

Webinar

Approaches to Utility Resilience: Creating an Energy Sector that is Prepared for the Unexpected

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Indian Grid...One of the World's Largest



- 1 national synchronous grid
- electricity generation
- 3 electricity consumption
- installed generation capacity
- transmission system
- 4 wind generation
- 5 solar generation
- renewable energy generation
- 7 hydro generation

Source: IEA Key World Energy Statistics 2019
(2017 data, 2018 provisional data)

Dimensions

370 GW+
generation capacity

182 GW+
peak demand

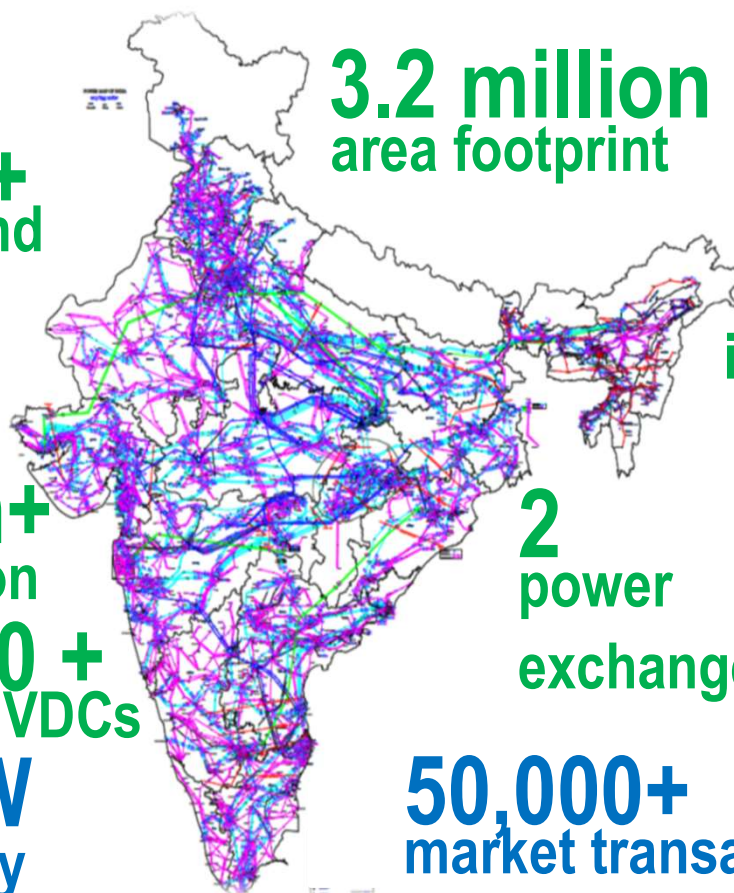
> 4 TWh
daily energy met

425,000 ckm+
EHV transmission

87 GW+
renewables

10 +
HVDCs

~ 100 GW
inter-regional capacity



3.2 million km²
area footprint

1.3 Billion+
people served

3 GW+
international exchanges

120 TWh+
annual market trades

2
power
exchanges

50,000+
market transactions

6000+
market participants

POSOCO: Focal Point of Indian Power Sector



Policy Making	Central Government	CEA	State Government
Regulators	Central Electricity Regulatory Commission	State Electricity Regulatory Commission	
System Operators	National Load Despatch Centre	Regional Load Despatch Centres	State Load Despatch Centres
Generation	Central Generating Stations	State Generating Stations	Private Sector Players
Transmission	Central Transmission Utility	State Transmission Utilities	Private Sector Players
Distribution	State Sector Distribution Licensee	Private Sector Distribution Licensee	
Markets	Trading Licensee	Power Exchanges	Bilateral Markets



<http://www.forumofregulators.gov.in/Data/Reports/FOR%20Report%20CABIL.pdf>

India – Natural Disasters



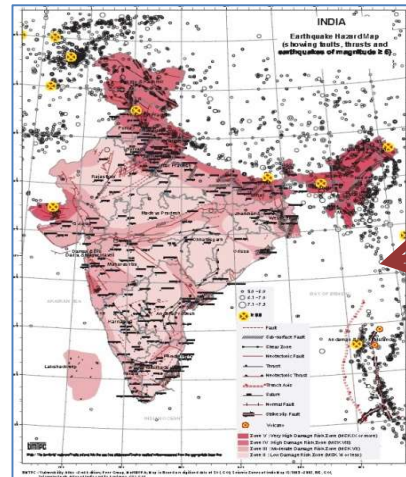
Unique Climatic
Regime

Two monsoon seasons
(southwest & northeast
monsoons)

Two cyclone seasons (pre
& post monsoon cyclone
seasons)

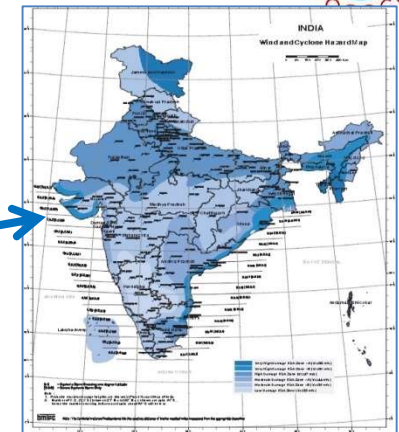
Hot weather season
characterised by violent
convective precipitation

Cold weather season
characterised by violent
snow storms in the
mountains



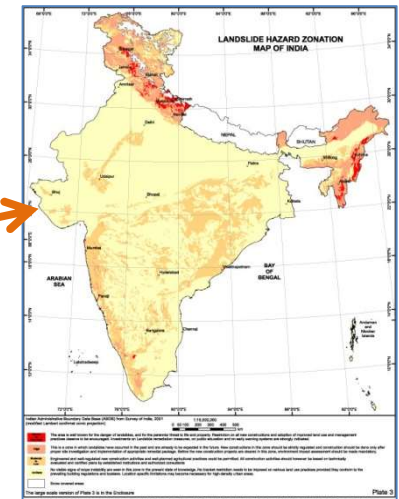
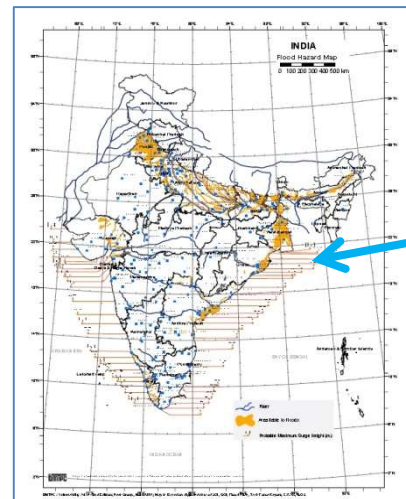
58 % of landmass prone to
earthquake of moderate to
very high intensity

8 % of landmass prone
to cyclone and tsunami



12 % of landmass
prone to flood and river
erosion.

15 % of land mass is prone
to land-slides and
avalanches



Source: www.portal.gsi.gov.in



Natural Disasters in Recent History which impacted Electricity Grid in India

Cyclones

- Phailin (**2013**)
- Hud-Hud (**2014**)
- Vardah (**2016**)
- Titli, Gaja (**2018**)
- Fani, Bulbul (**2019**)
- Amphan (**2020**)
- Nisarga (**2020**)

Floods

- Uttarakhand (2013)
- Chennai (2015)
- Assam (2016)
- Chennai(2017)
- Kerala (2018)
- Karnataka(2019)
- Kerala(2019)
- Pune(2019)
- Vadodara(2019)

List of Major Earthquakes on India

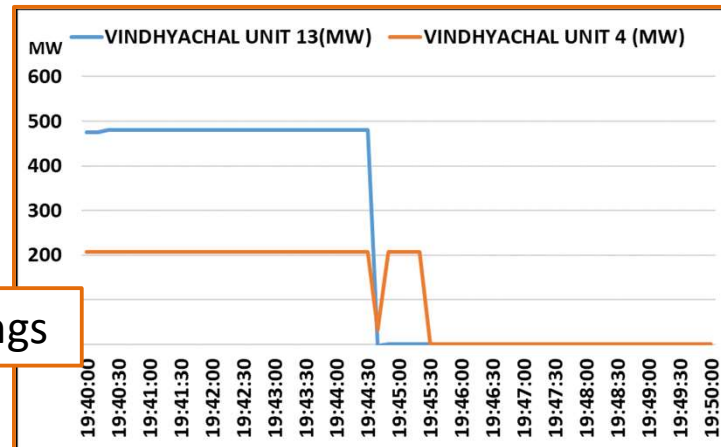
Date	Location	Intensity
10 April 2018	India	4.6
03 Jan 2017	India, Bangladesh	5.7
04 Jan 2016	India, Myanmar, Bangladesh	6.7
26 Oct 2015	Afghanistan, India, Pakistan	7.7
12 May 2015	Nepal, India	7.3
25 April 2015	Nepal, India	7.8
01 May 2013	Kashmir	5.7

Impact due to Earthquake on 10th April, 2018

Richter scale: 4.6



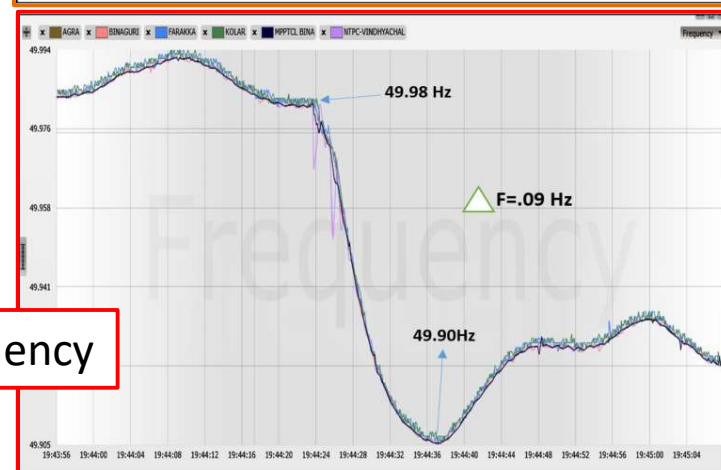
Voltage Transients



Unit Trippings



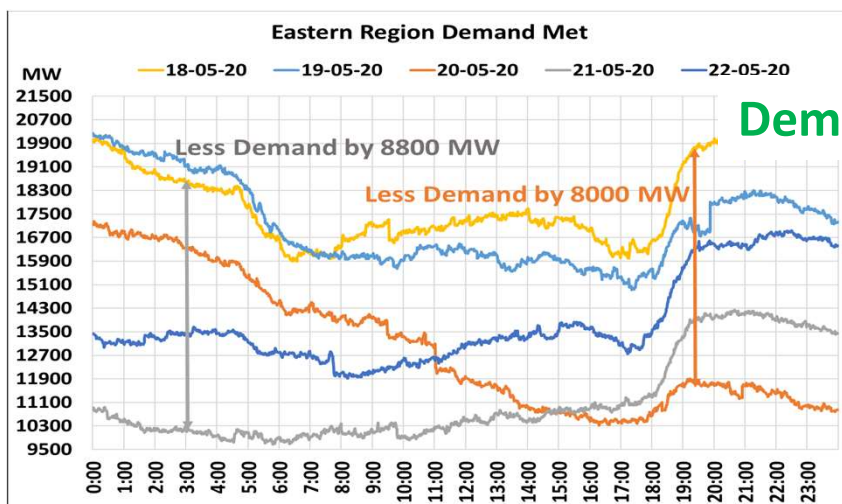
Angular Stress



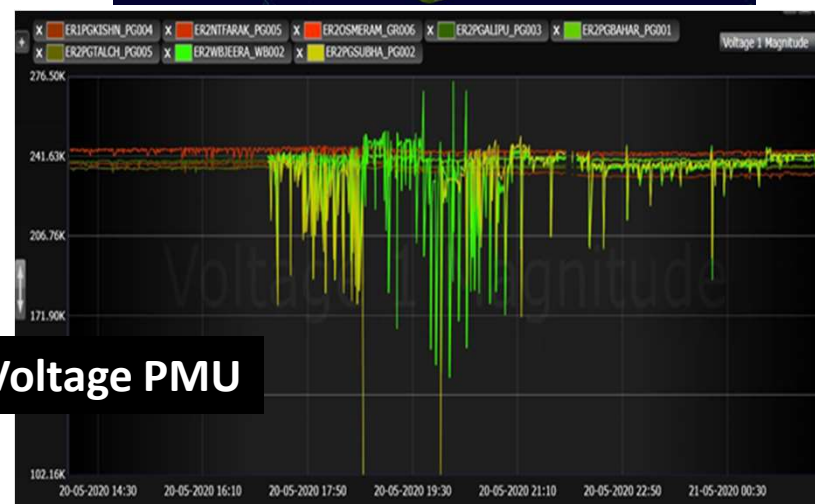
Drop in Frequency

Cyclone Amphan

- Super Cyclonic Storm named 'Amphan' – 20 May 2020
- Wind speed of more than 120 kmph
- West Bengal and Odisha affected
- Generation Loss: 260 MW
- Stations affected: 400 kV: 5, 220 kV :11, 132 kV : 13, 33 kV : 280 +
- Lines tripped: 400 kV :12, 220 kV : 17, 132 kV:40 +



Demand



Voltage PMU

Approach for Resiliency

Long Term: Crisis & Disaster Management Plan (C&DMP) For Power Sector in INDIA

- Formulated in 2004 and updated in 2012 by Central Electricity Authority (CEA)
- Provide guidelines for assistance to utilities
- Inputs provided by experts and stakeholders
- Covers
 - planning,
 - quick response
 - recover from unexpected events and situations
 - ensuring safety of people, protection of environment, protection of installation
 - and restoration of power supply by utilities

Nodal Agency: National Load Despatch Centre (NLDC) for Power Sector

Operation

- Wide dissemination of forecast on cyclones:
 - Trajectory
 - Timing of the landfall by the IMD
- Unit Commitment and rescheduling of critical Generation
- Reduction of the power flow on likely affected transmission
- Toggling of HVDC Links
- Movement of ERS Towers/additional equipment as well as Emergency Response Teams at all critical sub-stations
- Emergency Response Teams at NLDC / RLDC / SLDC (System Operator)
- Precautionary Interventions/Curtailment in Electricity Market
- Advance plans for restoration of the distribution network

Real Time Coordination:

Visualization of faults through Phasor Measurement Units (PMUs)

Logistics and Coordination for Resiliency



- Recovery equipment and spares inventory
- Communication facilities
- Transport and Mobility arrangements
- Financial resources
- Dewatering pumps
- Mobile Diesel Generator (DG) sets
- Emergency Restoration System (ERS) for transmission
- Black start facilities
- Regular check up for healthiness and regular drills
- Annual safety audit
- Regular interaction with disaster management groups

ENHANCING POWER SYSTEM RESILIENCY

Damage Prevention

- Strengthening of transmission towers
- Cyber Security Measures
- Vegetation Management
- Planned maintenance
- Selective underground cabling
- Keeping:
 - Emergency Restoration System (ERS) for transmission
 - Recovery equipment and spares inventory

System Recovery

- Quick Damage assessment
- Movement of restoration teams to pin point locations
- Early restoration of important centers
- Satellite based area assessment and communication system
- Effective use of Real time security desk
- Spare equipment strategies
- Black start facilities
- Effective use of weather information provided by metrological department.

Future

- More distributed generation options such as fuel cell, solar PV & wind to enable urgent services to mobile phones, hospitals and traffic lights.
- Switching of mobile network from local to satellite system .
- Grid forming based solar and wind plants.
- Research on high impact low frequency events.
- Enhancing reliability of Nuclear Power plants.

ENHANCING POWER SYSTEM RESILIENCY

Generation

- Design to minimize damage
- Advance Fuel supply and storage system
- More interconnection lines for plants.
- Black Start capabilities
- Protection from Malware attacks
- Bringing in more flexibility

Transmission

- Protection from cyclone, flood, earthquake and high winds.
- Selective underground cabling
- Protection Relay redundancy
- Vulnerability assessment based on real-life examples
- Online monitoring of spare components
- Protection from Cyber attacks

Distribution

- Reinforcement from overhead distribution system
- Distributed Storage system
- Underground cabling in targeted important areas
- Decentralized restoration system
- Distributed Generation
- Smart Grid technology
- Online health Monitoring of assets at station level

Indian grid operation after Covid-19 pandemic outbreak



22 March 2020

Janta curfew



**25 March - 14 April 2020
extended to 31 May 2020**

Complete India lockdown



5th April 2020

*Pan-India lights
switch off for
9 minutes @ 9 PM*

Advisory/Guidelines pan-India control centres

General sanitization & social distancing protocols



Personal hygiene



Stay at home



Social Distancing



Travel Advisory



Teleworking

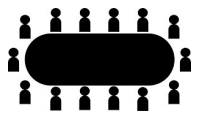


Keep objects and surface clean



Wearing PPE

Ensuring continuity of load despatch centre operations



Strategic Oversight /
Tactical Teams



Critical Staff for
Core Functions



Lockdown Travel
Permission



Health Monitoring of
Control Room Staff



Temporary Control
Room in same premises



Cyber security



Remote access

Impact on reliability of electricity grid



Interactions by system operators at
RLDCs/NLDC with other stakeholders
(neighbouring countries too)



Identification of
reserve manpower
/ roster depth



Load forecasting/
demand variation



Maintenance
(Planned) / Forced
outage of G & T



Fuel stock
monitoring



Transmission
capability & grid
security

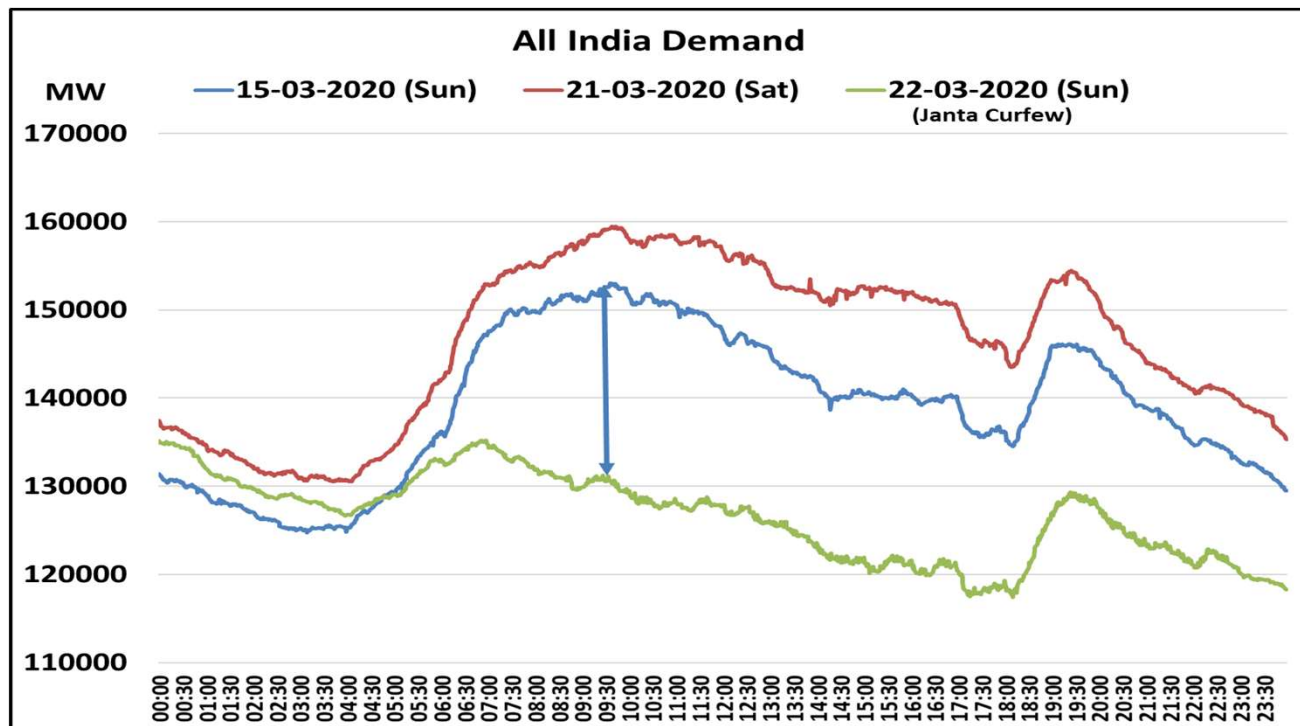


Generation unit
availability and
reserves

NERC Report on High-Impact, Low-Frequency Event Risk to the North American Bulk Power System June, 2010

<https://www.energy.gov/sites/prod/files/High-Impact%20Low-Frequency%20Event%20Risk%20to%20the%20North%20American%20Bulk%20Power%20System%20-%202010.pdf>

All India load curve on Janta curfew day compared to previous day/week



All India

Reduction in energy consumption
~ 300 GWh

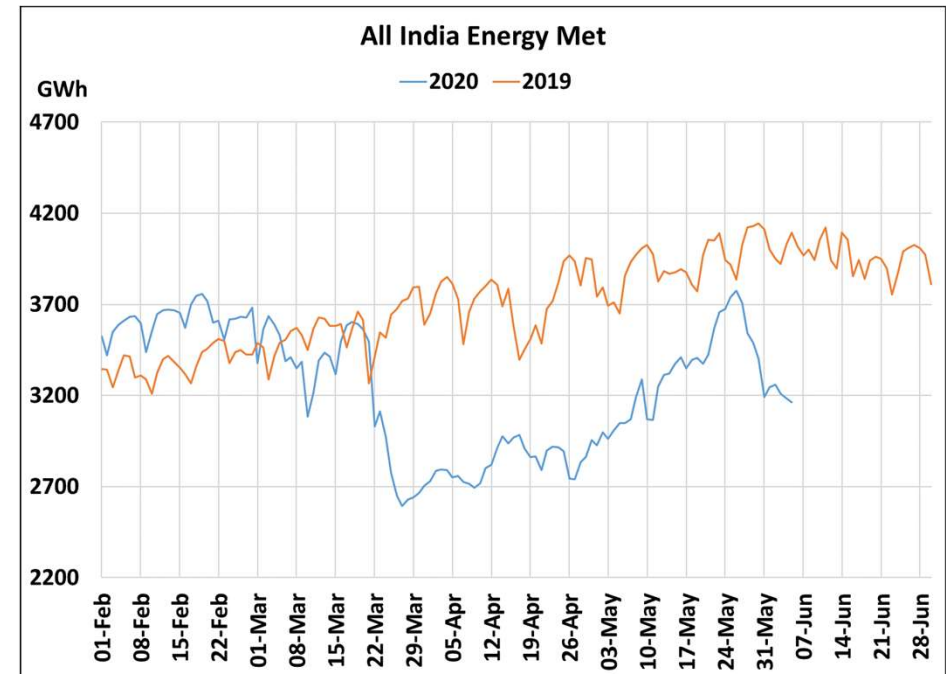
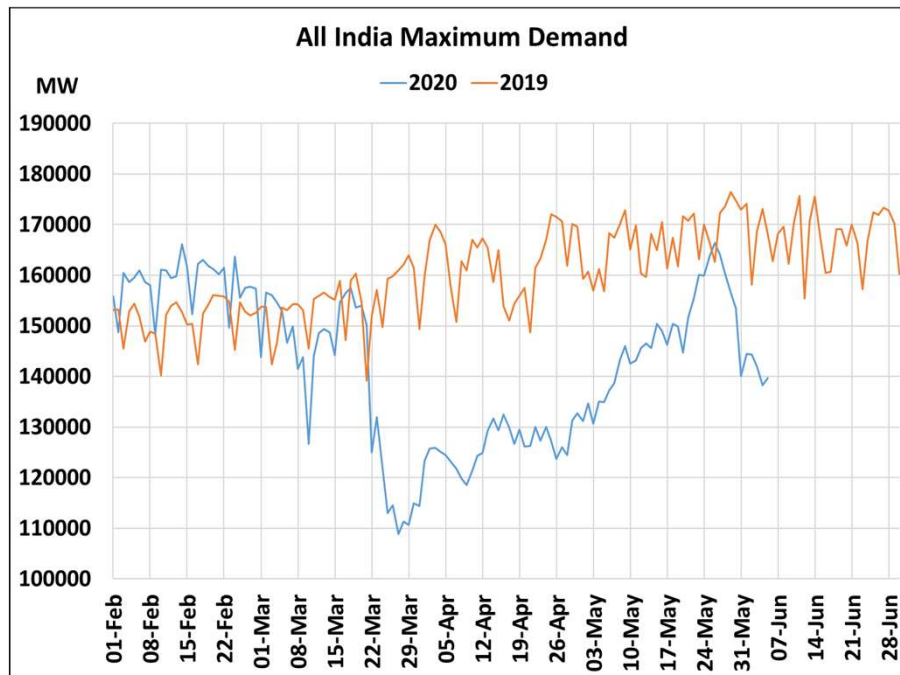
Peak demand suppressed
~ 20 GW

Compared to previous Sunday
(15th March, 2020)

Commercial load reduction

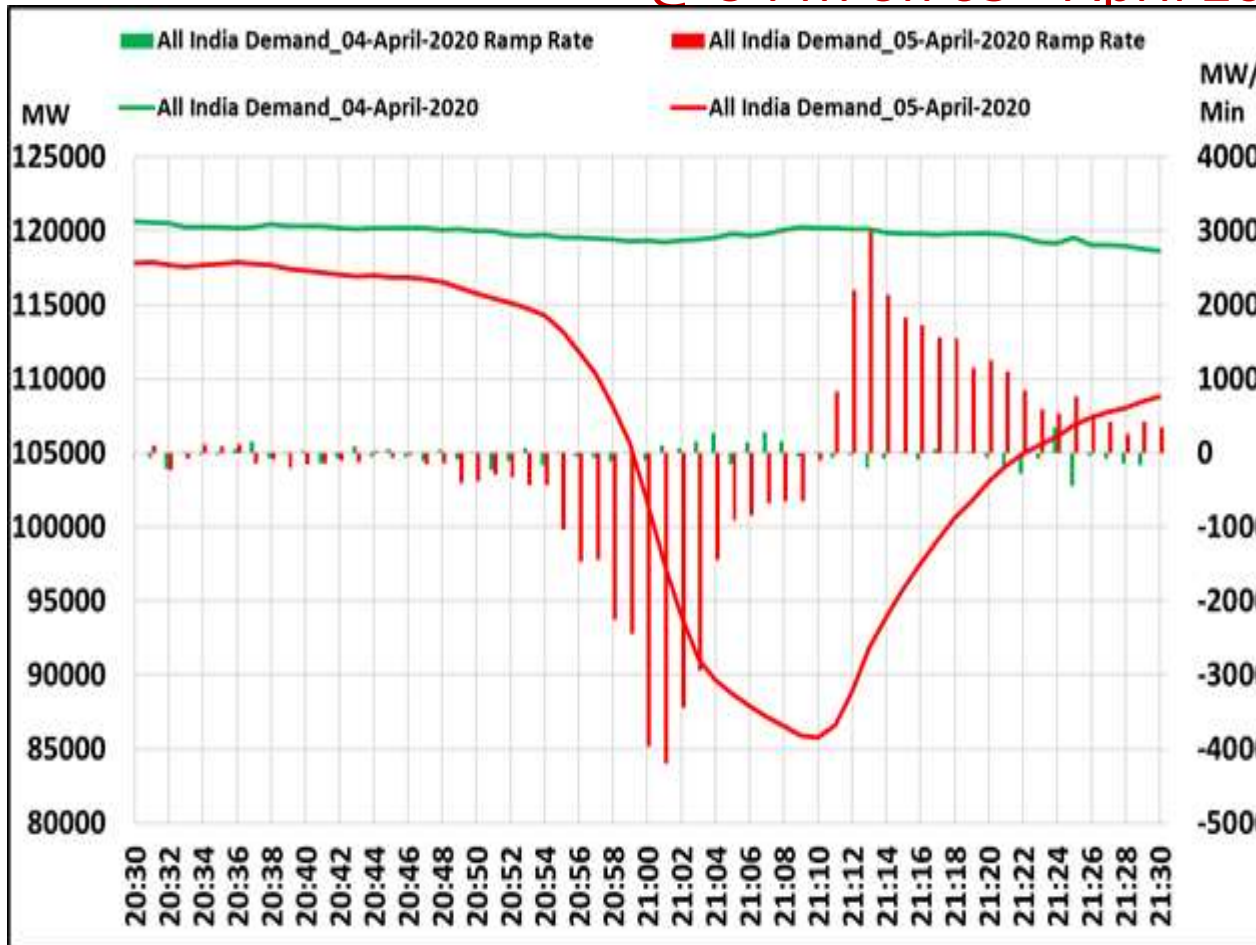
Date	Energy Consumption (GWh)					
	Northern Region	Western Region	Southern Region	Eastern Region	North Eastern Region	All India
15-March-2020	774	1119	1061	345	39.82	3339
22-March-2020	739	977	965	319	35.10	3035

25 March - 14 April 2020 extended to 31 May 2020 Complete India lockdown



- All India energy consumption at the start of lock down period is less by 20-30 % compared to normal day
- Percentage reduction in energy met is highest for NR followed by Western region and Southern region
- Energy reduction > 30 % - Uttarakhand, HP, AP, Telangana, TN, Arunachal, Assam and Meghalaya.
- Consumption kept on increasing with rise in temperature due to upcoming summer.

Actual All India demand during lights switch off event @ 9 PM on 05th April 2020

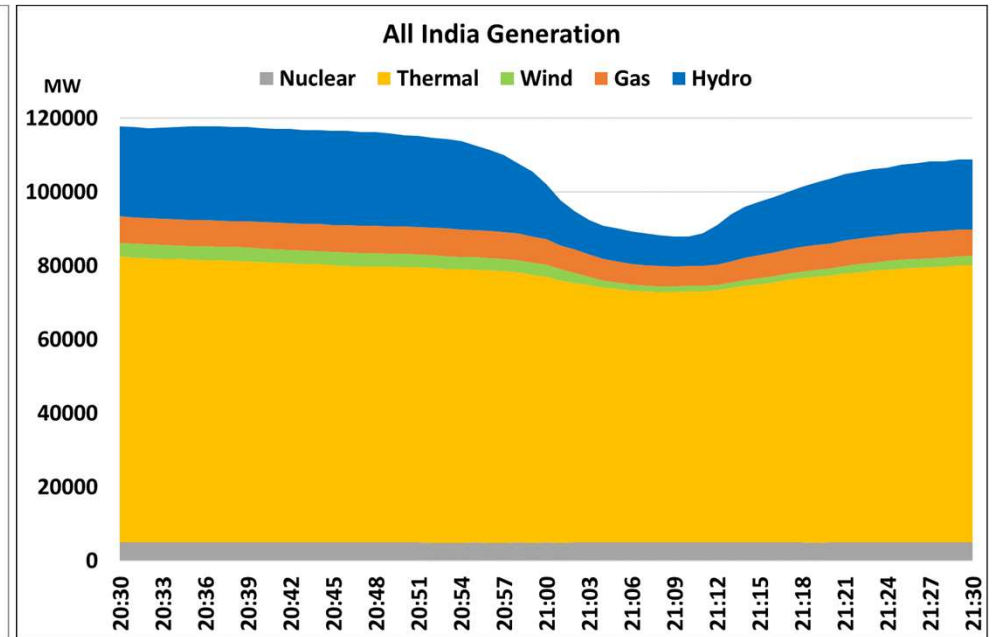
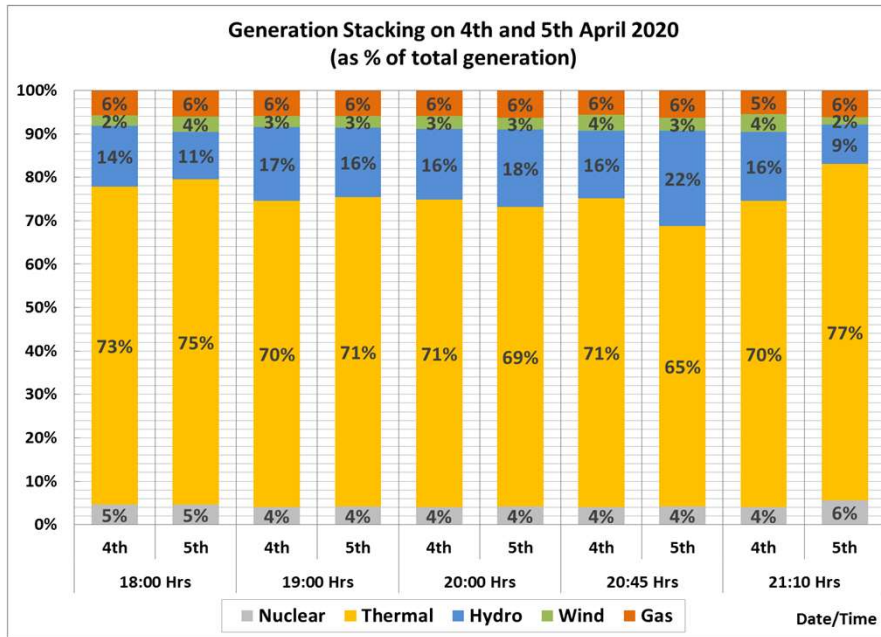


The total reduction in all India demand recorded during the event was **31089 MW**.

All India demand started reducing from **20:45 Hrs** and minimum demand of **85,799 MW** was recorded at **21:10 Hrs**.

Subsequently, from **21:10 Hrs**, the demand started picking up and settled around **114400 MW** at **22:10 Hrs**.

Generation Profile during lights switch off event on 05th April 2020



- 22 % hydro generation on 05th April, 2020 as compared to 16 % on previous day at 2045 hrs (⬆️)
- 9 % of hydro generation on 05th April, 2020 as compared to 16 % on previous day at 2110 hrs (⬇️)

<https://posoco.in/wp-content/uploads/2020/05/Report-on-Pan-India-Lights-Off-Event-9-PM-9-Minutes-on-5th-April-2020-1.pdf>

Resiliency: Covid-19

- Shutdown of costly Generation
 - Low prices in the market
- Incentives for flexibility: Ramping
- Focus of hydro generation and pumped storage
- Starting of Real-Time Market from 1st June 2020
- Expansion of Security Constrained Economic Dispatch
- Renewable Energy Management Centres
- Government of India intervention and support

“Faith is the bird that feels the light and sings when the dawn is still dark.” – Rabindranath Tagore

Thank you !!

STOP
Coronavirus!

