Energy transition in India

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Strategic Transition

1. Low Carbon Development of Electricity Systems
2. Develop an Integrated, Efficient, Inclusive, Low-Carbon Transport System
3. Promoting Adaptation in Urban Design, Energy and Material-Efficiency in Buildings, and Sustainable Urbanisation
4. Promoting economy-wide decoupling of growth from emissions and development of an efficient, innovative, low-carbon industrial system
5. CO2 Removal and Related Engineering Solutions
6. Enhancing Forest and Vegetation Cover
7. Economic and Financial Aspects of Low-Carbon Development and Long-Term Transition to Net-Zero by 2070

Clean Energy Transition

Recognize all sources, options and commercially viable technologies, along with new innovations that can help in a time-bound manner in achieving a clean energy transition.

- Expansion of solar, hydro and wind capacities
- Increase share of energy from waste and biomass
- More nuclear power capacities addition
- Flexibilisation of coal based plants
- Energy storage system- PSP, BESS
- Carbon capture utilization and storage (CCUS) technologies in coal based plants
- Ammonia co-firing with coal

Green hydrogen is likely to play a significant role in decarbonizing energy use in many of the emission intensive industries.

Zero Emission Vehicles (ZEVs) and biofuels also offer a promising potential to transition the sector away from fossil fuels.

Advances in battery technology, mass manufacturing, and development of related infrastructure are critical for fast-tracking the transition in transportation sector.

Research and Innovation

Innovative Technologies in Energy Sector

- Development of Bio-Based Clean Energy Innovations
- Development of Carbon Dioxide Removal Technologies
- Energy Storage Systems
- Hydrogen Economy
- Development of Biomass-to-Liquids Fuel Production
- Commercialization and Initiatives of Cellulosic Ethanol
- Waste Heat Recovery Systems for Utilizing the Flue Gas
- Integrated Gasification Combined Cycle (IGCC) Technology

Innovative Technologies in Industrial Systems

- Low-carbon development of the industrial sector
- Aviation Industry
- Steel and Cement Industry

Policies and Programme

a) **Ambitious RE targets**

b) **'Must-run' priority dispatch status for renewables:** Preference is given to RE power in the merit order despatch, despite costs,

c) **Renewable Purchase Obligations (RPO):** These are obligations for the purchase of RE power, specified by State Electricity Regulatory Commissions for distribution companies, open access consumers and captive plants.

d) **Promotion of Hydro Power**: This is being undertaken through several policy measures to tap hydro power potential in the country, including the introduction of Hydro Purchase Obligation.

e) **Energy Storage Obligations**: These are being progressively introduced. However, their expansion will depend on decreasing cost of storage technologies, transfer of this type of technology and concessional finance.

f) **Green energy corridors:** These are being developed to strengthen transmission networks in eight RE rich States.

g) **Policy and financial incentives**: These include solar park development, accelerated depreciation on investment, waiver on transmission charges, and capital subsidy for residential solar roof-top.

h) **Thrust to increase nuclear installed capacity.**

i) **Agricultural solar pumps are being promoted .** The consumption of energy in the agriculture sector is an important aspect to ensure the food security aspect of the country and the globe, as large energy consumption is required for irrigation pumps.

Policies and Programme

j) **Manufacturing support** such as production-linked incentives for solar, electric vehicles and battery storage systems.

k) **Establishment** of a 'Renewable Energy Management Centre' for supervision, monitoring and control of RE.

l) **Policy and financial assistance** for promotion of waste to energy measures.

m) **Enabling bundling of thermal and hydro** power with RE to enhance flexibility.

n) **Policies** to support biomass use for power generation.

o) **Roadmap of a sustainable and holistic approach** to National Energy Efficiency (ROSHANEE) for Revised National Mission for Enhanced Energy Efficiency: This will enable alignment with the goals of the NDC, mainly through energy efficiency and conservation activities included under standards and labelling programme for appliances, building efficiency programme, industrial efficiency improvement under **Perform, Achieve and Trade (PAT)** scheme.

p) **Green hydrogen** mission to incentivise green hydrogen production.

q) **Support to R&D** in carbon capture and utilisation.

r) **Developing** or deploying storage systems (Pumped Storage Plants, Battery Energy Storage Systems etc.)

Promoting Markets and Competition

1) Increasing electrolyser manufacturing capacity several fold by 2030 to become a global leader.

2) India envisages becoming a leading exporter of Green Hydrogen (GH) and Green Ammonia (GA) by 2030.

3) Encourage adoption of green hydrogen and green ammonia in hard to abate sectors, and ensuring availability of low-cost green electricity for green hydrogen.

4) Promote co-firing of green ammonia in thermal power plants (TPPs). Beyond 2030, this would involve:

    a. Enhancing industrial demand for green hydrogen and green ammonia (fuel switching – GH/GA replacing coke and natural gas)

    b. Expanding infrastructure for transporting and storing hydrogen, including pipelines, and storage tanks.

5) Several of the above strategies will require research and development.

Installed capacity

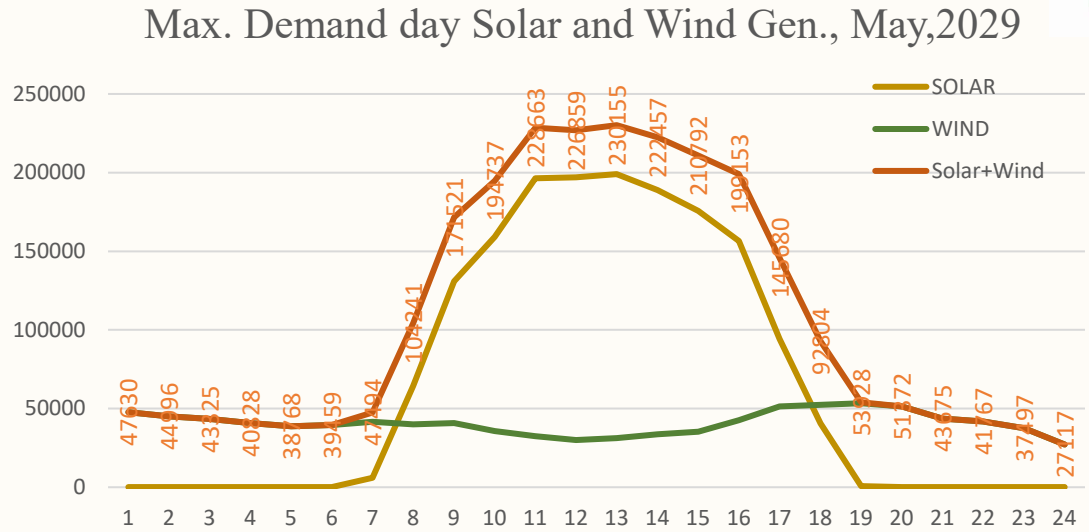
	Actual as on 31.07.2023		Target as on 31.03.2030	
	(GW)	(%)	(GW)	(%)
Thermal:	212.51	50.27	267.00	**32.09**
Hydro:	46.85	11.08	76.00 (*)	8.77
Gas:	25.04	5.92	25.00	3.00
Nuclear:	7.48	1.77	19.00	2.04
Renewable:	**130.89**	**30.96**	**450.00**	**54.09**
Total	**422.77**	**100.00**	**837.00**	**100.00**

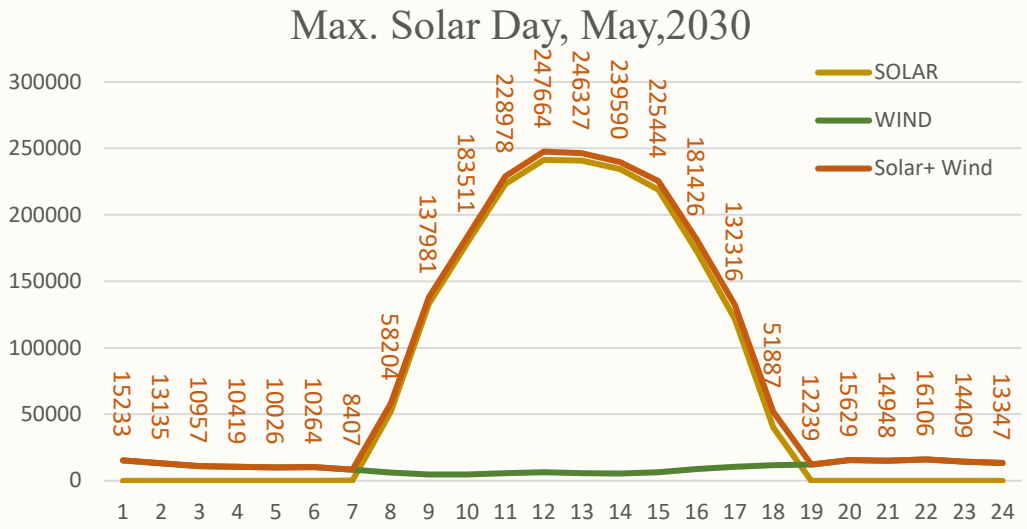
Non- fossile: Hydro + Nuclear + Solar+ Wind = 185.22 GW (43.84%)

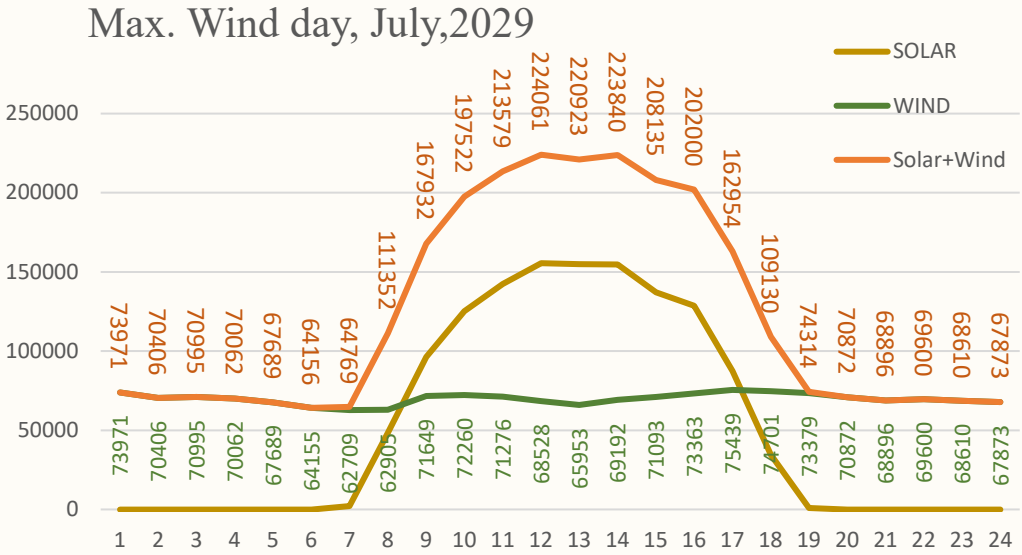
(*) Including PSP of 18.9 GW

Maximum Solar/Wind Generation (GW) in 2029-30

Recommended Battery Storage capacity: 42 GW

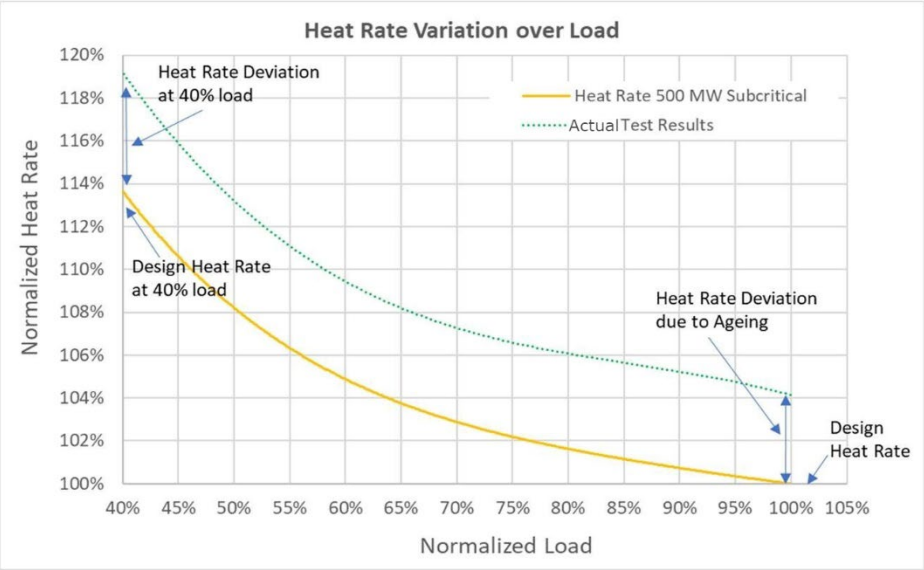






Effects of low load operation

Efficiency: At part load the efficiency of unit shall be decreased which is major part of flexibilisation cost.



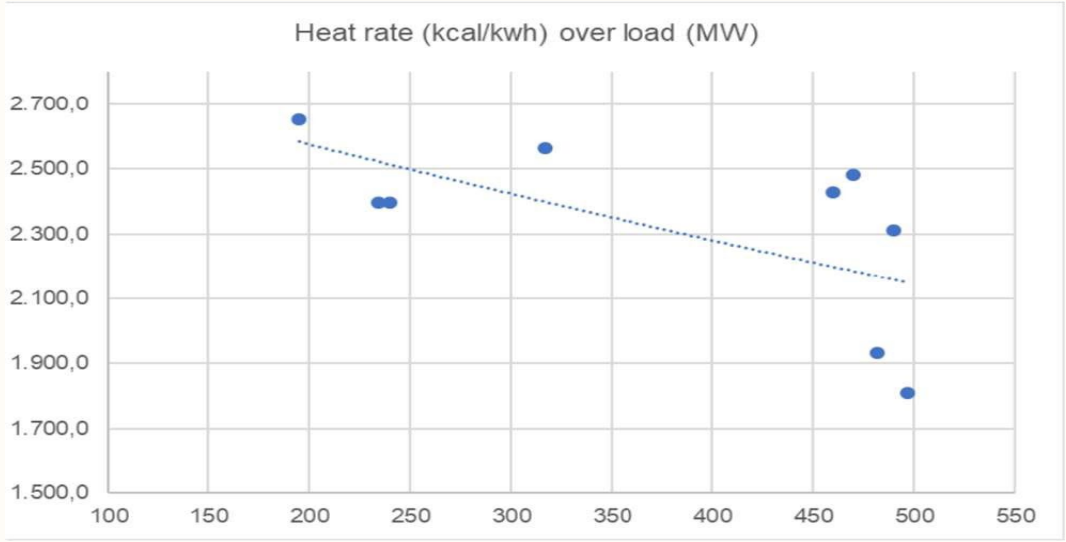
Maintenance and unit Operators: The maintenance strategy has to be developed based on the extent of flexibilization as flexible operation leads to increased life consumption of plant components, increased outages and failures.

Impact on Life of Plant: Flexible operation increases the creep-fatigue damage caused by thermal stresses. Almost all components of the Boiler, turbine and generator are affected ranging from severe to moderate.

These damages impact the thermal units by

- Increased life consumption leading to increased maintenance
- Efficiency loss due to increase of heat rate at lower load
- Increased auxiliary power consumption
- The measures shall increased number of start due to increased Equivalent Forced Outage Rate (EFOR).

Units operating in flexible mode needs to be suitably compensated for the above damages.



Compensation for operating a unit at 40% load

1. Capital Expenditure: One-time expenditure to be incurred for retrofitting of various measures to make the plant capable of low load operation. An estimated capital investment of Rs 10 crores to 30 crores for each unit shall be required depending on unit's age, size, existing plant's control & instrumentation system etc.

Unit size (MW)	Loading (%)	Increase in tariff (paisa/kWh)	
		Min. capex (10 cr.)	Max. capex (30 cr.)
200	40%	2.56	7.68
500	40%	1.02	3.07
660	40%	0.85	2.56
800	40%	0.64	1.92

2. O&M cost due to increased Life Consumption (damage costs): Flexible operation leads to a higher rate of deterioration of plant's components. This is observed in increased failure rate and more frequent replacement of components.

Capacity (MW)	Loading (%)	O&M cost Increase (%)	Increase in O&M cost (Rs Cr.)	Increase in O&M cost (Paisa/kWh)
200	40%	20.00	14.62	14.88
500	40%	20.00	24.97	10.16
660	40%	20.00	29.66	9.14
800	40%	20.00	32.35	8.23

3. Cost due to increase in Net Heat Rate: After analyzing the HBD report of major OEMs (BHEL/GE/Siemens) and actual test report of low load operation unit size wise Net Heat Rate increase including it's tariff impacts has been prepared

Unit size (MW)	Increase in tariff (paisa/kWh)			
	Capex =10 crores		Capex = 30 crores	
	Pit head	Non-pit head	Pit head	Non-pit head
200	40.33	54.55	45.45	59.67
500	33.71	47.70	35.76	49.75
660	29.73	41.91	31.44	43.62
800	28.45	40.52	29.73	41.80

Unit Size (MW)	Loading (%)	Net Heat Rate increase (%)	Pit head unit	Non-pit head unit
			Variable Tariff increase (Paisa/kWh)	Variable Tariff increase (Paisa/kWh)
200	40%	16.00	21.89	36.11
500	40%	16.00	21.53	35.52
660	40%	14.60	18.74	30.92
800	40%	15.00	18.58	30.65

4. EFOR: The additional EFOR due to regular low load operation of thermal generating units may increase specific oil consumption from 0.5 ml/kWh to 0.7 ml/kWh. Therefore 1.0 paisa per kWh may increase due to EFOR.

Flexible Operation of Thermal Power Stations

- **CEA (Flexible operation of coal based thermal power generating units) Regulations, 2023** –Notified on 30th January, 2023
- A report on Flexiblization of coal fired Thermal Power Plants – A Roadmap for achieving **40%Technical Minimum Load** has been prepared, published and widely circulated, phasing plan for implementation is under finalization.
- 23 GW equivalent BSS capacity can be created by flexible operation
- Another 20 GW peak support possibility is being explored by 2 shift operation
- **Compensation mechanism** for below 55% low load operation upto 40% - Methodology **has been approved by MOP and sent to CERC.**

New Environment Norms

Emission parameter	TPPs (units) installed before 31.12.2003	TPPs (units) installed after 01.01.2004 and up to 31.12.2016	TPPs (units) to be installed from 01.01.2017
Particulate Matter	100 mg/Nm^3	50 mg/Nm^3	30 mg/Nm^3
Sulphur Dioxide (SO_2)	600 mg/Nm^3 for units less than 500MW capacity	600 mg/Nm^3 for units less than 500MW capacity	100 mg/Nm^3
	200 mg/Nm^3 for units 500MW and above	200 mg/Nm^3 for units 500MW and above	
Oxides of Nitrogen (NOx)	600 mg/Nm^3	450 mg/Nm^3	100 mg/Nm^3
Mercury	0.03 mg/Nm^3	0.03 mg/Nm^3	0.03 mg/Nm^3
WATER NORMS	I. All existing CT based plants shall reduce specific water consumption up-to maximum of 3.5 m^3/MWh within a period of 2 years. II. New plants to be installed after 1.1.2017 shall have to meet specific water consumption of 3 m3/ MWh & achieve zero water discharge.		

Other Low-Carbon Technologies

1) **Exploring a significantly greater role for nuclear power**: Nuclear power currently provides 3% of electricity generation. Sufficient production and share of nuclear power are highly significant for ensuring country's energy security.

2) **The potential for establishment of small modular nuclear reactors is to be explored**, and this will require sharing and transfer of relevant technologies.

3) **Promoting R&D for frontier technologies**: Emergent technologies includes:
   i. coal gasification,
   ii. carbon capture, utilization and storage systems,
   iii. biomass co-firing,
   iv. offshore wind,
   v. high efficiency fuel cells,
   vi. advanced solar materials,
   vii. advanced chemistry cells,
   viii. tidal power,
   ix. small modular reactors,
   x. and smart demand response systems.

India will promote the R&D of such technologies to be ready to capitalize on such expertise as and when the opportunity arises.

Thank you