm	150	outside
114	Ind Barath (Tuticorin) TPP U2	Coal	TAMIL NADU	Ind. Barath Power Ltd.	Comm	150	outside
115	Mutiara (Melamurthur) TPP U1	Coal	TAMIL NADU	Coastal Energaen	Comm	600	outside
116	Melamaruthur TPP, U-2	Coal	TAMIL NADU	Coastal Energen	Comm	600	outside
117	ITPCL TPP U-1 (Cuddalore)	Coal	TAMIL NADU	IL & FS Power Ltd	Comm	600	outside

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITION AL
118	ITPCL TPP U-2 (Cuddalore)	Coal	TAMIL NADU	IL & FS Power Ltd	UC	600	outside
119	Jorethang Loop HEP U1	Hydro	SIKKIM	DANS Pvt. Ltd	Comm	48	Target
120	Jorethang Loop HEP U2	Hydro	SIKKIM	DANS Pvt. Ltd	Comm	48	Target
121	Teesta-III HEP U1	Hydro	SIKKIM	Teesta Urja Ltd	UC	200	Target
122	Teesta-III HEP U2	Hydro	SIKKIM	Teesta Urja Ltd	UC	200	Target
123	Teesta-III HEP U3	Hydro	SIKKIM	Teesta Urja Ltd	UC	200	Target
124	Chujachen HEP U1	Hydro	SIKKIM	Gati Infrastructure Ltd.	Comm	49.5	Target
125	Chujachen HEP U2	Hydro	SIKKIM	Gati Infrastructure Ltd.	Comm	49.5	Target
126	Dikchu HEP U1	Hydro	SIKKIM	Sneha Kinetic power projects Ltd	UC	32	Outside
127	Dikchu HEP U2	Hydro	SIKKIM	Sneha Kinetic power projects Ltd	UC	32	Outside
128	Dikchu HEP U3	Hydro	SIKKIM	Sneha Kinetic power projects Ltd	UC	32	Outside
129	Tashiding HEP U1	Hydro	SIKKIM	Shiga Energy Pvt. Ltd.	UC	48.5	Outside
130	Tashiding HEP U2	Hydro	SIKKIM	Shiga Energy Pvt. Ltd.	UC	48.5	Outside
131	Adhunik Power & Natural Resources Ltd TPP U1	Coal	JHARKHAND	Adhunik Power & Natural Resources Ltd.	Comm	270	Target
132	Adhunik Power & Natural Resources Ltd TPP U2	Coal	JHARKHAND	Adhunik Power & Natural	Comm	270	Target

Sl. No.	PROJECT NAME	FUEL TYPE	STATE	AGENCY	STATUS	CAPACITY	TARGET/ ADDITIONAL
				Resources Ltd.			
133	Derang TPP U1	Coal	ODISHA	Jindal India Thermal Power Ltd	Comm	600	Target
134	Derang TPP U2	Coal	ODISHA	Jindal India Thermal Power Ltd	Comm	600	outside
135	Utkal (Ind Barath Energy Pvt. Ltd.) TPP U1	Coal	ODISHA	Ind. Barath power (Utkal) Ltd.	Comm	350	Target
136	Utkal (Ind Barath Energy Pvt. Ltd.) TPP U2	Coal	ODISHA	Ind. Barath power (Utkal) Ltd.	UC	350	Target
137	Kamalanga TPP U1	Coal	ODISHA	GMR Energy	Comm	350	Target
138	Kamalanga TPP U2	Coal	ODISHA	GMR Energy	Comm	350	Target
139	Kamalanga TPP U3	Coal	ODISHA	GMR Energy	Comm	350	Target
140	Sterlite TPP U4	Coal	ODISHA	Sterlite Energy	Comm	600	Target
141	Lanco Babandh Dhenkanal TPP U1	Coal	ODISHA	Lanco Babandh	UC	660	Target
142	Haldia TPP U1	Coal	WEST BENGAL	CESC	Comm	300	Target
143	Haldia TPP U2	Coal	WEST BENGAL	CESC	Comm	300	Target
144	Haldia TPP (IEL) U1	Coal	WEST BENGAL	IEL	UC	150	outside
	SUB TOTAL(PRIVATE SECTOR)					**57186.5**	
	TOTAL(12TH PLAN)					**101645.2**	

Comm : Projects commissioned till 31st March,2016

UC: Projects under construction for benefits during 12th Plan.

Annexure 2.3

Details of Gas Power plants Under Construction/Ready for commissioning

State	Project Name	Sector	Impl Agency	Cap.(MW)
AP	Panduranga CCPP	Private	Panduranga Power Ltd	116
AP	RVK Gas Engine	Private	RVK (Rajahmundry) Pvt.Ltd	76
AP	RVKCCPP	Private	RVK (Rajahmundry) PVT.Ltd	360
AP	Samalkot CCPP-II	Private	Reliance Power	2400
Maharashtra	Mangaon CCPP	Private	PGPL	388
Telangana	Astha Gas Engines	Private	Astha	34.88
TN	Ind Barath Gas Project	Private	Ind Barath	65
Utrakhand	Kashipur CCPP	Private	Sravanthi Energy Pvt. Ltd	225
Uttarakhand	Beta CCPP	Private	BIPL	225
Uttarakhand	Gama CCPP	Private	GIPL	225
Uttarakhand	Kashipur CCPP-II	Private	Sravanthi Energy Pvt. Ltd	225
			Total (Private Sector)	**4339.88**

Annexure 2.4

State wise Capacity likely to slip from 12TH PLAN

Sl. No.	STATE/ UTs	Target for 12th Plan	Capacity Slipped from 12th Plan Target	% Slippage wrt to capacity addition Target
1.	DELHI	750	0	
2.	HARYANA	1160	0	
3.	HIMACHAL PRADESH	3583	1385	
4.	JAMMU & KASHMIR	1109	330	
5.	PUNJAB	3920	0	
6.	RAJASTHAN	2930	1400	
7.	UTTAR PRADESH	4730	660	
8.	UTTARAKHAND	1025	695	
	SUB TOTAL NR	**19207**	**4470**	**23.2%**
9.	CHHATTISGARH	12840	2655	
10	GUJARAT	4252	1400	
11	MAHARASHTRA	10300	1860	
12	MADHYA PRADESH	7380	1060	
	SUB TOTAL WR	**34772**	**6975**	**20%**
13	UNITED ANDHRA PRADESH	8770	2680	
14	KERALA	100	100	
15	TAMIL NADU	7270	660	
	SUB TOTAL SR	**16140**	**3440**	**21.31%**
16	BIHAR	4690	2480	
17	JHARKHAND	2080	540	
18	ODISHA	3960	350	
19	SIKKIM	2066	1271	
20	WEST BENGAL	2092	0	
	SUB TOTAL ER	**14888**	**4641**	**31.1%**
21	ARUNACHAL PRADESH	1710	1300	
22	ASSAM	850	500	
23	MIZORAM	60	60	
24	MEGHALAYA	82	0	
25	TRIPURA	828	0	
	SUB TOTAL NER	**3530**	**1860**	**52.7%**
	TOTAL (All India)	**88537**	**21386**	**24.1%**

Annexure 2.5

List of Projects likely to slip from 12th Plan capacity addition target

(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	Barh STPP-I U1	Coal	BIHAR	NTPC	660
15	Barh STPP-I U2	Coal	BIHAR	NTPC	660
16	Barh STPP-I U3	Coal	BIHAR	NTPC	660
17	Nabinagar TPP U3	Coal	BIHAR	NTPC JV	250
18	Nabinagar TPP U4	Coal	BIHAR	NTPC JV	250
19	Bongaigaon TPP U2	Coal	ASSAM	NTPC	250
20	Bongaigaon TPP U3	Coal	ASSAM	NTPC	250
21	Kameng HEP U3	Hydro	ARUNACHAL PRADESH	NEEPCO	150
22	Kameng HEP U4	Hydro	ARUNACHAL PRADESH	NEEPCO	150
23	Subansiri Lower HEP U1	Hydro	ARUNACHAL PRADESH	NHPC	250
24	Subansiri Lower HEP U2	Hydro	ARUNACHAL PRADESH	NHPC	250
25	Subansiri Lower HEP U3	Hydro	ARUNACHAL PRADESH	NHPC	250
26	Subansiri Lower HEP U4	Hydro	ARUNACHAL PRADESH	NHPC	250

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
27	Tuirial HEP U1	Hydro	MIZORAM	NEEPCO	30
28	Tuirial HEP U2	Hydro	MIZORAM	NEEPCO	30
	SUB TOTAL(CENTRAL SECTOR)				**8790**
	STATE SECTOR				
1	Uhl-III HEP U1	Hydro	HIMACHAL PRADESH	BVPC	33.33
2	Uhl-III HEP U2	Hydro	HIMACHAL PRADESH	BVPC	33.33
3	Uhl-III HEP U3	Hydro	HIMACHAL PRADESH	BVPC	33.33
4	Sawara Kuddu HEP	Hydro	HIMACHAL PRADESH	HPPCL	111
5	Kashang II HEP	Hydro	HIMACHAL PRADESH	HPPCL	65
6	Kashang III HEP	Hydro	HIMACHAL PRADESH	HPPCL	65
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 U3	Hydro	TELANGANA	TSGENCO	30
13	Pulichintala HEP U4	Hydro	TELANGANA	TSGENCO	30
	SUB TOTAL(STATE SECTOR)				**1101**
	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
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

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
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	Vinjkote (Darrampura) TPP U2	Coal	CHHATTISGARH	SKS Ispat and Power Ltd.	300
16	Vinjkote (Darrampura) TPP U3	Coal	CHHATTISGARH	SKS Ispat and Power Ltd.	300
17	Akaltara (Nariyara) TPP U3	Coal	CHHATTISGARH	KSK Mahanadi Power Company Limited	600
18	Vandana Vidyut TPP U2	Coal	CHHATTISGARH	Vandana Vidyut	135
19	India Bulls - Nasik TPP Ph-I, U4	Coal	MAHARASHTRA	India Bulls Realtech Limited	270
20	India Bulls - Nasik TPP Ph-I, U5	Coal	MAHARASHTRA	India Bulls Realtech Limited	270
21	Lanco Mahanadi, Vidarbha TPP U1	Coal	MAHARASHTRA	Lanco Mahanadi Power Pvt Ltd	660
22	Lanco Mahanadi, Vidarbha TPP U2	Coal	MAHARASHTRA	Lanco Mahanadi Power Pvt Ltd	660
23	D B Power TPP, Sidhi U-1	Coal	MADHYA PRADESH	DB Power (Madhya Pradesh) Ltd	660
24	Maheshwar HEP U1	Hydro	MADHYA PRADESH	SMHPCL	40

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
25	Maheshwar HEP U2	Hydro	MADHYA PRADESH	SMHPCL	40
26	Maheshwar HEP U3	Hydro	MADHYA PRADESH	SMHPCL	40
27	Maheshwar HEP U4	Hydro	MADHYA PRADESH	SMHPCL	40
28	Maheshwar HEP U5	Hydro	MADHYA PRADESH	SMHPCL	40
29	Maheshwar HEP U6	Hydro	MADHYA PRADESH	SMHPCL	40
30	Maheshwar HEP U7	Hydro	MADHYA PRADESH	SMHPCL	40
31	Maheshwar HEP U8	Hydro	MADHYA PRADESH	SMHPCL	40
32	Maheshwar HEP U9	Hydro	MADHYA PRADESH	SMHPCL	40
33	Maheshwar HEP U10	Hydro	MADHYA PRADESH	SMHPCL	40
34	Thamminapatnam TPP U3	Coal	ANDHRA PRADESH	Meenakshi Energy Pvt. Ltd.,	350
35	Thamminapatnam TPP U4	Coal	ANDHRA PRADESH	Meenakshi Energy Pvt. Ltd.,	350
36	Bhavanapaddu TPP U1	Coal	ANDHRA PRADESH	East Coast Energy	660
37	Bhavanapaddu TPP U2	Coal	ANDHRA PRADESH	East Coast Energy	660
38	Ind Barath TPP U1	Coal	TAMIL NADU	Ind Barath Power (Madras) Ltd	660
39	Bhasmey HEP U1	Hydro	SIKKIM	Gati Infrastructure Ltd.	17
40	Bhasmey HEP U2	Hydro	SIKKIM	Gati Infrastructure Ltd.	17
41	Bhasmey HEP U3	Hydro	SIKKIM	Gati Infrastructure Ltd.	17
42	Rangit-IV HEP U1	Hydro	SIKKIM	Jal Power Corp. Ltd.	40
43	Rangit-IV HEP U2	Hydro	SIKKIM	Jal Power Corp. Ltd.	40
44	Rangit-IV HEP U3	Hydro	SIKKIM	Jal Power Corp. Ltd.	40
45	Teesta-VI HEP U1	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125
46	Teesta-VI HEP U2	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125
47	Teesta-VI HEP U3	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125

Sl. No.	PLANT NAME	FUEL TYPE	STATE	AGENCY	CAPACITY
48	Teesta-VI HEP U4	Hydro	SIKKIM	Lanco Energy Pvt. Ltd.	125
49	Teesta-III HEP U4	Hydro	SIKKIM	Teesta Urja Ltd	200
50	Teesta-III HEP U5	Hydro	SIKKIM	Teesta Urja Ltd	200
51	Teesta-III HEP U6	Hydro	SIKKIM	Teesta Urja Ltd	200
52	Mata Shri Usha TPP Ph-I U1	Coal	JHARKHAND	Corporate Power Ltd.	270
53	Mata Shri Usha TPP Ph-I U2	Coal	JHARKHAND	Corporate Power Ltd.	270
54	K.V.K. Nilanchal TPP U1	Coal	ORISSA	K.V.K. Nilachal Power Pvt. Ltd.	350
	SUB TOTAL(PRIVATE SECTOR)				**11495**
	TOTAL(12TH PLAN)				**21,386**

Annexure 2.6

Details Achievements of LE and R&M Programme during 12th Plan upto 31.03.2016

	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**			

Total LE	**18 (2131.76)**	**State**	**07 (units)**	**870**
		Centre	**11 (units)**	**1261.76**
Total R&M	**11 (2060.50)**	**State**	**05 (units)**	**850**
		Centre	**06 (units)**	**1210.5**
Grand Total			**29 (units)**	**4192.26**

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/Rs (kg of oil equivalent/Rs) and it came down to 0.0131 kgoe/Rs 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

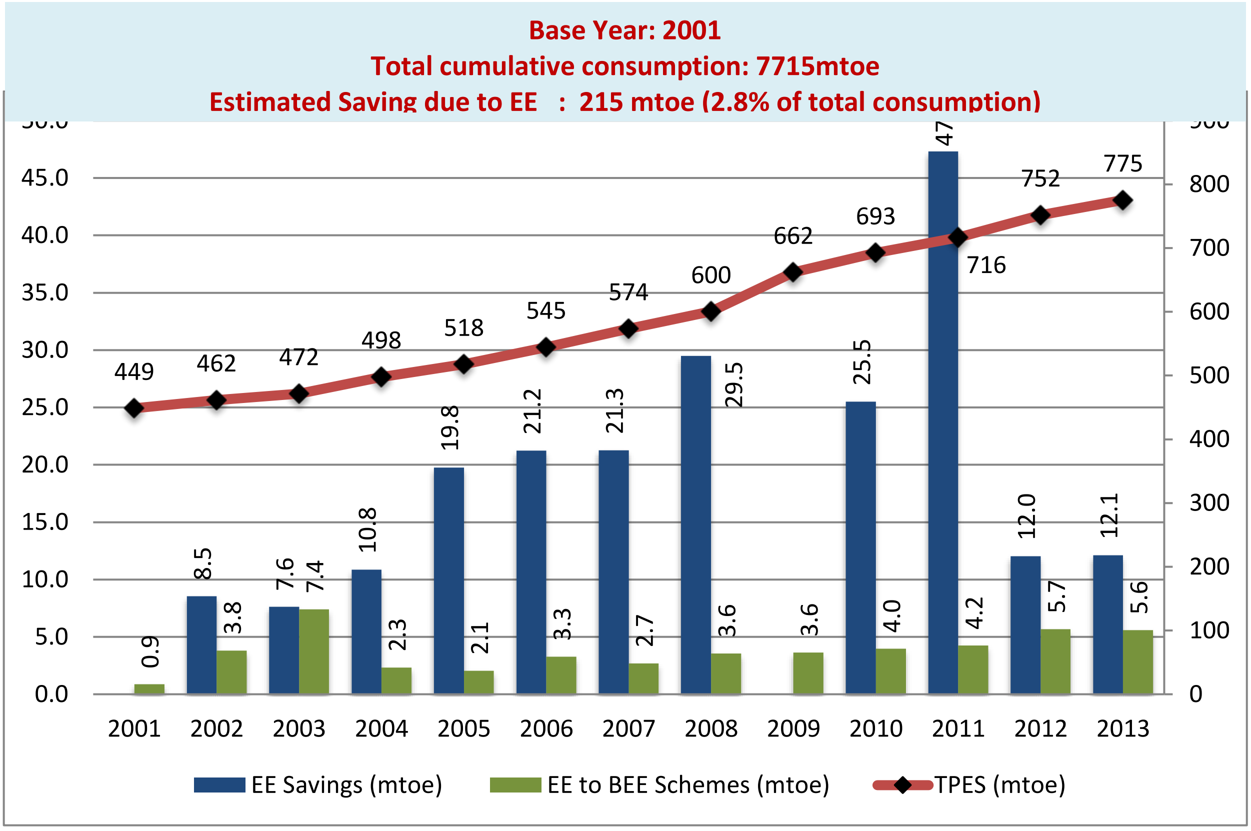
Energy Efficiency Initiatives by BEE

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 (**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	29771
2	Building (ECBC)	14.2
3	Bachat Lamp Yojana	427
4	Strengthening of State Designated Agency	1065
5	Designated Consumers and Small & Medium Enterprises	2.1
6	Agricultural DSM(AgDSM) and Municipality DSM (MuDSM)	0.70
7	National Energy Conservation Award	5043
	TOTAL	**36323**

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) and Table 3.3(b)**

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**

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(b)

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**

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)	7693	8411	8838	9432	10055
Peak Avoided (MW) due to installation of SWHS*	800	800	800	800	800
GDP (Billion Rs)	81138	86798	92852	99328	106256
Savings/GDP (kgoe/ Rs GDP)	0.00043	0.00052	0.00056	0.00057	0.00059
Energy Intensity (BAU) - kgtoe/Rs 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 Rs)	113667	121595	130076	139149	148854
Savings/GDP (kgoe/ Rs GDP)	0.00058	0.00058	0.00057	0.00057	0.00057
Energy Intensity (BAU) - kgtoe/Rs 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 given in **Annexure 3.1.**

3.5 MEASURES TO BE ADOPTED TO ACHIEVE THE TARGET

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

A1. Standard and Labelling (S&L) Program

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

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

(ii) Widen the Program

1. 28 appliances are to be covered by 2017. However, 7 will be mandatory out of these 28 appliances.

(iii) Deepen the Program

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

(iv) S&L for Transport Sector

1. 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.

A2. 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.

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

B1. 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.

B2. 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.

B3. 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

B4. 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.

B5. 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.

C. 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

D. Regulatory Instruments

(i) 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.

(ii) 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.

E. 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 Rs 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 Rs. 32,612 crores, including a budgetary support of Rs. 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 Rs. 44,011 crores including a budgetary support of Rs. 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.

F. Affordable Energy Efficient Lighting Solution

(i) The Lighting Industry has seen a strong growth of more than 67% from Rs. 8500 Crores in 2010 to Rs. 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:

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 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 Rs. 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 Rs. 775 crores.

(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 CO_2.

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 31st March, 2015. From 1st April, 2015 to 14th August, 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.

(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 Rs. 10 each as against their market price of Rs. 350-600.

Key features: DELP scheme

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 INR as against a market price of 350 to 600 INR
- 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:

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 INR
Approximate cost reduction for DISCOMS per annum	16.9 crore INR
Upfront investment by State/ DISCOM	Nil
Investment by EESL	22.785 crore INR

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 Rs. 64 crores has been invested by EESL and will be recovered over a 7 years' period. The municipality will pay EESL a sum of Rs. 18.5 crore every year whereas its overall costs savings would be Rs. 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:

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	**Rs. 64 crore**
Estimated cost savings to municipalities every year	**Rs. 31 crore**
Annual payments to EESL for 7 years (inclusive of O&M Costs)	**Rs. 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 Rs. 100 crores. Under this program, maximum of Rs. 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) 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".

(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 Rs. 3 crores (has been proposed to increase to Rs. 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 Rs. 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 Rs. 2 crores, whichever is less. The support has been provided to only Government buildings, private buildings (commercial or multi-storied residential buildings) and municipalities.

(5) Other initiatives of Government for enhancing energy efficiency in Generation sector

- **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. 44 Nos. supercritical units of sizes 660/800 MW with a total capacity of 30,125 MW have been commissioned and 48,085MW capacity are under construction. In the period 2017-22, coal based capacity addition would be 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

- **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.

- **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 1731 MW has been retired till 31.3.2016.

- 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 3,192 MW have been completed up to Dec, 2015. During the years 2017-22 R&M and LE works for total capacity 32,020 MW (tentative) are being considered.

- **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 deg.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

1. 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.
2. Encourage implementation of ToD Tariffs for industries and commercial consumers in phased manner and include domestic consumers subsequently.
3. DISCOMs may be advised to carry out annual audits of energy flow of their distribution system

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

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 a 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, 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 electrical 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) has been constituted by CEA in June, 2015. The terms of reference of the Committee is as under:

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

ii. To project the perspective electricity demand for the year 2031-32 and 2036-37.

The Report of 19th Electric Power Survey Committee is likely to be submitted shortly. Changes, if any, in demand projections will be suitably incorporated while finalising the National Electricity Plan.

For the interim period, electricity demand has been assessed for carrying out generation and transmission expansion planning studies for the National Electricity Plan.

4.2. METHODOLOGY ADOPTED FOR FORECAST OF ELECTRICAL ENERGY REQUIREMENT OF STATES/UTs/REGIONS AND FOR THE COUNTRY

Projection of electrical energy requirement and peak demand has been done for Utilities. Following methodologies have been used to forecast the electrical energy requirement on all-India basis:

(i) **Methodology 1**: Forecast of electricity consumption of all the States/UTs has been done by adopting suitable growth rate, from which the electrical energy requirement of each States/UT was obtained by adding T&D loss of the State/UT. Electrical energy requirement at all-India level was obtained by summation of the electrical energy requirement of all the States/UTs.

(ii) **Methodology 2**: Forecast of electrical energy consumption on all-India basis has been done using regression technique considering growth in past years at all-India level. The electrical energy requirement on all-India basis has been obtained by adding the all-India T&D loss to the electrical energy consumption.

4.2.1 Methodology 1: All-India electrical energy requirement as summation of the forecast of electrical energy requirement of all the States/UTs.

Past electricity consumption data from the year 1979-80 to 2013-14 was taken from General Review Report of CEA. The forecast of electrical energy consumption for each State/UT was obtained by applying suitable growth rate to the electricity consumption in the past. Selection of growth rate is outlined in Section 4.2.1.1. Forecast of electrical energy requirement was obtained by adding T&D loss to the electrical energy consumption. The effect of increase in electricity consumption on account of Power for All has been suitably incorporated.

The forecast of electricity demand of States/UTs was then moderated by incorporating the effect of DSM, energy efficiency and conservation measures as per details provided by Sub-Committee 2 on DSM, Energy Efficiency and Conservation, under the main NEP committee. This has been discussed in Section 4.3.

4.2.1.1 Selection of growth rate of electricity consumption for the States/UTs

To analyse the growth rate of electricity consumption of different States/UTs during different periods, the study period has been divided into three groups as detailed below:

Group I: Electricity consumption from 1979-80 to 2013-14.
Group II: Electricity consumption from 2000-01 to 2013-14.
Group III: Electricity consumption from 2009-10 to 2013-14.

Group I would give the overall growth rate taking into account the pre and post Electricity Act, 2003 period. Group II covers the period immediately preceding the enactment of Electricity Act, 2003, and also covers the period of reforms. Group III covers the period of latest trends of growth in electricity consumption as prevalent in the system.

Based on the above grouping method, the growth rate for the above periods were studied along with the standard deviations of these growth rates. Growth rate with lower standard deviation show consistency of growth during that period. This growth rate was chosen to work out the forecast. However, if the growth rates corresponding to least standard deviation were found to be lower than in other periods, they were suitably modified to account for growth due to PFA programme and make in India Programme of Government of India. The growth rate identified for each State/UT was used to work out the electricity consumption of the State/UT in future years. Growth rates in the first two years viz. 2014-15 & 2015-16 were adjusted to take into account the actual electrical energy requirement of these years.

4.2.1.2 Selection of T&D losses

The actual T&D losses for the year 2013-14 has been taken as the base. T&D loss on all-India basis was 22.84% during the year 2013-14. Thereafter the T&D losses were assumed to reduce during the period 2014-15 to 2026-27. The electrical energy requirement of each State/UT was obtained by adding the T&D losses to the electrical energy consumption.

4.2.1.3 Selection of Load Factor

The electrical energy requirement at all-India level was obtained by summation of the electrical energy requirement of individual States/UTs. All-India peak demand has been obtained by applying load factor at all-India level. Load factor on all-India basis was 84.40

% during the year 2013-14. The load factors assumed for the forecast period on all-India basis are given in **Table 4.1**.

Table 4.1

Load factor for the forecast period

Year	Load Factor (%)
2016-17	82.15
2021-22	81.54
2026-27	80.81

4.2.1.4 Electrical Energy Requirement and Peak Demand on All-India basis

Electrical energy requirement for the country (Utilities) has been worked out by aggregating the electrical energy requirement of all the States/UTs. Peak demand on all-India basis was calculated by assuming load factor as given in Table 4.1. The forecast of electrical energy requirement and peak demand on all-India basis for the years 2016-17, 2021-22 and 2026-27 is given in **Table 4.2**.

Table 4.2

Electrical energy requirement and peak demand an all-India basis (Utilities)

Year	Electrical Energy Requirement (MU)	CAGR of energy requirement (%)	Peak Demand (MW)	CAGR of Peak Demand (%)
2016-17	1230264		170950	
2021-22	1748251	7.28	244753	7.44
2026-27	2335987	6.00	329998	6.15

CAGR of electrical energy requirement for the period 2016-17 to 2021-22 works out to 7.28 % on all-India basis. The actual growth in electrical energy requirement on all- India basis, during the period 2009-10 to 2015-16, has been 5.02 %. It is felt that the higher growth rate of electrical energy requirement envisaged in future would by and large take care of the increase in electrical energy requirement on account of Power for All (PFA) initiative.

4.2.2 Methodology 2: Forecast of electrical energy consumption using regression technique at all-India level

The forecast of electrical energy consumption on all-India level was also worked out using regression technique with dependent variable as energy consumption and independent variables as third and fourth degree time variables. The forecast of electrical energy consumption was fitted by regression on a 3rd and 4th degree curve and the electrical energy consumption for the forecast period was obtained.

4.2.2.1 Results of 3rd degree regression analysis on all-India basis

Electrical Energy Consumption = $29.01978t^3-966.933t^2+22171.28t+40252.89$

$R^2=0.98646$

The forecast of electrical energy consumption obtained using 3rd degree regression analysis and the corresponding forecast of electrical energy requirement is given in **Table 4.3**.

4.2.2.2 Results of 4th degree regression analysis on all-India basis

Electrical Energy Consumption = $0.71t^4 - 28.85t^3 +486.18t^2 + 8221.48t + 56971.26$

$R^2 = 0.987458$

The forecast of electrical energy consumption obtained using 4th degree regression analysis and the corresponding forecast of electrical energy requirement is given in **Table 4.3**. The forecasts obtained using different methods have been compared pictorially in **Exhibit 4.1**.

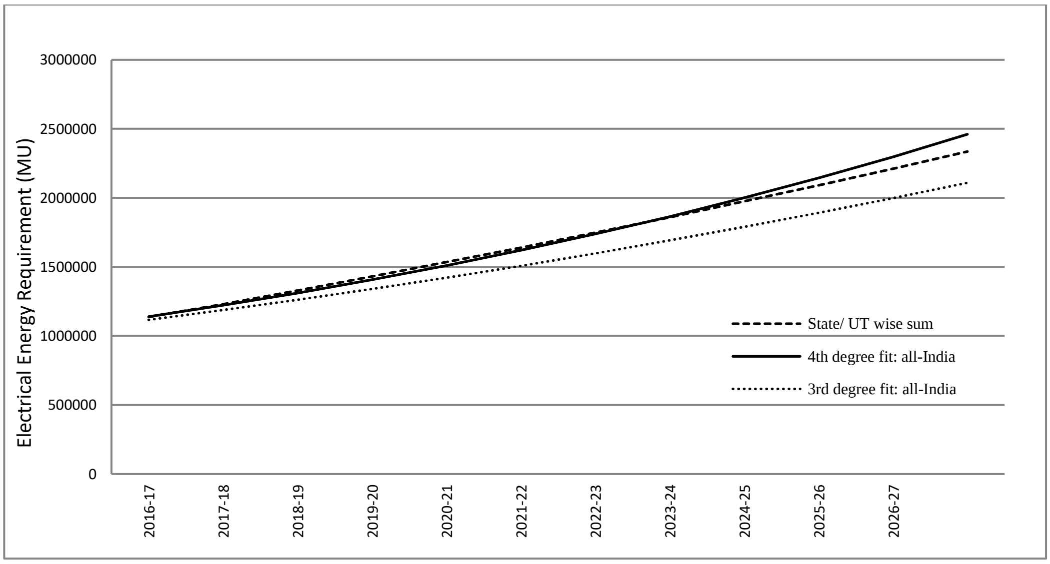
Table 4.3

Electrical energy consumption and electrical energy requirement on all-India basis (Utilities)

Year	Based on growth rate in the States/UTs		4th degree regression (R^2=0.987458; Standard Error = 23060) Electrical Energy Consumption = $0.71t^4 - 28.85t^3 +486.18t^2 + 8221.48t + 56971.26$		3rd degree regression (R^2=0.98646; Standard Error = 23202) Electrical Energy Consumption = $29.01978t^3-966.933t^2+22171.28t+40252.89$	
	Electrical energy consumption (MU)	Electrical Energy Requirement (MU)	Electrical energy consumption (MU)	Electrical Energy Requirement (MU)	Electrical energy consumption (MU)	Electrical Energy Requirement (MU)
2016-17	973237	1230264	966852	1222198	939221	1187270
2017-18	1059641	1328124	1046093	1311144	1006798	1261893
2018-19	1151273	1430242	1132498	1406917	1078884	1340312
2019-20	1246443	1534152	1226566	1509686	1155652	1422404
2020-21	1345034	1639854	1328813	1620078	1237277	1508478
2021-22	1448067	1748251	1439773	1738238	1323933	1598384
2022-23	1556000	1859917	1559996	1864693	1415794	1692326
2023-24	1668763	1974589	1690048	1999775	1513035	1790321
2024-25	1786027	2091826	1830514	2143930	1615828	1892486
2025-26	1908486	2212333	1981996	2297546	1724349	1998880
2026-27	2036057	2335987	2145110	2461105	1838771	2109639

Exhibit 4.1

Comparison of Electrical Energy Requirement using different methods



4.2.3 Comparison of electrical energy requirement on all-India basis

Electrical energy requirement on all-India basis (Utilities) as per different methodologies is summarised in **Table 4.4**.

Table 4.4

Growth rate of electrical energy requirement in different methodologies (Utilities)

Year	Summation of requirement of all States/UTs	CAGR (%)	4th degree regression	CAGR (%)	3rd degree regression	CAGR (%)
2016-17	1230264		1222198		1187270	
2021-22	1748251	7.28	1738238	7.29	1598384	6.12
2026-27	2335987	6.00	2461105	7.20	2109639	5.71

Forecast obtained by 3rd degree regression analysis on all-India basis are 3.49 %, 8.57 % and 9.69 % lower during the years 2016-17, 2021-22 and 2026-27 respectively as compared to the forecast obtained on all-India basis by summation of forecasts of States/UTs. Forecast obtained by 4th degree regression analysis on all-India basis are 0.66 % and 0.57 % lower during the years 2016-17 and 2021-22 respectively as compared to the forecast obtained on all-India basis by summation of forecasts of States/UTs. However, forecast obtained by 4th degree regression analysis on all-India basis is 5.36 % higher than the forecast obtained by summation of forecasts of States/UTs during 2026-27.

Summation of State/UT wise electrical energy requirement has been chosen to arrive at the all-India forecast because the forecast is based on more granular data viz. electricity consumption, T&D loss, load factor etc. of all the States/UTs in the country.

4.3. ENERGY SAVINGS ON ACCOUNT OF VARIOUS MEASURES

4.3.1 Energy savings on account of DSM, Energy Efficiency & Conservation measures

Energy savings on account of DSM, Energy Efficiency & Conservation measures and corresponding reduction in peak demand has not been considered in the demand forecast arrived at in Section 4.2. As per the Report of sub-Committee 2 on DSM, Energy Efficiency & Conservation, under the main NEP Committee, 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. As per the report of sub-committee 2, the electrical energy savings on all-India level as a result of DSM, energy efficiency and conservation programs is given in **Table 4.5**.

Table 4.5

Electrical energy savings on account of DSM, Energy Efficiency & Conservation Measures (on all-India basis)

Year	Energy Savings Utilities (BU)	Incremental Energy Savings over 2015-16 figures (BU)
2015-16	69	
2016-17	95	26
2021-22	206	137
2026-27	273	204

Energy savings during the forecast period has been moderated considering the savings envisaged during the year 2015-16. Incremental energy savings during the year 2016-17, 2021-22 and 2026-27 would be 26 BU, 137 BU and 204 BU respectively.

4.3.2 Reduction in peak demand on account of DSM, Energy Efficiency & Conservation measures

DSM, energy efficiency & conservation measures would also lead to reduction in peak demand. The corresponding reduction in peak demand as per the report of Sub-Committee 2 is shown in **Table 4.6**.

Table 4.6

Reduction in peak demand on account of DSM, Energy Efficiency & Conservation measures (on All-India basis)

	2016-17	2021-22	2026-27
Reduction in peak demand (MW) Utilities	7277	9436	12324

Assuming (i) electrical energy savings on account of DSM, energy efficiency and conservation measures and (ii) reduction in peak demand on account of DSM, energy efficiency and conservation measures, the electrical energy requirement and peak demand on all-India basis (utilities) would be as given in **Table 4.7**.

Table 4.7

Net electrical energy requirement and peak demand on all-India basis considering energy savings on account of DSM, energy efficiency and conservation measures (utilities)

Year	Electrical Energy Requirement in Base Case (MU)	Peak demand in Base Case (MW)	Load factor (%) in base case	Savings in electrical energy requirement on account of DSM, energy efficiency and conservation measures (MU)	Net electrical energy requirement considering savings on account of DSM, energy efficiency and conservation measures (MU)	Reduction in peak demand on account of DSM, energy efficiency and conservation measures (MW)	Peak demand considering DSM, energy efficiency and conservation measures (MW)	Load Factor (%) considering DSM, energy efficiency and conservation measures
2016-17	1230264	170950	82.15	26000	1204264	7277	163673	84.00
2021-22	1748251	244753	81.54	137000	1611251	9436	235317	78.16
2026-27	2335987	329998	80.81	204000	2131987	12324	317674	76.61

4.3.3 Captive Power Generation

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. A number of industries have set up their captive power plants to have better quality power supply in place of supply from the utility grid.

Considering gradual transfer of energy consumption by industries from captive power plants to utility grid due to the improvement in grid supply, it is estimated that additional electrical energy of about 40 BU and about 100 BU would be required during 2021-22 and 2026-27 respectively. This increase in demand due to shifting of industries from captive power to utility grid has been captured in the generation scenario analysis carried out in Chapter 5: Generation Planning.

4.3.4 Penetration of roof-top solar

MNRE has furnished programme of installation of roof-top solar of 40,000 MW by 2021-22. Only the roof-top solar installations with storage would lead to reduction in all-India peak demand. However, in the present exercise, contribution of roof-top solar installation towards reduction in electrical energy requirement and peak demand has not been considered. Roof top solar and other solar generation projects would be treated as generation source while carrying out generation expansion planning exercise.

4.4 CONCLUSIONS

Projection of electrical energy requirement and peak demand has been done for utilities. Two scenarios of electricity demand forecast have been worked out – without and with the consideration of DSM, energy efficiency and conservation measures and are summarised below:

(i) Electrical energy requirement and peak demand on all-India basis without considering DSM, energy efficiency and conservation measures (Utilities).

Year	Electrical Energy Requirement (MU)	Peak Demand (MW)
2021-22	17,48,251	2,44,753
2026-27	23,35,987	3,29,998

(ii) Electrical energy requirement and peak demand on all-India basis considering DSM, energy efficiency and conservation measures (Utilities).

Year	Electrical Energy Requirement (MU)	Peak Demand (MW)
2021-22	16,11,251	2,35,317
2026-27	21,31,987	3,17,674

The Report of 19th Electric Power Survey Committee is likely to be submitted shortly. Changes, if any, in demand projections will be suitably incorporated while finalising the National Electricity Plan.

Reduction in peak demand and electrical energy requirement on account of roof-top solar installations has not been factored in the demand forecast. Roof-top solar would be treated as a generation source and suitably factored in generation expansion planning studies.

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. However, in view of the limited available fuel resources for generation, to meet this demand the capacity addition has to be planned very optimally.

During the 12th Plan (2012-17), a capacity addition of 1,01,645 MW is expected to be 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 would be achieved which is likely to be about 115 % 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 from RES 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
- New and 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 needs to be resolved to exploit full potential. As on 31.03.2016, the installed capacity of hydroelectric power plants in the country is 42,784 MW. This is about 50.9% of the total hydro potential of the country.

5.2.2 Nuclear

Presently, Nuclear Power Corporation India Limited is operating 20 reactors with an installed capacity of 5,680 MW. Out of these 20 reactors presently 12 reactors with an installed capacity of 3,280 MW are under IAEA Safeguards and use imported fuel. Remaining 8 reactors with a 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 31.03.2016, the installed capacity of Nuclear power plants in the country is 5,780 MW.

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 38 to 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 natural gas.

As on 31.03.2016, the installed capacity of gas based power stations is 25,503 MW (including liquid based). Also a capacity of 4,340 MW is ready for commissioning/under construction but due to acute shortage of natural gas, is not in a position to commission.

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 33,500 MW based on Super critical technology has already 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 is 1,85,172.88 MW as on 31.03.2016 which is almost 62% of the total installed capacity of the country.

5.3 GENERATION FROM RENEWABLE ENERGY SOURCES

The installed capacity from renewable energy sources is 42,849 MW as on 31.03.2016. Share of Renewable Energy Sources (RES) in the total installed capacity is about 13%. 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.

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 for 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 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 growth 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 generation with load 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 will 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.

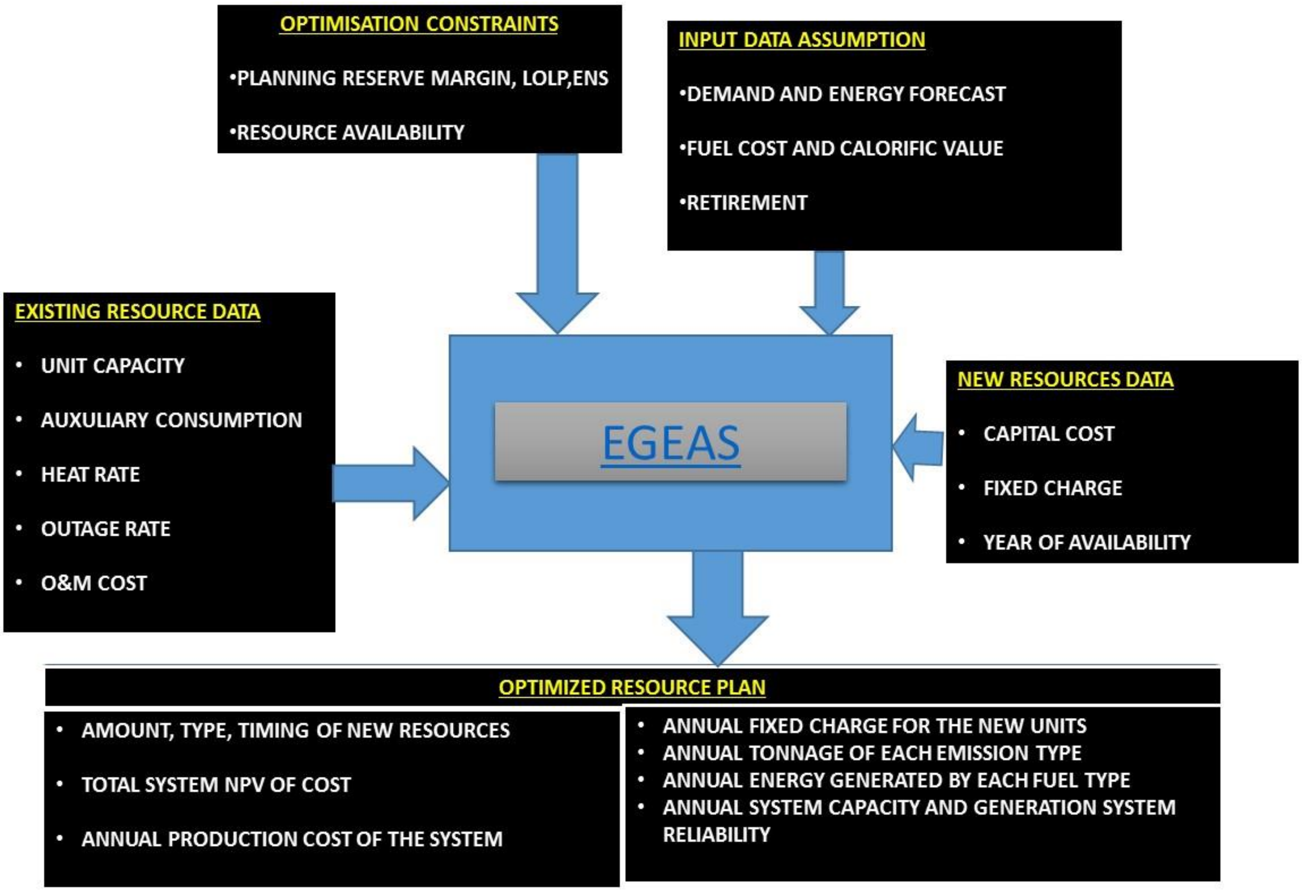
5.5 PLANNING TOOLS - DETAILS OF PLANNING MODELS

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 as shown in **Exhibit 5.1.**

Exhibit 5.1



5.6 PLANNING APPROACH

Planning approach has been to meet the peak demand and energy requirements. In view of generation being delicenced and high capacity addition programme from Renewable Energy sources, it therefore, 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:

Since 19th Electric Power Survey (EPS) Report is under preparation, Generation expansion planning studies has been carried out based on the Electricity demand assessed by the Sub-Committee on Demand projection constituted under NEP. The estimated peak demand (MW) and Energy requirement (BU) in the years 2021-22 and 2026-27 are given in **Table 5.1**. The Report of 19th Electric Power Survey Committee is likely to be submitted shortly. Changes, if any, in demand projections will be suitably incorporated while finalising the National Electricity Plan.

Table 5.1

Projected Electricity Demand

Year	Energy Requirement (BU) *	Peak Demand in (MW)*	Net Energy Requirement (BU) after considering RES generation**	Net Peak Demand in MW after considering RES generation***
2021-22	1611	235317	1337	224997
2026-27	2132	317674	1701	300404

*After considering reduction in demand due to DSM

**reducing solar and wind generation (i.e. VRE generation)

*** after reducing contribution of renewable energy sources during peak

5.6.2 Preparation of All India Load profile

The data was collected for past three years (2012-13, 2013-14 and 2014-15) 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.

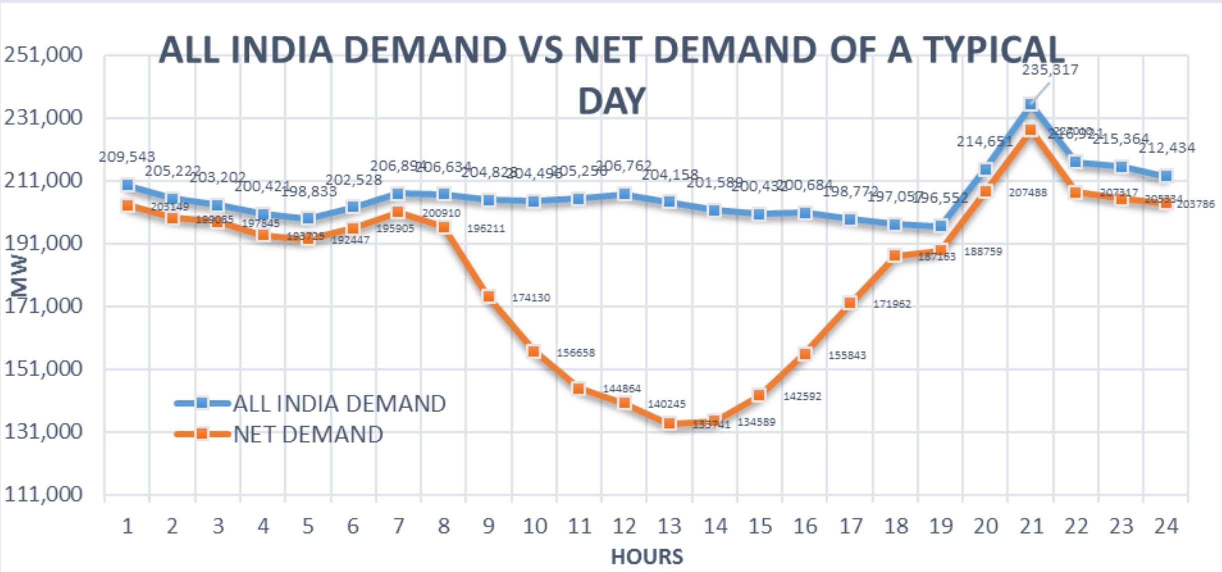
In view of the massive capacity addition programme from renewable energy sources (Solar and wind) during the years from 2017-18 to 2021-22, the All India Load profile was adjusted to arrive at All India Net load curve by treating generation from renewable energy sources as negative load.

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.
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

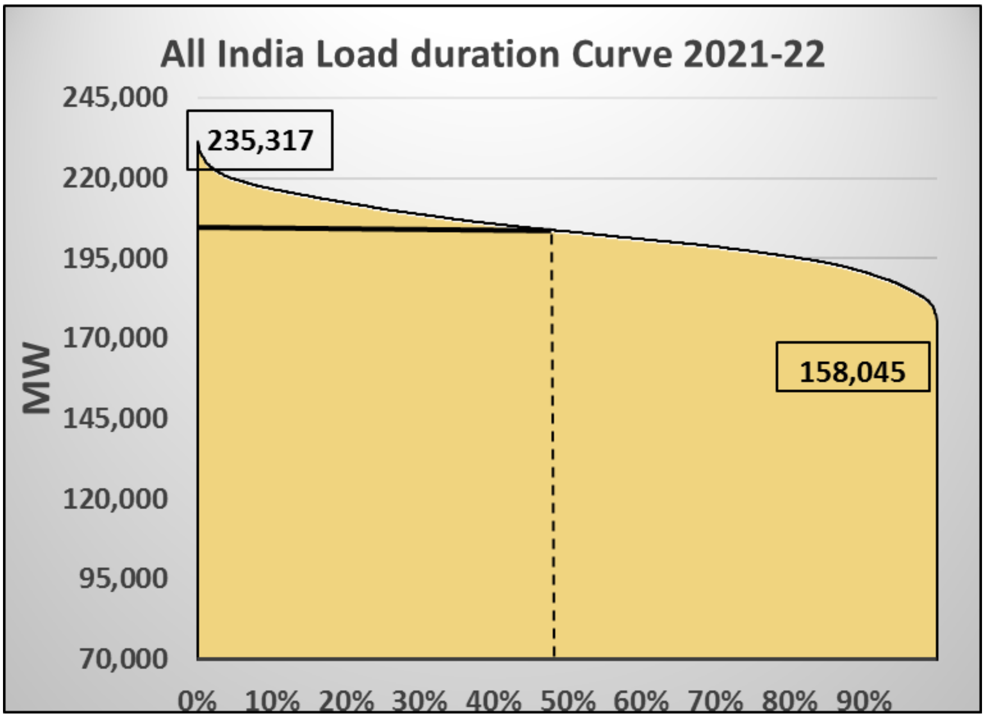
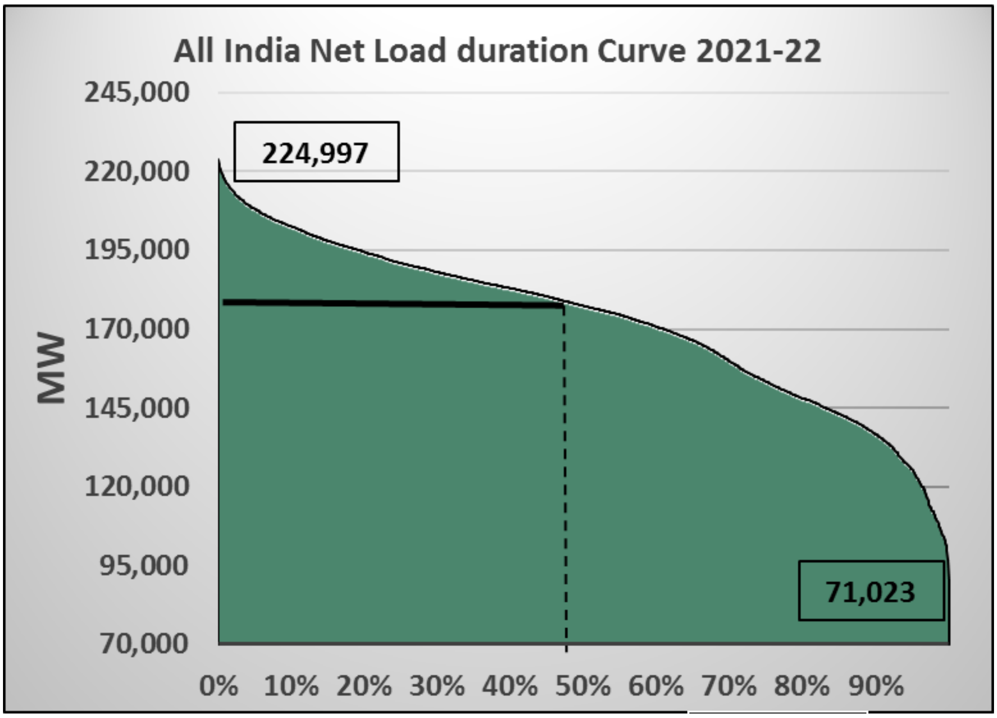


Exhibit 5.4



From **Exhibit 5.4**, it is seen that the system becomes peakier as far as load from conventional generating stations is to be met, 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 plants by 5%.

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 EGEAS software then calculates 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 retired old thermal power plants and plants likely to be considered for retirement. In addition, all the smaller size units upto 100 MW and coal based plants with life exceeding 40 years have been considered as retired in the study.

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, these 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 website 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 planning purposes.

5.8 PLANNING NORMS

The planning studies require accurate performance parameters of various type 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 and 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 800MW 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**	
	220 MW BWR **200/220 MW PHWR**	**12** **10.0**

\

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

Unit Size	Gross Heat rate (kcal/kWh)
800 MW	2225
660 MW	2250
660MW(Sipat+Barh)	2300
500 MW	2365
200/210/250 MW KWU	2400
200/210/250 MW LMZ	2500
110 MW	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 Parameter

(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	2.5
7	DEPRECIATION - POWER PLANT	5.28 FOR 12 YEARS

5.9 GENERATION EXPANSION PLANNING DURING THE YEARS 2017-22

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. The Studies are based on the following assumptions:

- Electricity Demand projections considered

Year	Energy Requirement* (BU)	Peak Demand (MW)*	Net Energy Requirement (BU) after considering RES generation**	Net Peak Demand in MW after considering RES generation***
2021-22	1611	235317	1337	224997

*After considering reduction in demand due to DSM

**After considering reduction in demand due to likely solar and wind generation in year 2021-22

***After reducing contribution of RES during peak in year 2021-22

- Likely Installed Capacity from conventional and renewable energy sources by 31.03.2017

(Figures in MW)

	Installed Capacity as on 31.03.2016	Likely addition during 2016-17	Likely Installed Capacity as on 31.03.2017
Coal	185173	13315	198488
Gas	25502	126	25628
Total Thermal	**210675**	**13441**	**224116**
Hydro	42784	1714	44498
Nuclear	5780	1500	7280
Total Conventional	**259239**	**16655**	**275894**
Solar	6763	12000	18763
Wind	26866	4100	30966
Others	9220	725	9945
Total RES	**42849**	**16825**	**59674**
Total	**302088**	**33480**	**335568**

Likely Capacity addition considered from conventional energy sources during 12th Plan (2012-17) is **1,01,645** MW. (Thermal 93,620 MW, Hydro 5,525MW and Nuclear 2,500 MW).

- **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%.**
- Capacity considered for retirement by the end of 2021-22 is about 5200 MW apart from units already retired during 12th plan and includes coal & lignite based units under 100 MW and or plants more than 40 years old.
- 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.
- Hydro Imports of 5,100 MW (Bhutan) by the end of 2021-22 has been considered.
- Gas based capacity addition of 4,340 MW during 2017-22 has been considered.
- Studies have been carried out corresponding to three different Scenarios of capacity addition from RES viz installed capacity of 1,75,000 MW, 150,000 MW and 1,25,000 MW by 2021-22 as shown below:

(All figures in MW)

Scenario	RES Category	Target RES IC as on 31.3.2022	Likely RES Installed Capacity as on 31.3.2017	Expected RES Capacity addition from 2017-22
Scenario I	Solar	100000	18763	81237
	Wind	60000	30967	29034
	BioMass	10000	5446	4554
	Small Hydro	5000	4498	502
	Total	**175000**	**59674**	**115326**
Scenario II	Solar	80000	18763	61237
	Wind	55000	30967	24034
	BioMass	10000	5446	4554
	Small Hydro	5000	4498	502
	Total	**150000**	**59674**	**90326**
Scenario III	Solar	60000	18763	41237
	Wind	50000	30967	19034
	BioMass	10000	5446	4554
	Small Hydro	5000	4498	502
	Total	**125000**	**59674**	**65326**

- The likely generation considered from Variable Renewable Energy Sources (Solar and Wind) in three different scenarios are given below:

Scenario	RES Category	Generation (BU)	RES energy contribution in total energy requirement (%)
Scenario I (175000)	Solar	162	
	Wind	112	
	Bio mass & SHP	53	
	Total	**327**	**20.3**
Scenario II (150000)	Solar	129	
	Wind	104	
	Bio mass & SHP	53	
	Total	**286**	**17.7**
Scenario III (125000)	Solar	97	
	Wind	95	
	Bio mass & SHP	53	
	Total	**245**	**15.2**

- Projects considered in the study during 2017-22 are as under: -

a) Hydro

Considering the status of various hydro projects, a hydro capacity addition of about 15,330 MW is likely during the years 2017-22. This comprises of 11,788 MW of capacity which is under various stages of construction and 3,542 MW of capacity accorded concurrence by CEA, but yet to be taken up for construction. Details of hydro projects are furnished in **Annexure 5.1.** The hydro projects have been considered as must run in EGEAS study in line with our Low Carbon Growth Strategy.

b) Nuclear

A nuclear capacity addition of 2,800 MW has been considered for the period 2017-22 as per the information furnished by DOAE. Details are furnished in **Annexure 5.2.**

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 4,340 MW is ready for commissioning/under construction but stranded due to non-availability of natural gas. The plants have been considered to be available during the year 2017-22 for the purpose of studies. Details of gas based power plants is given at **Annexure 2.3**. As the availability of gas is uncertain no additional gas based projects have been considered during the year 2017-22.

- **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.

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

EGEAS Studies were carried out to assess the total capacity addition requirement to meet the projected demand in the year 2021-22 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 has been considered as must run in the various Scenarios. Renewable capacity has also been considered as must run capacity. Three scenarios considering different combination of installed capacity from renewable energy sources have been developed for determining the generating capacity addition during the period 2017-22. The scenarios are as follows:

Scenario I (**Base Case)**–175,000 MW Renewables- 100,000 MW Solar, 60,000 MW Wind, Biomass – 10,000 MW and Small Hydro 5000 MW

Scenario II –150,000 MW Renewables - 80,000 MW Solar, 55,000MW Wind, Biomass – 10,000 MW and Small Hydro 5000 MW

Scenario III –125,000 MW Renewables - 60,000 MW Solar, 50,000MW Wind**,** Biomass – 10,000 MW and Small Hydro 5000 MW

Details from the study results depicting coal based capacity addition requirement under various scenarios are furnished at Table **5.7(a), Table 5.7(b), Table 5.7(c).**

Table 5.7(a)

Capacity addition during 2017-22 in Scenario – I (Base Case)

(1,75,000 MW Renewables by 2022)

(All figures in MW)

Sources	Capacity addition during 2017-22
Conventional	
Hydro*	15,330
Thermal	4,340
Coal	0
Gas	4,340
Nuclear	2,800
Sub Total (Conventional)	**22,470**
Renewables	
Wind	29,034
Solar	81,237
Other RES	5,055
Sub Total (Renewables)	**1,15,326**
Total Capacity Addition	**1,37,796**

*** excludes 5,100 MW imports from hydro plants of neighbouring countries.**

Table 5.7(b)

Capacity addition during 2017-22 in Scenario – II

(1,50,000 MW Renewables by 2022)

(All figures in MW)

Sources	Capacity addition during 2017-22
Conventional	
Hydro*	15,330
Thermal	4,340
Coal	0
Gas	4,340
Nuclear	2,800
Sub Total (Conventional)	**22,470**
Renewables	
Wind	24,034
Solar	61,237
Other RES	5,055
Sub Total (RES)	**90,326**
Total Capacity Addition	**112,796**

*** excludes 5,100 MW imports from hydro plants of neighbouring countries**

Table 5.7(c)
Capacity addition during 2017-22 in Scenario – III
(1,25,000 MW Renewables by 2022)

(All figures in MW)

TYPE	Capacity addition during 2017-22
Conventional	
Hydro*	15,330
Thermal	4,340
Coal	0
Gas	4,340
Nuclear	2,800
Sub Total (Conventional)	**22,470**
Renewables	
Wind	19,034
Solar	41,237
Other RES	5,055
Sub Total (RES)	**65,326**
Total Capacity Addition	**87,796**

*** excludes 5,100 MW imports from hydro plants of neighbouring countries**

It may be seen from study results shown in Table 5.7 (a) to 5.7 (c) that no additional coal based capacity is required during the years 2017-22 with committed capacity of Hydro -15330 MW, Gas – 4340 MW, Nuclear 2,800 MW and with various RES capacity addition scenarios (Installed capacity of RES of 1,75,000 MW, 1,50,000 MW and 1,25,000MW by year 2022). However, a coal based capacity addition of 50,025 MW is already under construction and is likely to be commissioned during 2017-22.

Details of Energy generated by coal based power plants, their average PLF with likely capacity addition of 50,025 MW from coal based power plants during 2017-22 (already under construction) in three scenarios of RES capacity addition by year 2022 are shown in **Table 5.8.**

Table 5.8

Energy Generated from coal, RES and Average PLF of coal based stations in the three scenarios

Scenario	Committed Hydro (MW)	Committed Nuclear (MW)	Committed Gas (MW)	Additional Coal Based Capacity Required (MW)	Coal Based Generation (Gross) (GWh) +++	PLF of Coal Based Plants (%)*
I	15330	2800	4340	0	1018	47.9
II				0	1071	50.4
III				0	1122	52.8

* PLF has been computed with capacity addition of 50,025 MW from coal based power plants which is under construction and likely to yield benefits during 2017-22,

+++ assuming Auxiliary Power consumption of coal stations as 6.5%

The likely installed capacity from different fuel types at the end of 2021-22 in base case works out to be 5,23,389 MW including 50,025 MW of Coal based capacity addition currently under construction and likely to yield benefits during 2017-22and is given in **Table 5.9** and **Exhibit 5.5**.

Table 5.9

Projected Installed capacity by the end of 2021-22

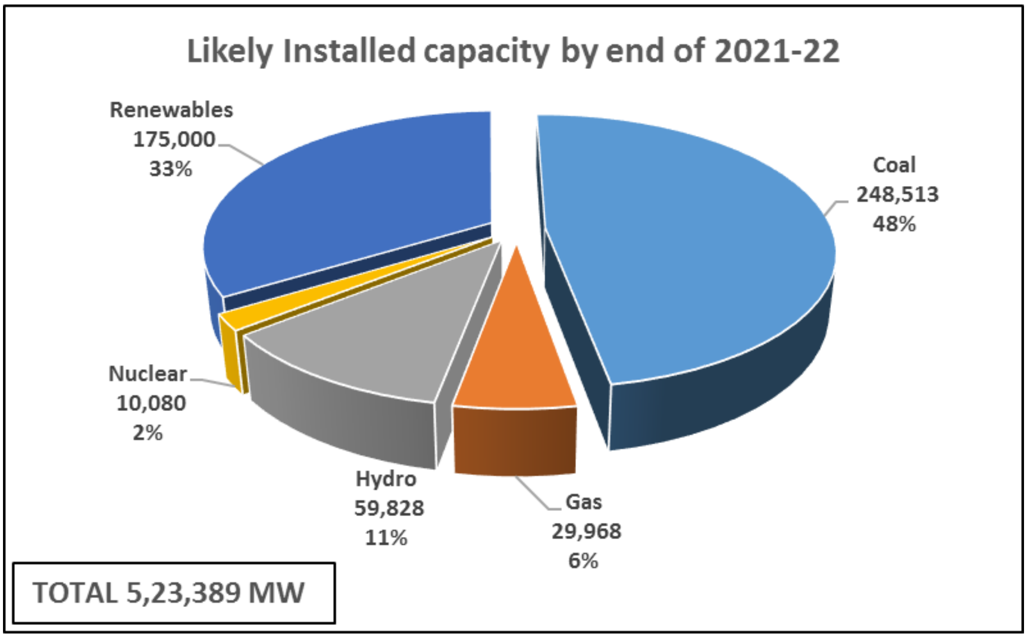
Fuel Type	Capacity (MW)	%
Hydro	59,828	
Coal + Lignite	248,513*	
Gas	29,968	
Nuclear	10,080	
Total Conventional Capacity *	**348,389**	**67%**
Total Renewable Capacity	**175,000**	**33%**
Total Capacity by 2021-22	**523,389**	**100%**

*This includes 50,025 MW of Coal based capacity addition currently under construction and likely to yield benefits during 2017-22.

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

Exhibit 5.5

(All figures in MW)



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 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 Sub-committee on Demand projections constituted under NEP committee is 2,35,317 MW and 1611 BU respectively which is around 17% and 15.4 % lower than the 18th EPS projections. Also, a capacity of 1,01,645 MW is likely to be commissioned against a target of 88,537 MW during 12th plan (2012-17). Therefore, during 12th plan, capacity addition to the extent of 13,108 MW is likely to be 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 SENSITIVITY ANALYSIS OF 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.

This para highlights various scenarios considered for Generation Expansion Planning taking into account the various parameters which are time variants.

5.11.1 Scenarios considered for generation capacity addition during 2017-22

A sensitivity analysis has been carried out on various factors such as projected demand growth rates, hydro power plants capacity addition programmes and the proposed capacity addition from RES to get a clear picture of the effect of variation of different decision variables on the requirement of additional capacity.

a) Demand Forecast

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 the extent of successful implementation thereof etc.

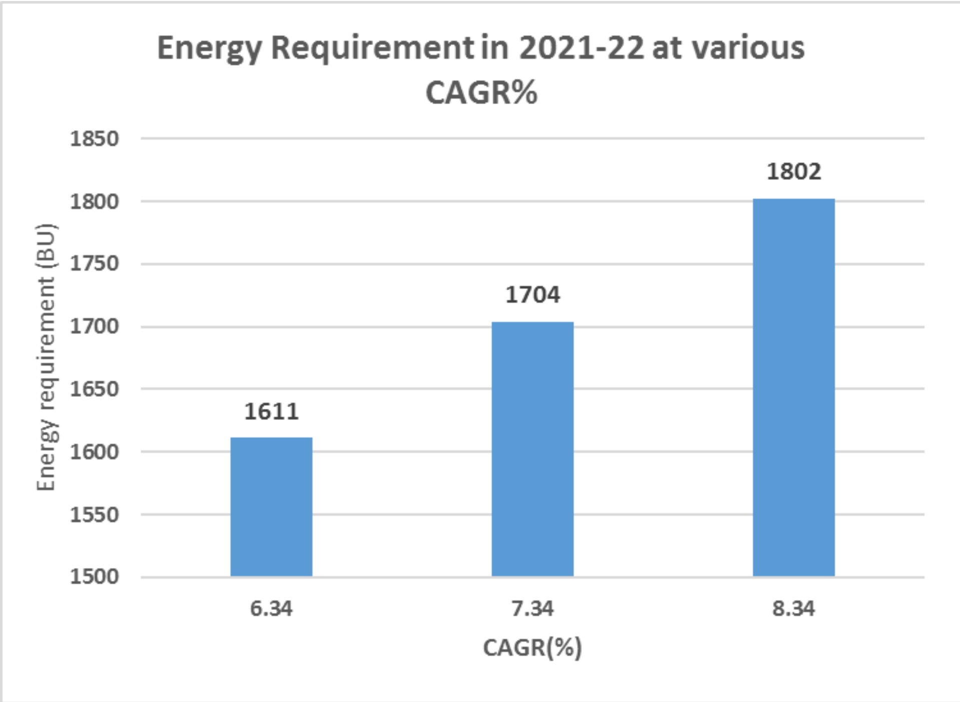
Based on methodology adopted (Chapter 3) in estimating electricity demand in future years considering DSM measures, the electricity energy requirement for the year 2021-22 has been estimated as 1611 BU with a Compounded Annual Growth Rate (CAGR) of 6.34% with reference to 2015-16. However, due to uncertainties associated with demand forecasting, two additional scenarios have been considered in the Generation planning studies i.e CAGR of 7.34 % and 8.34% (**Exhibit 5.6**).

CAGR: 6.34%: Electricity Demand: 1611 BU

CAGR: 7.34%: Electricity Demand: 1704 BU

CAGR: 8.34%: Electricity Demand: 1802 BU

Exhibit 5.6



b) Committed Units

While arriving at the requirement of additional generating capacity, Committed units are also taken into account. Committed units are the units which are likely to be commissioned during the planning period. Normally, the units which are in some stage of construction are taken as "Committed Units". The gestation period of the units varies from one category of units to another. Gestation period of a thermal unit is very different from that of a hydro unit, or a nuclear unit. Further, within the same category, location, availability of funds, environmental and geological issues, political climate etc. also influence the gestation period. Therefore, estimation of commissioning of committed units is also equally difficult.

i) Hydro: In the past, there has been considerable slippage from target w.r.t. capacity addition from Hydro sources. During the 12th Plan (2012-17), it is estimated that out of the target capacity addition of 10,897 MW from Hydro sources, the expected capacity addition shall be only 5,525 MW. Therefore, there is likely to be significant gap between target and actual achievement specially in case of Hydro power generating units.

Therefore, two scenarios have been considered for committed Hydro units for the generation planning studies:

1. **High Hydro Scenario-:** – a capacity addition of **15,330** MW from hydro has been considered based on the units which are likely to be commissioned (units under

construction including the units slipped from 12th Plan as well as concurred by CEA) during the years 2017-22.

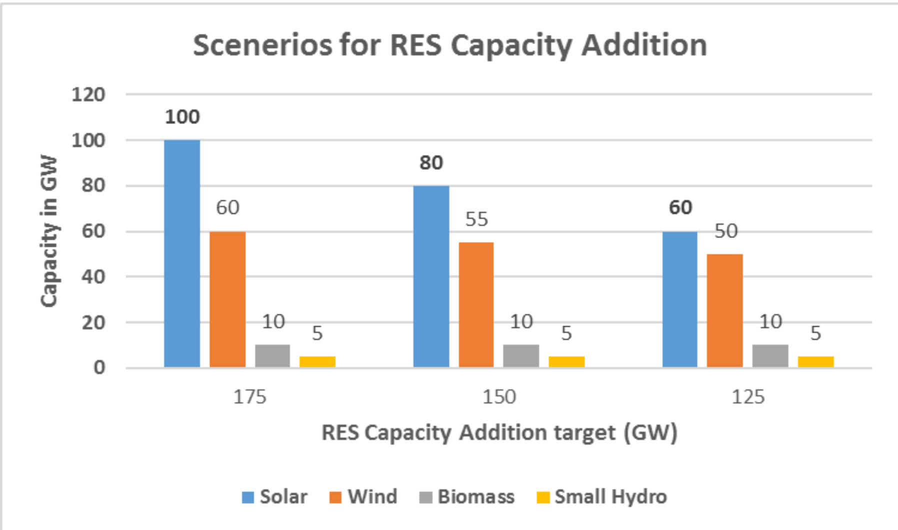
2. **Low Hydro Scenario-:** - a capacity addition of **11,788** MW from hydro has been considered, based on the assessment of the units which are actually under construction including the units slipped from 12th Plan and are most likely to be commissioned during the years 2017-22. Details of hydro projects which are under construction are furnished in **Annexure 5.1.**

ii) Nuclear: The expected capacity addition considered during the years 2017-22 from Nuclear power is 2,800 MW. Since the quantum of addition is considerably small, no additional scenario has been considered.

c) Capacity Addition Programme from Renewable Energy Sources

Renewable Energy sector is now poised for a quantum jump as India has reset its Renewable Energy capacity addition target so as to have installed capacity of 175 GW by 2022. The likely installed capacity of RES as on 31.03.2017 is estimated to be 59,674 MW. Therefore, the balance capacity of 115,326 MW is to be added during 2017-22 from RES. Considering that this is a huge capacity, three Scenarios for RES capacity till March,2022 have been considered for the studies: i.e. **175 GW, 150 GW and 125 GW** and is shown in **Exhibit 5.7.**

Exhibit 5.7

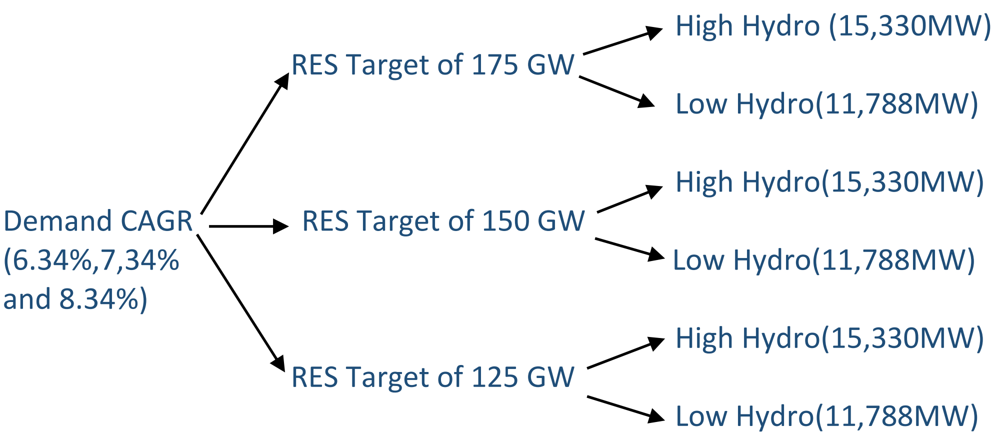


d) Retirement of the old and inefficient Units: A capacity of about 5,200 MW has been considered to retire during the years 2017-22. This estimate is based on the age, capacity and performance of the units. Government of India has recently notified stricter environmental norms for existing as well as new thermal power stations. However, as the effect of notification is yet to emerge, no other scenario has been considered.

Therefore, following scenarios (18 Nos.) have been considered at three different CAGR for Electrical Energy requirement for Generation Expansion Studies as shown in **Exhibit 5.8**.

Exhibit 5.8

TREE REPRESENTATION OF DECISION VARIABLES IN SENSITYVITY ANALYSIS STUDY



5.11.2 Results

Based on the various scenarios considered for the generation planning studies, the capacity addition required from coal based units and their expected Plant Load factor % are shown in the **Table 5.10**. The studies have been carried out by estimating Energy requirement and Peak Demand by assuming three different Compounded Annual Growth Rate of Energy Demand i.e. 6.34%, 7.34% and 8.34%.

Table 5.10
Results of sensitivity analysis

CAGR from 2015-16 to 2021-22 (%)	Demand in 2021-22		Additional Coal based capacity Requirement as per studies during 2017-22 (MW)	Coal based capacity which is already under construction for benefit during 2017-22 (MW)	Expected PLF% * during 2021-22 with Likely coal based capacity addition 500,25 MW during 2017-22
	Energy (BU)	Peak (GW)			
RES: 175 GW High Hydro: 15330 MW					
6.34^β	1611	235	0	50,025	47.9
7.34	1704	248	7020	50,025	52.6
8.34	1802	261	21370	50,025	57.4
RES: 175 GW Low Hydro: 11788 MW					
6.34	1611	235	0	50,025	48.6
7.34	1704	248	8450	50,025	53.3
8.34	1802	261	23980	50,025	58.2
RES: 150 GW High Hydro: 15330 MW					
6.34^β	1611	235	0	50,025	50.4
7.34	1704	248	8620	50,025	55.1
8.34	1802	261	22670	50,025	60.0
RES: 150 GW Low Hydro: 11788 MW					
6.34	1611	235	0	50,025	51.1
7.34	1704	248	9940	50,025	55.8
8.34	1802	261	25500	50,025	60.8
RES: 125 GW High Hydro: 15330 MW					
6.34^β	1611	235	0	50,025	52.8
7.34	1704	248	10715	50,025	57.5
8.34	1802	261	24900	50,025	62.3
RES: 125 GW Low Hydro: 11788 MW					
6.34	1611	235	0	50,025	53.5
7.34	1704	248	12040	50,025	58.1
8.34	1802	261	27600	50,025	63.0

^β considered as scenario I, II and III in para 5.10 above.

*PLF % has been estimated based on the assumption that coal based capacity of 50025 MW which is already under construction and likely to yield benefit during 2017-22 is available at the start of the year 2021-22.

Exhibit 5.9 and **Exhibit 5.10** shows the variation in Plant Load Factor (%) of coal based power stations with different RES capacity addition target in both High Hydro and Low Hydro scenario.

Exhibit 5.9

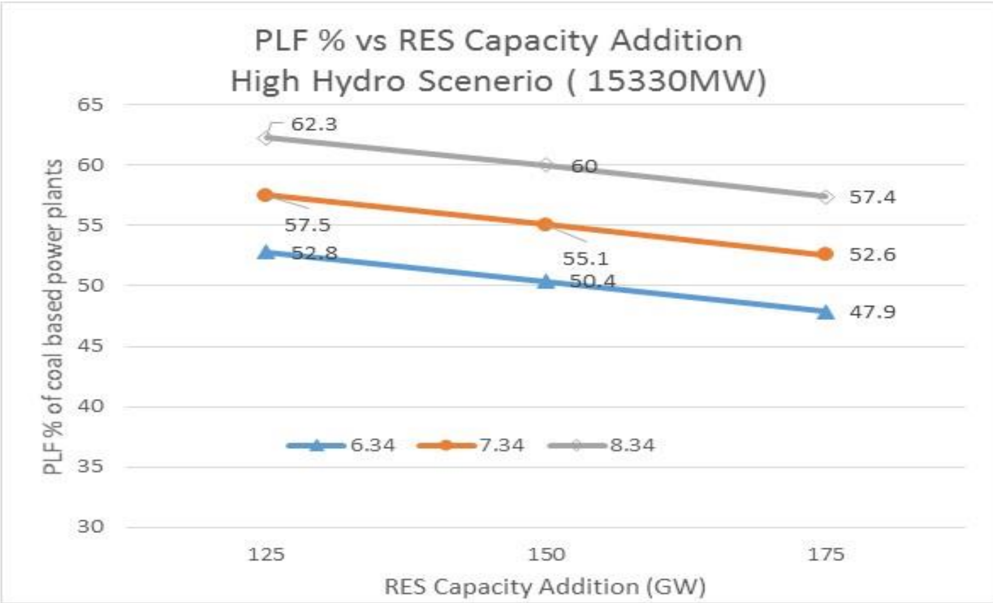
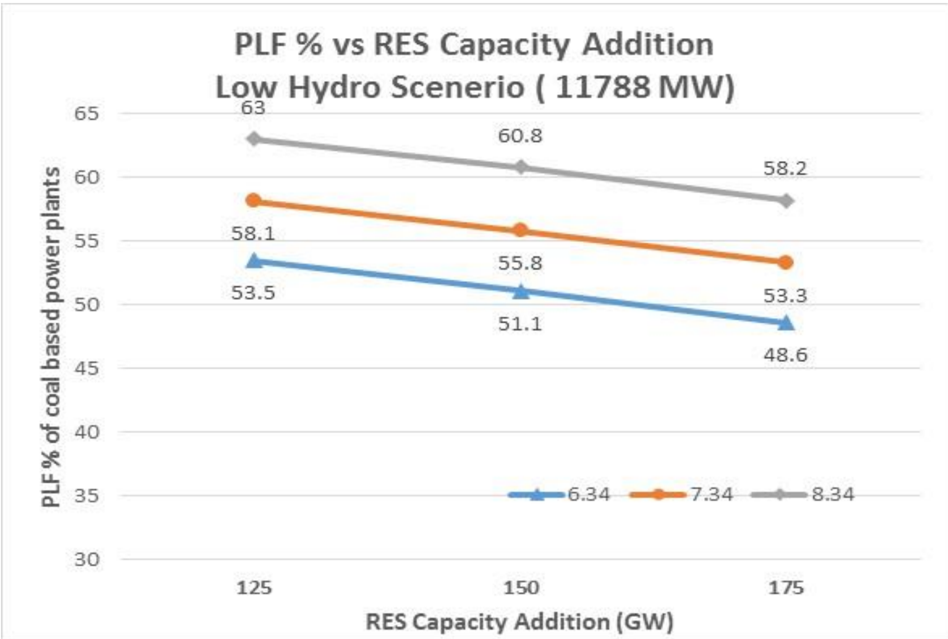


Exhibit 5.10



5.11.3 Results of Sensitivity Analysis

i) Scenario with CAGR 6.34%

These scenarios have been studied based on the Energy Requirement (BU) and Peak Demand (MW) estimated by Sub Committee on Demand projection. The CAGR of Electrical Energy requirement from the year 2015-16 to 2021-22 is coming out to be 6.34%.

It may be seen that <u>no coal based capacity addition is required in all the scenarios during the years 2017-22 to meet the energy demand</u>. However, the PLF % of coal based power stations will increase with lower achievement in Hydro and/or RES capacity addition.

ii) Scenario with CAGR 7.34%

These scenarios have been studied based on the Electrical Energy Requirement (BU) and Peak Demand (MW) estimated by considering a CAGR of 7.34% in Electrical Energy requirement instead of 6.34% worked out in the Base case.

It may be seen that coal based capacity addition in the range of 7020 MW to 12040 MW is required in various scenarios. The PLF % of coal based power station will increase with lower achievement in Hydro or RES capacity addition targets.

iii) Scenario with CAGR 8.34%

These scenarios have been studied based on the Energy Requirement (BU) and Peak Demand (MW) estimated by considering a CAGR of 8.34% in Electrical Energy requirement instead of 6.34% estimated in Base case.

It may be seen that coal based capacity addition in the range of 21,370 MW to 27,600 MW is required in various scenarios. The PLF % of coal based power station will vary with lower achievement in Hydro or RES capacity addition.

iv) Relationship between RES generation and PLF (%) of coal based thermal plants

It is seen that, under a constant demand and hydro condition, the PLF of coal based stations is almost negatively linearly co-related with RES capacity. Detailed studies have shown that, as the RES generation increases there is equivalent quantum decrease in thermal generation. This shows that any increase in RES generation is mostly replacing the thermal generation. ***Therefore, <u>with the increased infusion of RES generation into the grid, the PLF of the coal based plants decreases</u>.***

5.12 TENTATIVE PLANNING FOR GENERATION EXPANSION DURING THE YEARS 2022-27

A Computer Model Study on Electric Generation Expansion Analysis System (EGEAS) programme was also carried out in CEA to assess the tentative installed capacity required to meet the projected Electricity demand for the year 2026-27 on the basis of All India Net load curve. The Studies are based on the following assumptions: -

- Electricity Demand considered is given in **Table 5.11.**

Table 5.11

Year	Energy Requirement (BU) *	Peak Demand in (MW)*	Energy Requirement (BU) after considering RES generation**	Peak Demand in MW after considering RES generation (MW)***
2026-27	2,132	3,17,674	1701	3,00,404

*After considering reduction in demand due to DSM

** after reducing solar and wind generation estimated in 2026-27

*** after reducing contribution of renewable energy during peak

- Spinning Reserve -5%
- Reliability Criteria – LOLP≤ 0.2 % and ENS ≤ 0.05 %.
- Likely Capacity addition considered during 12th Plan is **1,01,645** MW.
- Conventional capacity addition in years 2017-22 as in Base Case of about **22,470** MW (Coal – 0 MW, Hydro 15,330 MW, Gas 4340 MW, Nuclear 2,800 MW) and installed capacity of 1,75,000 MW from Renewables by the end of 2022.
- Anticipated capacity addition from renewable energy sources during 2022-27 of 1,00,000 MW (50,000 MW – Solar, 40,000 MW Wind, 7,000 MW Biomass and 3,000 MW Hydro)
- The likely generation considered from renewables (Solar and Wind) by the end of 2026-27 is estimated as 431 BU.
- Hydro projects totalling to 12,000 MW have been considered for likely benefit during the years 2022-27.
- 4,800 MW nuclear capacity addition during the years 2022-27 has been considered as per the programme of Department of Atomic Energy. Details are furnished in **Annexure 5.3.**
- Net Import from hydro power projects of neighbouring countries by the end of 2026-27 – 21,600 MW Hydro capacity. Details are given in **Table 5.12**.

Table 5.12

Net Electricity (Hydro) Import from neighbouring countries

(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**

5.13 RESULTS OF GENERATION EXPANSION PLANNING STUDIES FOR THE PERIOD 2022-27

EGEAS Studies were carried out to assess the total capacity addition requirement to meet the projected demand in the year 2026-27 with assumptions mentioned in Para 5.12.

Hydro, Gas and Nuclear based capacity is given the foremost priority due to their inherent advantages to move towards a Low Carbon Growth. Renewable capacity has also been considered as must run capacity in the system.

Considering the anticipated capacity addition from hydro, nuclear and gas based power plants during 2022-27, the balance capacity is proposed to be met from coal based plants. This capacity addition Scenario during 2022-27 is based on the Base Case Scenario materialising during the period 2017-22 (Coal – 0 MW, Hydro 15,330 MW, Gas 4340 MW, Nuclear 2,800 MW and installed capacity of 1,75,000 MW from Renewables by the end of 2022).

The details of coal based capacity addition requirement during the period 2022-27 for base case are given in **Table 5.13**.

Table 5.13

Capacity addition during 2022-27 (Base Case)

(All figures in MW)

FUEL TYPE	Capacity addition during 2022-27
Hydro*	12,000
Thermal	44,085
Coal	44,085
Gas	0
Nuclear	4,800
Sub Total (Conventional)	**60,885**
Wind	40,000
Solar	50,000
Bio Mass	7,000
Small Hydro Plants	3,000
Sub Total (RES)	**100,000**
Total Capacity Addition	**1,60,885**

*** excludes 21,600 MW imports from hydro plants of neighbouring countries.**

The projected coal based capacity addition requirement during the period 2022-27 is 44,085 MW considering no coal based capacity addition during 2017-22 Table 5.7(a).

Studies indicate that a coal based capacity of 44,085 MW is required during the period 2022-27 with no coal based capacity addition requirement during the year 2017-22. Now a coal based capacity of 50,025 MW is already under construction which likely to yield benefits during 2017-22. Therefore, this excess coal based capacity would fulfil the capacity requirement for the years 2022-27.

The likely installed capacity from different fuel type by the end of year 2026-27 is given in **Table 5.14 and Exhibit 5.13**.

Table 5.14

Projected Installed capacity by the end of 2026-27

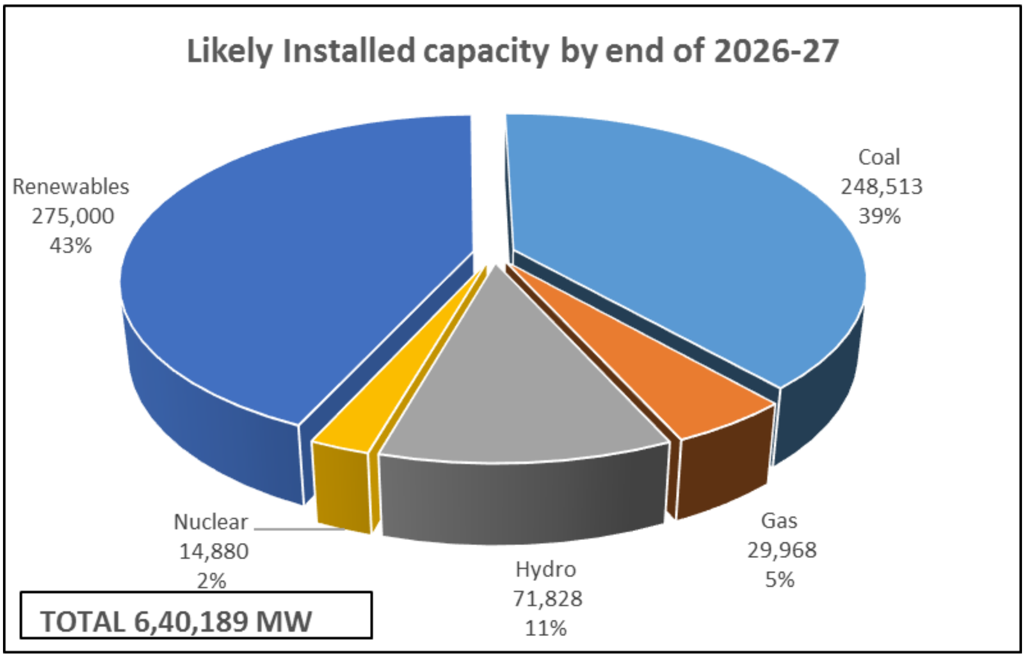
Fuel Type	Capacity (MW)	%
Hydro	71,828	
Coal + Lignite	2,48,513*	
Gas	29,968	
Nuclear	14,880	
Total Conventional Capacity *	**3,65,189**	**57%**
Total Renewable Capacity	**2,75,000**	**43%**
Total Capacity by 2026-27	**6,40,189**	**100%**

*Including 50,025 MW of Coal based capacity addition currently under construction and likely to yield benefits in 2017-22 and NO coal based capacity addition 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 5.11

(All figures in MW)



5.14 ADDITIONAL SCENERIO FOR THE YEARS 2022 – 27

Study has been carried out for capacity addition requirement during the years 2022-27, considering low hydro capacity addition of 11,788 MW in the years 2017-22 and 5,000 MW during the years 2022-27.

The details of coal based capacity addition requirement for the years 2022-27 in this scenario are shown in **Table 5.15**.

Table 5.15

Capacity addition required during 2022-27 in Low Hydro scenario

(All figures in MW)

TYPE	**Capacity addition during 2022-27**
Conventional	
Hydro*	5000
Thermal Coal Gas	50,025 0 50,025
Nuclear	4,800
Sub Total (Conventional)	**59,825**
Renewables	
Wind	40,000
Solar	50,000
Other RES	10,000
Sub Total (Renewables)	**1,00,000**
Total Capacity Addition	**1,59,825**

*** excludes 21,600 MW imports from hydro plants of neighbouring countries.**

It can be seen that in low hydro scenario, coal based capacity requirement has increased from 44,085 MW **(Table 5.12)** to 50,025 MW.

Studies indicate that a coal based capacity of 50,025 MW is required during the period 2022-27 with no coal based capacity addition requirement during the year 2017-22. Now a coal based capacity of 50,025 MW is already under construction which likely to yield benefits during 2017-22. Therefore, this excess coal based capacity would fulfil the capacity requirement for the years 2022-27.

5.15 CONCLUSIONS

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

Year	Energy Requirement (BU) *	Peak Demand (MW)*
2021-22	1,611	2,35,317
2026-27	2,131	3,17,674

*Including DSM measures

The electricity demand has been estimated by Sub-committee on Demand projections constituted under NEP committee. The Report of 19th Electric Power Survey Committee is likely to be submitted shortly. Changes, if any, in demand projections will be suitably incorporated while finalising the National Electricity Plan.

- Considering capacity addition from Gas – 4,340 MW, Hydro 15,330 MW, Nuclear - 2800 and RES – 1,15,326 MW as committed capacity during 2017-22 and likely capacity addition of 101,645 MW from conventional sources during 12th plan and projected demand for the year 2021-22, the study result reveals that no coal based capacity addition is required during the years 2017-22. However, a total capacity of 50,025 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 1,87,821 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.

- The study result for the period 2017-22 indicated that no coal based capacity addition is required. Considering this as input for the studies for the period 2022-27 and committed capacity addition of Nuclear -4,800 MW, Hydro-12,000 MW and RES 100,000 MW during 2022-27 and demand projections for the year 2026-27, study for the period 2022-27 reveals that a coal based capacity addition of 44,085 MW is required. However, as coal based capacity of 50,025 MW is already under construction which is likely to yield benefits during 2017-22, this coal based capacity would fulfil the capacity requirement for the years 2022-27.

- It is estimated that Generation from RES will contribute almost 20.3 % of total energy requirement in the year 2021-22.

- Net Imports from neighbouring countries will increase from 5,100 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 6.34%. 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.

Therefore, energy demand of 1611 BU and Peak Demand of 235 GW in March 2022 under CAGR = 6.34% look realistic and most likely to occur.

Annexure 5.1

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

Sl. No.	Project Name	State	Agency	No. of Units x MW	Likely Benefits during 2017-22 (MW)	Status
1	Kameng	Arunachal Pradesh	NEEPCO	4x150	300	Under construction
2	Subansiri Lower	Arunachal Pradesh	NHPC	8x250	2,000	Under construction
3	Parbati St. II	Himachal Pradesh	NHPC	4x200	800	Under construction
4	Kishanganga	Jammu & Kashmir	NHPC	3x110	330	Under construction
5	Tuirial	Mizoram	NEEPCO	2x30	60	Under construction
6	Tapovan Vishnugad	Uttarakhand	NTPC	4x130	520	Under construction
7	Tehri PSS	Uttarakhand	THDC	4x250	1,000	Under construction
8	Vishnugad Pipalkoti	Uttarakhand	THDC	4x111	444	Under construction
9	Lata Tapovan	Uttarakhand	NTPC	3x57	171	Under construction
10	Rammam - III	West Bengal	NTPC	3x40	120	Under construction
	Central Sector Total				**5,745**	
1	Indira Sagar (Pollavaram MPP)	Arunachal Pradesh	APID	12x80	960	Under construction
2	Kashang-II & III	Himachal Pradesh	HPPCL	1x65+1x65	130	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	Thottiyar	Kerala	KSEB	1x30+1x10	40	Under construction
8	Koyna Left Bank PSS	Maharashtra	WRD, GO Mah.	2x40	80	Under construction
9	Shahpurkandi	Punjab	Irr. Deptt.	3x33+3x3	206	Under construction

			& PSPCL	3+1x8		
10	Pulichintala	Telengana	TSGENCO	4x30	60	Under construction
11	Vyasi	Uttarakhand	UJVNL	2x60	120	Under construction
	State Sector Total				**2,317**	
1	Gongri	Arunachal Pradesh	DEPL	2x72	144	Under construction
2	Bajoli Holi	Himachal Pradesh	GMR	3x60	180	Under construction
3	Sorang	Himachal Pradesh	HSPL	2x50	100	Under construction
4	Tangnu Romai- I	Himachal Pradesh	TRPG	2x22	44	Under construction
5	Tidong-I	Himachal Pradesh	M/s NSL Tidong	2x50	100	Under construction
6	Ratle	Jammu & Kashmir	RHEPPL	4x205+1x 30	850	Under construction
7	Maheshwar	Madhya Pradesh	SMHPCL	10x40	400	Under construction
8	Bhasmey	Sikkim	Gati Infrastruct ure	3x17	51	Under construction
9	Panan	Sikkim	HHEPL	4x75	300	Under construction
10	Rangit-II	Sikkim	SHPL	2x33	66	Under construction
11	Rangit-IV	Sikkim	Jal Power	3x40	120	Under construction
12	Rongnichu	Sikkim	MBPCL	2x48	96	Under construction
13	Teesta- VI	Sikkim	LANCO	4x125	500	Under construction
14	Teesta-III	Sikkim	Teesta Urja Ltd	6x200	600	Under construction
15	Phata Byung	Uttarakhand	LANCO	2x38	76	Under construction
16	Singoli Bhatwari	Uttarakhand	L&T	3x33	99	Under construction
	Private Sector Total				**3,726**	
I	**Sub Total Under Construction (2017-22)**				**11,788**	
			Central Sector			
1	Devsari	Uttarakhand	SJVNL	3x84	252	Concurred
2	Kotlibhel-St-1A	Uttarakhand	NHPC	3x65	195	Concurred
	Central Sector Total				**447**	

State Sector						
1	New Ganderbal	Jammu & Kashmir	JKPDC	3x31	93	Concurred
	State Sector Total				**93**	
	Private Sector					
1	Demwe Lower	Arunachal Pradesh	Athena Demwe	5x342+1x 40	724	Concurred
2	Dibbin	Arunachal Pradesh	KSK	2x60	120	Concurred
3	Heo	Arunachal Pradesh	HHPPL	3x80	240	Concurred
4	Nafra	Arunachal Pradesh	SEW	2x60	120	Concurred
5	Nyamjangchhu	Arunachal Pradesh	Bhilwara Energy Ltd	6x130	780	Concurred
6	Talong Londa	Arunachal Pradesh	GMR	3x75	225	Concurred
7	Tato-I	Arunachal Pradesh	SHHPL	3x62	186	Concurred
8	Chango Yangthang	Himachal Pradesh	MPCL	3x60	180	Concurred
9	Kutehr	Himachal Pradesh	JSW	3x80	240	Concurred
10	Dikhu	Nagaland	Manu Energy	3x62	186	Concurred
	Private Sector Total				**3,002**	
II	**Sub Total Concurred**				**3,542**	
	Total (I+II)				**15,330**	

Annexure 5.2

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

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
	Total (2017-22)				**2,800**

Annexure 5.3

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

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	2x1000	2,000
2	Gorakpur Haryana Anu Vidyut Pariyojana	Haryana	NPCIL	2x700	1,400
3	New PHWR	Madhya Pradesh*	NPCIL	2x700	1,400
	Total (2022-27)				**4,800**

*Note :Procurement of Land in advance stage

CHAPTER 6

RENEWABLE ENERGY SOURCES

6.0 INTRODUCTION

The World Energy Forum has predicted that fossil-based oil, coal and gas reserve 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 ever 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 RES

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 renewable.

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 shares 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.

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 plan of capacity addition from Renewable Energy Sources.

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 end of June 2016. This increase suggests 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 31.03.2016, the total RES capacity was 42,849 MW out of total Installed Generation Capacity of 302,088 MW. This represents almost 14.2% of the total Installed Capacity. An Action Plan has been formulated by Government of India for achievement of a total capacity of 175,000 MW from Renewable Energy Sources by March, 2022.

6.2 RENEWABLE ENERGY SOURCES

Renewable energies are energy sources 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 form 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.**

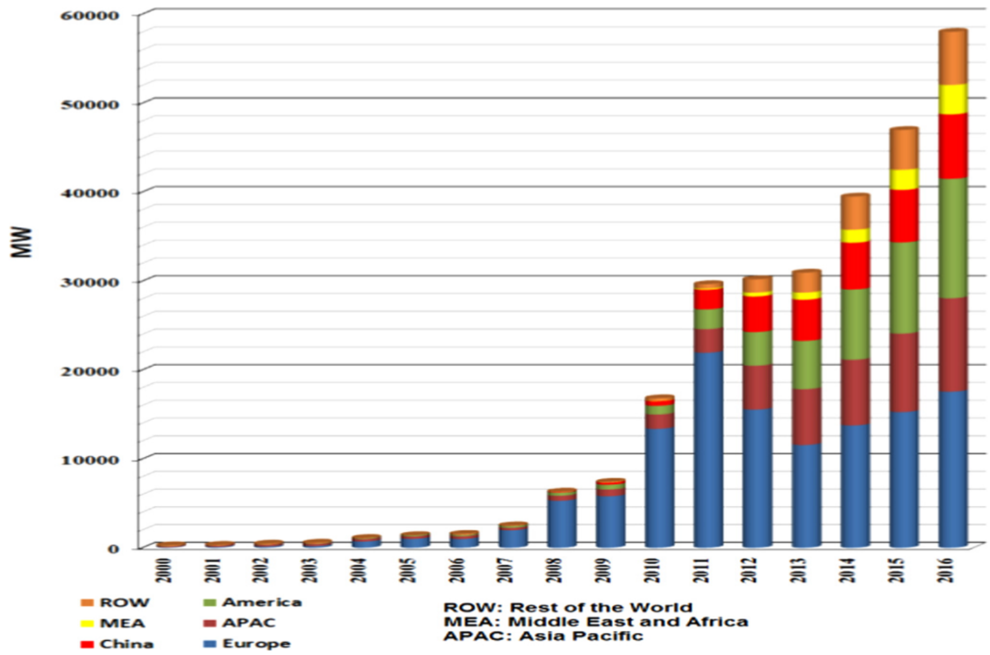
6.2.1.1 Solar Photovoltaic:

Solar photovoltaic (PV) systems directly converts 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 no. 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 until 2016.

Exhibit 6.1



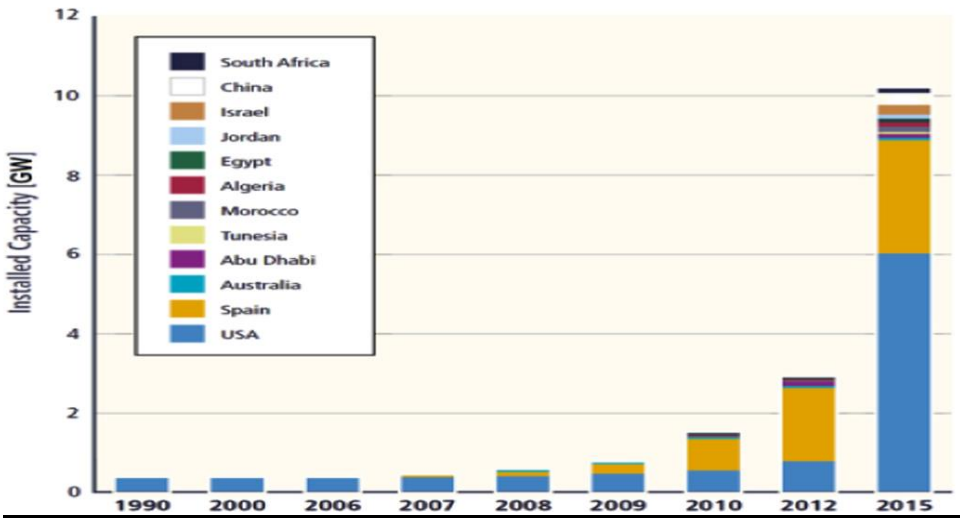
(Source: European photovoltaic industry association, (www.epia.org)).

6.2.1.2 Concentrated Solar Power

In Concentrated Solar Power (CSP) technologies concentrates direct beam solar irradiance. This is then used to heat a liquid, solid or gas that is then 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 applied 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



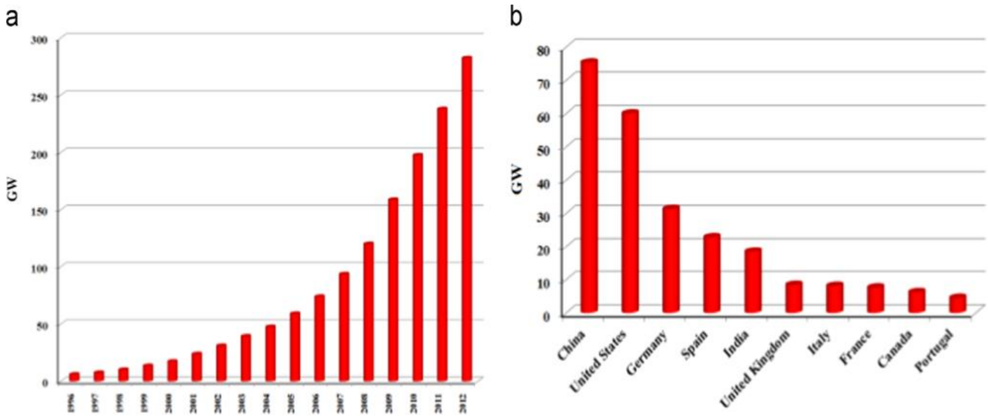
(Source:www.cambridge.org; 2012.)

6.2.2 Wind Power

Wind power is produced through the conversion of kinetic energy associated with wind into mechanical energy first and then into 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 generators 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

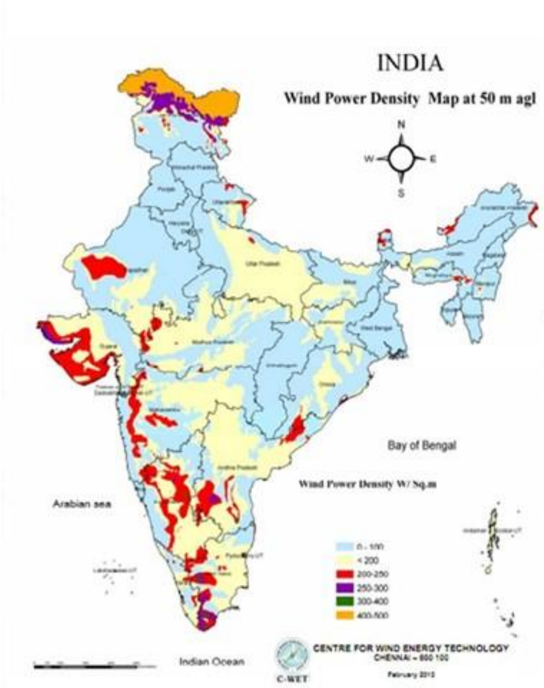
Wave power, which captures the energy of ocean surface waves, and tidal power, converting the energy of tides, are two forms of hydro power with future potential. However, they are not yet widely employed commercially.

6.3 POTENTIAL OF RENEWABLE ENERGY GENERATION IN INDIA

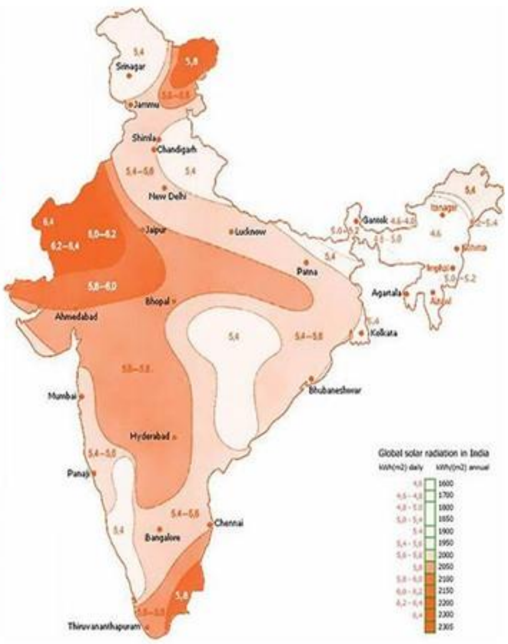
In order to arrest the climate change and in view of the depleting conventional energy sources, India is taking firm steps towards development of renewable energy. India has significant potential of electricity generation from Renewable Energy Sources. The Renewable Energy (RE) potential in India is estimated as 896,602 MW comprising of 748,990 MW of Solar Power, 102,772 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 given in **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



Wind Energy Resources



Solar Energy Resources

(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, Uttarakand and Sikkim which are located in the Himalayan belt also receive similar average global insolation annually. The eastern Himalayan states of

Arunachala 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 Tamilnadu (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, which starts in May-June, when cool, humid air moves towards the land and the weaker north-east monsoon, which starts in October, when cool dry air moves towards the ocean. During the period March to August, the winds are uniform and strong over the whole Indian peninsula, except the eastern peninsular coast. Wind speed during the period November to March is relatively weak.

No offshore wind farm utilizing traditional fixed-bottom wind turbine technologies in shallow sea areas or floating wind turbine technologies 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 10,252 MW as at the end of 10th plan (i.e. on 31.03.2007) and the same had grown to 24,920 MW at the end of 11th plan (i.e. on 31.03.2012). With a consistent growth, the installed capacity of renewable energy sources has reached 42,849.38 MW as on 31.03.2016. The development of India in recent past and installed capacity of grid connected renewable power plants is shown in **Exhibit 6.5** and **Table 6.1** respectively.

Exhibit 6.5

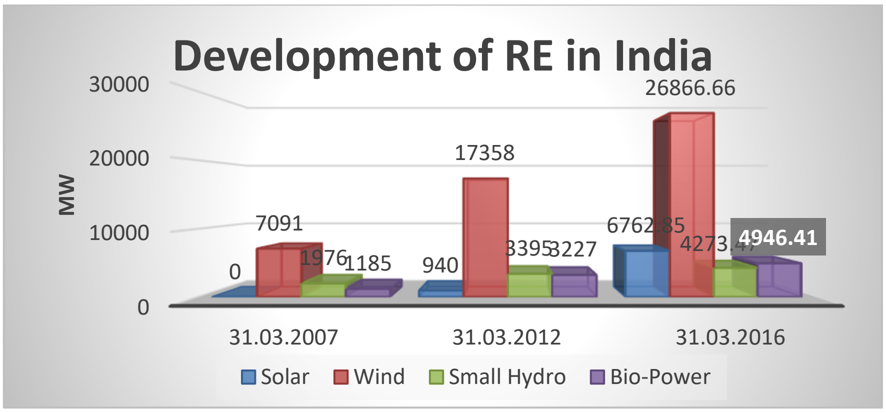


Table 6.1

Installed Capacity of Grid-connected Renewable Power Plants (As on 31.03.2016)

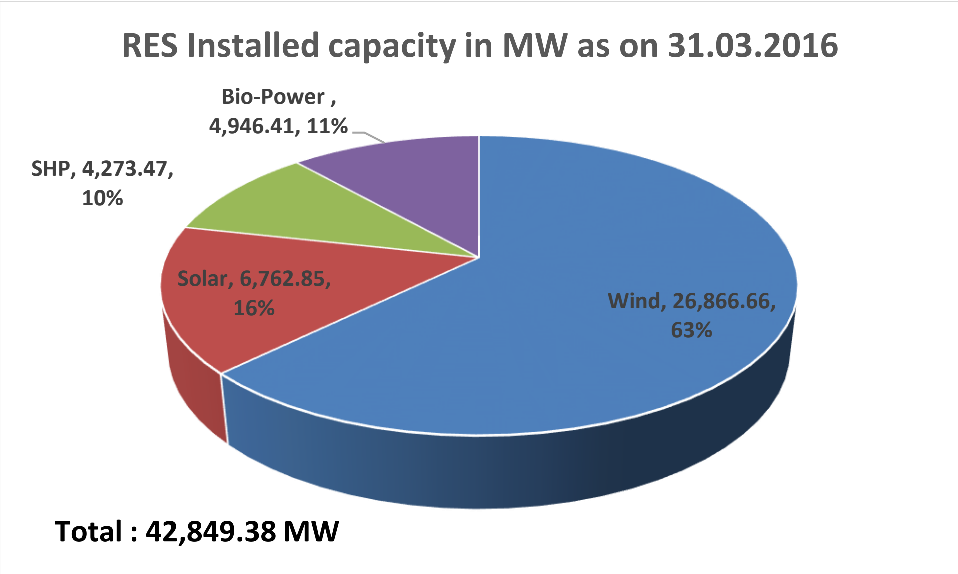
Renewable Energy Source	Installed capacity in MW
Solar Power	6,762.85
Wind Power	26,866.66
Bio-Power & Waste Power	4,946.41
Small Hydro Power	4,273.47
Total	**42,849.38**

The installed capacity of Wind power in India as on 31 March 2016 was 26,866.66 MW, which is 63% of total Renewable Installed Capacity in India, mostly located in South, West and North regions. This capacity of wind power is mainly spread across Tamil Nadu (7613.86 MW), Maharashtra (4654.15 MW), Gujarat (4037.50 MW), Rajasthan (3993.95 MW), Karnataka (2869.15 MW), Madhya Pradesh (2141.10 MW), Andhra Pradesh (1431.45 MW), Telangana (77.70 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 2016, the installed capacity of Solar power in India was 6,762.85 MW, which is 16% of total Renewable Installed Capacity in India. This Solar capacity is mainly spread across Rajasthan (1269.93 MW), Gujarat (1119.17 MW), Tamil Nadu (1061.82 MW), Madhya Pradesh (776.37 MW), Andhra Pradesh (572.96 MW), Telangana (527.84 MW), Punjab (405 MW) etc. The installed capacity of Biomass power in India as on 31 March 2016, was 4,946.41 MW, which is 12% of total Renewable Installed Capacity in India. Small hydro power with capacity of 4,273.47 MW as on 31 March 2016, represents 10% of total Renewable Installed Capacity in India. Total Renewable Installed Capacity in India is shown in **Exhibit 6.6**.

Exhibit 6.6

(All figures in MW)



The State-wise Installed Capacity of Grid Interactive Renewable Power as on 31.03.2016 is given in **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 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 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 to the capacity of 175 GW by 2022 is shown in **Table 6.2.**

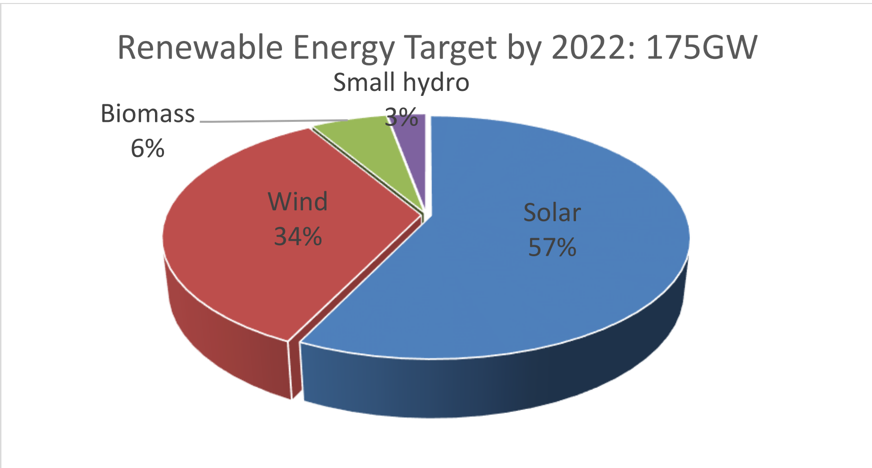
Table 6.2

Targeted contribution of the major renewable energy sources

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

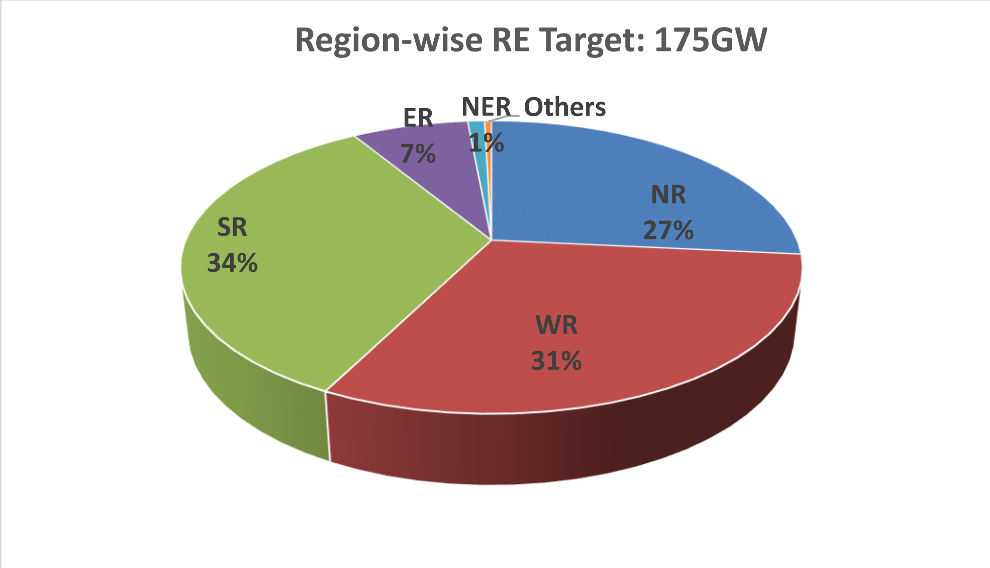
The substantial higher capacity target of renewables will ensure greater energy security, improved energy access and enhanced employment opportunities. With the accomplishment of these ambitious targets, India will become one of the largest Green Energy producers in the world, surpassing several developed countries. Renewable Energy Target of India type-wise and Region-wise, by 2022 is shown in **Exhibit 6.7** and **Exhibit 6.8** respectively.

Exhibit 6.7



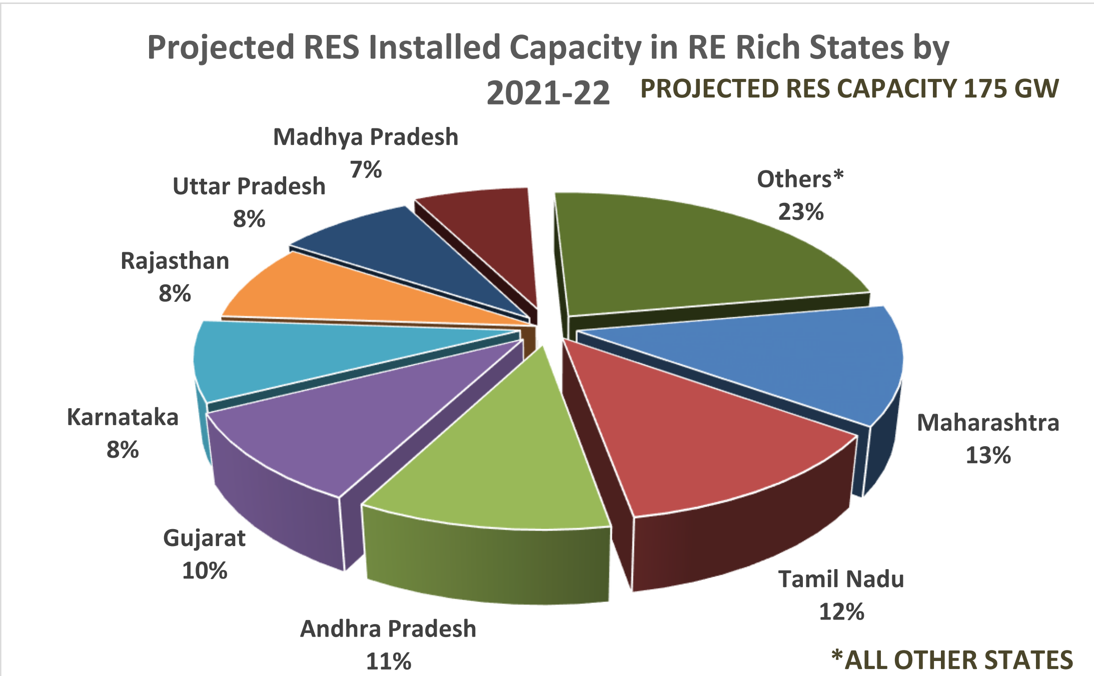
A comparison between Exhibit 6.6 and Exhibit 6.7 indicates that even though wind plants are predominant today, in future Solar Plants shall have more installed capacity than that of Wind Plants.

Exhibit 6.8



The tentative State-wise break-up of Renewable Power target corresponding to installed capacity of 175 GW to be achieved by the year 2022 in **Exhibit 6.9**. Details are given in **Annexure-6.3.**

Exhibit 6.9



It is seen from the above that 9 States in India shall contribute almost 77% of the RE 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 is 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*
Solar					
Rooftop	5,000	6,000	7,000	8,000	8100
Ground Mounted Solar	10,000	10,000	10,000	9,500	7637
Total Solar	**15,000**	**16,000**	**17,000**	**17,500**	**15,737**
Wind	4,700	5,300	6,000	6,700	6,334
Biomass	750	850	950	1,000	1,005
SHP	100	100	100	100	100
TOTAL	**20,550**	**22,250**	**24,050**	**25,300**	**23,176**

***the capacity has been adjusted to arrive at total capacity from RES of 1,75000MW by 2021-22**

6.6 PROJECTION OF RENEWABLE ENERGY GENERATION

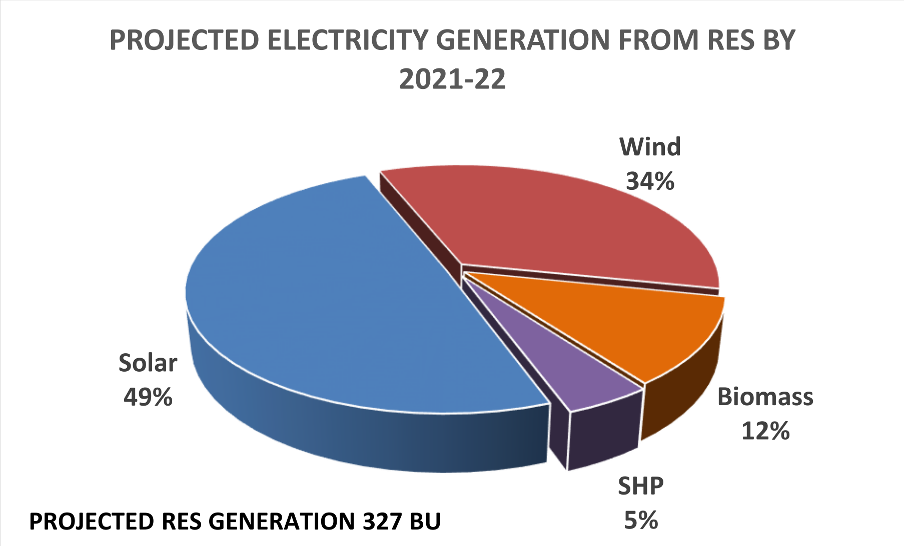
Based on the projections of capacity addition targets from Renewable Energy Sources by the year 2021-22 as furnished by MNRE and considering a RES capacity addition of 100,000 MW during the period 2022-27, expected electricity generation from various Renewable Energy sources has been estimated and are given in **Table 6.4 and Exhibit 6.10**. It can be seen that contribution of RES will be around 20% of the total energy requirement 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	Expected Generation in (BU)					Total Energy Requirement (BU)	% Contribution of RES to Total Energy Demand
		Solar	Wind	Biomass	SHP	Total		
2021-22	175 GW	162	112	38	15	327	1611	20.3
2026-27	275GW	243	188	64	21	516	2132	24.2

Exhibit 6.10



6.7 RECENT ACHIEVEMENTS IN DEVELOPMENT OF RENEWABLE ENERGY

1. Largest ever wind power capacity addition of 3,300 MW in 2015-16 exceeding target by 38%.
2. Largest ever solar power capacity addition of 3,019 MW in 2015-16 exceeding target by 116%.
3. 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 award.
4. International Solar Alliance of 121 tropical countries to develop and promote solar energy, to be headquartered in India.
5. First Renewable Energy Global Investors meet (Re-invest) was held and received a total Commitments of 266 GW by Power Producers in the solar, wind, small hydro and bio energy sectors and 41 GW by manufacturers in the solar and wind energy sectors.
6. Sanctioned 32 Solar parks of capacity 19,400 MW in 20 States.
7. Rs. 38,000 crores Green Energy Corridor being set up to ensure evacuation of power generated from renewable energy sources.
8. Clean environment cess increased 8 times from Rs. 50 to Rs. 400 per tonne to finance Clean Energy Projects and Ganga Rejuvenation.
9. 31,472 solar pumps installed in 2015-16 which is higher than total number of pumps installed during last 24 years i.e. since beginning of the programme in 1991.

6.8 RECENT RE 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. 33 no. of solar parks in 21 States with an aggregate capacity of 19,400 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 planned in India. Large chunks of land are available in some 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 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 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 7600 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 offshore wind power development.

The scheme would be applicable throughout the country depending upon 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 in 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 development of 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 to increase outputs, income and also provide 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 Rs. 353.50 crore was released to various agencies for the purpose.

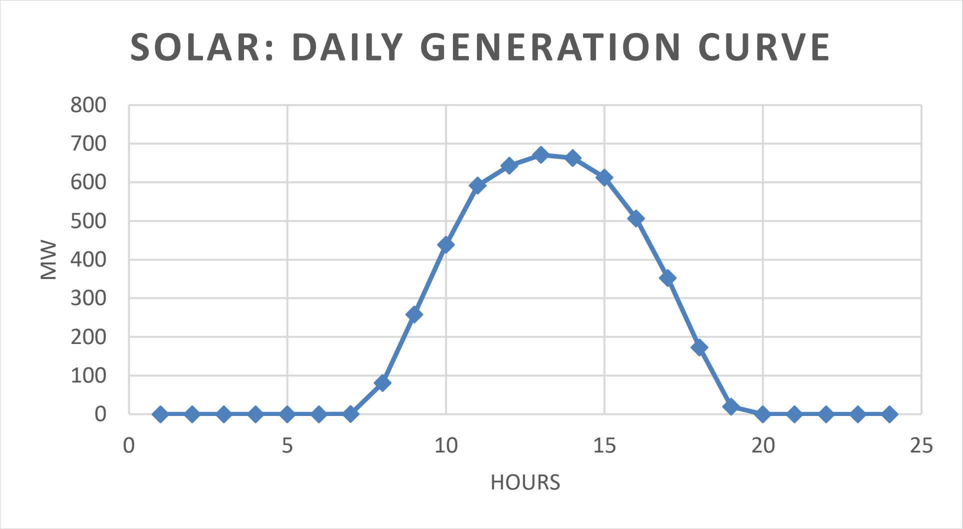
6.8.6 SOLAR PROJECTS UNDER NATIONAL SOLAR MISSION

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 (NVVN) 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 some 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 also help reduce consumption of kerosene and diesel, which is presently in use to meet the unmet demand.

6.9 GENERATION PROFILE OF SOLAR AND WIND

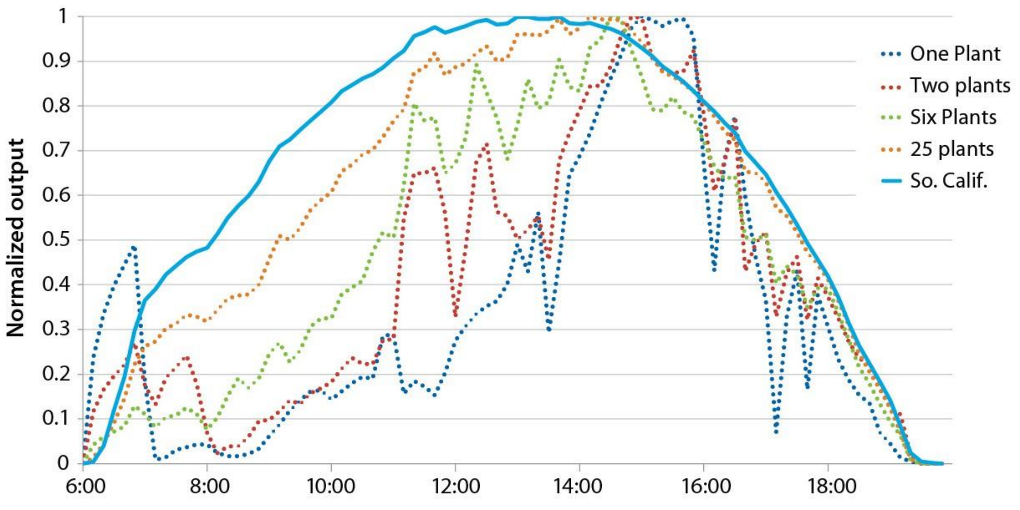
Normally generation from a solar plant gradually increases after dawn and reaches a maximum around noon and then gradually decreases and becomes “Zero” with the advent of evening. An ideal Generation Profile of a solar plant is shown in **Exhibit 6.11.**

Exhibit 6.11



However, 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 as 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 is shown in **Exhibit 6.12.**

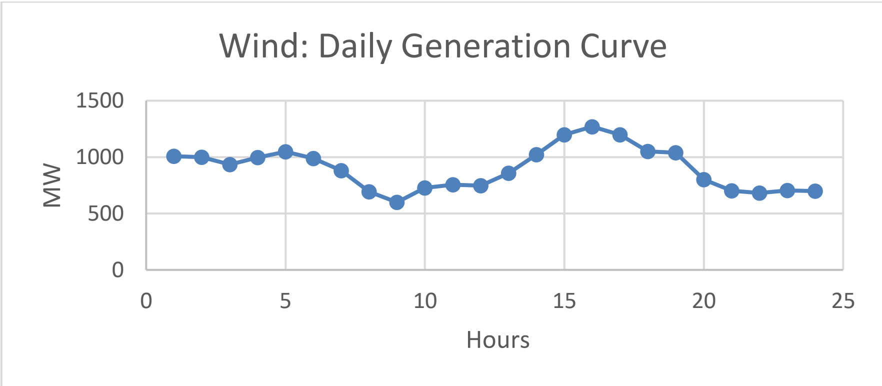
Exhibit 6.12



(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 6.13.**

Exhibit 6.13



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 plants 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 generations from all the solar plants and wind plants. Expected generation pattern of solar and wind for different seasons are given in the **Exhibit 6.14(a) to (e).**

Exhibit 6.14(a)

Seasonal variation of RES Generation

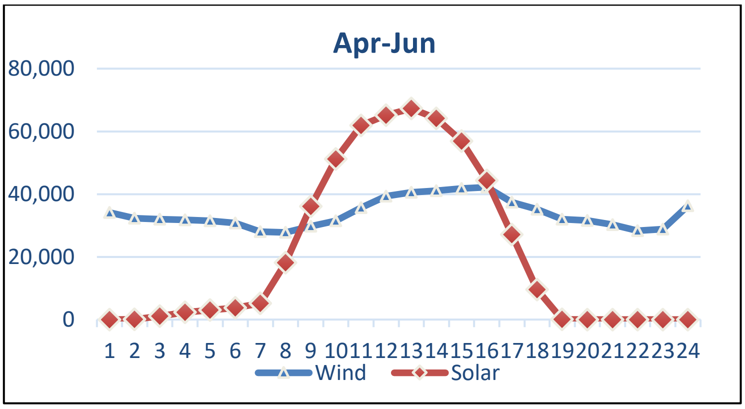


Exhibit 6.14(b)

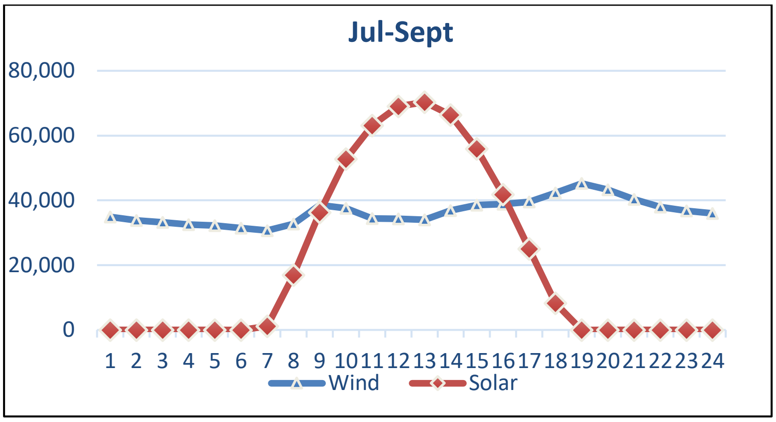


Exhibit 6.14(c)

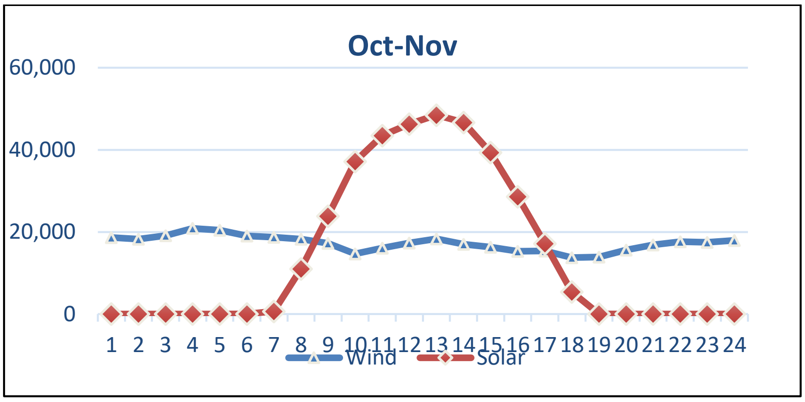


Exhibit 6.14(d)

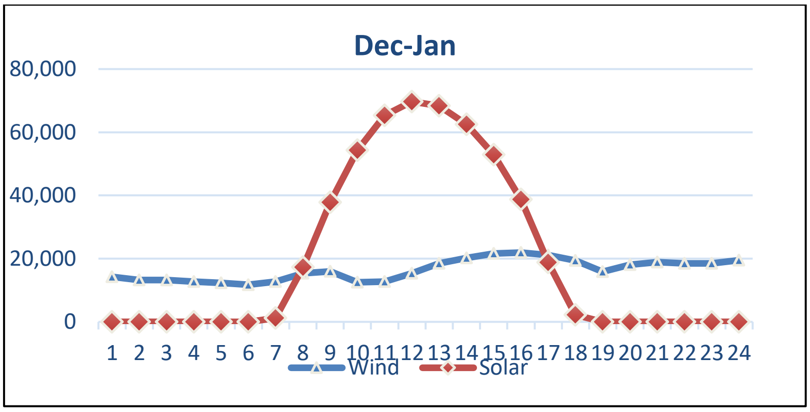
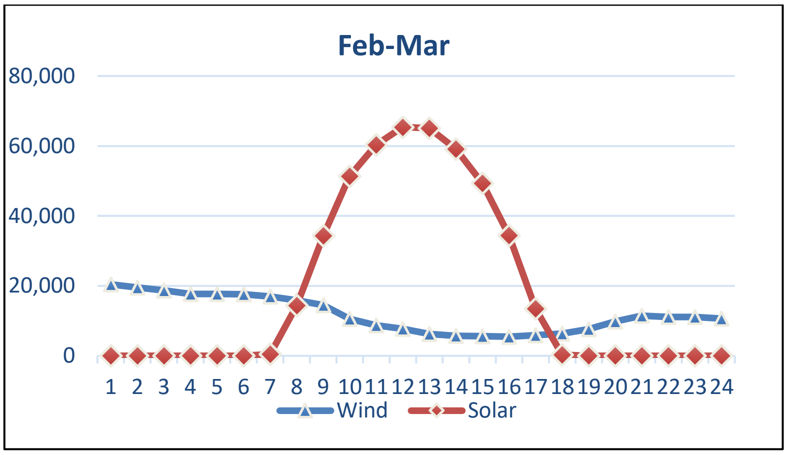
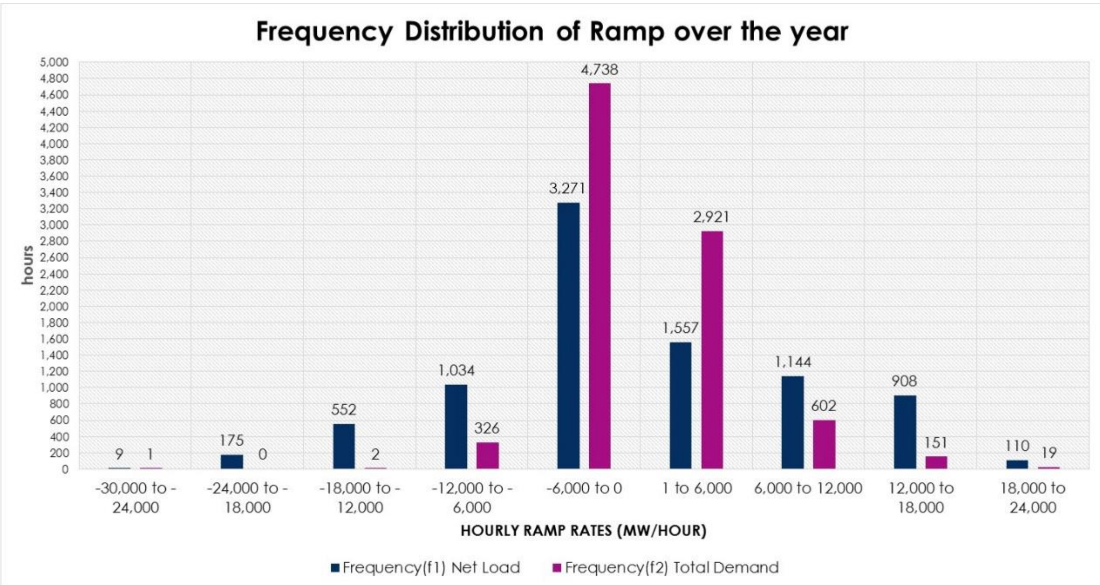


Exhibit 6.14(e)



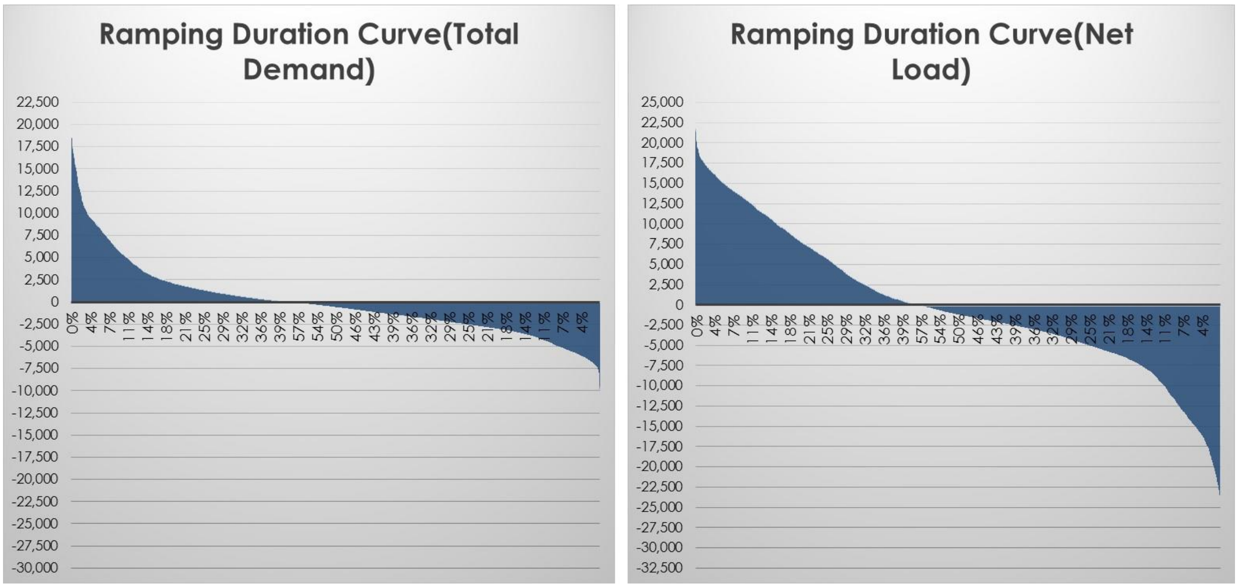
It can be seen from the above that the maximum generation from VRE sources would be available during the day at noon time when the system demand is very low. During evening, the availability of generation from VRE is very limited. In India, normally the peak demand occurs in the evening. During that 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- 6.15**.

Exhibit 6.15



A comparison of the ramping duration curve for the Total Demand and Net Demand is shown at **Exhibit 6.16**.

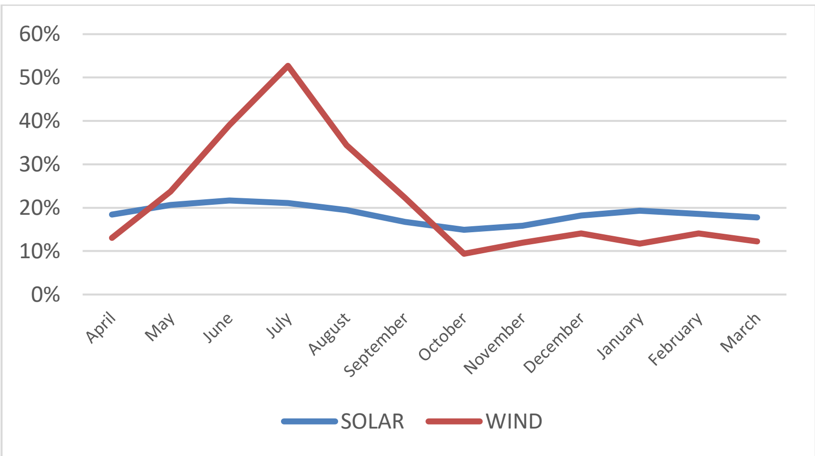
Exhibit 6.16



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 are 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 6.17.**

Exhibit 6.17



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 is independent of the electricity demand of the grid and 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 may be mostly at the distribution levels or at customers ends. There may again be bi-directional flow of electricity- from grid to customers and from customers to the grid. Again, as the generation from VRE are variable and uncertain, requisite balancing power from conventional sources 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 minimum and has "ZERO" generation at 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 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 plant, Pump Storage Plant, 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 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 power gas plants normally run as baseload or intermediary plant. While open cycle gas power plants are capable of cycling and ramping, combined-cycle natural gas power plants can 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.

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, 9 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 the transported to the load centers through transmission networks. This requires strengthening of existing networks of the grid.

In India, Green Corridor 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 more efficiently commit or de-commit generators to accommodate changes in wind and solar generation and prepare for extreme events in which renewable generation is unusually high or low. Forecasts can help reduce the amount of operating reserves needed for the system, reducing costs of balancing the system.

Internationally, improvements have been made in recent years toward 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 option 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 encourage the customers to maximize their use while the supply is naturally high. For example, when wind and solar PV are producing at their peak, demand response is most suitable that can shift the load to low rates without any serious consequences. 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 renovations 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. 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.

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.

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 cost and contribution of conventional power plants of higher operating costs in the power system, increased wear-and-tear and maintenance costs of plants.

Balancing requirement for integration of Renewable Energy Sources into the Grid would be separately covered in "National Electricity Plan - Vol-II Transmission".

6.11 CONCLUSIONS

i) India has achieved a total installed capacity of 42,849.38 MW from Renewable Energy Sources as on 31.03.2016

ii) The country has revised its Renewable Energy capacity addition 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.

ANNEXURE-6.1

State-wise details of Estimated Potential for Renewable Power in India

(All figures in MW)

Sl.	STATES / UTs	Wind Power	Small Hydro Power	Bio-Energy		Solar Power	Total Estimated Potential
				Biomass Power/ Bagasse Cogen.	Waste to Energy		
1	Andhra Pradesh	14497	978	578	423	38440	54916
2	Arunachal Pradesh	236	1341	8	0	8650	10236
3	Assam	112	239	212	8	13760	14330
4	Bihar	144	223	619	373	11200	12559
5	Chhattisgarh	314	1107	236	24	18270	19951
6	Goa	0	7	26	0	880	912
7	Gujarat	35071	202	1221	462	35770	72726
8	Haryana	93	110	1333	374	4560	6470
9	Himachal Pradesh	64	2398	142	2	33840	36446
10	Jammu & Kashmir	5685	1431	43	0	111050	118208
11	Jharkhand	91	209	90	10	18180	18580
12	Karnataka	13593	4141	1131	450	24700	44015
13	Kerala	837	704	1044	36	6110	8732
14	Madhya Pradesh	2931	820	1364	78	61660	66853
15	Maharashtra	5961	794	1887	1537	64320	74500
16	Manipur	56	109	13	2	10630	10811
17	Meghalaya	82	230	11	2	5860	6185
18	Mizoram	0	169	1	2	9090	9261
19	Nagaland	16	197	10	0	7290	7513
20	Odisha	1384	295	246	22	25780	27728
21	Punjab	0	441	3172	345	2810	6768
22	Rajasthan	5050	57	1039	62	142310	148518
23	Sikkim	98	267	2	0	4940	5307
24	Tamil Nadu	14152	660	1070	601	17670	34152
25	Telangana	0	0	0	0	20410	20410
26	Tripura	0	47	3	2	2080	2131

27	Uttar Pradesh	1260	461	1617	1426	22830	27593
28	Uttarakhand	534	1708	24	5	16800	19071
29	West Bengal	22	396	396	148	6260	7222
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	2050	2181
35	Lakshadweep	0	0	0	0	0	0
36	Pondicherry	120	0	0	3	0	123
37	Others	0	0	0	1022	790	1812
	Total	**102772**	**19749**	**17536**	**2554**	**748990**	**896602**

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

ANNEXURE-6.2

State-wise installed capacity of Grid Interactive Renewable Power as on 31.03.2016.

(All figures in MW)

Sl. No.	STATES / UTs	Small Hydro Power	Wind Power	Bio-Power		Solar Power	Total Capacity
				Biomass Power/Cogen.	Waste to Energy		
1	Andhra Pradesh	232.98	1431.45	380.75	58.16	572.96	2676.30
2	Arunachal Pradesh	104.61				0.27	104.87
3	Assam	34.11				0.00	34.11
4	Bihar	70.70		43.42		5.10	119.22
5	Chhattisgarh	52.00		279.90		93.58	425.48
6	Goa	0.05				0.00	0.05
7	Gujarat	16.60	4037.50	56.30		1119.173	5229.57
8	Haryana	73.50		45.30		15.39	134.19
9	Himachal Pradesh	793.31				0.20	793.51
10	Jammu & Kashmir	156.53				1.00	157.53
11	Jharkhand	4.05				16.19	20.24
12	Karnataka	1217.73	2869.15	872.18	1.00	145.462	5105.52
13	Kerala	198.92	43.50			13.045	255.47
14	Madhya Pradesh	86.16	2141.10	35.00	3.90	776.37	3042.53
15	Maharashtra	339.88	4654.15	1220.78	12.72	385.756	6613.28
16	Manipur	5.45				0.00	5.45
17	Meghalaya	31.03				0.00	31.03
18	Mizoram	36.47				0.10	36.57
19	Nagaland	30.67				0.00	30.67
20	Odisha	64.63		20.00		66.92	151.55
21	Punjab	170.90		155.50	10.25	405.063	741.71
22	Rajasthan	23.85	3993.95	108.30		1269.932	5396.03
23	Sikkim	52.11				0.00	52.11
24	Tamil Nadu	123.05	7613.86	641.90	8.05	1061.82	9448.68
25	Telangana		77.70			527.843	605.54
26	Tripura	16.01				5.00	21.01
27	Uttar Pradesh	25.10		870.00	5.00	143.50	1043.60
28	Uttarakhand	209.33		76.00		41.15	326.48

29	West Bengal	98.50		26.00		7.77	132.27
30	Andaman & Nicobar	5.25				5.10	10.35
31	Chandigarh					6.81	6.81
32	Dadar & Nagar Haveli					0.00	0.00
33	Daman & Diu					4	4.00
34	Delhi				16.00	14.28	30.28
35	Lakshadweep					0.75	0.75
36	Pondicherry					0.025	0.03
37	Others		4.30			**58.31**	62.61
	Total (MW)	**4273.47**	**26866.66**	**4831.33**	**115.08**	**6762.85**	**42849.39**

(Source: Ministry of New and Renewable Energy, India)

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	2762				2762
Haryana	4142		25	209	4376
Himachal Pradesh	776		1500		2276
Jammu & Kashmir	1155		150		1305
Punjab	4772		50	244	5066
Rajasthan	5762	8600			14362
Uttar Pradesh	10697		25	3499	14221
Uttarakhand	900		700	197	1797
Chandigarh	153				153
Northern Region	**31120**	**8600**	**2450**	**4149**	**46319**
Goa	358				358
Gujarat	8020	8800	25	288	17133
Chhattisgarh	1783		25		1808
Madhya Pradesh	5675	6200	25	118	12018
Maharashtra	11926	7600	50	2469	22045
D. & N. Haveli	449				449
Daman & Diu	199				199
Western Region	**28410**	**22600**	**125**	**2875**	**54010**
Andhra Pradesh	9834	8100		543	18477
Telangana		2000			2000
Karnataka	5697	6200	1500	1420	14817
Kerala	1870		100		1970
Tamil Nadu	8884	11900	75	649	21508
Puducherry	246				246
Southern Region	**26531**	**28200**	**1675**	**2612**	**59018**
Bihar	2493		25	244	2762
Jharkhand	1995		10		2005
Orissa	2377				2377
West Bengal	5336		50		5386

State/UTs	Solar Power	Wind Power	Small Hydro Power	Biomass Power	TOTAL
Sikkim	36		50		86
Eastern Region	**12237**		**135**	**244**	**12616**
Assam	663		25		688
Manipur	105				105
Meghalaya	161		50		211
Nagaland	61		15		76
Tripura	105				105
Arunachal Pradesh	39		500		539
Mizoram	72		25		97
North Eastern Region	**1205**		**615**		**1820**
Andaman & Nicobar Islands	27				27
Lakshadweep	4				4
Other (New States)		600		120	720
All India	**99533**	**60000**	**5000**	**10000**	**174533**

(Source: Ministry of New and Renewable Energy, India)

CHAPTER 7

HYDRO POWER IN INDIA

7.0 INTRODUCTION

India has considerable Hydro potential, and the source being renewable in nature efforts and efforts are afoot to exploit the same so as to reduce the carbon footprint of the Indian Power sector. Hydro power station has 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. A Hydro Electric Projects has a long useful life extending to well over 50 years and helps in conserving scarce fossil fuels. With the increasing emphasis on reduced carbon emission from the power sector, low carbon growth strategy is being adopted in the Indian Power Sector, which inter alia gives emphasis on hydro capacity addition. 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.

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 which 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. 1512 no. of small hydro-electric schemes having aggregate installed capacity of above 6782 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 19749MW.

As on 31.03.2016, Hydro Electric Schemes (above 25 MW capacity) have a total installed capacity of 42,784 MW including Pumped storage schemes (PSS) capacity of 4,785 MW. The hydro schemes under construction, account to capacity of 12,422 MW (excluding PSS of 1,080 MW). Hydro Electric schemes totaling to capacity of 26,302 MW are concurred by CEA and yet to be taken up for construction, schemes totaling to 6,365 MW are under examination in CEA, DPRs of capacity totaling to 8496 MW has been appraised but returned for resubmission, Schemes totaling to 9005 MW are under study and investigation(S&I) and schemes totaling to 18914 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 31.03.2016

	Conventional			Pumped Storage		
	Nos.	**Capacity (MW)**	**(%)**	**Nos.**	**Capacity (MW)**	**(%)**
Total Potential		145320*			96524	
Schemes under Operation	187#	37997.8	26.15	9	4785.6	4.95
Schemes under Construction	45	12422.0	8.55	2	1080	1.11
DPRs Concurred by CEA & yet to be taken up for construction	42	26302	18.1	-	-	-
DPRs under Examination by CEA	11	6365	4.38	1	1000	1.04
DPRs returned by CEA for resubmission	26	8496	5.85	1	500	0.5
Under S & I for preparation of DPRs	38	9005	6.19	-	0	0
Schemes under S&I- Held up	55	18914	13.02	0	0	0
Total Developed/ under Development	**404**	**119501.8**	**82.23**	**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 31.03.2016)

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	18302.3	35.02	5032.0	9.63	28928.8	55.35
Western	8928	8131	5552.0	68.28	400.0	4.92	2179.0	26.80
Southern	16458	15890	9586.9	60.33	1310.0	8.24	4993.2	31.42
Eastern	10949	10680	3314.7	31.04	2726.0	25.52	4639.3	43.44
North	58971	58356	1242.0	2.13	2954.0	5.06	54160.0	92.81
All India	**148701**	**145320**	**37997.8**	**26.15**	**12422.0**	**8.55**	**94900.2**	**65.30**

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

Exhibit 7.1

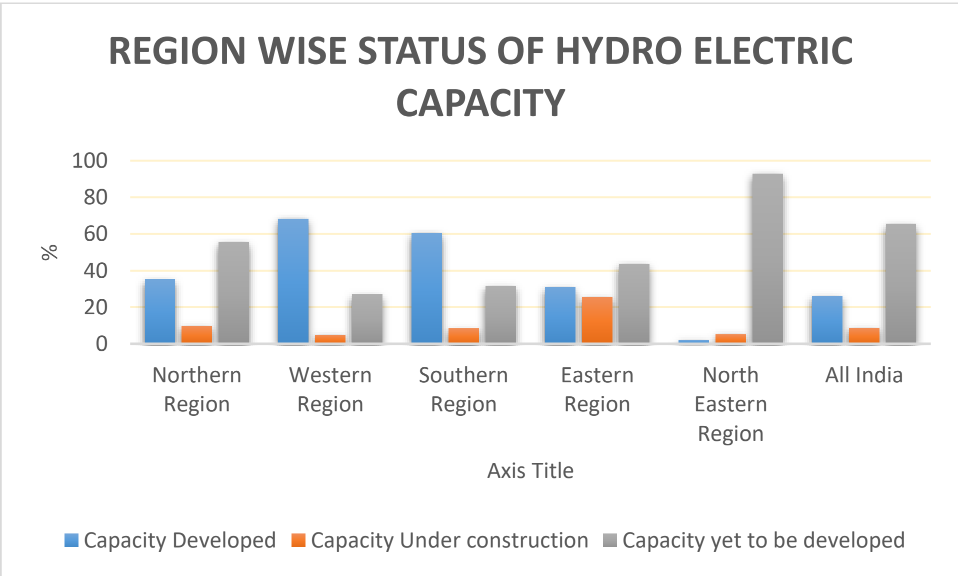


Table 7.3

Basin wise Status of H.E. Potential Development-Basin wise

(In Terms of Installed Capacity-Above 25 Mw as on 31.03.2016)

River Basin	Identified Capacity as per Reassessment		Capacity Developed		Capacity Under Constructio		Capacity Yet to be Developed	
	Total	**Above 25 MW**	**(MW)**	**(%)**	**(MW)**	**(%)**	**(MW)**	**(%)**
Indus	33832	33028	13573.3	41.10	3491.0	10.57	15963.69	48.33
Ganga	20711	2025	5317	26.	1541.	7.6	13393.	66.1
Central Indian	4152	3868	3147.5	81.37	400.0	10.34	320.50	8.29
West Flowing	9430	8997	5660.7	62.92	100.0	1.11	3236.30	35.97
East Flowing	14511	13775	8003.2	58.10	1210.0	8.78	4561.9	33.12
Brahmaput	66065	6540	2296	3.5	5680.	8.6	57424.	87.8
Total	**148701**	**14532**	**3799**	**26.**	**12422**	**8.5**	**94900.**	**65.3**

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 42,784 MW as on 31.03.2016 from Hydro Electric station 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 through-out 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 hydroelectric plants and trend of hydro capacity & generation over the years are indicated in **Table-7.4** and at **Exhibits 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 14.35% at the end of 2015-16. The generation from hydro stations during the year 2015-16, accounts for 10.96% of the total energy generation in the country. Region wise summary of Hydro Installed capacity are indicated in **Table 7.5.**

Sector-wise distribution of hydro installed capacity as on 31.03.2016 in Central, State and Private Sectors is 27.05%, 65.66% and 7.29% respectively. Sector wise contribution of hydro generation during the year 2015-16 in Central, State and Private sectors were 46.72%, 43.78% and 9.50% respectively. These details are illustrated in **Exhibits 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 %	Total (MU)	Hydro (MU)	Hydro as % of Total
1947	1362	508	37.3	4072	2194	53.88
1950	1713	560	32.6	5106	2519	49.33
1955-56	2886	1061	36.7	9145	4295	46.97
1960-61	4653	1917	41.2	1693	7837	46.27
1962-63	5801	2936	50.6	2236	11805	52.78
1965-66	9027	4124	45.6	3289	15225	46.29
1968-69	12957	5907	45.5	4743	20723	43.69
1973-74	16664	6966	41.8	6668	28972	43.44
1978-79	26680	10833	40.6	10252	47159	46.00
1979-80	28448	11384	40.0	10462	45478	43.47
1984-85	42585	14460	33.9	15685	53948	34.39
1989-90	63636	18307	28.7	24543	62116	25.31
1991-92	69065	19194	27.7	28702	72757	25.35
1996-97	85795	21658	25.2	39588	68901	17.40
1997-98	89203	21904	24.5	42174	74582	17.68
1998-99	92269	22479	24.1	44746	82923	18.53
1999-00	97837	23857	24.3	48112	80755	16.78
2000-01	101450	25153	24.7	49942	74362	14.89
2001-02	105046	26269	25.0	51506	73759	14.32
2002-03	107877	26767	24.8	53160	63834	12.01
2003-04	112684	29507	26.1	55811	73775	13.22
2004-05	118419	30936	26.1	58741	84495	14.38
2005-06	124287	32326	26.0	62463	101293	16.22
2006-07	132321	34662	26.1	65951	113359	17.19
2007-08	143061	37002	25.8	70446	123424	17.52
2008-09*	147917	36846	24.9	71465	109840	15.37
2009-10*	159398	36863	23.1	76342	103916	13.61
2010-11*	173626	37567	21.6	80553	114257	14.18
2011-12*	199877	38990	19.5	87160	130510	14.97
2012-13*	223344	39491	17.6	90726	113720	12.53
2013-14*	243029	40531	16.6	96155	134848	14.02
2014-15*	267637	41267	15.4	10436	129244	12.38
2015-16*	302088	42783	14.3	11073	121341	10.96

Note: Capacity above 25 MW only has been considered.

Exhibits 7.2

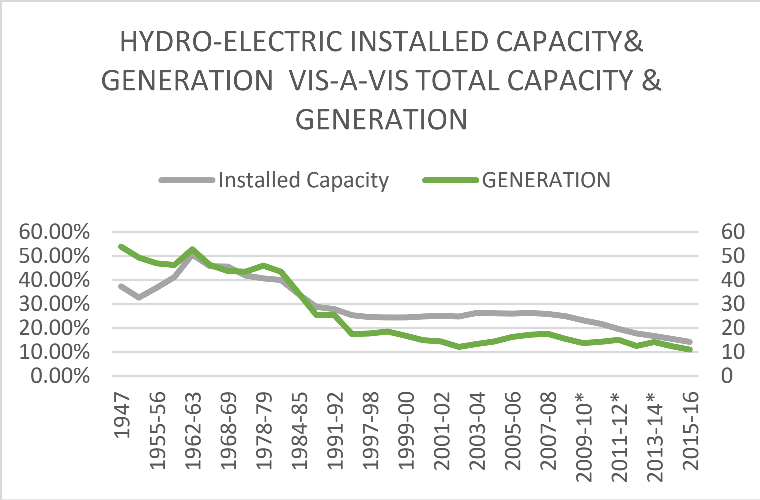
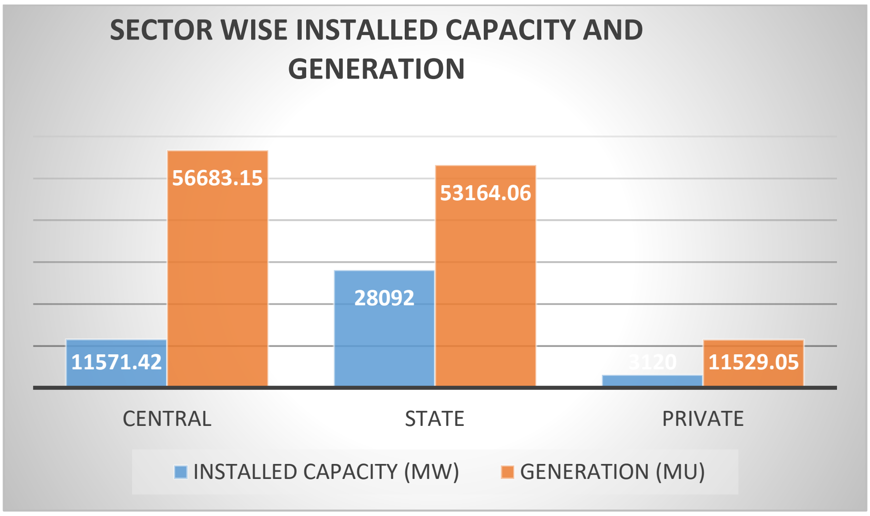


Table 7.5

Region wise Summary of Hydro Electric Installed Capacity (Above 25 MW Capacity as On 31.03.2016)

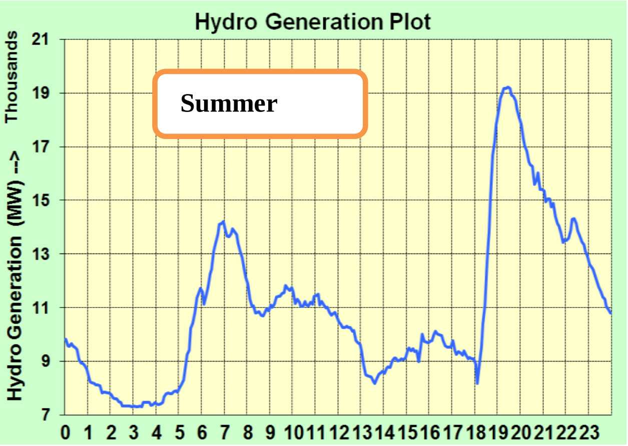
REGION	NO. OF	NO.OF UNITS	CAPACITY (MW)
NORTHERN	68	234	18302.27
WESTERN	2	101	7392.00
SOUTHERN	6	247	
EASTERN	19	6	4254.70
NORTH EASTERN		2	
ALL INDIA (TOTAL)	**1**	**676**	**42783.42**

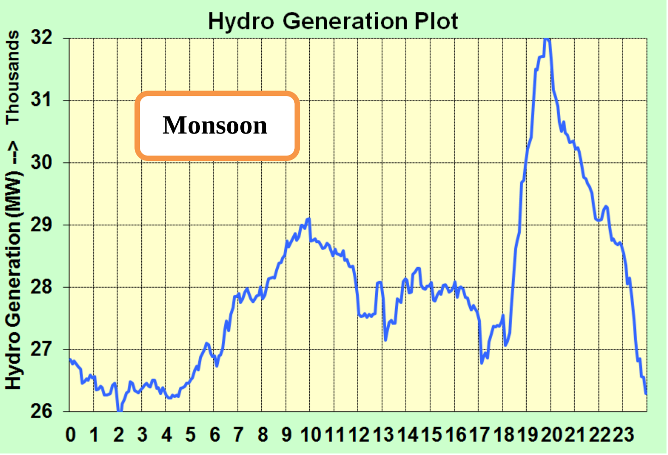
Exhibit 7.3

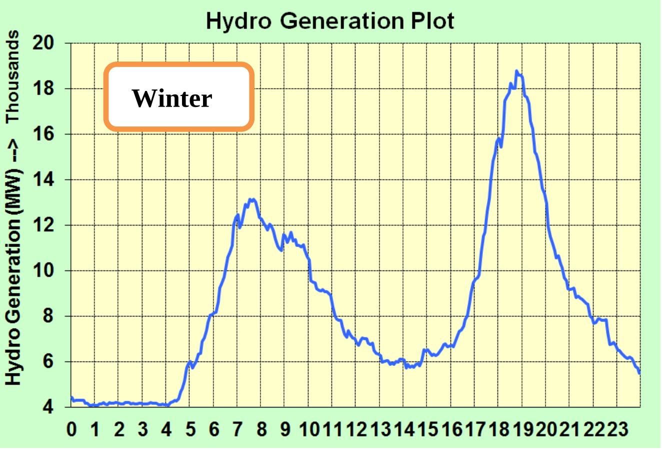


Typical variation in hydro generation in different seasons are shown in Exhibit 7.4.

Exhibit 7.4







7.2 HYDRO POWER – A FLEXIBILE 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 plants (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 units have a broad band of operations and normally operate at 60-80% of maximum power.

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 42,784 MW (as on 31.03.2016) consist of 9,296 MW Run of River(RoR); 8,083 MW RoR with pondage; 25,405 MW storage type includes 4785 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

Fig. in MW

Region	RoR	RoR with Pondage	Storage	Total
Northern Region	7428.67	5273.00	5600.60	18302.27
Western Region	314.00	395.00	6683.00	7392.00
Southern Region	940.00	1086.00	9566.45	11592.45
Eastern Region	267.00	924.00	3063.70	4254.70
North Eastern Region	346.00	405.00	491.00	1242.00
All India	**9295.67**	**8083.00**	**25404.75**	**42783.42**

Considering 80% availability of storage type of plant 50% availability of RoR with pondage type of hydro plant the ramp up capacity provided by the existing hydro plants is 24,365 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 4786 MW are in operation out of which only 5 Nos. plants with aggregate installed capacity of 2600 MW are being operated in pumping mode. The remaining 4 Nos. plants with an installed capacity of about 2200 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)

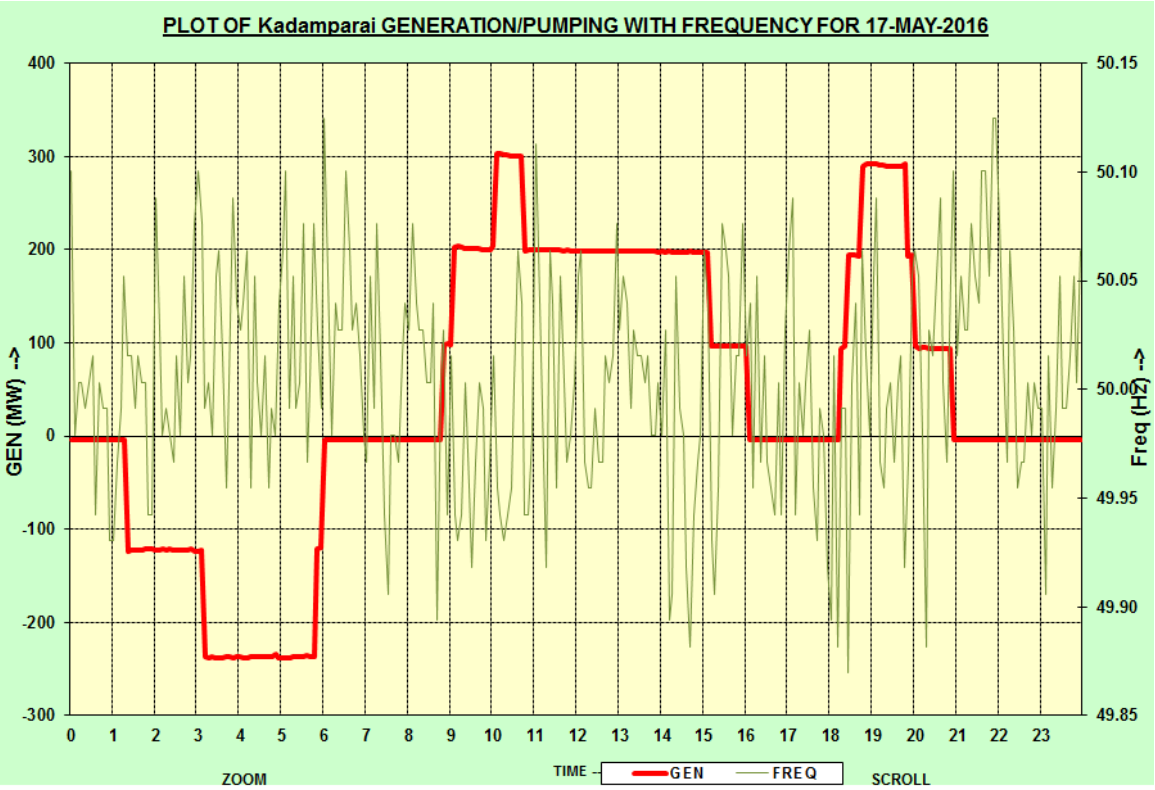


Exhibit 7.5(b)

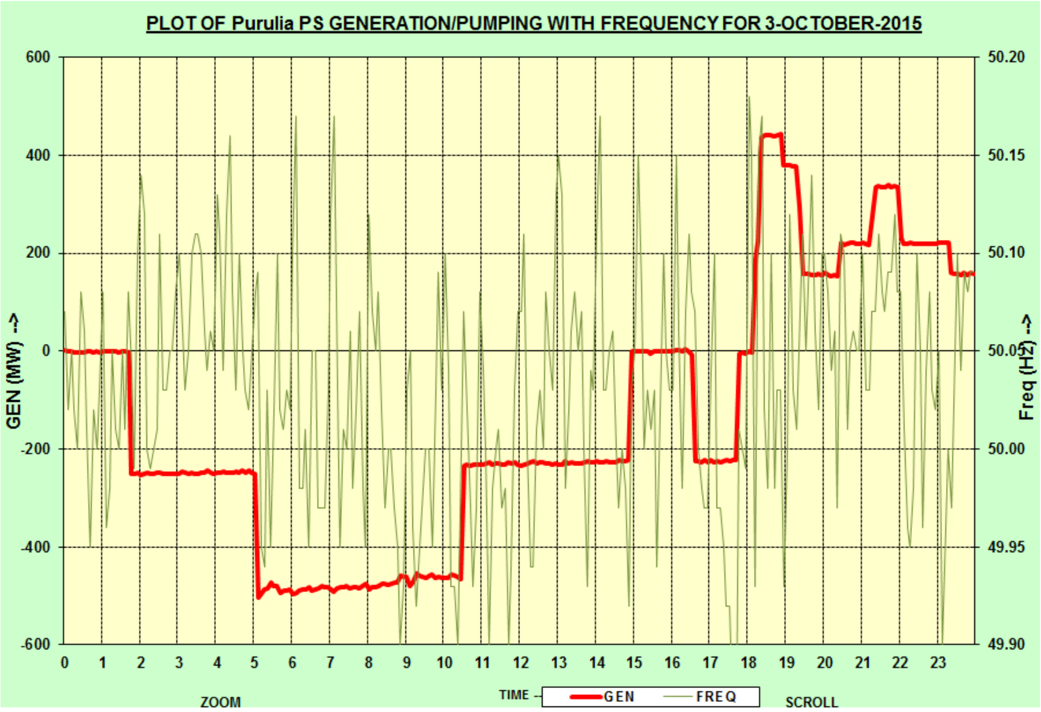
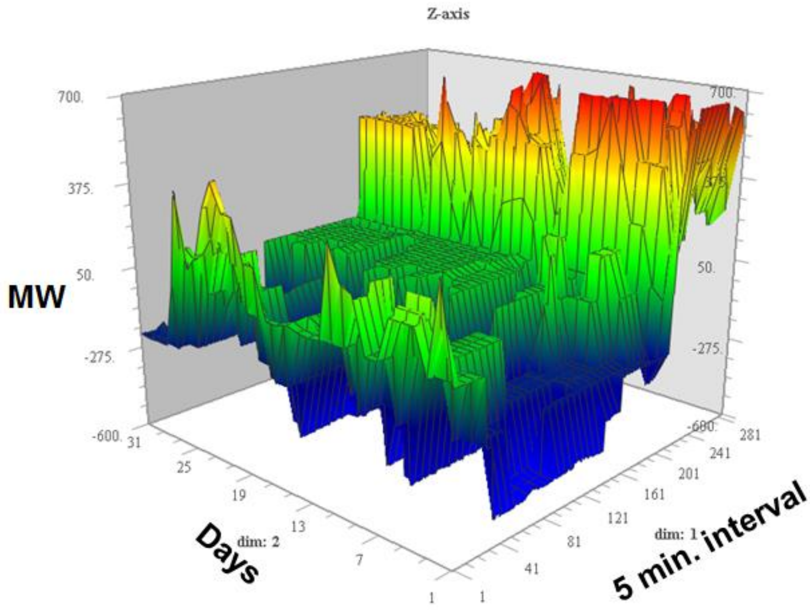


Exhibit 7.5(c)

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 Rs./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 unbalance 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 3,02,088 MW as on 31.03.2016 is dominated by thermal power with around 69.7% share. Hydro, with an installed capacity of 42,784 MW has a share of around 14.2%. 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.

i. 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.

ii. 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.

iii. Rehabilitation & Resettlement Issues

Construction and operation of hydropower dams can significantly affect natural river systems as well as fish and wildlife populations. Furthermore, 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.

iv. 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.

v. 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.

vi. 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.

vii. Natural Calamities

Natural calamities like unprecedented rain / flash floods, cloud burst, earthquake etc delay the completion of project.

viii. 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.

ix. 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.

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 31.3.2008. 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. Exemption from competitive bidding extended up to 2022.

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

i. 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.

ii. Hydro plants shall be considered for compensation for balancing the grid by implementing differential tariff for peak and off-peak power. Pump storage plants should be encouraged to operate in pump mode by providing incentive for its operation.

iii. 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.

CHAPTER 8

GAS BASED POWER PLANTS

8.0 INTRODUCTION

Natural Gas is one of the cleanest fuel 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 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.

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’s, 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-gassified 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 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 KG D6 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 KGD-6 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 KG D6 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 KG D6 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 KG D6 gas to power sector in May 2008 and October 2009. The EGoM in its meeting held on 23.08.2013 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 KG D6 gas was started in 2009-10 with 39.67 MMSCMD and reached a peak of 55.35 MMSCMD in 2010-11. The gas from KGD-6 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 KG D6 field fell to 16 MMSCMD in March, 2013, the supplies to power sector got reduced to zero.

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 3,02,088 MW as on 31st March 2016, a capacity of 24,508 MW (about 8.11%) is from gas based power plants. However, capacity of 23,075 MW is being monitored by CEA. Out of the total monitored capacity, a capacity of 20,210 MW is connected with Main Pipeline/Gas grid and 2,865 MW is connected with isolated gas fields. Of the grid connected gas based capacity of 20,210 MW, 8,042 MW is predominantly APM gas based and 6,897 MW is predominantly on KG D6 gas. Besides this a capacity of 5,271 MW has been commissioned without any gas allocation. In addition, 3,839 MW of new gas based capacity is ready for commissioning in the immediate future if gas is made available. A capacity of 500 MW gas based capacity is under construction.

Normative Gas requirement to operate the existing Power plants of capacity of 23,075 MW at 90% Plant Load Factor(PLF) is about 113 MMSCMD. However, the total domestic gas allocated to power projects is 87.46 MMSCMD and average gas supplied to these gas based power plants during the year 2015-16 was only 28.26 MMSCMD. The gas grid connected capacity had received 18.75 MMSCMD gas during the year 2015-16 and achieved average PLF of 19.55 % only and gas based capacity connected with isolated gas field had received 9.51 MMSCMD gas and achieved average PLF of 50.57 %. Therefore, the average Plant Load Factor of gas based generation capacity in the country during 2015-16 is about 23%. Details of gas based capacity with gas supply position for the year 2015-16 is given at **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

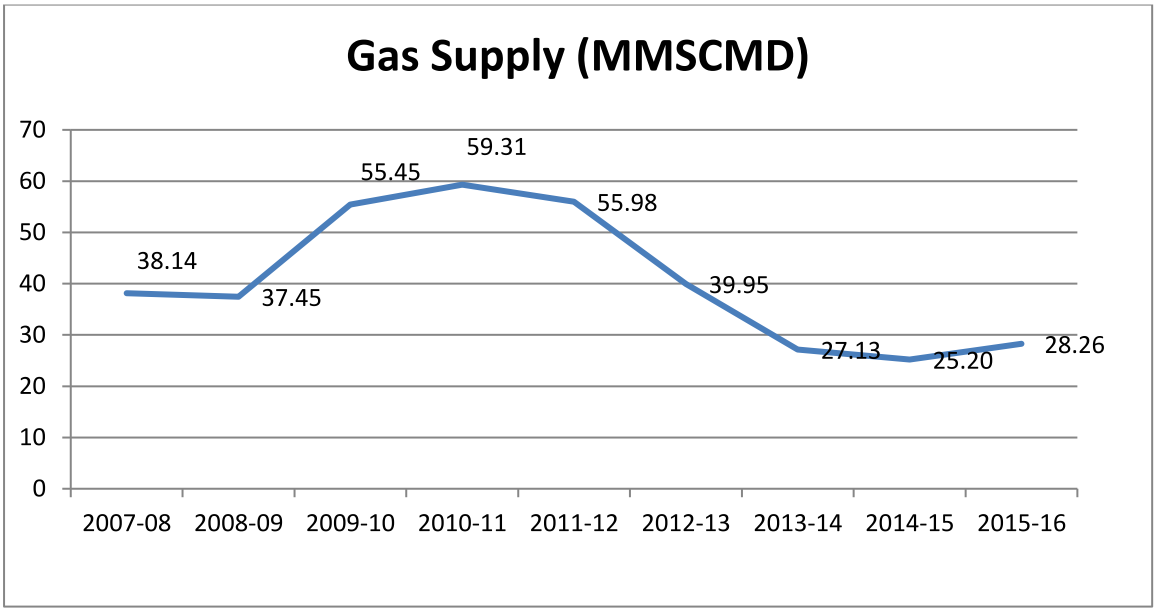
Average Gas Supply and Shortfall

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

*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**.

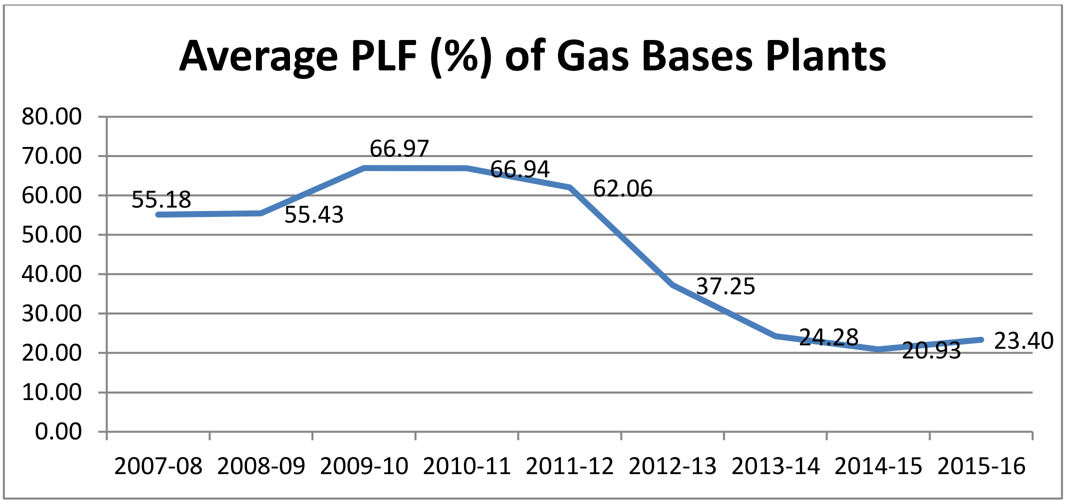
Exhibit 8.1



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 2015-16, domestic gas supply to gas based power plants was only 28.26 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 2015-16 average PLF came down to around 23% only.

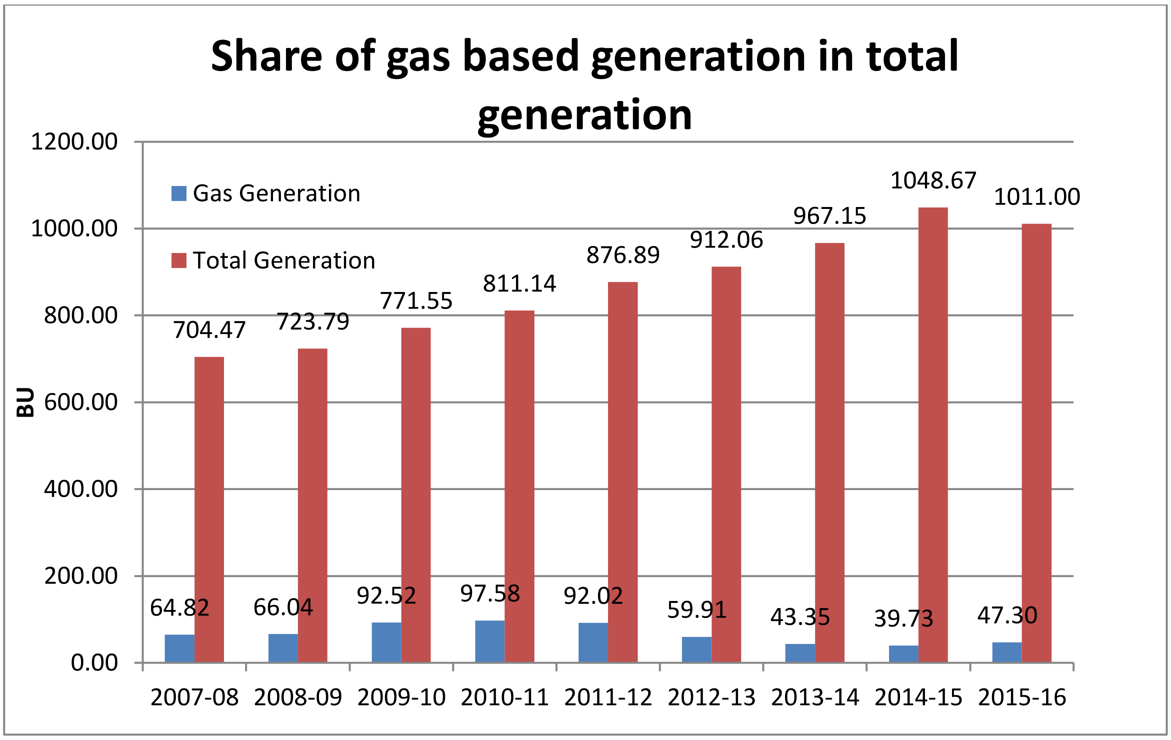
Exhibit 8.2



Share of gas based power generation in total generation from 2007-08 to 2014-15 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 7.7% 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.

[1] World Bank – World Development Indicators data

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.

As on 31.03.2016 a gas based capacity of 4339 MW is ready for commissioning/under construction in the country which includes a capacity of 3839 MW which is ready for commissioning, if gas is made available. Due to uncertainty in availability of domestic gas, no additional gas based power plant has been planned during 2017-18 to 2021-22.

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 42784 MW as on 31.03.2016, **25404** MW are storage type, **11795** MW are run-of the river type and the balance is of 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 PSPs are also not available. Therefore, for balancing, the grid has to lean heavily on the gas based plants. 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 23075.57 MW of gas based capacity available at present, 350 MW is open cycle only and the balance are closed cycle. However, the new gas-based combined cycle power plants offer higher efficiency and can go from start to full load quicker. The new technology of combined cycle gas plants can start up /stop to the extent of 2500 times in a year. The total start-up time is just 30 minutes (from warm start) and shutdown time is also 30 minutes. These are single shaft machines and can operate at a minimum load of 20% and therefore are best suited to cater the variability of RES.

Now, there is acute shortage of gas for the Gas Based Power Plants. During the year 2015-16, Gas Based Plants were running at a PLF of around 23%. To run gas plant at a PLF of 85%, normative gas requirement would be about 108 MMSCMD. This is significantly more than the present availability of 28.26 MMSCMD. The role of gas based plants during evening to meet the balancing power and ramping requirement is vital for the Indian grid. Therefore, it is proposed to run that gas based power stations at 85% PLF during the 6 hours in the evening. It is estimated that about 20 MMSCMD additional gas would be required over and above 28.26 MMSCMD already being supplied to gas based power stations.

Also, it is proposed that, to cater to intermittence of RES generation, a capacity of about 2000 MW gas based may be kept as reserve during off peak hours. Gas requirement for this capacity to run at 50% PLF would be about 5.3 MMSCMD.

Therefore, for effective utilisation of available gas based plants in India to meet the balancing and ramping requirement of the grid, availability of minimum quantum of gas to the tune of 53.56 MMSCMD needs to be ensured.

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 Rs 7500 crores (Rs 3500 crores and Rs 4000 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 KG D6 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 53.56 MMSCMD of gas to Gas Based Plants in the country needs to be ensured for this purpose.

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'15-March'16

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	2.79	0.65
2	NTPC, ANTA CCPP	419.33	RAJASTHAN	2.38	0.60
3	NTPC, AURAIYA CCPP	663.36	UTTAR PRADESH	3.33	0.94
4	NTPC, DADRI CCPP	829.78	UTTAR PRADESH	4.51	1.70
	Sub Total (NR)	**2344.06**		13.01	3.88
5	NTPC, GANDHAR(JHANORE) CCPP	657.39	GUJARAT	1.23	0.60
6	NTPC, KAWAS CCPP	656.2	GUJARAT	4.62	0.71
7	RATNAGIRI (RGPPL-DHABHOL)	1967	MAHARASHTRA	8.5	0.65
	Sub Total (WR)	**3280.59**		14.35	1.95
8	KATHALGURI (NEEPCO)	291	ASSAM	1.4	1.34
9	MONARCHAK (NEEPCO)	65.4	TRIPURA	0.5	0.08
10	AGARTALA GT+ST (NEEPCO)	109.5	TRIPURA	0.75	0.70
11	TRIPURA CCPP (ONGC)	726.6	TRIPURA	2.65	1.91
	Sub Total (NER)	**1192.5**		5.3	4.03
	Total (CS)	**6817.15**		**32.66**	9.87
(B) STATE SECTOR					
12	I.P.CCPP	270	DELHI	1.20	0.34
13	PRAGATI CCGT-III	1500	DELHI	2.49	1.03
14	PRAGATI CCPP	330.4	DELHI	2.05	0.84
15	DHOLPUR CCPP	330	RAJASTHAN	1.60	0.24
16	RAMGARH (RRVUNL,Jaisalmer)	273.8	RAJASTHAN	1.45	1.50
	Sub Total (NR)	**2704.2**		8.79	3.94
17	PIPAVAV CCPP	702	GUJARAT	0.00	0.03
18	DHUVARAN CCPP(GSECL)	594.72	GUJARAT	0.69	0.23
19	HAZIRA CCPP(GSEG)	156.1	GUJARAT	0.81	0.11
20	HAZIRA CCPP EXT	351	GUJARAT	0.00	0.00
21	UTRAN CCPP(GSECL)	518	GUJARAT	1.73	0.63
22	URAN CCPP (MAHAGENCO)	672	MAHARASHTRA	4.90	1.95
	Sub Total (WR)	**2993.82**		8.13	2.94
23	KARAIKAL CCPP (PPCL)	32.5	PUDUCHERRY	0.18	0.17

24	KOVIKALPAL (THIRUMAKOTTAI)	107	TAMIL NADU	*0.45*	*0.28*
25	KUTTALAM (TANGEDCO)	100	TAMIL NADU	*0.45*	*0.33*
26	VALUTHUR CCPP(Ramanand)	186.2	TAMIL NADU	*0.69*	*0.40*
	Sub Total (SR)	**425.7**		***1.77***	***1.17***
27	LAKWA GT (ASEB,Maibella)	157.2	ASSAM	*0.95*	*0.78*
28	NAMRUP CCPP + ST (APGCL)	119	ASSAM	*0.66*	*0.65*
29	BARAMURA GT (TSECL)	58.5	TRIPURA	*0.60*	*0.29*
30	ROKHIA GT (TSECL)	111	TRIPURA	*0.30*	*0.58*
	Sub Total (NER)	**445.7**		***2.51***	***2.31***
	Total (SS)	**6569.42**		**21.20**	***10.37***
(C) PVT SECTOR					
31	TROMBAY CCPP (TPC)	180	MAHARASHTRA	*1.50*	*0.74*
	Sub Total (WR)	**180**		***1.50***	***0.74***
(D) PVT IPP SECTOR					
32	RITHALA CCPP (NDPL)	108	DELHI	*0.40*	*0.00*
	Sub Total (NR)	**108**		***0.40***	***0.00***
33	BARODA CCPP (GIPCL)	160	GUJARAT	*0.45*	*0.14*
34	ESSAR CCPP **	300	GUJARAT	*1.17*	*0.00*
35	PAGUTHAN CCPP (GPEC)	655	GUJARAT	*1.43*	*0.51*
36	SUGEN CCPP (TORRENT)	1147.5	GUJARAT	*4.21*	*1.76*
37	UNOSUGEN CCPP	382.5	GUJARAT	*0.00*	*0.42*
38	DGEN Mega CCPP	1200	GUJARAT	*0.00*	*1.32*
	Sub Total (WR)	**3845**		***7.26***	***4.15***
39	GAUTAMI CCPP	464	ANDHRA PRADESH	*3.82*	*0.02*
40	GMR - KAKINADA (Tanirvavi)	220	ANDHRA PRADESH	*0.88*	*0.00*
41	GMR-Rajamundry Energy Ltd.	768	ANDHRA PRADESH	*0.00*	*0.28*
42	GODAVARI (SPECTRUM)	208	ANDHRA PRADESH	*1.43*	*0.32*
43	JEGURUPADU CCPP (GVK)	455.4	ANDHRA PRADESH	*3.53*	*0.42*
44	KONASEEMA CCPP	445	ANDHRA PRADESH	*3.38*	*0.00*
45	KONDAPALLI EXTN CCPP .	366	ANDHRA PRADESH	*1.46*	*0.07*
46	KONDAPALLI ST-3 CCPP (LANCO)	742	ANDHRA PRADESH		*0.53*
47	KONDAPALLI CCPP (LANCO)	350	ANDHRA PRADESH	*2.32*	*0.39*
48	PEDDAPURAM (BSES)	220	ANDHRA PRADESH	*1.09*	*0.00*
49	VEMAGIRI CCPP	370	ANDHRA PRADESH	*3.12*	*0.33*
50	VIJESWARAN CCPP	272	ANDHRA PRADESH	*0.00*	*0.45*
51	PENNA CEMENT INDUSTRIES	30	ANDHRA PRADESH	*0.12*	*0.00*

52	RVK ENERGY	28	ANDHRA PRADESH	***0.11***	***0.00***
53	SILK ROAD SUGAR	35	ANDHRA PRADESH	***0.10***	***0.00***
54	LVS POWER	55	ANDHRA PRADESH	***0.22***	***0.00***
55	KARUPPUR CCPP (ABAN)	119.8	TAMIL NADU	***0.50***	***0.32***
56	P.NALLUR CCPP (PPN)	330.5	TAMIL NADU	***1.50***	***0.00***
57	VALANTARVY CCPP	52.8	TAMIL NADU	***0.38***	***0.12***
	Sub Total (SR)	**5531.5**		***23.96***	***3.13***
58	DLF ASSAM GT	24.5	ASSAM	***0.10***	***0.00***
	Sub Total (NER)	**24.5**		***0.10***	***0.00***
	Total (PVT IPP S)=D	**9509**		**31.72**	***7.28***
	Total(PVT)=C+D	**9689**		**33.22**	***8.02***
	GRAND TOTAL=A+B+C+D	**23075.57**		**87.09**	***28.26***

MMSCMD – Million Metric Standard cubic meter per day

Annexure-8.2

List of Ready for commissioning/Under Construction gas based power plants

(All figures in MW)

Details of Gas Power Projects Under Construction/Ready for commissioning, awaiting Gas supplies.				
State	**Project Name**	**Sector**	**Implementing Agency**	**Capacity**
AP	Panduranga CCPP	Private	Panduranga Power Ltd	116
AP	RVK Gas Engine	Private	RVK (Rajahmundry) Pvt.Ltd	76
AP	RVKCCPP	Private	RVK (Rajahmundry) PVT.Ltd	360
AP	Samalkot CCPP-II	Private	Reliance Power	2400
Maharashtra	Mangaon CCPP	Private	PGPL	388
Telangana	Astha Gas Engines	Private	Astha	34.88
TN	Ind Barath Gas Project	Private	Ind Barath	65
Utrakhand	Kashipur CCPP	Private	Sravanthi Energy Pvt. Ltd	225
Uttarakhand	Beta CCPP	Private	BIPL	225
Uttarakhand	Gama CCPP	Private	GIPL	225
Uttarakhand	Kashipur CCPP-II	Private	Sravanthi Energy Pvt. Ltd	225
			Total (Private Sector)	**4339.88**

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 fuel 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 302,088 MW as on 31.03.2016, out of which about 185172.88 MW (61.3%) is coal based. Of the total power generated in the country, 77.8 % comes from coal based thermal power stations even though they constitute only 61.3% of the total installed capacity. 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 thermal power stations in the country has been decreasing steadily over the years. The PLF has decreased from 78.9 % in 2007-08 to 62.0% in 2015-16.

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 78000 MW which were likely to be commissioned by 31.03.2015. Out of 78000 MW, around 9840 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 as fixed by a Committee headed by Secretary, Planning Commission depending on the distance of the power plant from the mine-head is as per details 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

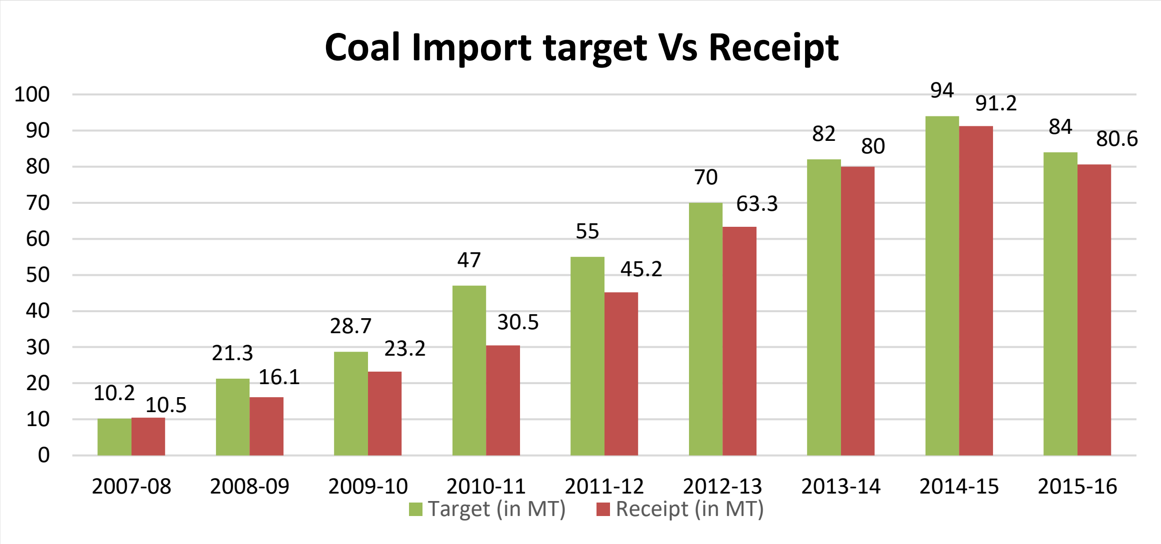
In the past, Power Utilities were advised to import coal to maintain the stipulations of Ministry of Environment and Forest regarding use of coal of less than 34% ash content and also to occasionally supplement the coal from indigenous sources. However, due to inadequate availability of domestic coal, 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 (upto 2015-16) 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

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. With the persistent efforts of Ministry of Power, Coal and Railways, the coal supply position in the power plants has been increasing. 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. Prior to 3rd February, 2015, all the power plants having coal stock less than 7 days were considered as critical and those less than 5 days were considered as super-critical. The criteria, given in **Table 9.3** below**,** is being adopted w.e.f. 3rd February, 2015 for classifying critical / super critical coal stock at the power plants.

Table 9.3

Criteria w.e.f. 3rd February, 2015 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 2015-16) 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 Critical Power plants	No. of Super Critical Power plants	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

Exhibit 9.2

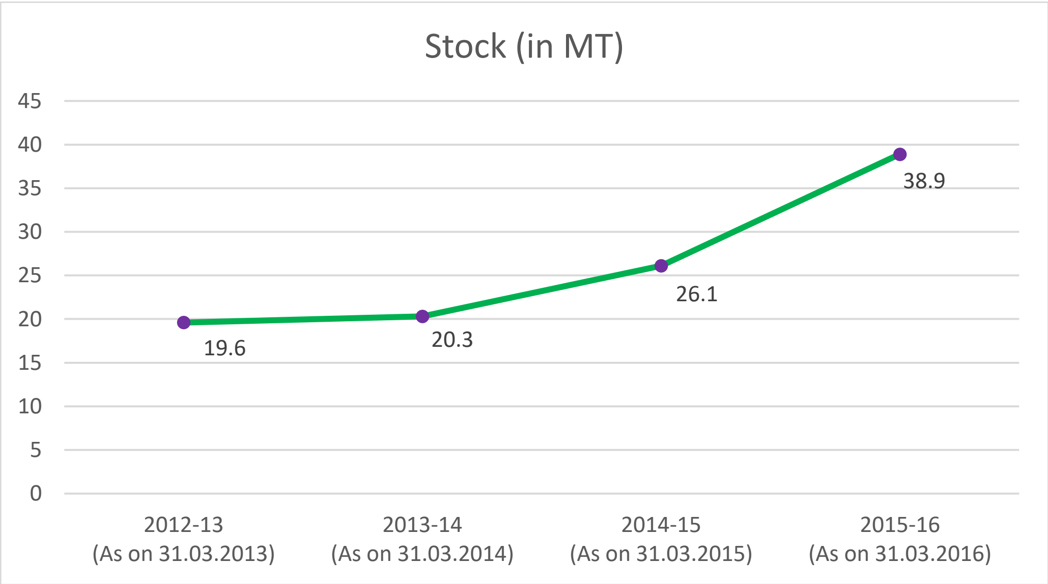
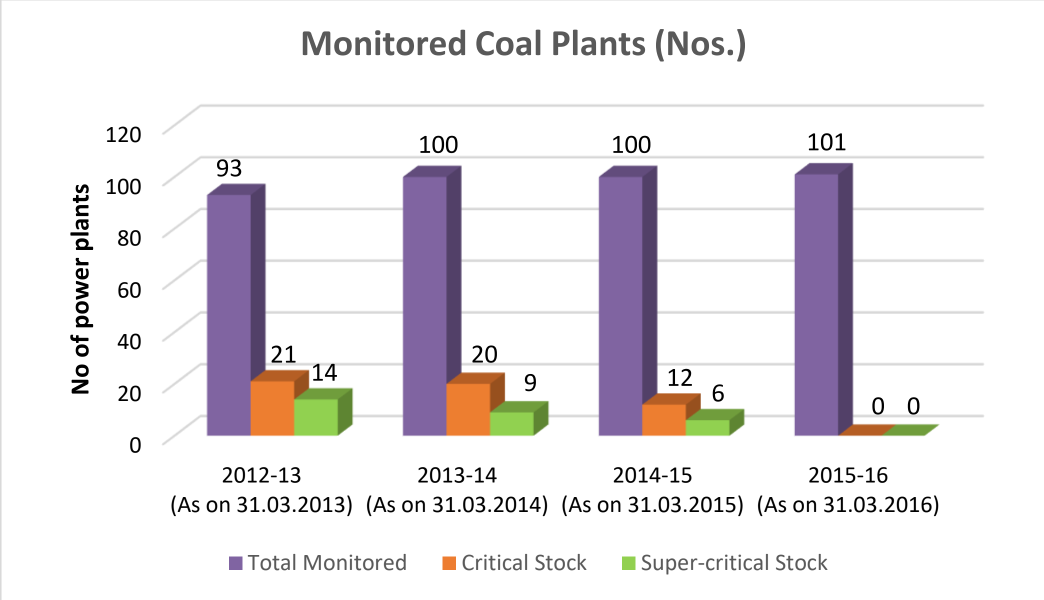


Exhibit 9.3



Note: CEA is monitoring the coal based plants above 100 MW where coal is being supplied by CIL/SCCL and involves Rail transportation.

With regular monitoring and follow up with coal companies & Railways, the coal stock position has been improving over the years. During the year 2015-16, the coal stock at the power plants have reached all time high of about 39 MT. Also during the financial year 2015-16, w.e.f 6th December, 2015, no power plants were having critical and super critical coal stock during remaining period of the year.

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. The details of generation loss reported by power utilities during 12th Plan (upto 2015-16) are given in **Table 9.5 and Exhibit 9.4**.

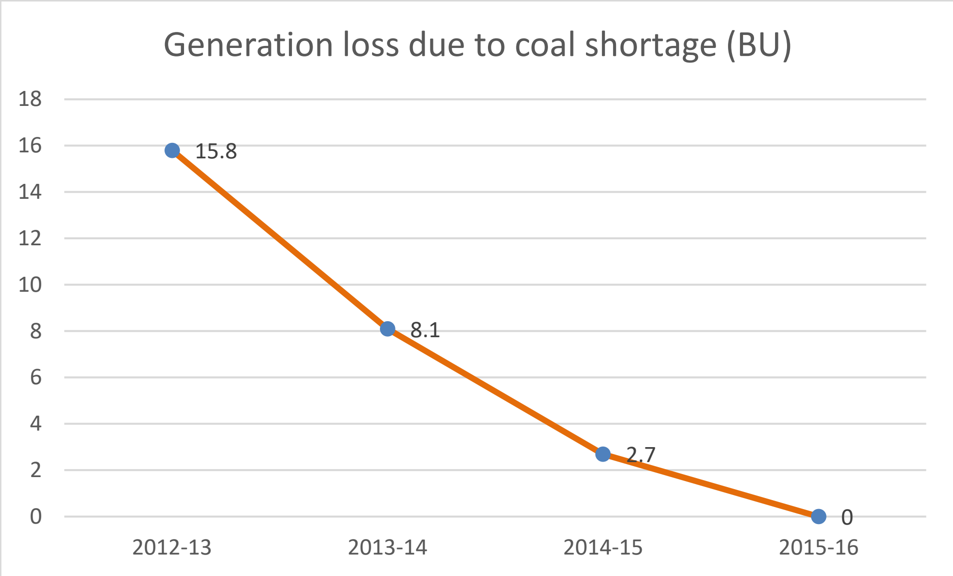
Table 9.5

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

Exhibit 9.4



9.2 COAL DEMAND AND SUPPLY

9.2.1.1 Coal Supply Position during 2014-15 and 2015-16:

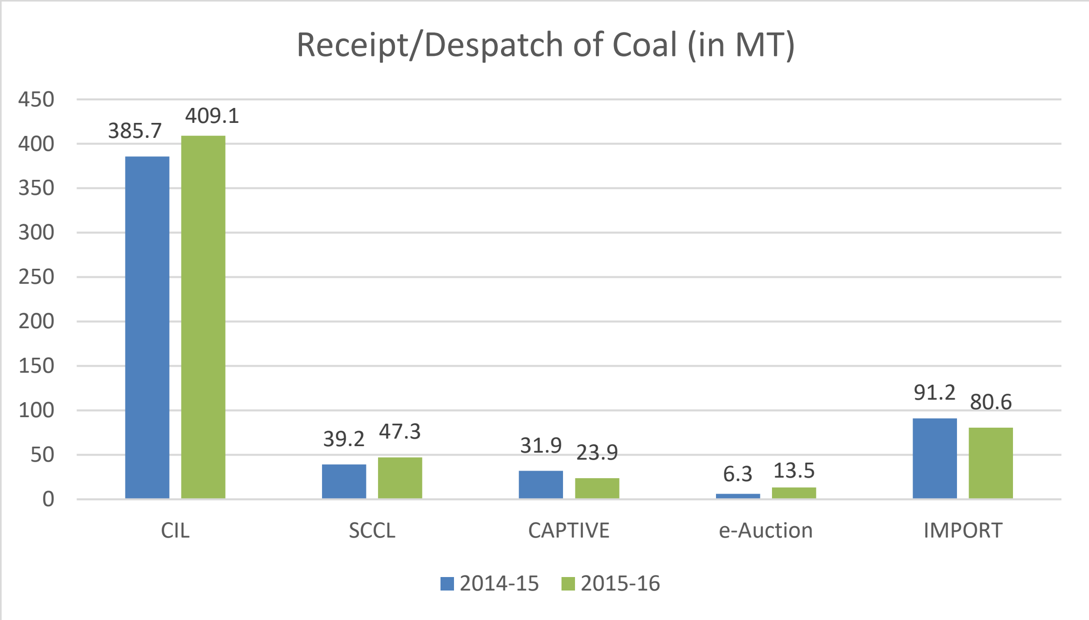
With the enhanced availability of domestic coal, coal supply to power plants has been comfortable during 2015-16 as compared to 2014-15. The coal stock at the power plants in the beginning of 2016-17 (as on 1st April, 2016) was more than 38 MT which was sufficient for operation of power plants for 27 days. The details of source-wise program and despatch/receipt of coal by power plants during 2014-15 and 2015-16 are given in **Table 9.6 and Exhibit 9.5**.

Table 9.6.
Source-wise program and despatch/receipt of coal by power plants

(In Million Tonnes)

	April, 2014- March 2015			April 2015- March,2016			Growth in Receipt (%)
Source	Program	Receipt	%	Program	Receipt	%	
CIL	405.0	385.7	95.2	435.0	409.1	94.0	6.1
SCCL	35.0	39.2	112	38.0	47.3	124.5	20.7
CAPTIVE	33.0	31.9	96.7	32.0	23.9	74.7	-25.1
e-Auction	0.0	6.3		10.0	13.5	135.0	114.3
IMPORT	94.0	91.2	97	84.0	80.6	95.9	-11.6
TOTAL	**567.0**	**554.3**	**97.8**	**599.0**	**574.4**	**95.9**	**3.6**

Exhibit 9.5



9.2.1.2 Coal Demand and Availability Position during the Year 2016-17

For the year 2016-17, coal based generation programme of 921 BU during 2016-17 has been estimated in consultation of the power utilities with estimated growth of 6.9%. The total coal requirement of 600 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 2016-17 are given in **Table 9.7**.

Table 9.7
Assessment of Coal Requirement for the Year 2016-17

S.No.	Description	Units	
1	**Coal based generation**		
1.1	Coal based generation programme during 2016-17 (estimated growth 6.9%)	BU	921
2	Coal Requirement		
2.1	For plants designed on domestic Coal	MT	552
2.2	For plants designed on imported coal	MT	48
2.3	**Total Coal Requirement**	MT	600
3	Coal Availability from Indigenous Sources		
3.1	From CIL	MT	450
3.2	From SCCL	MT	50
3.3	From Captive Mines	MT	40
3.4	From e-auction/Stock	MT	12
3.5	Total domestic coal availability	MT	552
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 about 48-49 MT to meet their coal requirement.

9.3 Coal Demand and Availability during the period 2021-22 & 2026-27

Preliminary Exercise has been carried out in CEA for assessing the power requirement of States/UTs considering past growth rates and the increase in Electrical Energy Requirement on account of Power for All, Make in India initiatives, reduction in demand

on account of DSM and various efficiency improvement measures being under taken by the Government. The total electricity requirement on All India basis has been assessed.
The work of 19th Electric Power Survey is under way and consultations are in process with the State utilities for finalizing the figures of Electricity Demand forecast. Accordingly, the same would be modified after finalization of 19th EPS.
With the provisional 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 addition of RES has been considered in three cases viz., Case-I: 1,15,326 MW, Case-II: 90,326 MW and Case-III: 65,326 MW by the terminal year 2021-22. With this estimate, the total capacity of RES would be 175 GW in Case-I, 150 GW in Case-II and 125 GW in Case-III respectively. Accordingly, in the year 2021-22, the estimated generation from coal based power plants would be around 1018 BU, 1071 BU and 1122 BU respectively. 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 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. With the capacity addition of 50,025 MW coal based power plants, the generation from coal based power plants is estimated as 1246 BU. The details of coal requirement for the year 2026-27 have been worked out considering 30% reduction in hydro generation due to failure of monsoon and is being supplemented by coal based generation.

With the above consideration, the coal requirement in the year 2021-22 and 2026-27 have been estimated as per details 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:150 GW	RES:125 GW	RES:275 GW
1	**Coal Requirement**					
1.1	Coal based generation	BU	1018	1071	1122	1246
1.2	Hydro based generation	BU	188.0	188.0	185.0	285.0
1.3	30% reduction in Hydro Generation assuming failure of monsoon	BU	56.4	56.4	55.5	85.5
1.4	Total coal based generation (1.1+1.3)	BU	1074.4	1127.4	1177.5	1331.5
1.6	**Coal Requirement**	**MT**	**727**	**763**	**797**	**901**
1.7	Imports by plants designed on imported coal	MT	50	50	50	50
2	**Domestic coal Requirement (1.6-1.7)**	**MT**	**677**	**713**	**747**	**851**

Exhibit 9.6

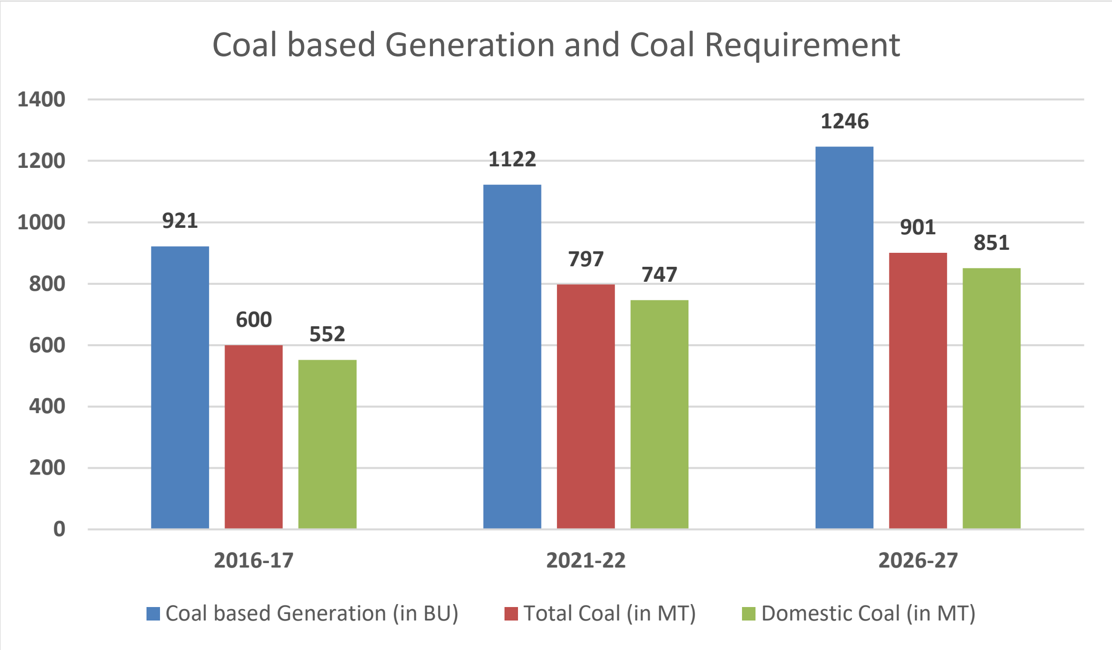
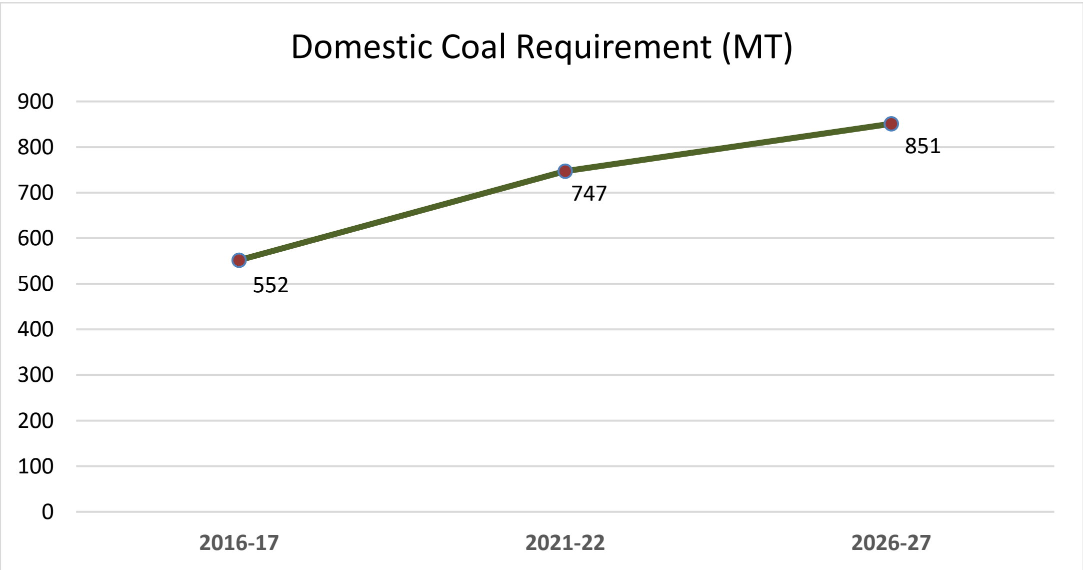


Exhibit 9.7



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

9.4.1.1 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 Rs.3500 to Rs.6000 crores.

i. The new Inter-Ministerial Task Force (IMTF) had recommended a three step approach for implementation. 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 Rs. 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 687Crores) 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.

iv. 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 Rs. 1371 crores of transportation cost.

9.4.1.2 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.

In the meeting, a committee was also 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 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 was decided in the meeting held on 28.10.2015 that recommendations of the Committee shall be considered by the Committee of Joint Secretary, Ministry of Coal and Joint Secretary, Ministry of Power. The Committee has since submitted its report to the committee of Joint Secretaries.

It has also 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.

9.4.1.3 Flexibility in Utilization of Domestic Coal

In order to achieve flexibility in utilization of domestic coal and for reducing the cost of power generation, the proposal of the Ministry of Power was approved on 4.05.2016. The flexibility in utilization of domestic coal will result in reduction of cost of electricity to the consumers. The broad methodology would promote use of coal in a flexible manner amongst power plants of Central generating stations, State generating stations, power plants of other State power utilities and Independent Power Producers (IPPs). The proposal of flexibility in utilization of domestic coal is proposed to be rolled out for Central Generating companies, State power utilities and could be rolled out for private companies subsequently. Central Electricity Authority in consultation with all the Stake holders has prepared and issued the methodology for flexibility in utilization of domestic coal.

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 between 750-1000 kms and 500-749 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 01st January, 2015 & 5th June 2016 respectively while power plants located beyond 1000 kms from pit head shall be supplied with and use raw or blended or beneficiated coal with ash content not exceeding thirty four percent on quarterly average basis with immediate effect. 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, particularly in the States of Tamil Nadu, Rajasthan and Gujarat having the limitations of transportation of coal to these regions. State-wise distribution of Lignite resources is shown in **Table- 9.9**.

Table 9.9

State-wise Lignite Reserves

State	Total[MT]
Tamil Nadu	33309.53
Rajasthan	4835.29
Gujarat	2722.05
Jammu & Kashmir	27.55
Others (Kerala, West Bengal)	11.44
Total	40905.86

The anticipated requirement of Lignite by NLC Ltd, Rajasthan, Gujarat & 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**

9.7 CONCLUSIONS

1. No power plant was critical in coal stock since 6th December, 2015.
2. No power plant has reported generation loss due to coal shortage during 2015-16.
3. 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 coal requirement in the year 2021-22 have been estimated as per Scenario-I, II and III is 677 MT, 713 MT and 747 MT respectively and 851 MT in 2026-2027.
4. Adequate coal is expected to be available for the coal based power plants during 2021-22 and 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 renewables 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 PLANS

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)

Source	Capacity (MW)
Coal + Lignite	69,800
Gas based	2,540
Hydro	10,897
Nuclear	5,300
Total	**88,537**

Table- 10.2

Anticipated Capacity addition – 12th Plan

(All Figures in MW)

12th Plan Capacity Addition Target (A)	88,537
Actual Capacity addition from targeted capacity as on **31-03-2016** (B)	57,721
Likely Capacity addition from targeted capacity during balance period of 12th Plan(C)	9,420
Likely slippage from targeted capacity during 12th Plan (D)	21,386
Total Capacity addition likely from targeted capacity of 12th Plan (B+C)	**67,141**
Additional Capacity addition (outside target) during 12th Plan- as on **31-03-2016** (E)	27,270
Additional Capacity likely to be added during balance period of 12th Plan(F)	7,234
Total Additional Capacity addition likely during 12th Plan (E+F)	**34,504**
Total Capacity Addition likely during the 12th plan	**1,01,645**

As may be seen the 12th Plan is likely to witness a total capacity addition of over 101 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, considering different scenarios of renewable capacity addition, 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)

Scenario	RES capacity addition (GW)	Conventional Capacity					Renewables capacity in March-2022
		Thermal		Hydro	Nuclear	Total	
		Coal	Gas				
I	175	0*	4,340	15,330	2800	**22,470**	175,000
Ii	150	0*	4,340	15,330	2800	**22,470**	150,000
Iii	125	0*	4,340	15,330	2800	**22,470**	125,000

Note: *Coal based capacity of 50,025 MW are in different stages of construction and are expected to be available during 2017-22.

As brought out in the last Para, the rising share of renewables along with additional capacity addition has led to a sharp drop in requirements of conventional capacity addition. 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					Renewables capacity addition
Thermal		Hydro	Nuclear	Total	
Coal	Gas				
44,085**	0	12,000	4,800	**16,800**	100,000

Note: **Since 50,025 MW of coal based plant are expected to come during 2017-22 and will not be required during 2017-22, therefore, this coal based capacity addition of 50,025 MW may be utilized during 2022-27. Hence, no 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	4000	4000
Alstom -Bharat Forge	-	4000
TJPS (Toshiba-JSW Power System)	-	3000
Thermax-Babcock & Wilcox	3000	-
Doosan Power Systems India Pvt Ltd	2200	-
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 system 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 planned 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

Castings & 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**.

Table- 10.9

Estimates of key materials for projects

(All figures in Million tons)

Material	2017-22					2022-27				
	Coal/ Lig 0 MW	Gas 4340 MW	Hydro 15,330 MW	Nuclear 2800 MW	**Total 22,470 MW**	Coal/ Lig** 44,085 MW	Gas 0 MW	Hydro 12000 MW	Nuclear 4800 MW	**Total** 16,800 MW**
Cement	0.00	0.26	14.66	0.55	**15.47**	6.61	0.00	11.47	0.94	**12.41**
Structural steel	0.00	0.13	0.52	0.31	**0.96**	3.75	0.00	0.41	0.53	**0.94**
Reinforcement steel	0.00	0.10	1.43	0.16	**1.69**	1.98	0.00	1.12	0.28	**1.40**
Stainless steel	0.00	0.0043	-	-	**0.0043**	0.09	0.00	-	--	**-**
Aluminium*	0.00	0.0022	0.0015	0.0018	**0.0055**	0.022	0.000	0.0012	0.0031	**0.0043**

Note: * Used in windows, metal cladding walls, control rooms

**Since 50,025 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 50,025 MW may be utilized during 2022-27. Hence, no additional coal based capacity addition may be required during 2022-27

Table- 10.10

Estimates of Castings/Forgings, Tubes/pipes and Plates

Figures in Million tons

Description	2017-22	2022-27
	Coal/lignite – 0 MW	**Coal/lignite – 44,085 MW**
Castings	0	0.026
Forgings	0	0.024
Tubes & Pipes	0	0.47
Thick Boiler Quality Plates	0	0.07

Note: The capacity of 44,085 indicated against 2022-27 Plan is already under construction and is expected to come during 2017-22. Thus no additional coal based capacity may be required during 2022-27

As may be seen from above, based on demand projections, the coal based capacity addition requirements during 2017-22 comes out to be zero, However, coal based projects to the tune of about 50,025 MW are already under construction and are likely to get commissioned during 2017-22. Some of these projects have been recently ordered and most of their inputs would still require to be tied up. Apart from these, several other projects have been recently ordered /being ordered. Thus projects with a total capacity of about 11000 MW would be required to tie up their inputs. The estimated requirements of materials for these coal based projects (recently ordered/being ordered is given in **Table 10.11**.

Table-10.11

Input Estimates for recently ordered coal based capacity

Figures in Thousand tons

Description	2017-22
	Coal/lignite – 11,000 MW
Cement	1650
Structural steel	935
Reinforcement steel	495
Stainless steel	22
Aluminium	5.5
Castings	6.5
Forgings	6.1
Tubes & Pipes	116
Thick Boiler Quality Plates	17.7

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 Karampura, 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 Karampura 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[1] 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 Rs. 173,448 crores and 208 nos. gauge conversion and doubling projects covering 18,976 km at a cost of Rs. 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.

[1] Indian Railways – A white paper - http://www.indianrailways.gov.in/railwayboard/uploads/directorate/finance_budget/Budget_2015-16/White_Paper-_English.pdf

- 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 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[2]. 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

[2] https://morth-owc.nic.in/auth/users/index.asp

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.
- Ensuring 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 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 there off.

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 enclosed as **Annexure-10.1**.

10.7 INLAND WATERWAYS

The following five major river/canal systems have been declared as National Waterways[3]:-

- 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

[3] http://iwai.nic.in/index1.php?lang=1&level=2&sublinkid=145&lid=164

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 2013-14. 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

Th**e** 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 16 MMTPA from present 10 MMTPA by 2016. 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.

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 then 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 will 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: -

i. Adequate manufacturing facilities exist for main plant equipment– Lack or orders is a concern of all manufacturers.

ii. 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.

iii. 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.

iv. 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.

v. 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.

vi. Inland waterways can become an attractive mode of transportation in conjunction with Rlys. 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. 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

1.1 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

2.1 The institutional structure for the appraisal/approval mechanism is specified.

3. APPLICABILITY

3.1 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.

3.2 The procedure specified herein will apply to all PPP projects with capital costs exceeding Rs. 100 crore or where the underlying assets are valued at a sum greater than Rs. 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

4.1 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 Rs. 250 crore or more or under NHDP costing Rs. 500 crore or more Projects of all sectors costing Rs. 250 crore or more or under NHDP costing Rs. 500 crore or more* Guidelines for Formulation, Appraisal and Approval of Central Sector Public Private Partnership Projects.

5. INTER-MINISTERIAL CONSULTATIONS

5.1 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.

5.2 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

6.1 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.

6.2 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.

6.3 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

7.1 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

8.1 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

9.1 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.

9.2 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.

9.3 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.

9.4 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.

9.5 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.

9.6 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

10.1 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

11.1 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 Rs. 250 crore or more or under NHDP costing Rs. 500 crore or more.

CHAPTER 11

FUND REQUIREMENT

11.0 INTRODUCTION

Power generation capacity along with the associated transmission and distribution network has increased many fold over the years. The fund availability plays a crucial role in achieving capacity addition requirement. This chapter estimates total fund requirement for capacity addition during 2017-22 and 2022-27.

11.1 FUND REQUIREMENT FOR THE YEARS 2017-22

The Requirement of funds for generation projects for the period 2017-2022 has been assessed, based on a total capacity addition of 72,495 MW, consisting of 50,025 MW of coal and lignite based power stations, 4340 MW of gas based power stations, 15330 MW of hydro generation and 2800 MW of nuclear generation. 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 capacity by the year 2022, out of which 1,15,326 MW is expected to be set up during the 2017-2022. Requirement of funds for transmission and distribution have been included in Volume-II of the National Electricity Plan, covering transmission and distribution requirements of the country.

The fund requirements have been assessed based on assumptions of cost per MW for various types of generation projects, based on present day costs and year-wise phasing of expenditure in accordance with the normal scenario. The details of assumptions of cost per MW and year-wise phasing of expenditure of different categories of generation projects are given in **Annexure 11.1**.

Based on the above, and the likely capacity addition as mentioned above for the year 2017-22, as well as year-wise expenditure phasing for the period 2017-2022 **for advance action for projects coming up during the period 2022-2027**, the total fund requirement is estimated to be Rs.10,33,375 crores. This expenditure includes expenditure requirement for the renewable capacity addition during the period 2017-2022, as well as the expenditure done during this period for the projects coming up during the years 2022-27. The break-up details are as given **Table 11.1**.

Table 11.1

Total fund requirement for Generation projects during 2017-2022

Details	**Fund requirement (Rs. Crores)**
During 2017 – 2022 - Capacity of 72,495 MW conventional generation and 1,15,326 MW from Renewable Energy Sources	8,59,369
Advance action for the period 2022-27	1,74,006
Total fund requirement for Generation projects during 2017-2022	Rs.10,33,375

The above details do not include funds required for R&M of power plants and captive power plants.

11.2 FUND REQUIREMENT FOR THE YEARS 2022-27

The fund requirements for the period 2022-27 has been calculated, based on capacity addition of 1,16,800 MW, consisting of 0 MW thermal, 12,000 MW hydro, 4800 MW nuclear and 1,00,000 MW renewable capacity addition.

The fund requirements have been assessed, based on assumptions of cost per MW for various types of generation projects, based on escalation of 20% of present day costs, except for solar projects, the cost of which has been retained, as was assumed during the period 2017-22, and year-wise phasing of expenditure in accordance with the normal scenario. The details of assumptions of cost per MW of different categories of generation projects are given in **Annexure 11.1**.

Based on the above, and the likely capacity addition as mentioned above, including the year-wise expenditure phasing for the period 2022-2027 **and not including advance action for projects coming up during the period 2027-2032**, the total fund requirement is estimated to be Rs. 6,05,965 crores, assuming that the capacity addition is equally spread out over each of the five years, in the absence of specific dates of commissioning. The details are given in **Table 11.2**.

Table 11.2.

Total fund requirement for Generation projects during 2022-2027

	Fund requirement (Rs. Crores)
2022 – 2027 - Capacity of 16,800 MW conventional generation and 1,00,000 MW from Renewable Energy Sources	**6,05,965**
Advance action for the period 2027-32	**0**
Total fund requirement for Generation projects during 2022-2027	**6,05,965**

Debt equity ratio and source of funds.

Debt equity ratios for the Central, State and Private sector, in accordance with normal practice, are as given in **Table 11.3**.

Table 11.3.

Sector	Debt	Equity
Centre	70%	30%
State	80%	20%
Private	75%	25%

Sources of debt

The sources of debt normally used by the developers are as given below.

1) Domestic Term Loans

- Banks
- Financial Institutions (PFC, REC)
- LIC

2) Domestic Bonds

- Public
- Private

3) Foreign Currency Loans

- Bonds
- Export Credits
- Developmental Agencies like World Bank, ADB, KfW etc.
- Commercial Banks

4) Subordinate Debt

Further, Govt. of India (through IREDA) proposes to set up US$ **1 to 1.5 billion** dedicated fund for renewable energy."

Annexure 11.1

Assumptions for estimating cost of power projects

S. No.	Type of Generation Project	Cost (crore/MW) 2017-22	Cost (crore/MW) (20% escalation except for Solar,Biomass,Wind) 2022-27
1	Coal + Lignite	7	-
2	Gas	4	-
3	Hydro	10	12
4	Solar	5.5	5.5
5	Wind	6	6
6	Biomass	5.7	5.7
7	SHP	7	8.4
8	Nuclear	10	12

Phasing of expenditure of generation projects, for the periods 2017-22 and 2022-27 is given as follows:

Type of Generation Project	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Coal + Lignite	10%	10%	20%	30%	30%	100%
Gas	40%	50%	10%	-	-	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%

Type of Generation Project	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Nuclear	3%	1%	4%	5%	10%	-
	Year 6	**Year 7**	**Year 8**	**Year 9**	**Year 10**	-
Nuclear	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 31.3.2016, coal based power generation capacity is around 61.3 % of the total installed capacity but generates almost 78 % 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.

12.1.1.2Sulphur 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 SOX 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 (accounting for about 50-55% of total annual greenhouse gas emissions) 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 however, 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.

Following are the 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:

	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%-40 % 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. Due to enormous quantity of ash content in Indian coal, approximately one acre per MW of installed thermal capacity is required for ash disposal.

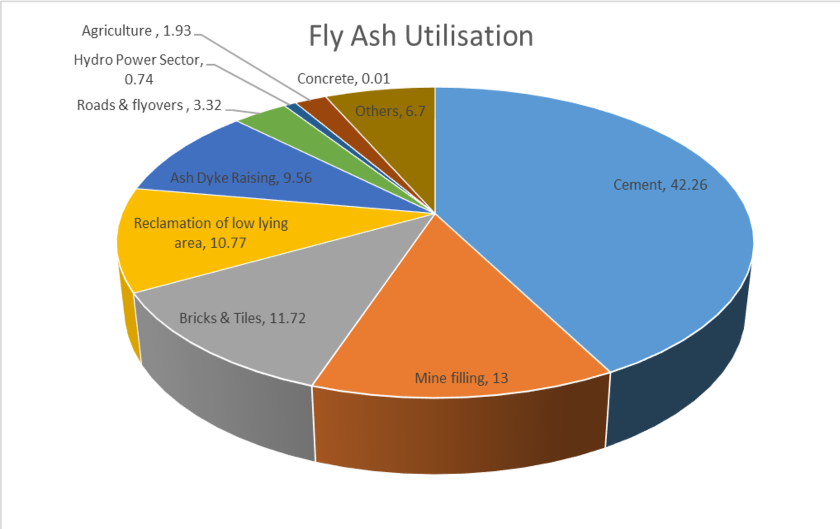
12.2 STEPS TAKEN BY THERMAL POWER STATIONS TO REDUCE EMISSIONS FROM POWER PLANTS

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 145 coal based thermal stations, with an Installed capacity of 1,38,915.80 MW, consuming coal of 549.72 Million tonnes and generating Fly Ash of 184.14 Million tonnes were analysed in 2014-15 by CEA. The analysis shows that country has achieved Fly Ash Utilization of 102.54 Million tonnes with

Percentage Utilization of 55.69 %. Fly ash utilisation in various sectors are shown in **Exhibit 12.1**.

Exhibit 12.1



- **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 7.12.2015. The **Table 12.1** shows the new environmental norms for thermal power stations which are to be complied at different time schedule.

Table 12.1

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 (SO_2)	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 (NO_x)	600 mg/Nm3	300 mg/Nm3	100 mg/Nm3

*To be complied within 2 years by existing stations and w.e.f 01.01.2017 for plants under construction.

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 here.

For implementing SOx reduction, coal based power stations have to install flue gas desulfurization plants. It is estimated that around 80000 MW of the total installed capacity of less than 500 MW units 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 4-6 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/NM3, 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 12.2**).

Table 12.2

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 2014-15 has been estimated at 805.4 million tonnes. Year wise carbon di-oxide emissions from Indian power sector during the last 5 years are given in **Table 12.3**.

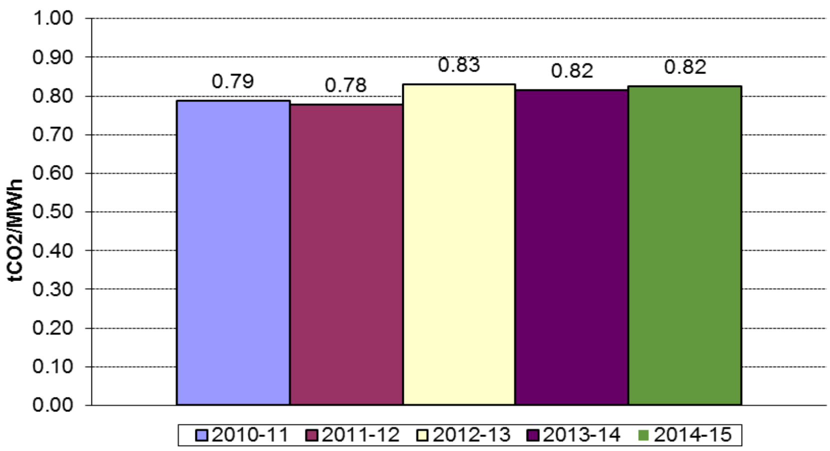
Table 12.3
Total Absolute Carbon Di-oxide Emissions of the power sector (2010-11 to 2014-15) in Mtonnes CO_2

	2010-11	2011-12	2012-13	2013-14	2014-15
India	598.35	637.8	696.5	727.4	805.4

Source: CEA CO_2 baseline database for the Indian power sector Ver 11.0 March 2016)

In the year 2014-15, the weighted average CO_2 emission rate from grid connected power stations (excluding captive power stations and stations on islands) is 0.82 $kgCO2/kWh_{net}$. During the year 2014-15, 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 12.4**.

Table 12.4

Weighted average specific emissions for fossil fuel-fired stations in FY 2014-15, in tCO_2/MWh_{net}

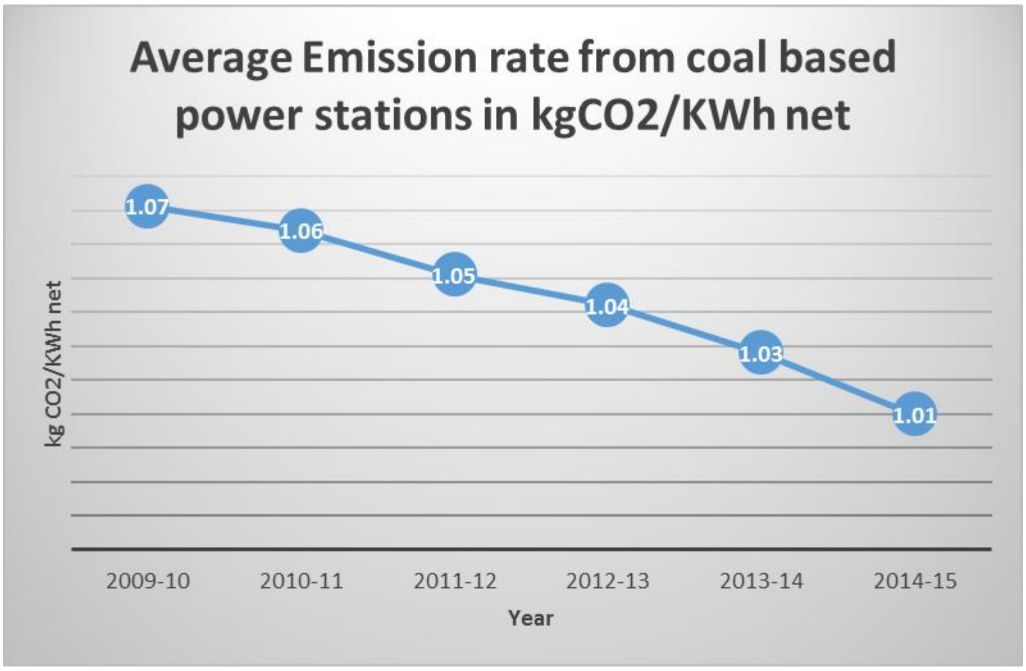
Coal	Diesel	Gas*	Lignite	Oil
1.01	0.58	0.49	1.35	0.64

* 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 1.01 kg CO_2/ kWh_{net} and 1.35 kg CO_2/ kWh_{net} respectively during the year 2014-15. 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 31 March 2016, 51 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 31 March 2016. It shows that about 6.073 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 12.5.**

Table 12.5

Impact of Supercritical technology based units on CO_2 emissions

A	Total Generation capacity added from Supercritical units as on 31.3.2016	34950 MW
B	Total actual gross generation from Supercritical units during 2015-16 in Million Units	164145.41 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 164145.41= 6.073 Million Tonnes

12.7 IMPACT ON CO_2 EMISSIONS DUE TO HUGE CAPACITY ADDITION FROM RENEWABLE ENERGY SOURCES.

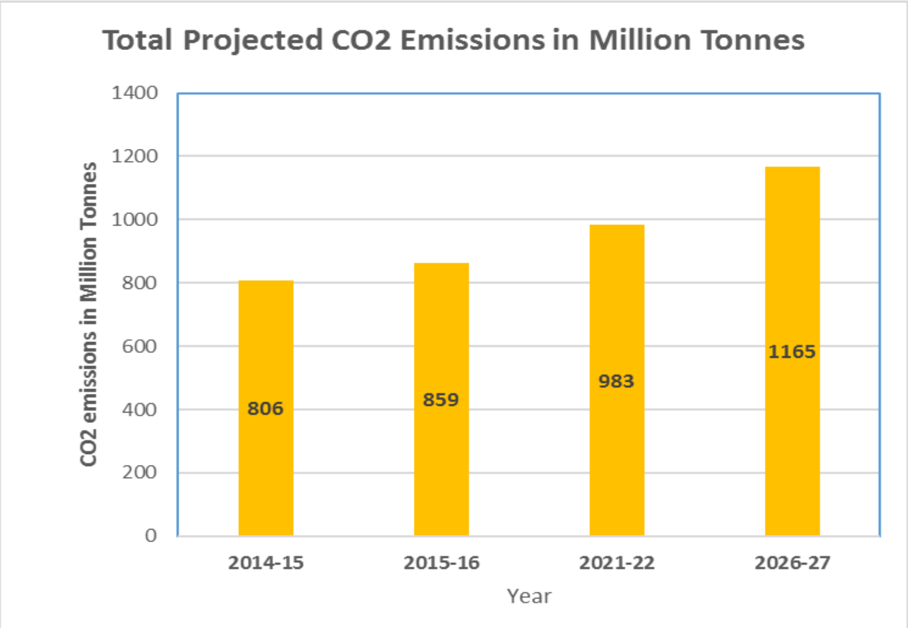
Government of India has announced a huge capacity addition from renewable energy sources by the year 2021-22. Target installed capacity of renewable energy sources is set at 1,75000 MW by the end of the year 2021-22 including 1,00,000 MW capacity from Solar and 60,000 MW from wind. 15000 MW has been planned to be 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

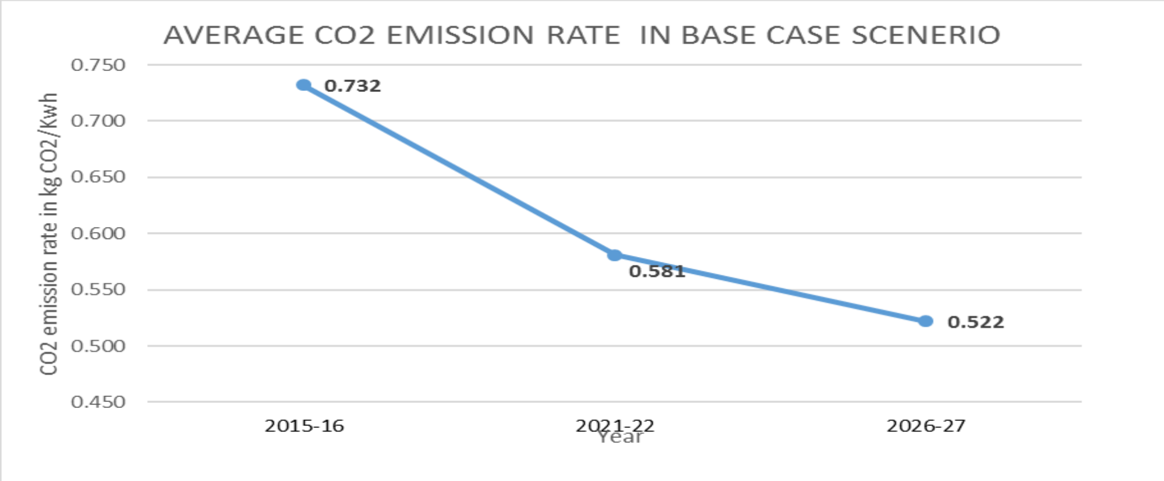
On the basis of generation from each fuel source including renewables, carbon footprint i.e. projected carbon emissions and the emission factors considering base year of 2014-15 have been worked out. The total CO_2 emissions projected will increase from 806 Million tonnes in 2014-15 to 983 Million tonnes in the year 2021-22 and 1165 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 0.581 kg CO_2/kWh in the year 2021-22 and to 0.522 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 CO2 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 recently in October,2015, India has 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 31.3.2016, share of non-fossil fuel based capacity (Hydro + Nuclear + RES) in the total installed capacity of the country is around 30 %. It is expected that the share of non-fossil based capacity will increase to 46.8% by the end of 2021-22 and will further increase to 56.5 % by the end of 2026-27. Details of expected installed capacity and % share is shown in **Table 12.6**.

Table 12.6

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	3,02,088	2,10,675	91,413	30.0%
March,2022	5,23,389	2,78,481	2,44,908	46.8%
March,2027	6,40,189	2,78,481	3,61,708	56.5%

** Non Fossil Fuel – Hydro, Nuclear and Renewable Energy Sources

Note: 1. Including 50,025 MW of Coal based capacity addition currently under construction and likely to yield benefits in 2017-22 and NO coal based capacity addition 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 983 Million tonnes by the end of 2021-22 and to 1165 Million tonnes by the end of year 2026-27.

Table 12.7 shows the emission intensity (kg CO_2/Rs GDP) in the year 2005 and expected emission intensity (kg CO_2/Rs 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 43 % by the end of 2021-22 and 53.96 % by the end of 2026-27 from the year 2005 level.

Table 12.7

CO_2 emissions Intensity from Power Sector

	Years		
	2005	**2022**	**2027**
Emission intensity kg/Rs GDP	0.0155479	0.0088617	0.0071577
% Reduction in emission intensity base 2005		43.00	53.96

12.11 CONCLUSIONS

1. Government of India has taken various measures to reduce environmental emissions from thermal power generation. This includes improving efficiency of power generation, notification of stricter environment norms and retiring old and inefficient plants, Perform Achieve and Trade scheme etc.
2. 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.
3. About 6.073 Million tonnes of CO_2 emissions have been saved due to commissioning of Supercritical technology based units.
4. 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.
5. Country has achieved Fly Ash Utilization of 102.54 Million tonnes with percentage utilization of 55.69 %.
6. Coal based power plants will face financial and technical issues in meeting the new environmental norms stipulated by MOEF & CC recently.

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 in the domain of CPSU's like BHEL, NTPC, NHPC, SJVNL and POWERGRID including under the MNRE, DST, R&D laboratories of CSIR and Academia (IITs, NITs and Engineering colleges) It is also pursued significantly by private sector companies, global R&D centres, etc. 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, 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 very high targets of capacity additions, particularly in solar 100000 MW and in wind and others by 75000 MW, adding to 175 GW of renewable energy have been announced by Government of India. These developments have given rise to new challenges and issues in the power sector. Some of these include:
- Integration of renewable energy with the Grid
- Impact of renewable energy generation on the existing and new coal fed generating stations,
- Transmission corridor for power generated from renewable sources

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 units and high voltage transmission lines necessitated the adoption of state of art of 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 and sustainably. 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 development. Hence a proactive policy approach for technology induction must be in place.

The in-house R&D arms of major CPSU's 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 has the role of identification of appropriate new technologies for the country. 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 (DUGJY) 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 CPRI, CSIR, DRDO, BARC and 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.

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 both 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 wind levels and sunlight, and so they are unavailable for long periods at a stretch and during this period, dependence would be exclusively on conventional power sources. Hence huge opportunities to improve the generation system, including aspects like better plant design, increasing efficiency, improvement in fuel quality and waste heat recovery. The following are the 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.

- **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 power 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%, leading to lower carbon emissions of 0.7 kg per kWh. 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 an 800 MWe Adv-USC Power Plant on a Mission Mode, as a collaborative project involving 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 and few experts in the country.

- **IGCC Technology**

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 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.

- **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 TG set using aqua-ammonia Cycle or Organic Rankine Cycle. (iv) Flue Gas Desalination of sea water (v) Flue Gas Blow cooling tower down recovery

- **Bulk ash utilization:**

Coal-based thermal power plants have been a major source of power generation in India where about 57% of the total power obtained is from coal-based thermal power plants. 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.

- **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 wear, 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) (ii) Silt erosion resistance of hydro parts.

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 cycling 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 modelling of sub and Supercritical boilers
- Development of Nano particles for application in high thermal coefficient lubricants, additives in water to reduce evaporation losses.
- AVR-PSS Tuning of Generators through Modelling and Simulation Studies
- Application of Synchro phasors for better power network stability
- Advanced NDT/NDE based diagnostics and inspection tools for condition assessment of plant components such as In-situ inspection of LP Turbine Blades by Ultrasonic Phased Array
- Design & development of Low Pressure Steam Turbine last stage blades through 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 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

- 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 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 AAS, XRD, IC, TOC, 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 DP, Ultrasonic tests, eddy current testing, video imaging, phased array testing, TOFD etc.
- Condition Monitoring and life assessment of high voltage transformers through dissolved gas analysis, PDC, 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. Slit erosion
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.

6. Integrated operation of cascade hydro power plants
7. Optimization studies for exploitation of hydro potential
8. Studies on benefits of pumped storage schemes in the Indian context for hybridization with the Renewable Schemes
9. Use of GIS/GPS
10. Numerical Flow Simulation using Computational Fluid Dynamics (CFD)
11. Technology for Spilt Runners/ Site Fabrication of Runners
12. Development of facilities for large size/weight casting and forging facilities
13. Development of Shaft Seal for Silty Water
14. Modernization of generators to increase efficiency
15. Variable speed drive for pumped storage schemes
16. Monitoring System for on-line measurement of Turbine Efficiency and Silt
17. Monitoring cavitation causing Erosion
18. Development of PTFE (Poly Tetra Fluoro Ethylene) material
19. Measures to tackle corrosion/erosion problems in acidic water
20. Construction Methodology for Arch Dams
21. RCC Dams - construction techniques and construction material
22. Measures to increase service life for silt flushing gates
23. Excavation of large size cavern with stabilization technology and soft rock tunneling
24. Measures to tackle bad geology in dam foundation and cut-off wall
25. Power generation technology assessment and development

26. Performance optimization of hydro plant components through Computational Fluid Dynamics approach

13.3 R&D IN TRANSMISSION

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 power. Due to the constraints in getting environmental clearances, and acquiring right of way, 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. Re-conducting of existing lines with High temperature and 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 addresses are: Design, development and testing of 220kV and 400kV towers and implementation in a utility as a pilot project.

Development of high temperature electrical conductors for transmission lines is essential, keeping in view of bulk power transfer. 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 keeping in view the current scenario. 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^{o}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 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 Alloy Aluminum 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 transmission.

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.

UHV DC +/- 800kV

Considering the implementation of next DC 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.

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 stability. The project envisages design, develop and deployment of 50MW 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.

Design and development of equipment for 1200kV UHV AC System

Power sector growth necessitates development of indigenous technology for absorption in to network at higher voltage levels, mainly to strengthen the system and power evacuation. The key equipment proposed for indigenous development: 1200kV sub-station, circuit breakers, shunt reactors and controlled shunt reactors for dynamic reactive power compensation. Development of High Energy (55MJ) ZnO blocks for lightning arrestor of class 5 duty is required for dissipation of high energy. Development of operating mechanism for 1200kV disconnector is essential in the light of UHV transmission system technology.

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, 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, 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.

Development of controllers for FACTS devices

Application of 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 shunts HVDC taps UPFC, IPFC, and STATCOM and deploy 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.

Automation

These studies are mainly “optimization studies” to make technology ready for future commercial implementation:

It is suggested to take up a pilot project by 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 IEDs at bay level etc. Integration of optical current transformers in place of conventional current transformer is also to be considered.

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/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.

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 SQL queries, (2) visual discovery tools to slice/dice data intuitively at the speed of thought. Some of the important topics for study should include the following:

Application & Features:

i. Advanced forecasting techniques for sustainable operations
    - Novel Forecasting Techniques
    - Advanced modelling tools
ii. Architectures & tools for operations
    - Self- Healing Grids
    - Control Methodologies for Sustainable self-aware services
iii. Simulators and training for operations of smart grids
iv. Transmission grids, real time security assessment
    - Innovative solutions to demands of real time security analysis
v. Prognostic Health Management in the Smart Grid.

Other major area of focus are mentioned below

- Real-time Power System Simulator
- Use of Space Technology
- Forecasting Grid Congestion for Transmission Grid Operation
- Transmission Towers with reduced Right of Way
- System Security and Operator Training

- Expansion Planning
- Transmission cost estimation
- Phase Measurement Units (PMUs)
- Nitrogen Injection Fire Prevention & Extinguishing System (NIFPES)
- Gas Insulated Transmission Lines
- 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 CRGO Silicon Steel for Transformer core
- High Quality Pressboard Insulation for transformers
- Resin Impregnated Paper Condenser bushing (RIP)
- 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 as the total power sector as a whole. The following areas need to be studied:

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 etc. High Voltage Distribution System 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 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 Unit's (RTU) and Fault Passage indicators (FPI's) 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 effort 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 charging, it is possible to factor in charges based on time-of-day and the ratio of peak energy to average energy consumption. This can have the effect of reducing the overhead of the power distributor. 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 of a 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 have guaranteed service, and do not need to use expensive gensets. 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 conditions and voltage collapse.

R&D in Solar Organic Polymer based Light Emitting Devices:

High power Silicon based light emitting diodes 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 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 back lighting of mobile phones.

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 need for electric power industry to look at other technologies of power generation through solar, wind, biomass, small hydro, fuel cells, geothermal etc.

Technologies related to wind, biomass, solar, small hydro, geo thermal, fuel cells, Waste to Energy (WtE) are need to be identified. Research focus is on grid connectivity of large wind mills, self-healing wind connected micro grids, distributed generation and large use of ethanol 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 PV 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 max 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 UAVs (Drone) & Li DAR 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.
11. Development of Centralized Solar PV Forecasting Solution

R&D in renewable energy includes different technologies which are listed below

- Integration of renewable energy with the power grid
- Uprising cost of storage in case of solar energy and wind power
- Bringing down the cost of solar PV cells and wind power generating
- O&M issues of renewable generations
- 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 gridding: 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 conditions 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.

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 power.
- 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, routers, blades, generator router, insulation, etc., for future applications with greater induction of solar 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 rational 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's fueled and how its requirements are managed, a Microgrid might run indefinitely. Microgrid connected to the grid at a point of common coupling 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

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 set to test battery powered inverters is developed. These inverters (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 THD on the EUT, a novel system is being developed, which is similar to an electronic Motor Generator set. This can also be deployed as a pulse width modulated power 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 Indian 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 infrastructure is highly required in India for carrying out extensive research in this area. Central Power Research Institute is a premier research institute of Ministry of Power, Govt. of India. Keeping in mind the existing infrastructure, expertise and the need of Indian Power sector, CPRI is an ideal choice for establishment of a micro grid research facility in India.

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. People did try to develop power line carrier communication separately riding purely on power lines itself. But it failed due to power network impedance issues. Power Grid was already planning to deploy fiber optic cable network along the entire transmission line across the country. It must be noted that electrical network is one the most widely dispersed networks along the length and width 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 last residence. These cables could be laid alongside HT cables and even 11 kV lines and down to 3 phase 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. 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 to modem or set top box interface modules- if not available, let it be indigenously developed. This will make the city/ town look neat without hanging wires, reduce road digging by multiple entities and bring in discipline- as no one really knows who has dug road where to lay what line.

Microwave towers are health risks too and result in RF radiation which is known to cause cancer in the long run. Also many companies are working on LIFI (Lighting based Field interface) as alternative to Wi-Fi. LEDs can also be used to carry signal information superposed on its powering current. Fluctuations in lumen output will not be noticeable. This was not possible with incandescent bulb or metal halide or sodium vapour lamps as bandwidth was 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 in the country accounting for about one half of the total emissions (MoEF, 2010). The share of the power sector CO_2 emissions in the total CO_2 emissions in India is higher than the global average of one-third. The main reason for such a high share is the power sector's heavy reliance upon coal.

There are various technologies and processes that have substantial potential to reduce GHG. Emissions, for instance, coal and biomass gasification technology; gas turbine technology; power generation with solar thermal and photovoltaic technology, fuel cells, etc. Clean coal technologies and renewable energy usage have been adopted by India as methods of best approach to discuss climate change.

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 appear to 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, or the use of imported coal. Retrofitting coal power plants with CO_2 capture technologies could be an option for the new coal power plants without CCS may be a good option for the country like India.

Developments of following technology ready methods are being tried:

1. Use of CO_2 for reduction in pH of ash water
2. CO_2 in 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 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 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 requirements which 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’S/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 VTs
- 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 400kV insulators
- Flashover test on 400kV insulators & 220kV 100MV X,

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 required are State Estimation, development of algorithm for optimal placement of PMU, calibration of Phasor Measurement Unit 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 need to gear up for performance tests as per IEEE C37.118.1, 2011, IEEE C37.118.1a, 2014, IEEE C37.242, 2013.

E) Tests for Power Equipment's/Apparatus

F) 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.

G) Electric Power Cables

- Establishment of Power cables laboratory for test facilities up to 750 kV.
- Up gradation of reactor module to 900 kV
- Setting up of Partial discharge laboratory for testing equipment rated up to 750 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.

H) Setting up of Superconducting Electrical apparatus laboratory for testing of transformers, motors, fault limiters etc.

I) Creation of facilities for testing and evaluation of Cryogenic systems for HTS based power apparatus like, Superconducting Magnetic Energy Storage devices, motors transformers etc.

J) EVALUATION OF CONDUCTORS

- Creep test (elevated temperature)
- Sag Tension Performance as per PGCIL standard
- Temperature Cycle test
- Stress-Strain test on Stranded Conductor and Core at elevated temperature as per PGCIL standard
- High Temperature Endurance & Creep test on Stranded Conductor as per PGCIL standard

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 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 National 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 R&D systems to 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 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

(i) 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 learning's as we migrate to higher and higher 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.

(ii) Need for creation of globally recognized 'Centres of Excellence' under national mission:

There is a need to identify the 'R&D needs' of the various sectors and various stake holders, and create 'Centres of Excellence' across the nation at various selected organizations on 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 IPRs, 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'.

(iii) National R&D programmes

The two national R&D programs of the Ministry Of Power, RSOP and NPP, administered through CPRI 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 the 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.

(iv) **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.

(v) **'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 build 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.

(vi) **Intellectual Property Management (IPR) 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.

(vii) 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.

(viii) 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 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.

(ix) 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.

(X) 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:

(xi) 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.

(xii) 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 when necessary
- In addition to subsidizing electricity through low tariffs, policy should support and subsidize purchase of energy efficient appliances

(xiii) Institutional and funding framework for R&D

Government should fund the R&D programme through schemes such as National Perspective Plan (NPP), Research Scheme on Power (RSoP). Some of them can be in collaborative mode with participation from CPSU's, 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 PAT by PSU's as part of 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:

1. Preparation of a well-defined R&D Vision and Policy document clearly highlighting the R&D plan for the next decade.
2. Enhance Delegation of Power to R&D division to improve the performance and delivery of the system.
3. 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.

4. Consideration of R&D projects of national importance that require serious intellectual and financial resource as National Mission projects with funding from Government.

5. Creation of ecosystems where MNC's, industry associations and professional societies may work in tandem in different R&D Programs of the nation to compliment schemes like "Make in India", Startup India", "Power for all" and help in creation of more jobs.

6. Creation of 'National Registry of experts & expertise' in various areas by competence mapping.

7. Creation of Centers of Excellence (CoE) in identified areas to take up application oriented research projects.

8. Establishment 'Power Academy' or 'CPRI Academy' to enhance the knowledge base of fresh and experienced engineers which will also serves as a 'finishing school' for young engineers and as 'refresher training centre' for middle level management.

9. 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.

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 with transmission and distribution infrastructure.

Manpower development including training facilities require commensurate upgradation with this capacity addition requirement. Further, 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 Norms considered for calculation of Manpower requirement

The norms considered for calculating manpower requirement for the years 2012-17, 2017-22 and 2022-27 are given in **Table 14.1**. The norms have been taken from Report of Sub-Group 9 on HRD and Capacity Building for Working Group on Power for 12th Plan.

Table 14.1
Norms for Manpower

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 10 MVA (33/11KV S/S)	

*** for generation, manpower in person/MW**

14.1.2 Manpower availability in 2012-17

The Capacity addition for 12th Plan (2012-17) is expected at about 1,36,400 MW (Conventional of 1,01,645 MW + Renewable of 34,755 MW). The total manpower by the end of 12th Plan (2012-17) shall be of the order of 1558.81 thousand out of which 1186.33 thousand will be technical and 372.48 thousand will be non-technical. Details are shown in **Table 14.2**.

Table 14.2

Total likely Manpower Available at the end of 2012-17

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal ***	174.82	57.98	**232.80**
2	**Hydro**	49.37	19.30	**68.67**
3	**Nuclear**	10.03	4.56	**14.60**
4	**Power System**			
	Transmission	27.36	8.74	**36.10**
	Distribution	924.75	281.89	**1206.65**
	Total	**1186.33**	**372.48**	**1558.81**

*** including Renewable Energy Sources**

14.1.3 Manpower requirement during the years 2017-22

A capacity addition of 1,87,821 MW has been considered (including renewables of 1,15,326 MW and 50,025 MW thermal plants already under construction and likely to yield benefit during 2017-22) during the years in 2017-22. Details are given in **Table 14.3**.

Table 14.3

Targeted Capacity addition during 2017-22

Particulars	Total (MW)
Thermal (Coal under construction – 50,025MW+Gas =4340 MW)	54365
Hydro	15330
Nuclear	2800
Sub-Total Conventional	72495
Renewable(Solar-81237, Wind-29034, Biomass-4553, SHP-502)	115326
Total	**187821**
Transmission system capacity addition Ckt/km **MVA capacity addition**	**62800 Ckt/km** **128000 MVA**
Distribution capacity addition (33/11 KV SS)	**110,000 MVA**

Manpower available during 2017-22 after considering 20% reduction due to retirement, death, change of profession etc. @ 4% per year is given in **Table 14.4.**

Table 14.4

Manpower available** during 2017-22

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation***	139.86	46.38	**186.24**
2	**Hydro Generation**	39.49	15.44	**54.93**
3	**Nuclear**	8.03	3.65	**11.68**
4	**Power System**			
	Transmission	21.89	6.99	**28.88**
	Distribution	739.80	225.52	**965.32**
	Total	**949.06**	**297.98**	**1247.05**

*Including Renewable Energy Sources

** After 20% reduction due to retirement, death, change of profession etc. @ 4% per year

Manpower recouped considering 7.5% Manpower recouped due to decommissioning @ 1.5% per year are shown in **Table 14.5.**

Table 14.5

Manpower recouped during 2017-22**

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation***	13.11	4.35	**17.46**
2	**Hydro Generation**	3.70	1.45	**5.15**
3	**Nuclear**	0.75	0.34	**1.09**
4	**Power System**			
	Transmission	2.05	0.66	**2.71**
	Distribution	69.36	21.14	**90.50**
	Total	**88.97**	**27.94**	**116.91**

*Including Renewable Energy Sources

** 7.5% Manpower recouped during 2017-22 due to decommissioning @ 1.5% per year

Total Manpower available during 2017-22 after considering retirement and recouping are shown in **Table 14.6.**

Table 14.6

Manpower available during 2017-22 after considering retirement and recouping (Table 14.4+Table14.5)

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation***	152.97	50.73	**203.70**
2	**Hydro Generation**	43.20	16.89	**60.08**
3	**Nuclear**	8.78	3.99	**12.77**
4	**Power System**			
	Transmission	23.94	7.65	**31.59**
	Distribution	809.16	246.66	**1055.81**
	Total	**1038.04**	**325.92**	**1363.96**

*Including Renewable Energy Sources

The additional manpower requirement shall be of the order of 269.20 thousand out of which 206.83 thousand will be technical and 62.37 thousand will be non-technical. Details are given in **Table 14.7**.

Table 14.7

Additional Manpower required due to Envisaged Capacity Addition of 187821 MW in 2017-22 Plan and HV, EHV & UHV Transmission Line Lengths of about 62,800 Ct.kms and an estimated 8.01 Crores Distribution Consumers

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation**	26.42	7.83	**34.25**
2	**Renewable Generation**			
	Solar	44.68	13.40	**58.08**
	Wind	9.32	2.79	**12.11**
	Biomass	2.21	0.66	**2.87**
3	**Small Hydro**	0.67	0.20	**0.88**
4	**Hydro Generation**	20.56	6.21	**26.77**
5	**Nuclear**	3.07	1.31	**4.38**
6	**Power System**			
	Transmission	3.43	1.20	**4.63**
	Distribution	96.46	28.94	**125.40**
	Total	**206.83**	**62.37**	**269.20**

* As per MNRE it is estimated that 91114 semi skilled persons (below ITI/Technician level) are also additionally employed in Solar, who have not been accounted for.

The total manpower by the end of 2017-22 shall be 1633.15 thousand, out of which 1244.87 thousand will be technical and 388.28 thousand will be non-technical. Details are given in **Table 14.8.**

Table 14.8
Total Likely Manpower at the end of 2017-22

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation**	236.28	75.61	**311.89**
2	**Hydro Generation**	63.75	23.10	**86.85**
3	**Nuclear**	11.85	5.30	**17.16**
4	**Power System**			
	Transmission	27.37	8.85	**36.22**
	Distribution	905.62	275.60	**1181.21**
	Total	**1244.87**	**388.28**	**1633.15**

Note: Inclusive of manpower for O&M of RES added for the period 2017-22 for Technical is 56.89 thousand and Non-Technical is 17.05 thousand.

14.1.4 Manpower requirement during the years 2022-27

A capacity addition of 1,16,800 MW has been considered (including 16,800 MW from conventional energy sources and renewables of 100,000 MW during the 2022-27. Details are given in **Table 14.9**.

Table 14.9
Targeted Capacity Addition during 2022-27

Particulars	Total(MW)
Thermal*	0
Hydro	12000
Nuclear	4800
Sub-Total Conventional	**16800**
Renewable	**100000**
Total	**116800**
Transmission system capacity addition ckt/km **MVA capacity addition**	**62800 ckm** **128000 MVA**
Distribution capacity addition (33/11 KV SS)	**110,000 MVA**

*Addition of 50,025 MW already considered during 2017-22 therefore requirement of 44,085 MW from coal based stations during 2022-27 not considered.

Manpower available during 2022-27 after considering 20% reduction due to retirement, death, change of profession etc. @ 4% per year is given in **Table 14.10.**

Table 14.10

Manpower available for the 2022-27**

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation**	189.02	60.49	**249.51**
2	**Hydro Generation**	51.00	18.48	**69.48**
3	**Nuclear**	9.48	4.24	**13.72**
4	**Power System**			
	Transmission	21.90	7.08	**28.98**
	Distribution	724.49	220.48	**944.97**
	Total	**995.90**	**310.63**	**1306.52**

*Including Renewable Energy Sources

* considering 20% reduction (due to retirement, death, change of profession etc. @ 4% per year

Manpower recouped considering 7.5% Manpower recouped due to decommissioning @ 1.5% per year are shown in **Table 14.11.**

Table 14.11

Manpower recouped during 2022-27

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation**	17.72	5.67	**23.39**
2	**Hydro Generation**	4.78	1.73	**6.51**
3	**Nuclear**	0.89	0.40	**1.29**
4	**Power System**			
	Transmission	2.05	0.66	**2.72**
	Distribution	67.92	20.67	**88.59**
	Total	**93.37**	**29.12**	**122.49**

*7.5% Manpower recouped during 2022-27 due to decommissioning @ 1.5% per year

Total Manpower available during 2022-27 after considering retirement and recouping are shown in **Table 14.12.**

Table 14.12

Manpower available during the 2022-27

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation**	206.74	66.16	**272.90**
2	**Hydro Generation**	55.78	20.21	**75.99**
3	**Nuclear**	10.37	4.64	**15.01**
4	**Power System**			
	Transmission	23.95	7.74	**31.69**
	Distribution	792.41	241.15	**1033.56**
	Total	**1089.26**	**339.75**	**1429.01**

*Including Renewable Energy Sources

* considering retirement of 20% and 7.5% recouping etc. (Table 14.11 + Table 14.12)

The additional manpower requirement shall be of the order of 220.41 thousand out of which 169.02 thousand will be technical and 51.39 thousand will be non-technical and are shown in **Table 14.13.**

Table 14.13

Additional Manpower required in 2022-27

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation#**	0.00	0.00	**0.00**
2	**Renewable**			
	Solar	27.50	8.25	**35.75**
	Wind	12.84	3.84	**16.68**
	Biomass	3.40	1.01	**4.41**
	Small Hydro	4.02	1.22	**5.24**
3	**Hydro Generation**	16.09	4.86	**20.95**
4	**Nuclear**	5.27	2.25	**7.52**
5	**Power System**			
	Transmission	3.43	1.20	**4.63**
	Distribution	96.46	28.94	**125.40**
	Total	**169.02**	**51.39**	**220.41**

#Manpower required for operationalizing 50,025 MW Thermal in 2017-22 would be utilized in 2022-27.

The total manpower by the end of 2022-27 shall be 1649.41 thousand, out of which 1258.28 thousand will be technical and 391.13 thousand will be non-technical. Details are given in Table 14.14.

Table 14.14

Total Manpower available at the end of 2022-27

(Figures in Thousand)

S No	Particulars	Technical	Non-Technical	Total
1	**Thermal Generation**	254.51	80.47	**334.98**
2	**Hydro Generation**	71.88	25.07	**96.94**
3	**Nuclear**	15.64	6.89	**22.53**
4	**Power System**			
	Transmission	27.38	8.94	**36.32**
	Distribution	888.87	270.09	**1158.96**
	Total	**1258.28**	**391.13**	**1649.41**

Note: Inclusive of manpower for O&M of RES added for the period 2022-27 for Technical is 47.77 thousand and Non-Technical is 14.31 thousand.

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 i.e. graduation, diploma pass out of Industrial Training Institutes (ITI), there are sufficient number of students passing out each year. However, the skill sets required for the power sector in few areas does not match with the needs of the industry.

Table 14.15

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	0.40	0.25
Management	3364	3.54	17.70	-	-
Polytechnics	3436	11.35	56.75	0.23	0.22
ITI	11964	16.92	84.60	0.86	0.74
Total	**22148**	**48.15**	**240.75**	**1.49**	**1.21**

From the **Table 14.15** 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.

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 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.

- **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 34,755 MW of Renewable Energy in the 2012-17 and 1,15,326 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, Top Level 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 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 regular 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 spheres 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 updated with 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 from 1.5% to 5% of the annual salary budget.

14.3.3 Training Infrastructure Requirements vis-à-vis Availability

Training Load

Training requirement for 2017-22 & 2022-27 have been worked out with the following assumptions and are given in **Table 14.16 and Table 14.17.** Details of simulator training infrastructure requirement are given in **Table 14.18** and **Table 14.19**.

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 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 to Technical & non-Technical is considered a must in the power sector.

iii) Minimum one-week training (Refresher/Managerial) every year for all technical and non-technical personnel in line with National Training Policy for Power Sector.

Table 14.16

Classroom Training Infrastructure Requirement vs Availability for 2017-22

(For O&M of Generating Projects and T&D system as per CEA norms)

(Infrastructure in Thousand-Man-Weeks/Year)

S No	Area	Training Load/ Classroom Infrastructure required	Classroom Infrastructure available	Deficit (-)	Cost (Rs Crs)
TECHNICAL					
1	**Thermal (O&M)**	**55.09**	**255.64**	**-**	**-**
	Engineers	30.44	133.66	-	-
	Operators	4.44	34.35	-	-
	Technicians	20.21	87.64	-	-
2	**Hydro (O&M)**	**38.03**	**31.72**	**-10.35**	**119.43**
	Engineers	28.78	18.43	-10.35	119.43
	Operators	2.06	2.75	-	-
	Technicians	7.20	10.54	-	-
3	**Nuclear**	**-**	**-**	**-**	**-**
3	**Power System**				
	Transmission	**4.31**	**45.13**	**-**	**-**
	Engineers	2.07	11.14	-	-
	Operators	1.87	6.15	-	-
	Technicians	0.37	27.84	-	-
	Distribution	**43.02**	**20.71**	**-22.31**	**257.48**
	Engineers	8.30	4.04	-4.26	49.11
	Operators	7.72	5.19	-2.53	29.20
	Technicians	27.01	11.48	-15.53	179.16
	Total	**140.45**	**353.20**	**-32.66**	**376.91**

Table 14.17

Classroom Training Infrastructure Requirement vs Availability for 2022-27

(For O&M of Generating Projects and T&D system as per CEA norms)

(Considering 10% increase in infrastructure from the previous Plan)

(Infrastructure in Thousand-Man-Weeks/Year)

S No	Area	Training Load/ Classroom Infrastructure required	Classroom Infrastructure available	Deficit (-)	Cost (Rs Crs)
TECHNICAL					
1	**Thermal (O&M)**	**0.00**	**281.21**	**-**	**-**
	Engineers	0.00	147.02	-	-
	Operators	0.00	37.78	-	-
	Technicians	0.00	96.40	-	-
2	**Hydro (O&M)**	**29.77**	**34.89**	**-2.26**	**26.03**
	Engineers	22.53	20.27	-2.26	26.03
	Operators	1.61	3.02	-	-
	Technicians	5.63	11.59	-	-
3	**Nuclear**	**-**	**-**	**-**	**-**
3	**Power System**				
	Transmission	**4.31**	**49.65**	**-**	**-**
	Engineers	2.07	12.25	-	-
	Operators	1.87	6.77	-	-
	Technicians	0.37	30.63	-	-
	Distribution	**43.02**	**22.78**	**-20.24**	**233.58**
	Engineers	8.30	4.44	-3.85	44.45
	Operators	7.72	5.70	-2.01	23.22
	Technicians	27.01	12.63	-14.38	165.92
	Total	**77.10**	**388.52**	**-22.5**	**259.61**

Table 14.18

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)	Cost (Rs Crs)
1	Thermal	5.81	4.80	-1.02	8.67
2	Hydro	3.08	0.45	-2.63	11.97
	Total	**8.90**	**5.25**	**-3.65**	**20.64**

NPTI is already in the process of procuring multi-functional Simulators at six (6) of its institutes and therefore, this additional expenditure may not required

Table 14.19

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)	Cost (Rs Crs)
1	Thermal	0.00	5.28	-	-
2	Hydro	2.41	0.50	-1.92	8.72
	Total	**2.41**	**5.77**	**-1.92**	**8.72**

(Considering 10% increase in infrastructure)

NPTI is already in the process of procuring multi-functional Simulators at six (6) of its institutes and therefore, this additional expenditure may not 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 140.45 thousand-man-weeks per year for 2017-22 and 77.10 thousand-man-weeks per year for the 2022-27. The infrastructure available for class-room training for engineers, supervisors and operators has been estimated as 353.20 thousand-man-weeks per year for 2017-22 and 388.52 thousand -man-weeks per year for 2022-27 considering 10% increase in infrastructure. Therefore, there is a small deficit of 10.35 & 2.26 thousand-man-week in O&M Training of Hydro Sector Engineers for 2017-22 and 2022-27 respectively. In the distribution sector the infrastructure requirement for class-room training for engineers, supervisors and operators has been calculated as 43.02 thousand-man-weeks per year for 2017-22 and 2022-27.The infrastructure available for class-room training for engineers, supervisors and operators for distribution sector has been estimated as 20.71 and 22.78 thousand-man-weeks per year for 2017-22 and 2022-27 respectively. Therefore, there is deficit of 22.31 and 20.24 thousand-man-weeks per year for 2017-22 and 2022-27 respectively considering 10%increase in infrastructure for 2022-27.

The cost of setting up a new institute, which can accommodate 100 trainees or augmenting an existing Institute is Rs. 60 crore approximately excluding cost of land. This would provide training equivalent to 5.2 thousand-man-weeks per year. The new infrastructure to be created should broadly include the following:

(i) Construction of Building which shall include Class-rooms, Office Chambers of Faculty, Conference Rooms, various Labs., Computer Labs., Audio-visual equipments, Library, etc.
(ii) Construction of Hostels for accommodating trainees.
(iii) Staff Quarters etc.

Therefore, to create the infrastructure required to cater to the training load deficit of 32.66 thousand-man-weeks per year during 2017-22, an investment of Rs. 376.91 crore shall be required, which is equivalent to setting up of 7 new Institutes or augmenting the existing Institutes as per the courses conducted and needs of the region.

It has been seen that about 74 institutes recognized by CEA are functioning in the power sector across the country. Apart from these institutes, companies like L&T, ABB, Siemens etc. have set up training institutes to meet their local and customer focussed requirements.

Instead of creating a new infrastructure, it is recommended that these 74 CEA recognized institutes may be augmented with all required facilities with the necessary infrastructure in place to train Thermal, Hydro and in particular T&D personnel and also to meet the requirements of Renewable Energy Sources. This would make available training in all areas to the concerned. It may be noted here that two (2) more Training Institutes are already coming up under the auspices of NPTI in Kerala & Madhya Pradesh.

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 4.80 thousand-man-weeks per year. The infrastructure requirement has been calculated as 5.81 thousand-man-weeks per year for the 2017-22. Therefore, there is small deficit of 1.02 thousand-man-weeks in Thermal simulator infrastructure.

The cost of setting up a new simulator is Rs. 6.00 crore approximately. 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 1.02 thousand-man-weeks per year during the 2017-22, the simulator infrastructure cost has been calculated as 8.67 crore. Thus, 02 simulators are required to meet the training requirement. No funding is required in this respect as NPTI is already in the process of acquiring a few Thermal 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 3.08 thousand-man-weeks per year for the 2017-22 and 2.41 thousand-man-weeks per year for the 2022-27. Therefore, there is a deficit of 2.63 thousand-man-weeks per year for the 2017-22 and 1.92 thousand-man-weeks per year for 2022-27 considering 10% increase of Simulator infrastructure for 2022-27.

The cost of setting up a new Simulator is Rs. 4.00 crore approximately. Considering a batch size of 10 and total number of 44 batches in a year, one training simulator can provide 0.88 thousand-man-weeks in a year. Therefore, to create the Simulator infrastructure required for deficit training requirement of 2.63 thousand-man-weeks per year during the 2017-22, the simulator infrastructure cost has been calculated as Rs. 11.97 crore. Thus, 03 Simulators are required to meet the training requirement. No funding is required in this respect as NPTI is already in the process of acquiring a few multi-functional Simulators at its various institutes.

1

14.4.4 Funding for Training

To create the infrastructure required to cater to the training load deficit of 32.66 thousand-man-weeks per year during 2017-22, an investment of Rs. 376.91 crore shall be required, which is equivalent to setting up of 7 new Institutes or augmenting the existing Institutes as per the courses conducted and needs of the region.

It has been seen that about 74 institutes recognized by CEA are functioning in the power sector across the country. Apart from these institutes, companies like L&T, ABB, Siemens etc. have set up training institutes to meet their local and customer focussed requirements.

Instead of creating a new infrastructure it is recommended that these 74 CEA recognized institutes may be augmented with all required facilities with the necessary infrastructure in place to train Thermal, Hydro and in particular T&D personnel and also to meet the requirements of Renewable Energy Sources. This would make available training in all areas to the concerned. It may be noted here that two (2) more Training Institutes are already coming up under the auspices of NPTI in Kerala & Madhya Pradesh.

14.5 RECOMMENDATIONS

a. It is proposed that all Central Sector Utilities, all State Sector Utilities and all IPPs should provide O&M training as per the norms stipulated in notification of September 2010 issued by CEA.

b. CEA recognized Training Institutes spread all across the country, may be strengthened with Distribution/Lineman training along with training in renewables such as Solar, Wind, Small Hydro etc. for Training in these areas to all concerned.

c. The following options are available to strengthen training: -

- All organizations as per National Training Policy should allocate training budget between 1.5% to 5% of annual salary budget.

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.

(1) 12TH PLAN CAPACITY ADDITION

i) In the 12th Plan, likely capacity addition from conventional sources as per review carried out as on 31.3.2016 will be 1,01,645 MW against a target of 88,537 MW. This is about 115% 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 is likely to be considerable slippage in capacity addition in respect of Hydro and Nuclear (Hydro – 5,601MW and Nuclear -2,800 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 is likely to contribute around 39% of the total capacity addition from coal based plants.

v) R&M/LE works in respect of 29 Nos. thermal units with aggregate capacity of 4,192 MW have been completed during 12th Plan up to 31.03.2016. During 12th Plan, a total of 22 hydro R&M schemes having an installed capacity of about 3,042 MW is expected to accrue benefit of about 567 MW through uprating, life extension and restoration.

vi) A capacity addition of 17,930 MW from Renewable Energy Sources has been achieved during the first four years of 12th Plan.

vii) Largest ever wind power capacity addition of 3,300 MW has been achieved in 2015-16. This has exceeded the target by 38%. Also India has registered highest ever yearly solar power capacity addition of 3,019 MW in 2015-16 exceeding target by 116%.

(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) Incremental energy savings during the year 2016-17, 2021-22 and 2026-27 is estimated to be 26 BU, 137 BU and 204 BU respectively over the year 2015-16. This will result in reduction in both Electrical Energy Requirement (BU) and Peak Demand (MW).

iii) A uniform approach for formulation of DSM regulations 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.

(3) DEMAND PROJECTIONS

i) The projected Peak Demand is 235 GW and Energy requirement is 1,611 BU at the end of 2021-22. This is around 17% and 15.4 % lower than the corresponding projections by 18th EPS report. Similarly, the projected Peak Demand is 317 GW and Energy requirement is 2,131 BU at the end of 2026-27 which is around 20.7% and 21.3 % lower than the corresponding projections by 18th EPS report.

The power demand projections for planning capacity addition requirement in the years 2021-22 and 2026-27 are as follows:

Year	Energy Requirement (BU*)	Peak Demand (GW*)
2021-22	1,611	235
2026-27	2,131	317

*Net of DSM measures

ii) 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.**

iii) The Report of 19th Electric Power Survey Committee is likely to be submitted shortly. Changes, if any, in demand projections will be suitably incorporated while finalizing the National Electricity Plan.

(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 15,330 MW has been considered during 2017-22 based on assessment of progress of actual status of the projects. Nuclear capacity of 2,800 MW during 2017-22 has been considered for planning studies as per the information furnished by DOAE. Gas based capacity of 4,340 MW has been considered based on the projects already ready for commissioning or under construction. No additional gas based power plants has been considered during 2017-22 in view of acute natural gas shortage in the country.

(ii) Considering capacity addition from Gas – 4,340 MW, Hydro 15,330 MW, Nuclear - 2800 and RES – 1,15,326 MW as committed capacity during 2017-22 and likely capacity addition of 101,645 MW from conventional sources during 12th plan and projected demand for the year 2021-22, the study result reveals that no coal based capacity addition is required during the years 2017-22. However, a total capacity of 50,025 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 1,87,821 MW.

(iii) 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.

(iv) 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 capacity addition involving various concerned ministries like MOP, MNRE, Department of Atomic Energy (DOAE) etc. needs to be adopted.

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 4,800 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) The study result for the period 2017-22 indicated that no coal based capacity addition is required. Considering this as input for the studies for the period 2022-27 and committed capacity addition of Nuclear -4,800 MW, Hydro-12,000 MW and RES 100,000 MW during 2022-27 and demand projections for the year 2026-27, study for the period 2022-27 reveals that a coal based capacity addition of 44,085 MW is required. However, as coal based capacity of 50,025 MW is already under construction which is likely to yield benefits during 2017-22, this coal based capacity would fulfil the capacity requirement for the years 2022-27.

iii) It is expected that the share of non-fossil based installed capacity (Nuclear + Hydro + Renewable Sources) will be increased to 46.8 % by the end of 2021-22 and will further increase to 56.5 % by the end of 2026-27 considering capacity addition of 50,025 MW coal based capacity already under construction and likely to yield benefits during 2017-22 and No coal based capacity addition during 2022-27.

iii) Study for the period 2022-27 has also been carried out by considering low hydro capacity addition of 11,788 MW in the years 2017-22 (plants already under construction) and 5,000 MW during the years 2022-27. Study reveals that a coal based capacity addition of 50,025 MW is required. However, as coal based capacity of 50,025 MW is already under construction which is likely to yield benefits during 2017-22, this coal based capacity would fulfil the capacity requirement for the years 2022-27 even in case of low hydro scenario.

(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 a comprehensive 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. The market mechanism through regulatory intervention needs to be evolved so that the owners of thermal plants are able to recoup the investment and at the same time, customers are not unnecessarily burdened with high tariff.

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.

6) FUEL REQUIREMENTS

i) For the year 2016-17, coal based generation programme of 921 BU during 2016-17 has been estimated in consultation of the power utilities with estimated growth of 6.9%. The total coal requirement of 600 MT for the power plants has been estimated considering normal monsoon year during the year 2016-17.

ii) No power plant has reported generation loss due to coal shortage during the year 2015-16.

iii) The total coal requirement in the year 2021-22 and 2026-27 has been estimated as 727 MT (Scenario – I with 175 GW installed capacity from RES by 2021-22) and 901 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.

iv) Adequate coal is expected to be available for the coal based power plants during 2021-22 and 2026-27.

v) Against a total domestic natural gas allocated to power plants of 87.46 MMSCMD, the average natural gas supplied to these gas based power plants during the year 2015-16 was only 28.26 MMSCMD**.**

vi) It has been estimated that the gas based power stations shall need atleast 53.56 MMSCMD of gas to meet the balancing requirement of the grid.

vii) 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.

viii) 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.

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 all the more felt with the rapid capacity addition in RES. 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 13 no. of PSPs with a total installed capacity of 7,365 MW. However, of these only 9 no. of PSP having IC of 4,786 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. PSP is an effective tool for grid management in the hands of the system operators. 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 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.

8) RENEWABLE ENERGY

i) India has achieved a total installed capacity of 42,849.38 MW from Renewable Energy Sources as on 31.03.2016.

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.

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,pPort 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 in detail and work out an optimized framework of site preparation, T&P requirements etc. for overall improvement in project execution.

10) FUND REQUIREMENTS

i) The total fund requirement for capacity addition is estimated to be Rs.10,33,375 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 Rs. 6,05,965 crores for the period 2022-27 and does not include advance action for projects coming up during the period 2027-2032.

11) ENVIORNMENT

i) The total CO_2 emissions projected for the year 2021-22 and 2026-27 is 983 Million tons and 1165 Million tons respectively.

ii) The current (2015-16) average emission factor from grid connected power stations is 0.732 kg CO_2/kWh. It is expected to reduce to 0.581 kg CO_2/kWh by the end of year 2021-22 and to 0.522 kg CO_2/kWh by the end of 2026-27.
iii) Emission intensity kgCO_2/GDP(Rs) from grid connected power stations is likely to reduce by 43 % by the end of 2021-22 and 53.96 % by the end of 2026-27 from the year 2005 level.

iv) It is estimated that 6.073 Million tonnes of CO_2 emissions have been avoided during the year 2015-16 due to commissioning of Super-critical technology based coal power plants. The estimate is based on commissioning of sub critical technology based units under BAU (Business as Usual) scenario.

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 55.69% of fly ash utilisation in the years 2014-15. In terms of absolute value, the same stands at 102.54 million tonnes.
viii) Coal based power plants may face a host of issues like financial, technical etc. in meeting the new environmental norms stipulated by MOEF&CC recently. Detailed unit-wise feasibility study covering all factors like technology, investment, time frame, suitability in Indian context etc. may be carried out.

12) R & D in POWER SECTOR

i) 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.

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 and schedule for providing O&M training 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 each organization should allocate training budget between 1.5% to 5% of annual salary budget. Training infrastructure for distribution could be funded.