India

India's Action Plan for Power Sector Decarbonisation

Grid Controller of India Limited (GRID-INDIA)

Delivered for the 14th Clean Energy Ministerial (CEM14)

July 2023

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

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BACKGROUND

A collaborative report from the Clean Energy Ministerial (CEM) on *Lessons Learned for Rapid Decarbonization of Power Sectors* was delivered to energy ministers and presented at the 13th CEM (CEM13) in the United States in September 2022. In light of these lessons learned and discussed at CEM13, several jurisdictions signaled intent to develop Action Plans for power sector decarbonization, to be released at CEM14 in India in July 2023.

These Action Plans complement, but are differentiated from, other international power sector initiatives such as the Breakthrough Agenda (whose broad purpose is to raise collective ambition) and the Global Power System Transformation (G-PST) Consortium (whose goals are to convene power system operators to accelerate research innovations and foster peer learning). The Action Plans, supported by the 21st Century Power Partnership and other CEM workstreams via direct technical assistance and capacity building, are intended to focus on select implementation actions given each country's existing power sector goals and activities, and are an opportunity for countries to display leadership in power sector decarbonization.

These Action Plans are voluntary, developed by each country individually, not comprehensive of all activities within the jurisdiction, and are living documents that are subject to change.

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Key National and International Efforts to Inform Actions

Ministry of Power Technical Committee on Renewable Integration	CEA Report on Flexible Operation of Thermal Power Plant for Integration of Renewable Generation	Greening-the-Grid Pathways to Integrate Renewable Energy into India's Electric Grid, — National, Regional and State Level Studies	Shaping Modern India's Power Systems Balancing The Grid: A Pilot On Secondary Reserves For Hydro Power Plants
https://powermin.nic.in/sites/default/files/uploads/Final_Consolidated_Report_RE_Technical_Committee.pdf	https://cea.nic.in/old/reports/others/thermal/trm/flexible_operation.pdf	https://www.nrel.gov/analysis/india-renewable-integration-study.html	https://sarepenergy.net/wp-content/uploads/2022/10/Case-Study-_Automatic-Generation-Control_Hydro_26082021.pdf

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I. PLANNING

Action Plan for Rapid Power Sector Decarbonisation

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Policy Initiatives by Government of India for Tackling the Climate Crisis (1)

- **National Action Plan on Climate Change (since 2008)**
- **Non-Fossil Fuel Capacity Target: Enhanced to 500 GW by 2030**
  - Preference is given to renewable power in the merit order dispatch: 'Must-Run' status
- **Renewable Purchase Obligations (RPO) trajectory until 2029-30**
  - Wind RPO, Hydropower Purchase Obligation (HPO)
  - Energy Storage Obligation
    - Pumped Storage, Battery Energy Storage Systems (BESS)
    - Pilot project – 500 MW/1000 MWh BESS awarded
    - Bids for 1500 MW/9000 MWh Energy Storage under progress
- **Bundling of Thermal Generation and Hydropower with RE**
  - Trajectory to replace 58 TWh of Thermal Energy having high tariffs with ~ 30 GW RE (@ 22% CUF) by 2025-26
  - Conservation of 34.7 MMT of coal and reduction in carbon emissions of 60.2 MMT

Table: Energy Storage Obligation

Financial Year	% Storage Obligation (on Energy Basis)
2023-24	1.0%
2024-25	1.5%
2025-26	2.0%
2026-27	2.5%
2027-28	3.0%
2028-29	3.5%
2029-30	4.0%

Source: Ministry of Power, 2022

India

Policy Initiatives by Government of India for Tackling the Climate Crisis (2)

CEA (Flexible Operation of Coal based Thermal Power Generating Units) Regulations, 2023

- ❑ Specify **Minimum Power Level of 40%** for Thermal Generating Units
- ❑ Requires thermal generators to be **capable of providing 1 % – 3 % ramp rate**

Source: https://cea.nic.in/wp-content/uploads/notification/2023/01/Gazette_Flexible_operation-2.pdf

Central Electricity Authority Phasing Plan (draft floated) for Implementation of 40% Technical Minimum Level, May 2023

Source: https://cea.nic.in/wp-content/uploads/news_live/2023/05/Draft_phasing_plan_merged_letter.pdf

- **Indian Electricity Grid Code, 2023**
  - ❑ Reduction of conventional thermal generation to the 55% levels or as per CEA Flexible Operation Regulations, 2023
- **CEA (Technical Standard for Construction of Electrical Plant and Electrical Lines), 2022**
  - ❑ Hot starts (less than 10 hours of unit shutdown): 4000
  - ❑ Warm starts (between 10 and 72 hours of unit shutdown): 1000
  - ❑ Cold starts (greater than 72 hours of unit shutdown): 150…
- **Terms and Conditions of Tariff Regulations, 2019**
  - ❑ Incentivized generators to provide ramping capability beyond the threshold of 1%

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Policy Initiatives by Government of India for Tackling the Climate Crisis (3)

- **Green Hydrogen Mission**
  - Incentivize green hydrogen production
- **Support to R&D in Carbon Capture and Utilization**
- **Increase Nuclear Capacity**
  - Three-fold rise in nuclear installed capacity by 2032
- **Promotion of Agricultural Solar Pumps**
  - PM-KUSUM (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) Scheme
- **Green Open Access Rules**
  - Reduced the Open Access limit from 1 MW to 100 kW
  - Paved the way for small consumers to also purchase RE
  - No limit for captive consumers

Figure. Agricultural Solar Pump Program Advertisement

Source: Ministry of New and Renewable Energy, 2022

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Policy Initiatives by Government of India for Tackling the Climate Crisis (4)

- **Investment Incentives for Green Energy**
  - Solar park development (www.solarrooftop.gov.in), accelerated depreciation on investments, waiver on transmission charges, and capital subsidies for residential rooftop solar PV
- **Unnat Jyoti by Affordable LED for All (UJALA) Programme**
  - Under UJALA scheme, LED bulbs, LED tube lights, and energy efficient fans are sold to domestic consumers to replace conventional and inefficient variants
- **Street Lighting National Programme (SLNP)**
  - Replacement of conventional streetlights with smart and energy efficient LED streetlights across India
- **Energy Conservation (Amendment) Act, 2022**
  - Promotes non-fossil sources, including green hydrogen, green ammonia, biomass, and ethanol for energy and industrial feedstocks
  - Plans to establish Carbon Markets

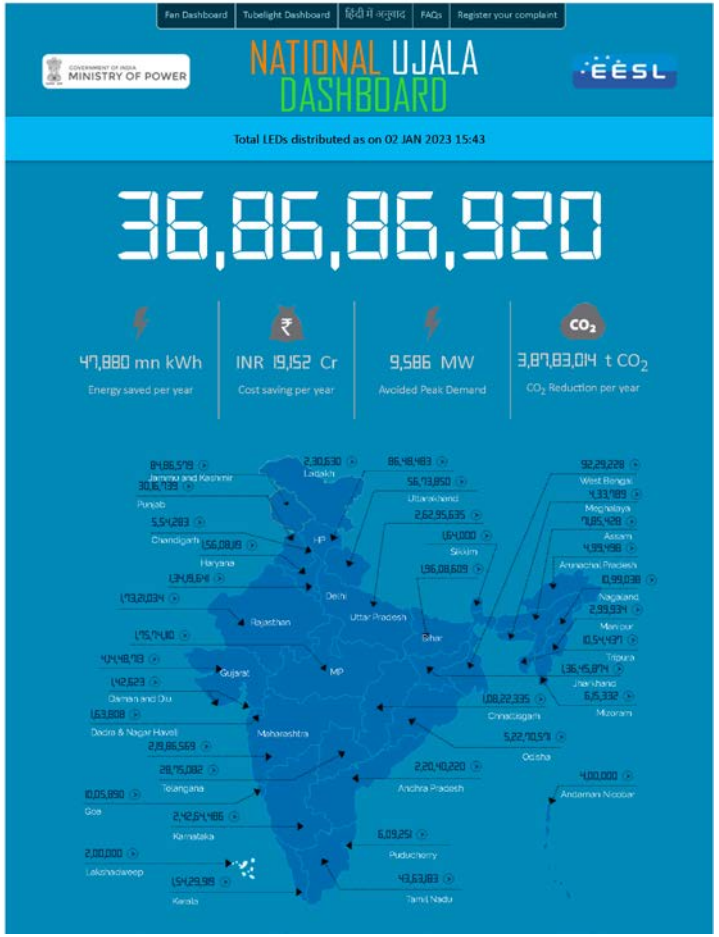

Figure. National UJALA Program Dashboard

Source: Ministry of Power

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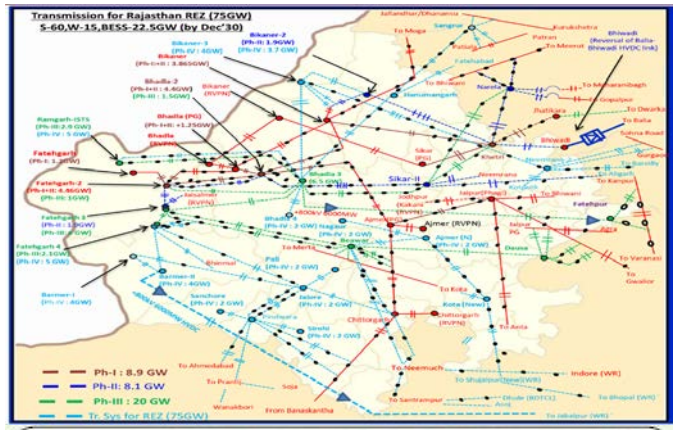
Policy Initiatives by Government of India for Tackling the Climate Crisis (5)

Detailed Plan: "Transmission System for Integration of over 500 GW RE Capacity by 2030"

Source: Central Electricity Authority, 2022

- The Plan has identified major upcoming non-fossil based generation centres in the country, which include Fatehgarh, Bhadla, Bikaner in Rajasthan, Khavda in Gujarat, Anantapur, Kurnool RE Zones in Andhra Pradesh, offshore wind potential in Tamil Nadu and Gujarat, and RE parks in Ladakh by 2030.
- The transmission plan anticipates the addition of 8,120 circuit-km (c-km) of High Voltage Direct Current (HVDC) transmission corridors (+800 kV and +350 kV), 25,960 c-km of 765 kV AC lines, 15,758 c-km of 400 kV AC lines, and 1,052 c-km of 220 kV AC lines.
- The transmission plan also includes the transmission lines required to evacuate 10 GW of offshore wind capacity located in Gujarat and Tamil Nadu.
- The Plan also includes installation of battery energy storage capacity of 51.5 GW by 2030 to provide "Round-the-Clock" power to end-consumers.



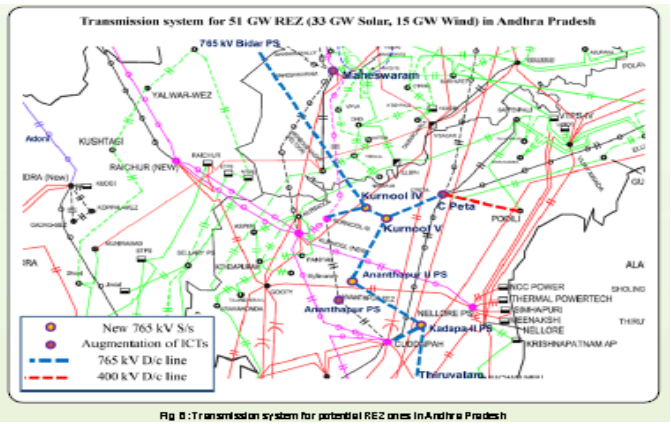


Fig 0 :Transmission system for potential REZ ones in Andhra Pradesh

Fig0: Transmission system for off-shore wind potential zones in Tamil Nadu

Fig 5: Transmission system for off-shore wind potential zones in Gujarat

21st CENTURY POWER PARTNERSHIP

ग्रिड-इंडिया GRID-INDIA

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II. BUILDING

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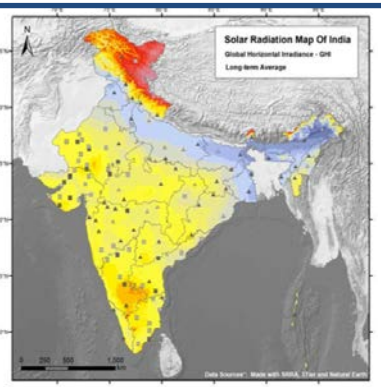
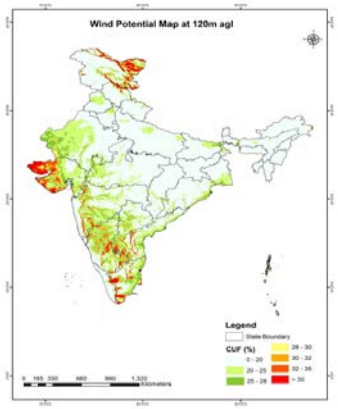
CLEAN ENERGY TRANSITION UNDERWAY IN INDIA

Solar Radiation Atlas



Source: Ministry of New and Renewable Energy

Wind Atlas



Offshore Wind

Present Total Installed Capacity ~422 GW

Present Non-fossil Fuel Installed Capacity ~ 184 GW

Solar Potential ~ 750 GW, Wind Potential @ 120 mtr agl ~ 700 GW

Off-shore wind potential ~ 70 GW (coast of Gujarat & Tamil Nadu)

Region/State (FY 2022-23)	Annual VRE Penetration (Energy Terms)	Maximum Daily VRE* Penetration (Energy Terms)	Maximum Instantaneous VRE Penetration (Energy Terms)
Rajasthan	14.57	35.81	56.00
Northern Region	10.56	18.36	46.75
Gujarat	15.44	35.80	55.80
Madhya Pradesh	11.01	32.40	53.90
Maharashtra	10.10	23.00	37.21
Western Region	11.03	23.10	35.13
Karnataka	27.52	65.38	132.00
Andhra Pradesh	20.50	58.59	81.00
Tamil Nadu	18.42	50.08	77.00
Telangana	12.17	17.63	49.00
Southern Region	16.91	36.32	61.00
All India	11.01	20.40	31.80

*VRE:Wind and Solar only

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Process for Procurement and Grid Interconnection

Roles and Responsibilities – Transmission Planning

- **Central Electricity Authority (CEA)**
  - National Electricity Plan (NEP)
  - Short Term and Perspective generation & transmission plans
  - Coordinate activities of the planning agencies
- **Central Transmission Utility (CTU)**
  - Network planning and development in accordance with NEP
  - Discharge all functions of planning and coordination related to the inter-state transmission system (ISTS)
- **State Transmission Utility (STU)**
  - Network planning and development in accordance with NEP
  - Nodal agency for Intra-State Transmission System planning in coordination with distribution licensees and intra-state generators connected/to be connected in the STU grid

- **National Electricity Plan - Generation**
  - http://www.cea.nic.in/reports/committee/nep/nep_jan_2018.pdf
- **National Electricity Plan - Transmission**
  - https://powermin.nic.in/sites/default/files/uploads/NEP-Trans.pdf
- **Indian Electricity Grid Code – Planning Code**
  - http://cercind.gov.in/2016/regulation/9.pdf
- **CEA Manual on Transmission Planning Criteria**
  - http://cea.nic.in/reports/others/ps/pspa2/tr_plg_criteria_manual_jan13.pdf
- **CERC (Planning, Coordination, and Development of Economic and Efficient Inter-State Transmission System by Central Transmission Utility) Regulations, 2018**
  - http://cercind.gov.in/2018/regulation/Transmission.pdf

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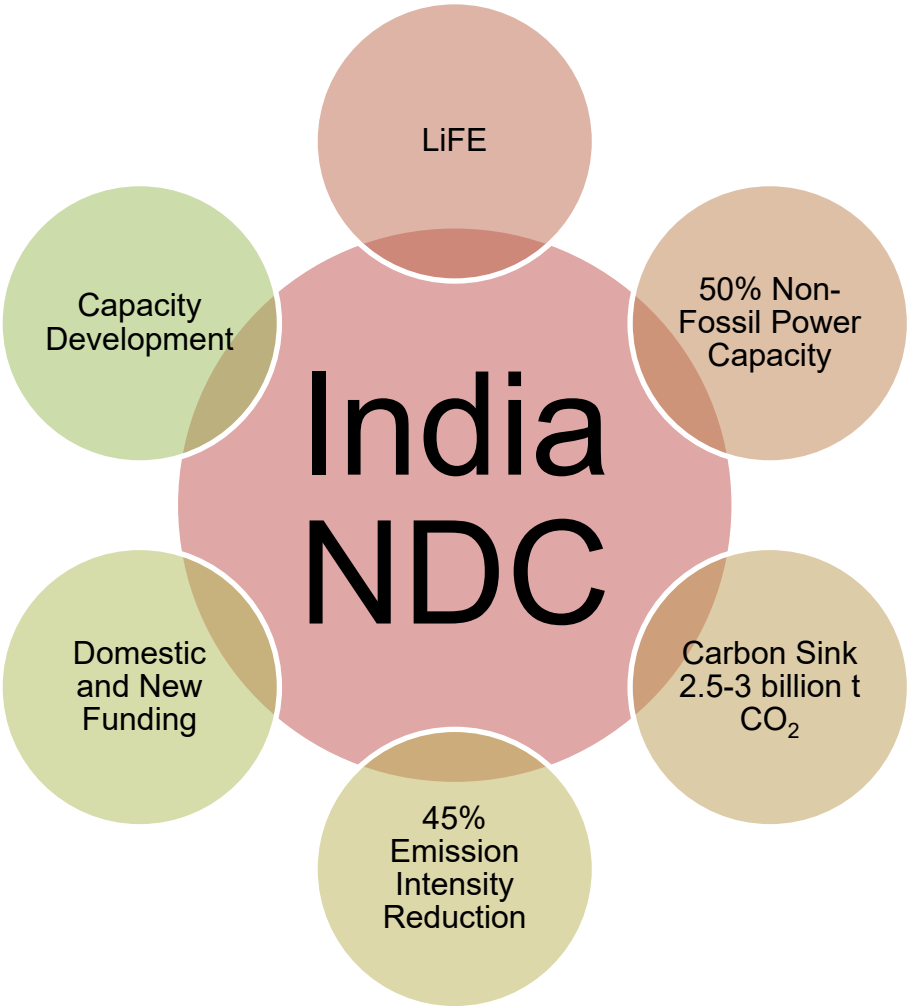
Energy Conservation (Amendment) Act, 2022 – Paving Way for Carbon Market

- **Non-fossil-fuel mandate for designated consumers (the largest consumers of energy)**
- **Setting up a carbon credit trading scheme:**
  - Increase private sector participation in emissions reductions
  - Attract climate finance from different sectors
  - Leverage learnings and successes of CDM (clean development mechanism), PAT (perform, achieve, and trade), and RECs (renewable energy credits) and convert to a single denomination
  - Current schemes are limited to obligated sectors, but large mitigation opportunities also exist in non-obligated and non-energy sectors
  - Tap opportunities such as fuel switching, resource efficiency, and cleaner production for GHG reductions
  - Explore linkages with international markets (e.g., CBAM and CORSIA)
- **Residential buildings are included in the new Energy Conservation and Sustainable Building Code**
- **Increase the purview of energy consumption standards to include vehicles and industrial units**



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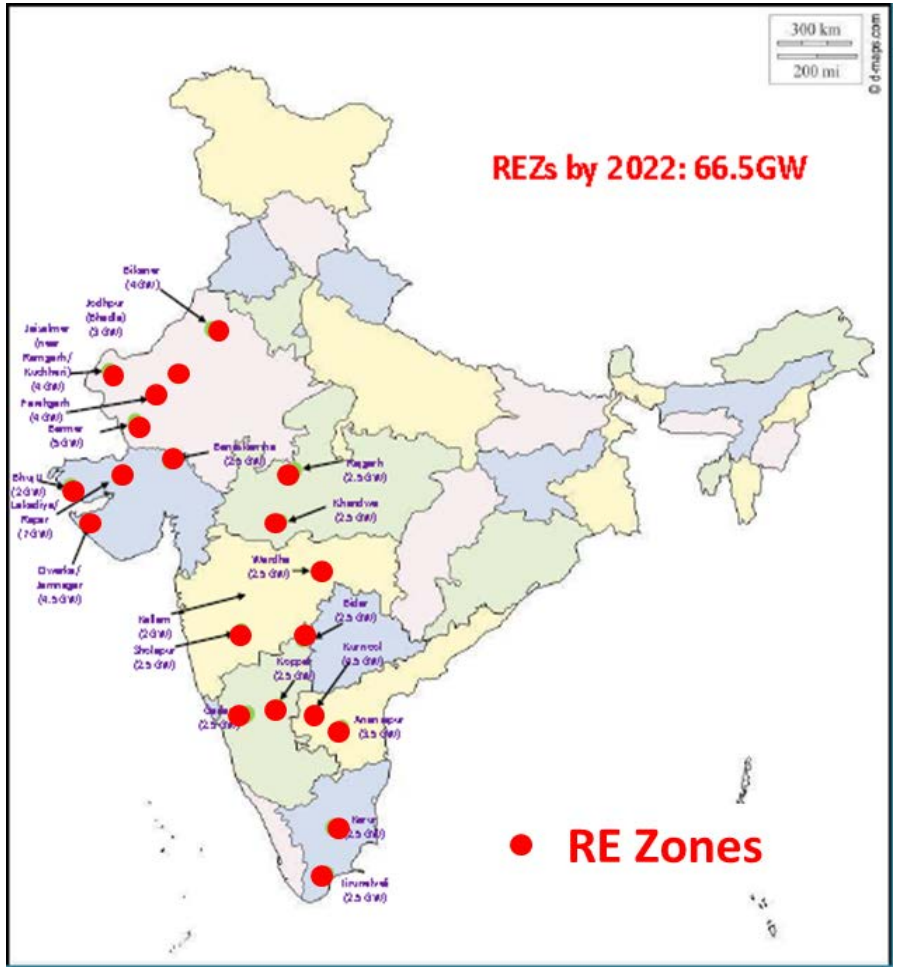
BUILD TRANSMISSION TO TRANSPORT CLEAN ELECTRICITY



Transmission Planning for 66.5 GW of Renewable Energy Zones (REZs) spread over 3 Regions

Solar Energy Zones – 50.5 GW	Wind Energy Zones – 16 GW

Additional Transmission Plan for Large RE Zones

Rajasthan – 20 GW (Solar)	Ladakh – 13 GW 4 GW Wind + 9 GW Solar	Khavda (Part B &C) 5 GW Wind + 12.2 GW Solar

Perspective Transmission Plan for 500 GW RE by 2030

Revised Manual on Transmission Planning Criteria – Notified in March 2023

https://cea.nic.in/wp-content/uploads/psp___a_ii/2023/03/Manual_on_Transmission_Planning_Criteria_2023.pdf

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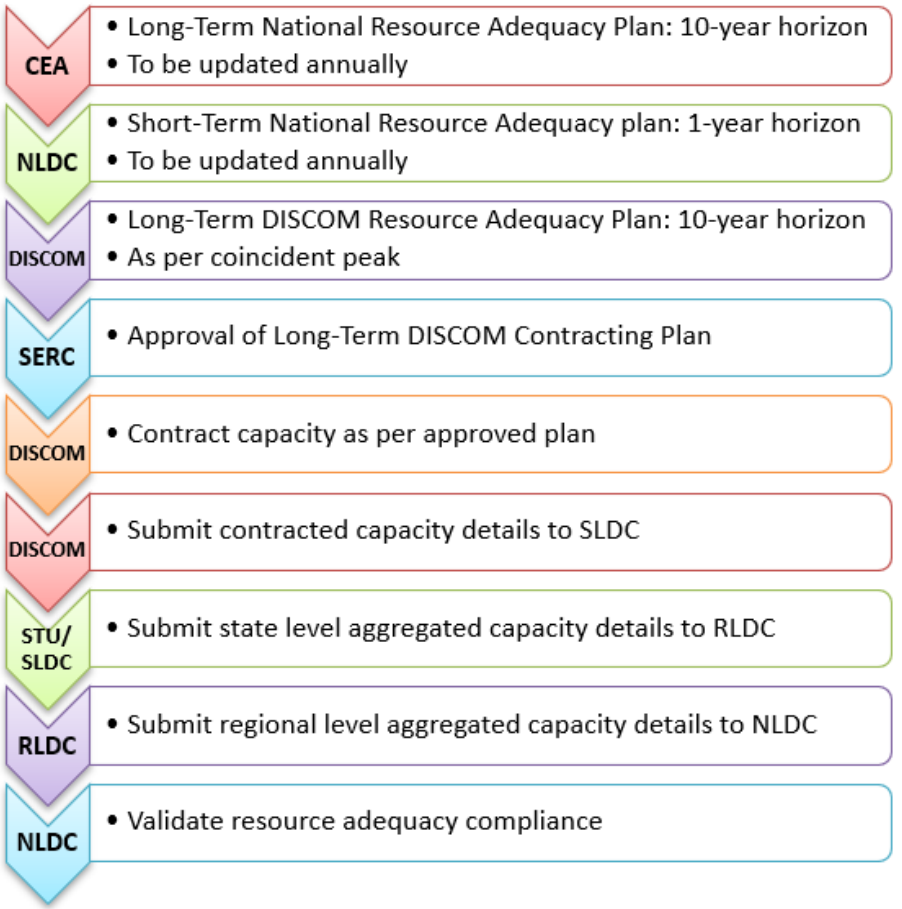
RESOURCE ADEQUACY GUIDELINES UNDER DEVELOPMENT

- **Electricity (Amendment) Rules, 2022 - notified on 29th December, 2022**
  - Mandated guidelines to assess resource adequacy during the generation planning stage (one year or beyond) as well as during the operational planning stage (up to one year)
  - Roles in Resource Adequacy
    - Central Electricity Authority: framing of guidelines
    - State Commissions: for respective distribution licensees
    - Review of resource adequacy on periodic basis
    - Non-compliance charges
    - Load Dispatch Centres: carry out assessments of resource adequacy for operational planning at the national, regional, and state levels, in accordance with the guidelines
- **CEA has developed draft guidelines for carrying out the Resource Adequacy Plan for Distribution utilities**



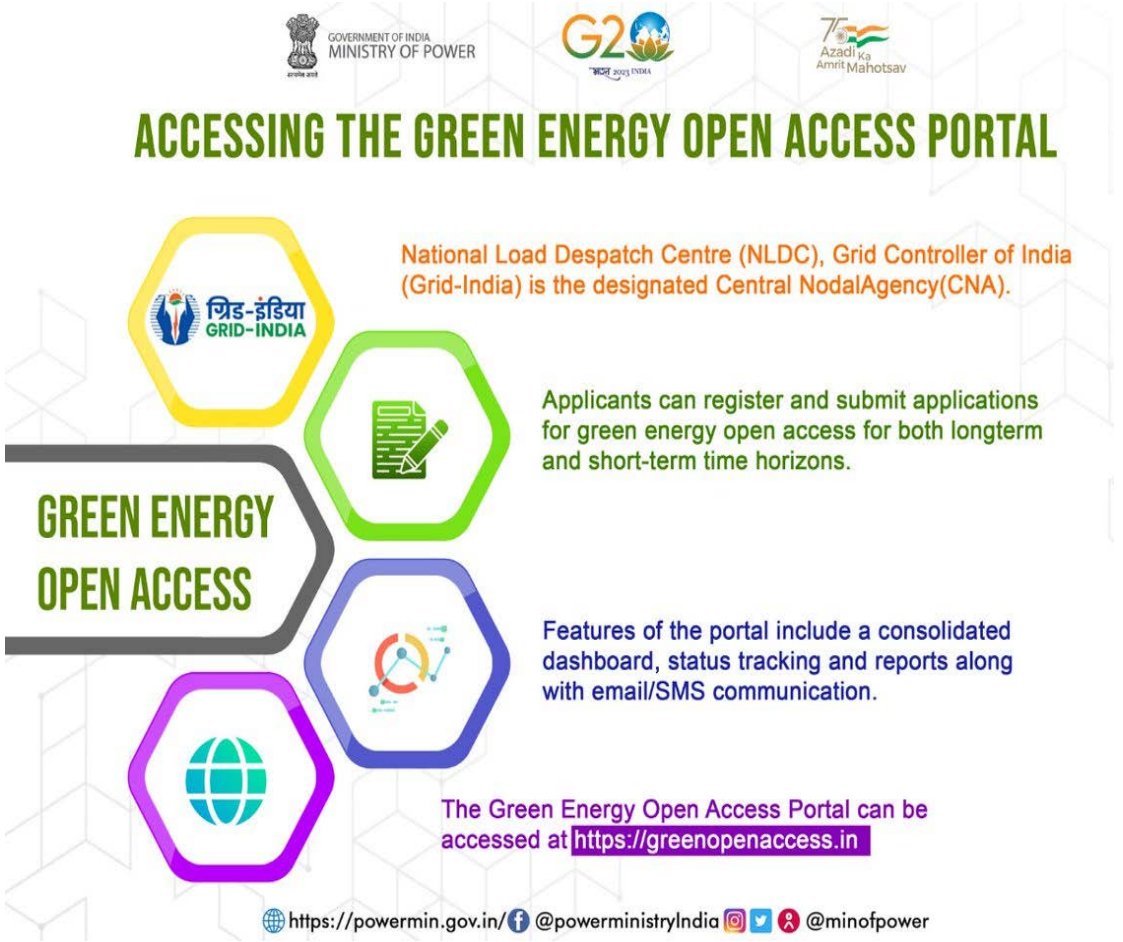
Source: Central Electricity Authority, 2022

India

GREEN OPEN ACCESS: GREENING EVERY INDIAN

Facilitating a mass movement for India's Green Energy Transition:

- Consumers access Renewable Energy power seamlessly, ensuring affordable, reliable, sustainable, and green energy for all.
- Reduction in the limit of open access transactions from 1 MW to 100 kW for green energy, which enables access to renewable power for even small consumers.
- Smaller industries, commercial consumers, and large households can now go green.
- Any consumer can demand green power from power distribution companies, which can be fulfilled through aggregation.
- No minimum limit for captive consumers.
- Simplified, transparent, and streamlined process with time bound approvals within 15 days.
- Facilitates renewable purchase obligation (RPO) fulfilment.
- Reduction in transaction costs for green open access.



Source: Ministry of Power, 2022

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III. OPERATING

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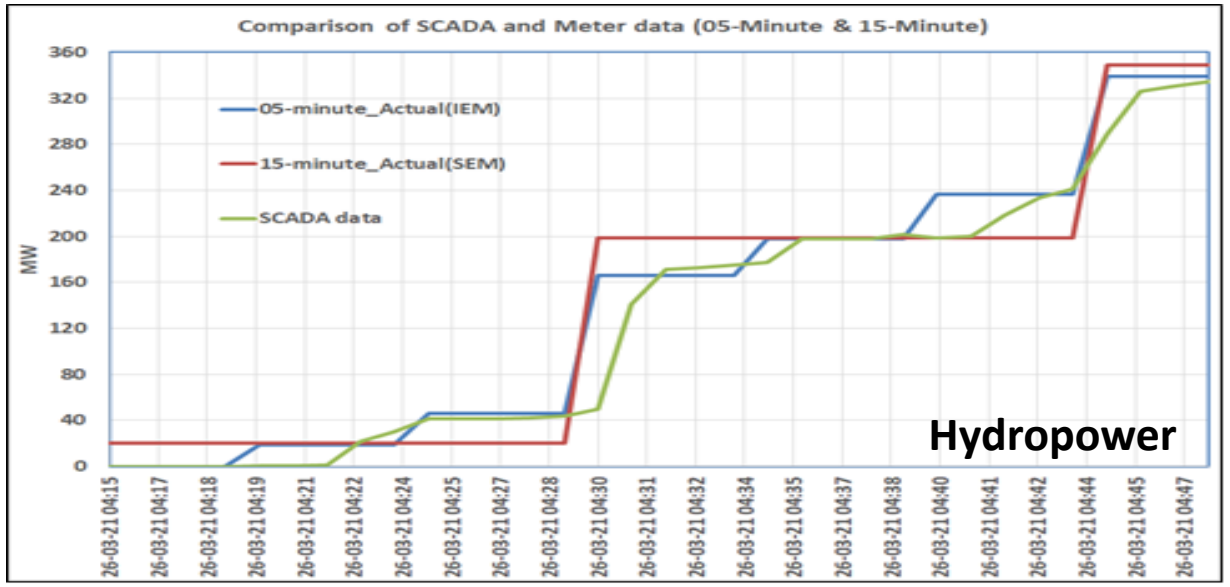
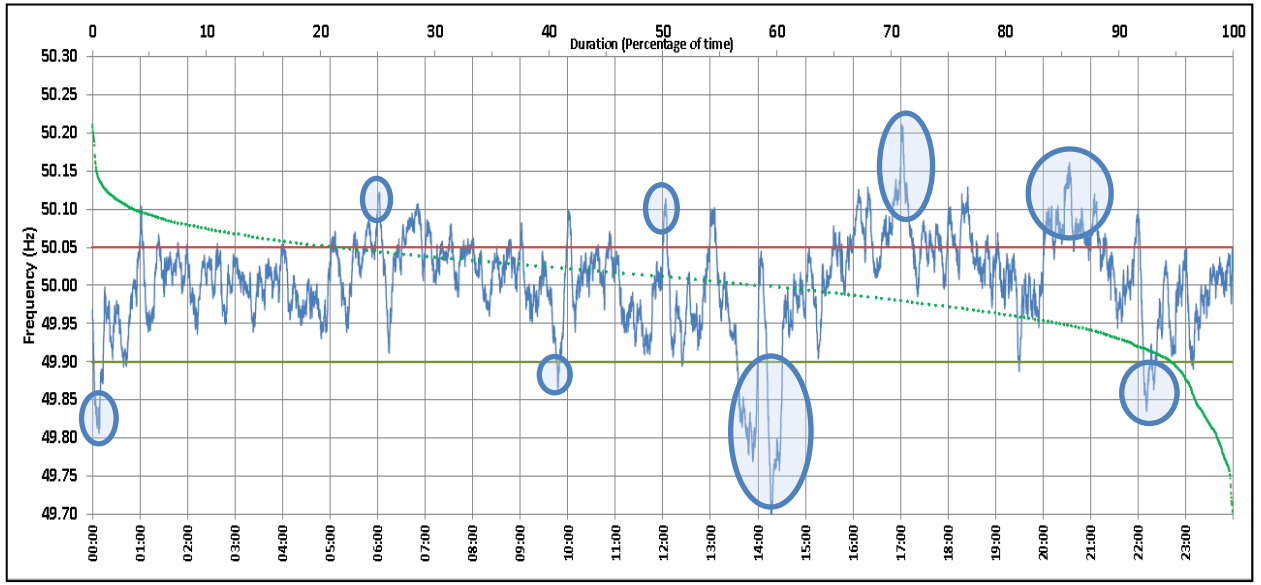
Moving Towards Faster & Granular Scheduling and Dispatch





Source: Grid-India

- Pilot project on five-minute metering, scheduling, accounting, and settlement of selected hydro/thermal generators in the Indian interconnected power system completed in 2020-21.
- Pilot facilitated gain in the experience in ancillary services and also provided insights for implementation of other emerging resources like batteries, electric vehicles, and demand response as ancillary services.
- NPC Joint Committee Technical Specifications on Five-Minute Meters, Automated Meter Reading, and Meter Data Processing formulated in July 2022 for procurement of meters.

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Managing High Instantaneous Penetrations of VRE

Regulations & Standards	Conducive Regulations & Grid Code to facilitate the grid operation under high Renewable Energy (RE) penetration levels
Transmission Planning	Addressing the seasonal and diurnal diversity in RE generation while planning transmission Analysis of system behavior under different RE generation scenarios
Flexibility	Understanding and harnessing flexibility in coal, hydro, and gas generation Managing demand and RE generation diversity with High Voltage Direct Current (HVDCs) and Flexible AC Transmission Systems (FACTS) devices
Forecasting, Scheduling and Imbalances	Enhancing forecast accuracy and utilization in system operation
Reserves, Ancillary Services and Markets	Maintaining adequate reserves for ramp, congestion management, and providing reliability support

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Regulatory Reforms: Indian Electricity Grid Code

- Load and Renewables Forecasting
- Unit Commitment and Economic Dispatch
- Resource Adequacy and Resilience
- Frequency Response Performance Assessment
- Primary, Secondary, and Tertiary Reserves
- Reactive Power and Inertia Support
- Communication and Telemetry at RE Pooling Stations
- Compliance Verification and Periodic Testing

Key Components of Indian Electricity Grid Code, 2023 - notified on 29th May, 2023

https://cercind.gov.in/Regulations/180-Regulations.pdf

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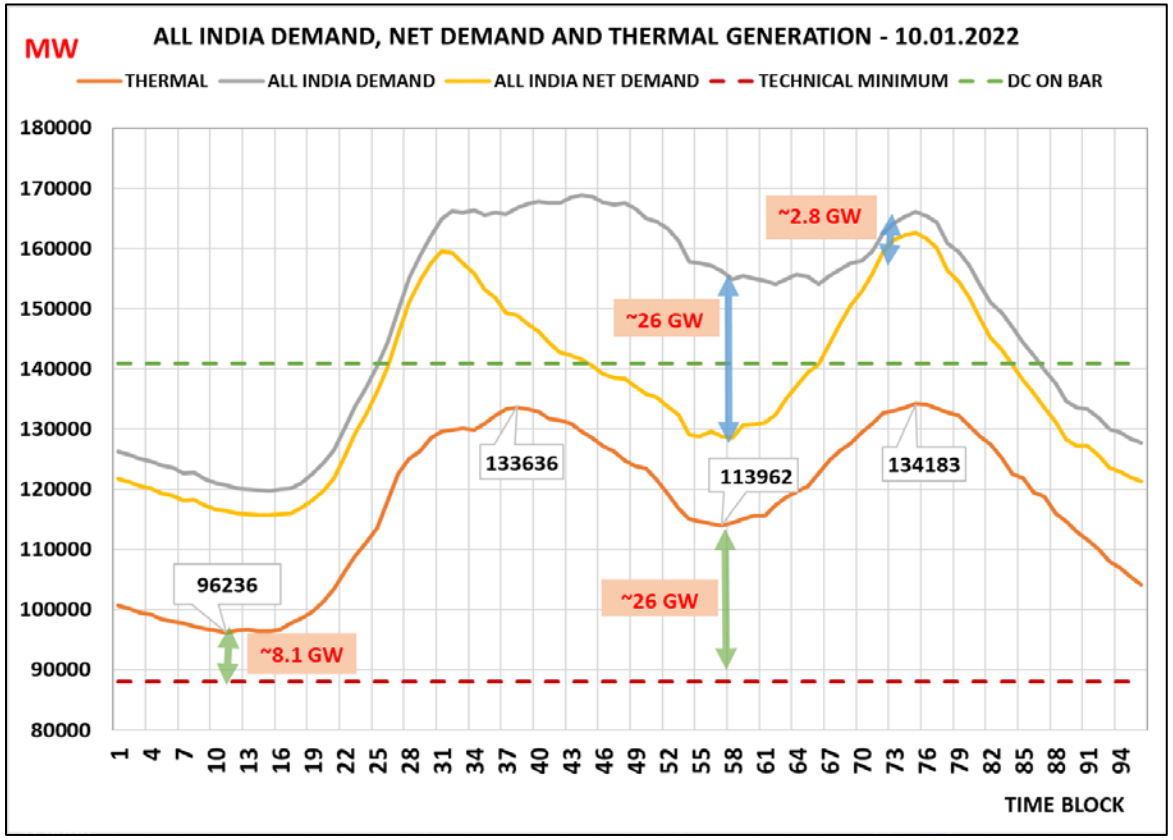
FLEXIBILITY IN GRID OPERATIONS



Major Challenges

- Increasing "Duck Curve" Belly
- Increasing gap between max. and min. demand
- Issues in absorbing additional RE (solar) beyond a certain quantum
- Storage + reduction in minimum operational level of both inter & intra state coal-fired plants required
- Improvement in 1% ramp rate of coal-fired plants

✓ Letter of Award given for 500 MW/1000 MWh standalone Battery Energy Storage System (BESS) pilot projects in India

✓ Central Electricity Authority (flexible operation of thermal power plants) Regulations, 2023 – Notified in January 2023

✓ Guidelines for Competitive Procurement of Energy Storage – Notified in March 2022

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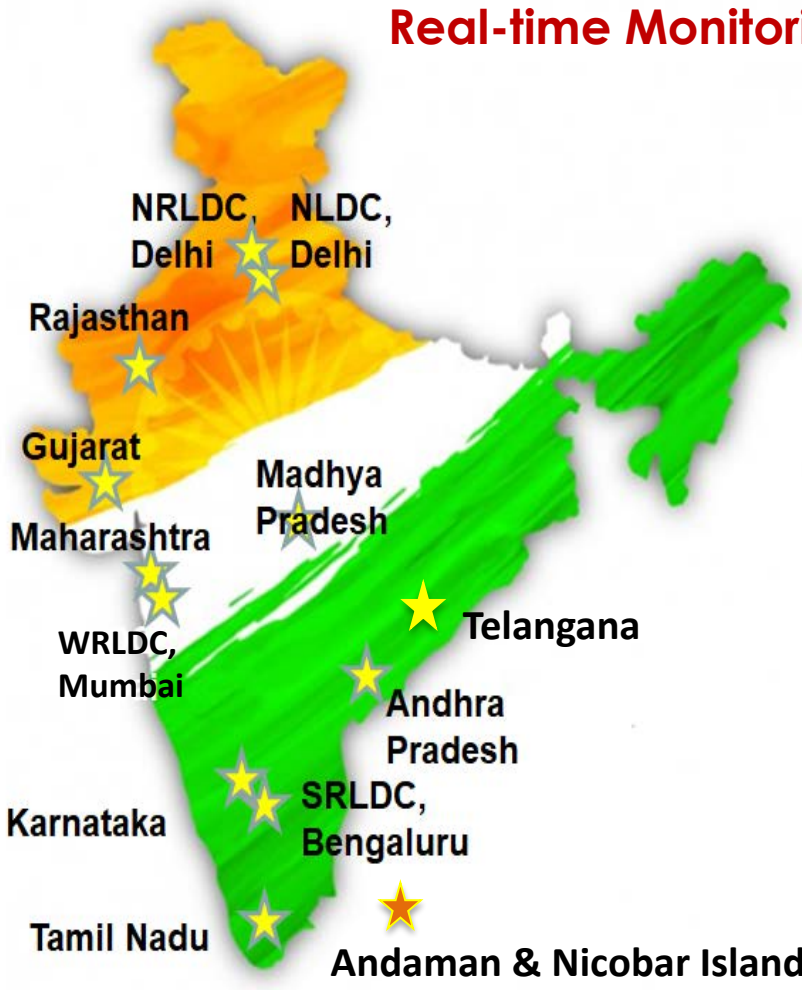
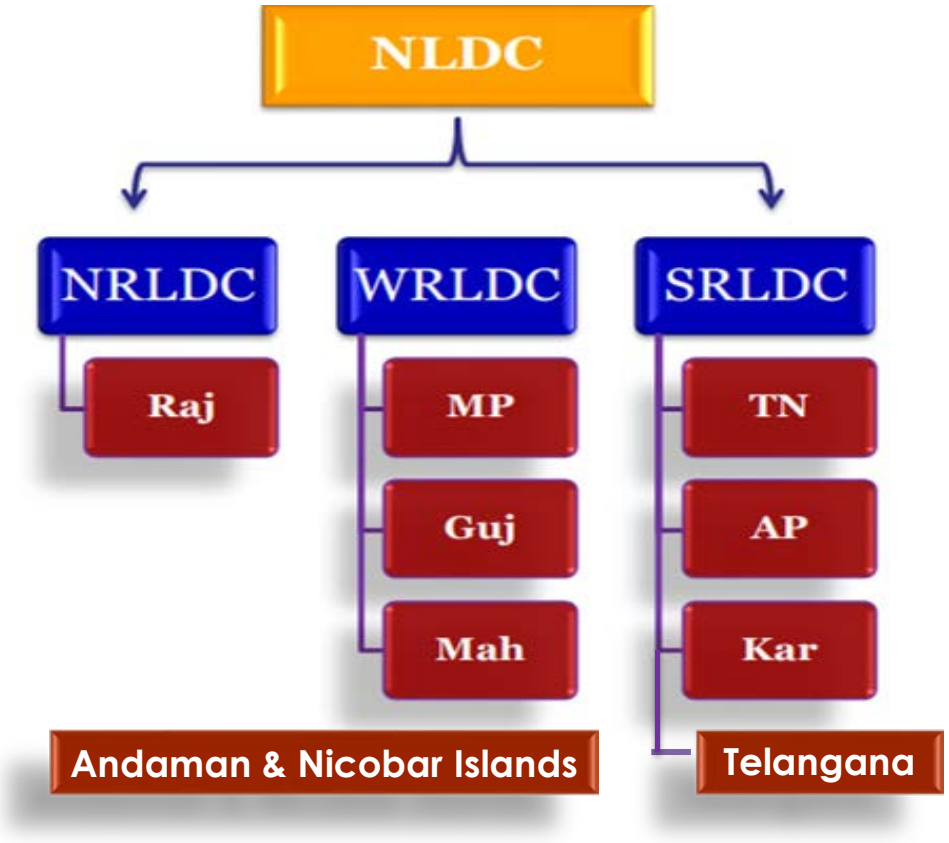
RENEWABLE ENERGY MANAGEMENT CENTRE (REMC)

Real-time Monitoring, Visualization, and Situational Awareness of Renewables



- 13 REMCs (State/Regional/National): Co-located with Load Dispatch Centres
- ~ 95 GW of wind and solar capacity being monitored through 11 REMCs
- ~ 23 GW+ scheduling at Inter-State level



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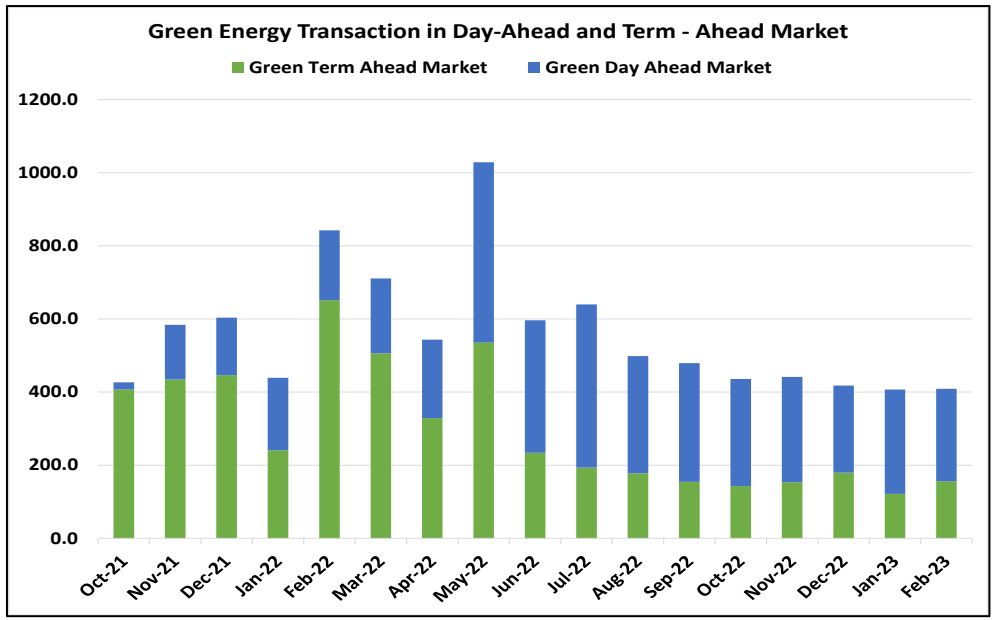
Green Energy Participation in Day-Ahead and Term-Ahead Markets

Facilitating a mass movement for India's Green Energy Transition: Green Energy Open Access

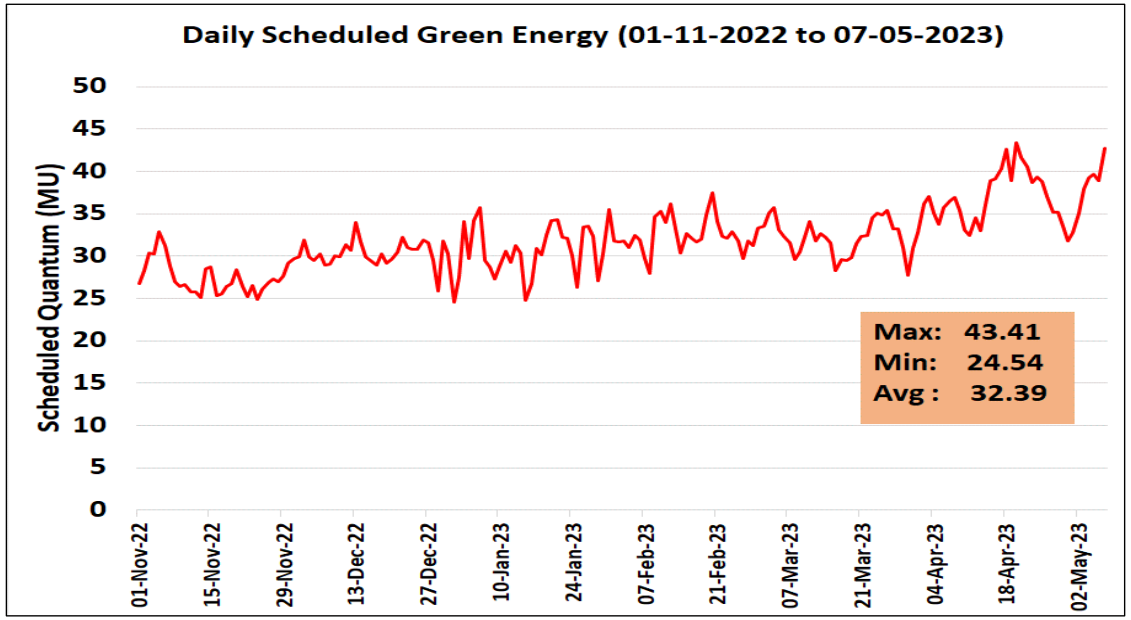
- Reduction in the limit of open access transactions from 1 MW to 100 kW for green energy, which enables access to renewable power for even small consumers.
- Smaller industries, commercial consumers, and large households can now go green.

14,542 MW – Total RE capacity registered in Green Energy Open Access

Green Term Ahead Market launched on 1 Sep 2020
Green Day Ahead Market launched on 25 Oct 2021



Green Energy Open Access portal launched on 11th November 2022



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Stakeholder Engagement and Inclusion

National Stakeholders

विद्युत मंत्रालय MINISTRY OF POWER

नवीन एवं नवीकरणीय ऊर्जा मंत्रालय MINISTRY OF NEW AND RENEWABLE ENERGY

DAE

केविप्रा CEA

केविआ CERC

Telangana State Electricity Regulatory Commission

Forum of Regulators

ग्रिड-इंडिया GRID-INDIA

एनटीपीसी NTPC

एनएचपीसी NHPC

पावरग्रिड POWERGRID

WBSEDCL

एनटीपीसी NTPC विद्युत व्यापार Vidyut Vyapar

FOLD

IEX INDIAN ENERGY EXCHANGE INNOVATION TECHNOLOGY FUTURE

HPX

PXIL Transforming Power Markets

International Partners

G015

cigre

IEEE

GLOBAL PST CONSORTIUM

NASPI

Pumped Storage Hydropower International Forum

iha

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PARIS2015 COP21-CMP11

NREL Transforming ENERGY

BERKELEY LAB Lawrence Berkeley National Laboratory

iea

IRENA International Renewable Energy Agency

Danish Energy Agency

THE WORLD BANK

USAID FROM THE AMERICAN PEOPLE

UKaid from the British people

ADB

JICA

نقل الكهرباء National Grid SA

TEPCO

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Next Steps for Action Plan Implementation

Standards and Regulatory Framework

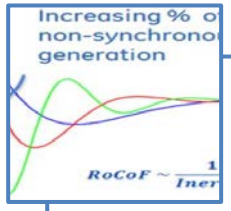
- Technical standards for connectivity
- Indian Electricity Grid Code
- Compliance testing
- Strengthening of standards & regulations

Resource Adequacy & Flexibility

- Adequate resources in all timeframes
- Harnessing flexibility in conventional generation
- Exploring new avenues: National Green Hydrogen Mission

Transmission Planning

- Evolving transmission planning philosophy
- Innovative solutions for grid stability



Reserves, Ancillary Services & Markets

- Primary, Secondary and Tertiary Control
- Voltage Control Ancillary Services
- Carbon Credit Trading Scheme

Real-time Monitoring, Visualization & Situational Awareness

- Renewable Energy Management Centers (REMCs) – 13 at present
- ~95 GW wind and solar capacity being monitored
- EMS (State Estimation, Contingency Analysis etc.) and Dynamic Security Assessment (DSA) Tools

India

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- https://sarepenergy.net/wp-content/uploads/2022/10/Case-Study-_Automatic-Generation-Control_Hydro_26082021.pdf
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- https://powermin.gov.in/sites/default/files/Renewable_Purchase_Obligation_and_Energy_Storage_Obligation_Trajectory_till_2029_30.pdf
- https://cea.nic.in/wp-content/uploads/notification/2023/01/Gazette_Flexible_operation-2.pdf
- https://cea.nic.in/wp-content/uploads/news_live/2023/05/Draft_phasing_plan_merged_letter.pdf
- https://cea.nic.in/wp-content/uploads/notification/2022/12/CEA_Tx_Plan_for_500GW_Non_fossil_capacity_by_2030.pdf
- http://www.cea.nic.in/reports/committee/nep/nep_jan_2018.pdf
- https://powermin.nic.in/sites/default/files/uploads/NEP-Trans.pdf
- http://cercind.gov.in/2016/regulation/9.pdf
- http://cea.nic.in/reports/others/ps/pspa2/tr_plg_criteria_manual_jan13.pdf
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India

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