



Session - 6

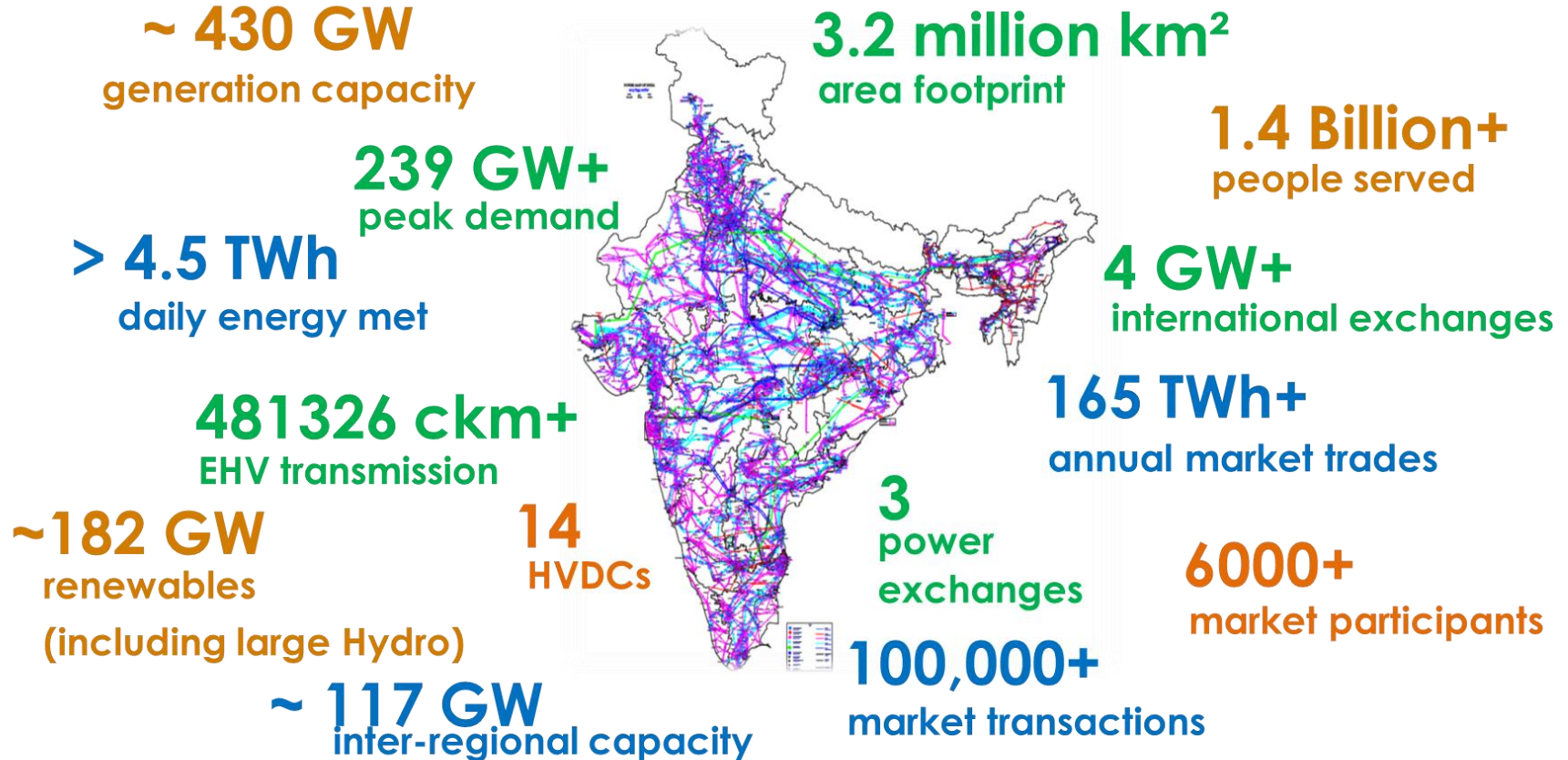
Climate Resilience of Future Grids

14th March 2024

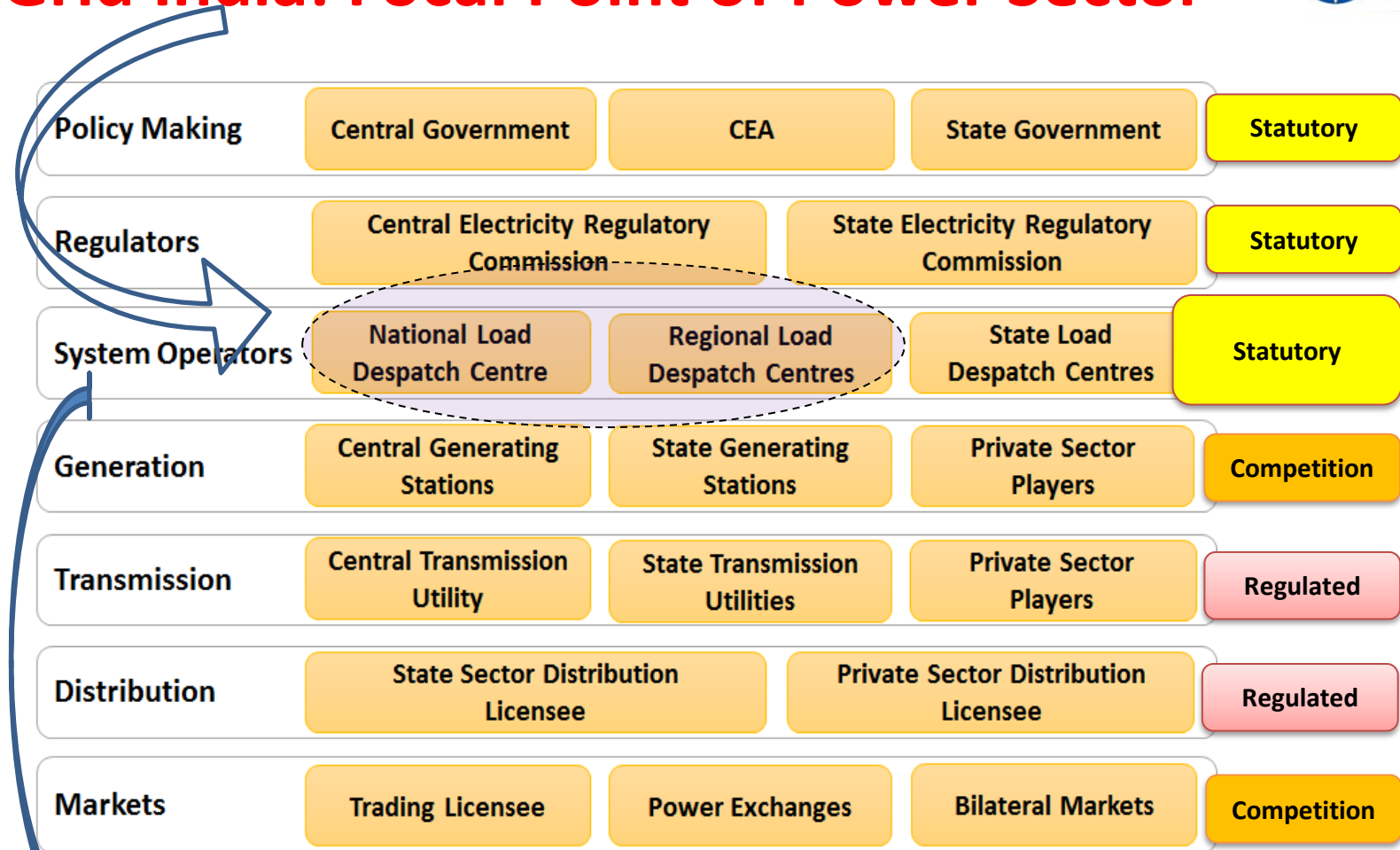
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Grid Controller of India Limited

Dimensions of Indian Power System



Grid India: Focal Point of Power Sector



'Vital link' between the administrators, planners & regulators on one end and physical system and market players on the other end

India – Susceptible to Natural Disasters

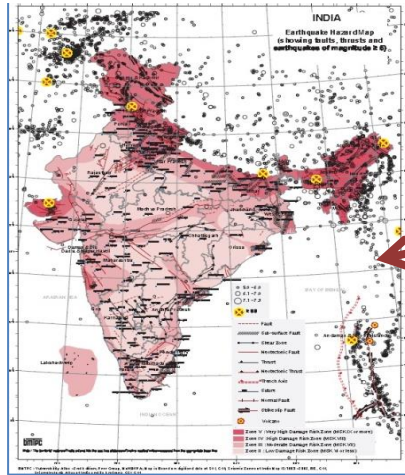
Unique Climatic
Regime

Two monsoon seasons
(southwest & northeast
monsoons)

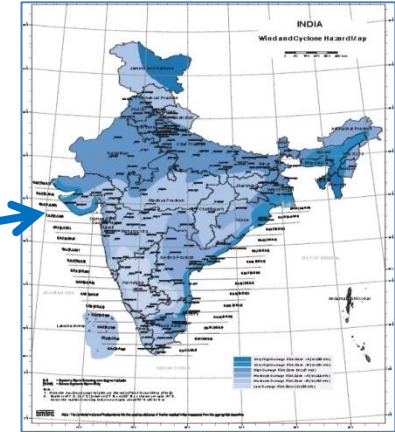
Two cyclone seasons (pre
& post monsoon cyclone
seasons)

Hot weather season
characterised by violent
convective precipitation

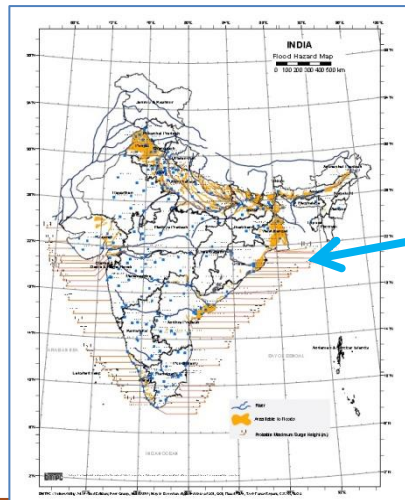
Cold weather season
characterised by violent
snow storms in the
mountains



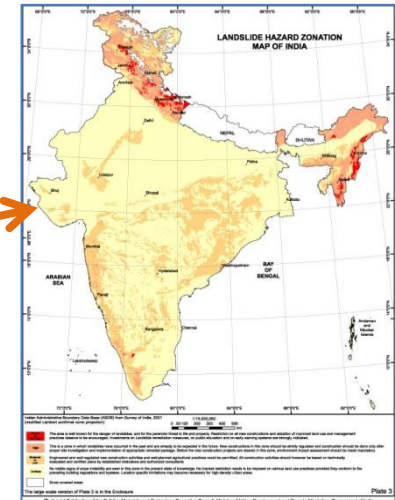
58 % of landmass prone to
earthquake of moderate to
very high intensity



8 % of landmass prone
to cyclone and tsunami



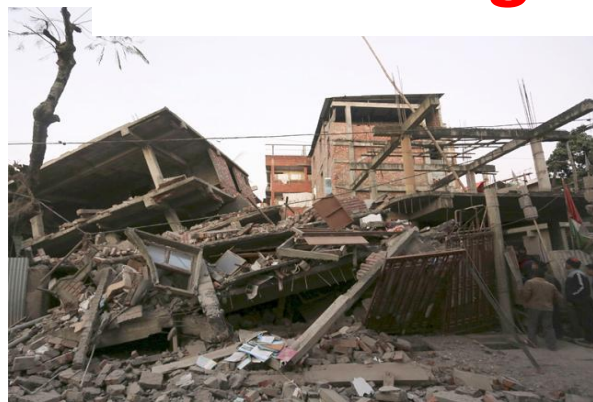
12 % of landmass
prone to flood and river
erosion.



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

Source: www.portal.gsi.gov.in

Damage to Power Infrastructure



Natural Disasters in Recent History which impacted Electricity Grid in India

Cyclones

- **2023:** Biparjoy, Michaung
- **2022:** Asani , Mandous
- **2021:** Tauktae , Yass
- **2020:** Amphan, Nivar
- **2019:** Fani, Bulbul
- **2018:** Titli, Gaja
- **2016:** Vardah
- **2014:** Hud-Hud
- **2013:** Phailin

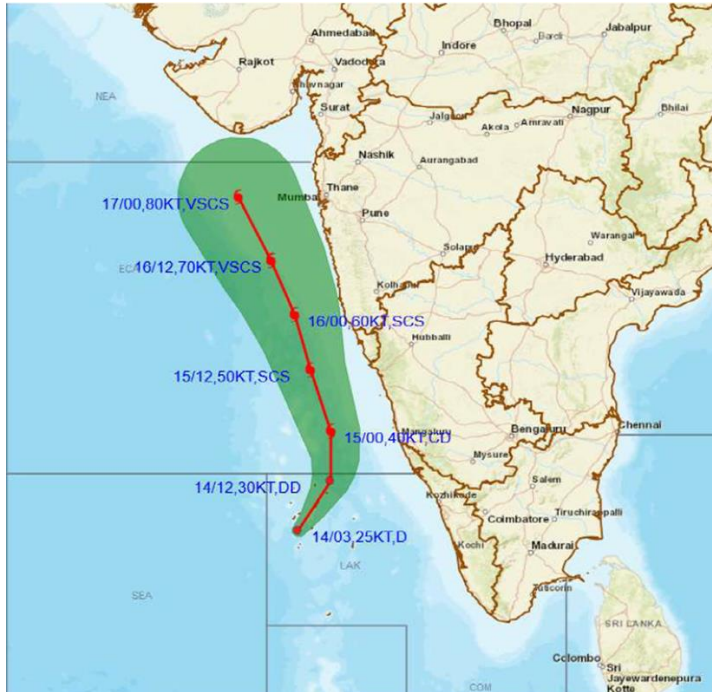
Floods

- **2023:** Chennai
- **2022:** Assam
- **2021:** Uttarakhand, Maharashtra
- **2020:** Assam, Telangana
- **2019:** Karnataka, Kerala
- **2018:** Kerala
- **2017:** Tamil Nadu
- **2016:** Assam
- **2015:** Tamil Nadu
- **2013:** Uttarakhand

Earthquakes

Date	Affected Area	Intensity
03 Nov 2023	India, Nepal	5.7
28 April 2021	India	6.0
10 April 2018	India	4.6
03 Jan 2017	India, Bangladesh	5.7
04 Jan 2016	India, Myanmar, Bangladesh	6.7
26 Oct 2015	India, Afghanistan, Pakistan	7.7
12 May 2015	India, Nepal	7.3
01 May 2013	India	5.7

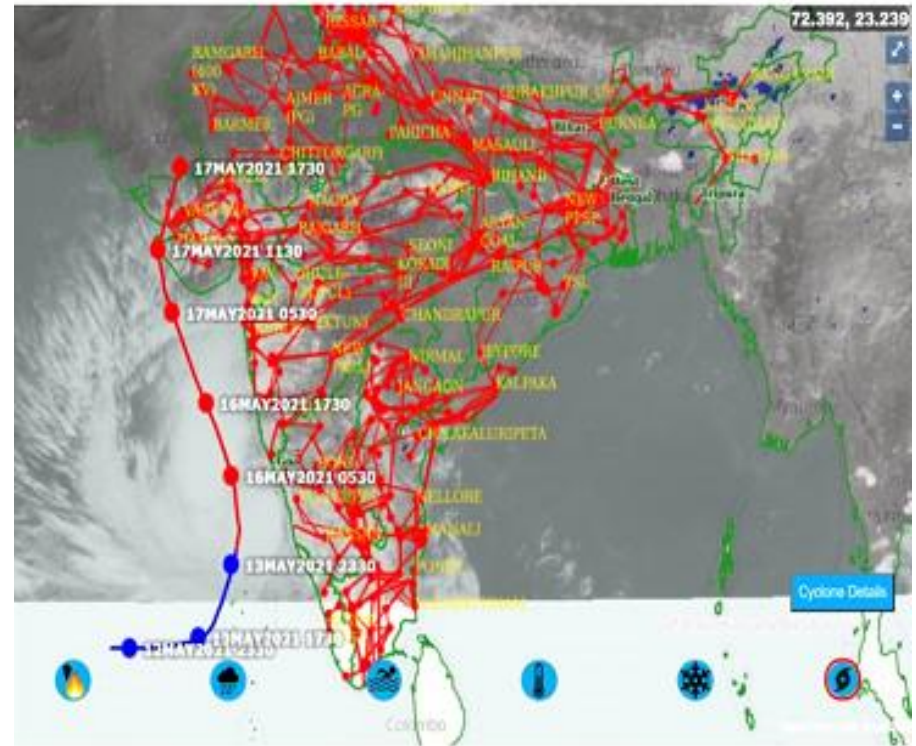
Advance Warning



Predicted Cyclone Track

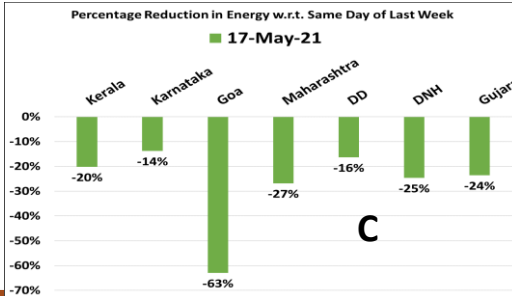
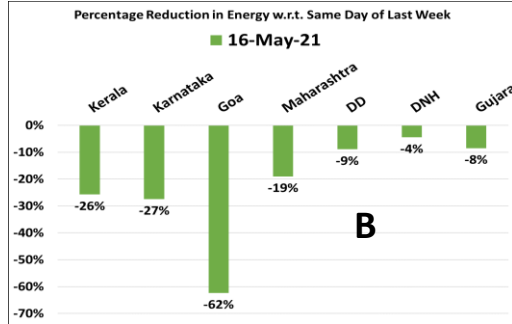
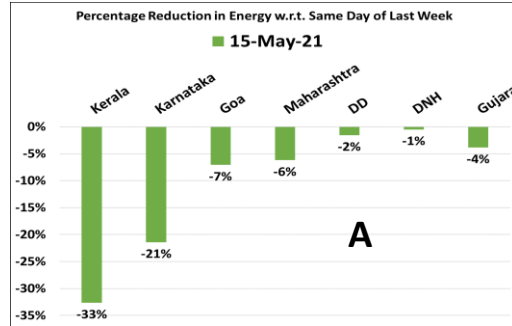
by Indian Meteorological Department on
14th May 2021

Risk Assessment

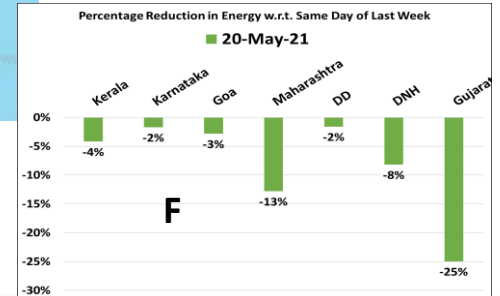
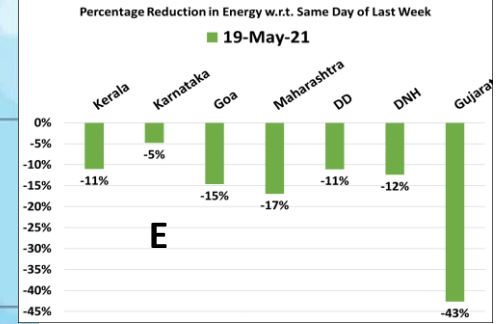
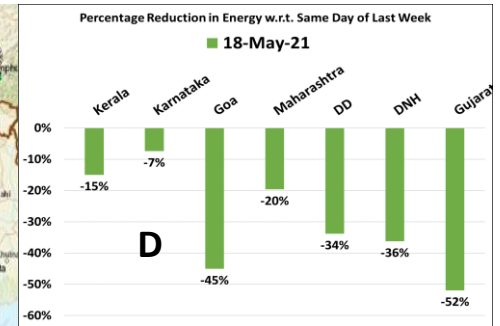


Satellite-based GIS Display from Indian Space
Research Organization

Extremely Severe Cyclonic Storm "Tauktae" May'21



D: Depression
DD: Deep Depression
CS: Cyclonic Storm
SCS: Severe Cyclonic Storm
VSCS: Very Severe Cyclonic Storm
ESCS: Extremely Severe Cyclonic Storm

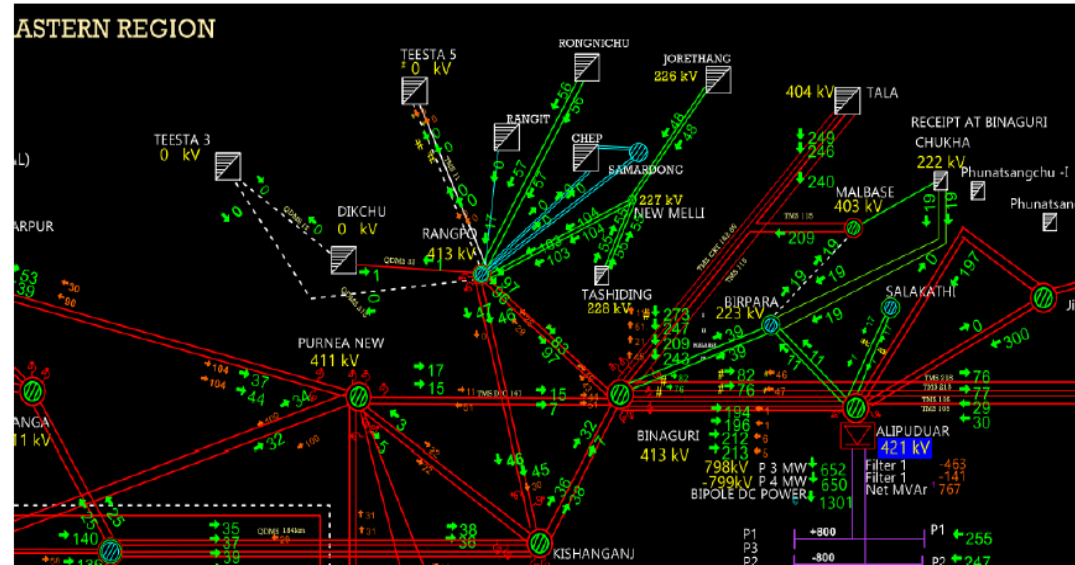


Cloudburst and Damage of Teesta Dam

04th October 2023

High impact Low frequency event in Teesta Valley

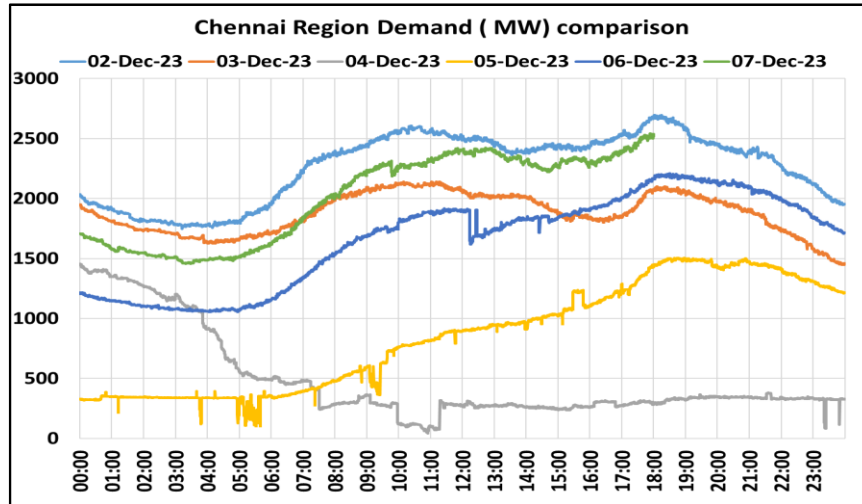
- Due to continuous high silt and rise in inflow due to cloud burst in the upstream area of the reservoir, **Teesta-III all units (6*200 MW)** (On bar gen around 1300 MW) taken out of bar at 00:50 Hrs on 04-10-2023.
- **Dikchu both units (2*48 MW)** taken out of bar at 01:49 hrs due to flash flood
- All 3 units of **Teesta V (3*170 MW)** (generating around 504 MW) taken out of bar at 02:37 hrs due continuous high silt
- **Entire ~1900 MW** of Hydro Generation is yet to be revived



Lines Under Forced Outage	Remarks
400KV-RANGPO-TEESTA-V-1	Tower collapsed at loc. 1 Hand-tripped as a precautionary measure
400KV-RANGPO-TEESTA-V-2	
400KV-TEESTA-III-RANGPO-1	
400KV-TEESTA-III-DIKCHU-1	
400KV-RANGPO-DIKCHU-1	

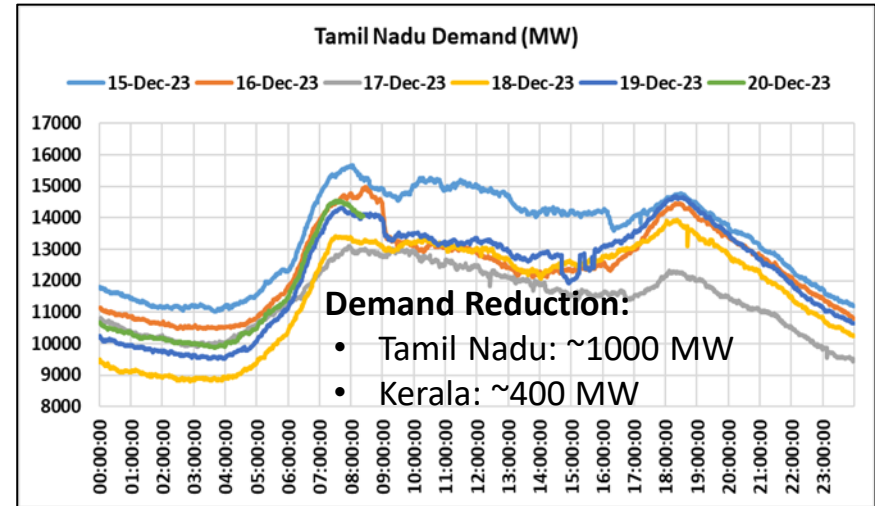
Floods Impact on Power System

Severe Cyclonic Storm “MICHAUNG” 05th Dec 2023



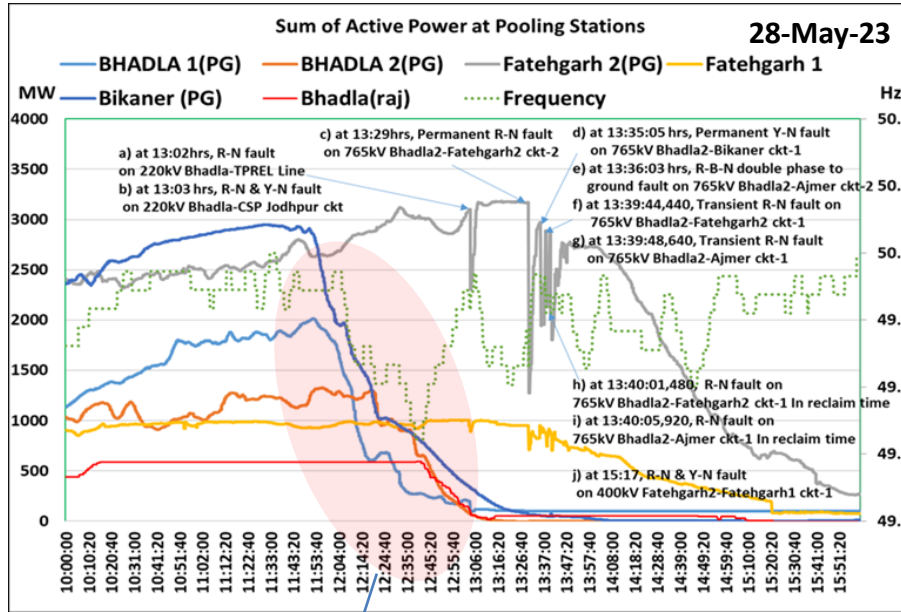
- Impact on System:
 - Floods in Chennai**
 - Demand reduction from almost 2500 MW to 300 MW
 - Tower Collapse in four lines
 - Demand Restored by 07th Dec 23.

Heavy Rainfall Activity Over Tamil Nadu & Kerala 17th Dec'23

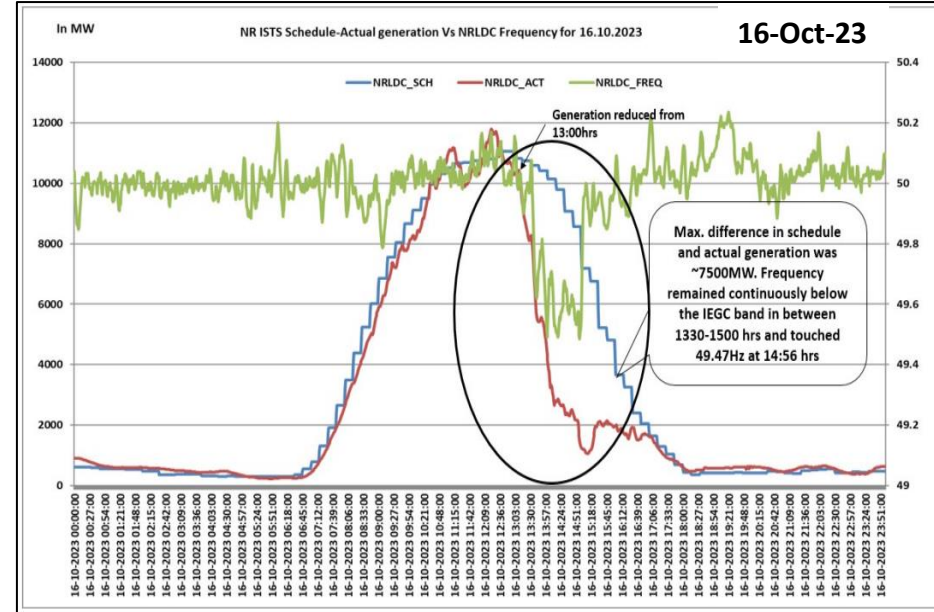


- Following Units hand tripped due to Water Logging:**
 - Coastal Energen unit-2: 600 MW
 - Tuticorin units 1 to 5 : 5*210 (1050 MW)
 - NTPL Unit-1 and Unit-2 : 2*500 (1000 MW)
 - Tuticorin_GRT Jewellers 150MW solar plant.
- Following Stations hand tripped due to Water Logging:**
 - 400kV Ottapidaram S/s
 - 230kV Tuticorin S/s

Impact of Cloud Covers on Power System



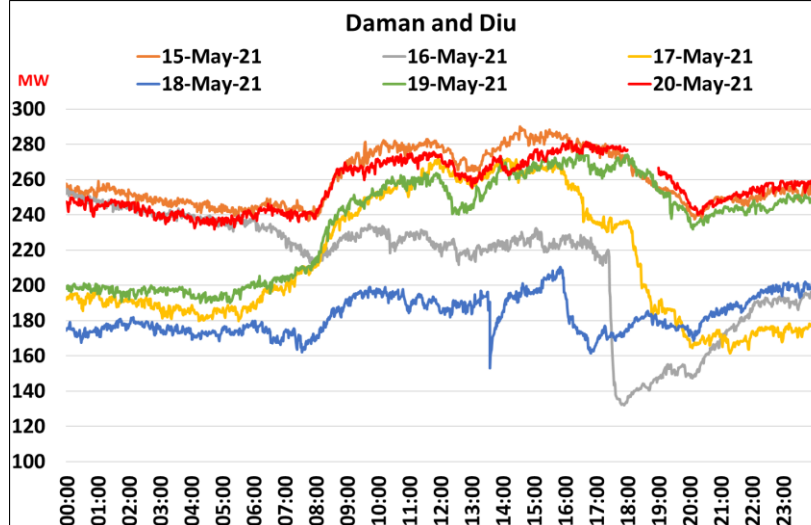
Approx. 8000 MW reduction in solar generation in 1 hour due to Cloud Cover



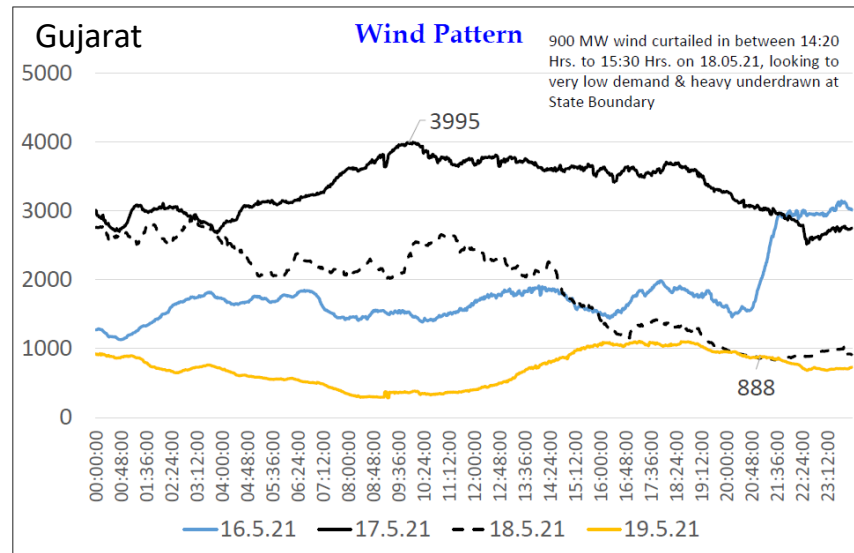
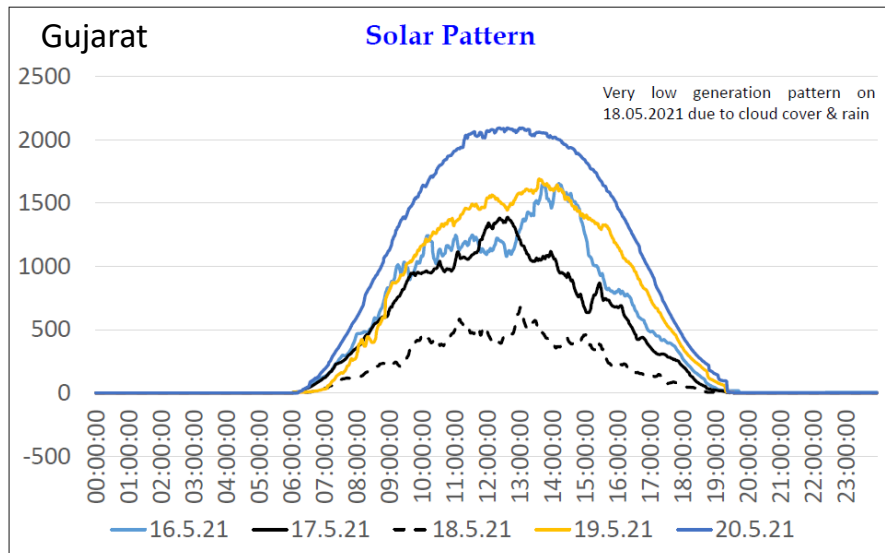
Approx. 7500 MW reduction in solar generation in 1 hour due to Cloud Cover

Impact of Cyclone On Diu Daman & Diu

- Landfall : Between Diu and Una, ~ 21:00 hrs, 17th May.
- Diu (17th May)
 - Power supply to Diu interrupted due to loss of supply at 66 kV Una S/s and 220 kV Dhokadva s/s consequent to tower collapse at many locations.
 - Power supply was extended to Diu at 20:04 hrs of 22nd May from Gujarat system.



Impact On Renewable Generation

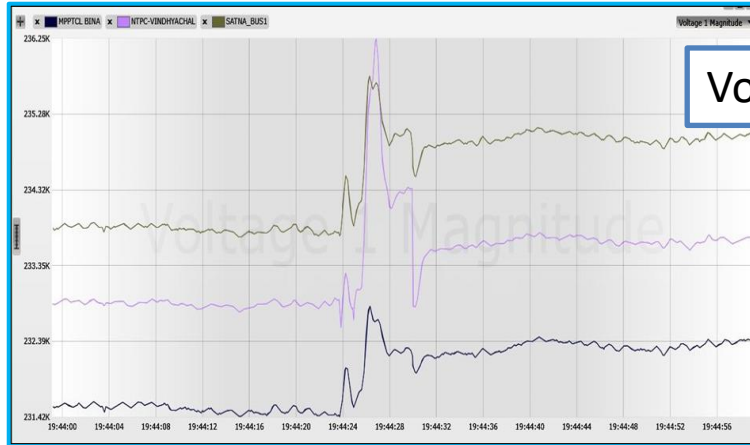


- High intermittency
- Low generation

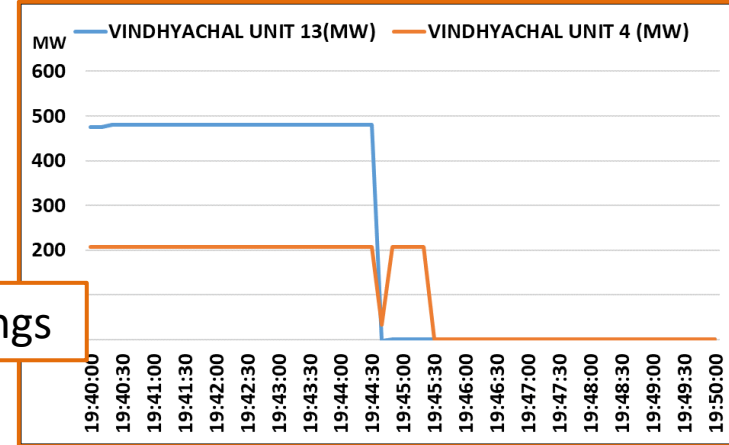
- Wind generation blocked out due to wind gust exceeding cut off speed.
- Wind Generation curtailed on 18th May to maintain ACE within limits.

Impact due to Earthquake on 10th April, 2018

Richter scale: 4.6



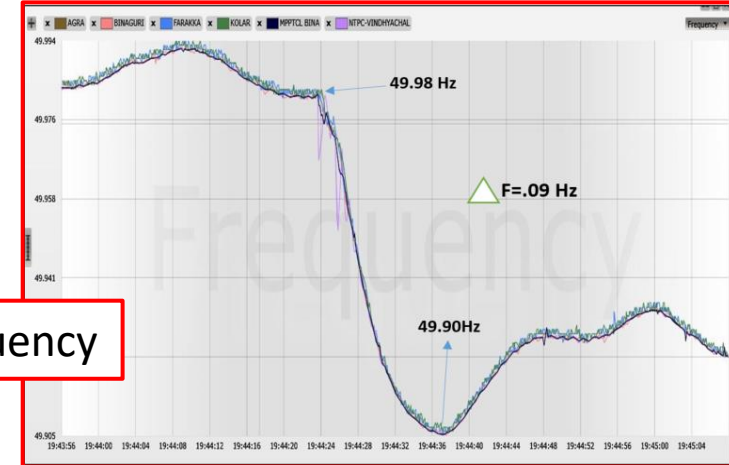
Voltage Transients



Unit Trippings



Angular Stress



Drop in Frequency

Lessons Learned

Key Success Factors

Early warning

- Early warning of cyclone/floods helped in operational planning and coordinating between multiple control centres and utilities.

Geo-Mapping of transmission assets

- Geo mapping of all available transmission, generation, distribution assets is required for impact assessment and restoration coordination.

System Visibility

- Availability of WAMS enabled facilitated quick response.

Seamless flow of information

- Platforms created for exchange of information between administration, nodal agency and utilities helped in effective crisis management.

Reinforcement of skilled personal on site & control centers

- Challenges in HR mobilisation on account of ongoing pandemic (another HILF) and lockdown affected restoration activities.

Adequacy of Pump for de-watering of substation

- Several substations required dewatering after cyclone induced rain.

Resilience through large synchronous interconnection

- Sequential and extended period of demand crash due to extreme weather events was successfully managed

Backup communication system

- Backup communication system availability and redundancy had helped a lot during the disruption of data in the Diu system while the cyclone impacted the system.

Crisis & Disaster Management Plan (C&DMP) For Power Sector

First formulated in 2004 and updated in 2023 by Central Electricity Authority (CEA)

To act as tool and provide guidelines for assistance to utilities

Inputs provided by experts and stakeholders

Broadly covered activities that enable various agencies to plan for, quick respond to and to recover from unexpected events and situations for ensuring safety of people, protection of environment, protection of installation and restoration of power supply by utilities

National Load Despatch Centre (NLDC) declared Nodal agency for coordination in natural and man made crisis situations in Power Sector

Standard Operating Procedure for Electricity Infrastructure

- Wide dissemination of forecast on cyclones indicating the trajectory and timing of the landfall by the IMD through website and electronic media
- Emergency Response Teams from utilities 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
- Planned Shutdown / Backing down of critical Generating Units
- Reduction of the power flow on the transmission lines
- Toggling of Inter-Regional HVDC Links
- Deployment of ERS Towers / additional equipment for quick restoration
- Visualization of faults through Phasor Measurement Units (PMUs)



Thank You!!

Long Outage of Important Transmission elements due to Tower Collapses

Sl. No.	Line Name	Owner	Outage	Revival	Reason/ Remarks
			Date	Date	
1	220 kV Gazipur(DTL)-Shahibabad(UP) (UP) Ckt-1	NR	30-04-2022	Still out	Tower tilted on one side at tower no 10 from Gazipur (DTL) end.
2	220 kV Gazipur(DTL)-Noida Sec62(UP) (UP) Ckt-2	NR	30-04-2022	Still out	In OCC meeting, UPPTCL representative highlighted funding issues with MCD.
3	220 KV Chamera_3(NH)-Chamba(PG) (PG) Ckt-2	NR	09.07.23	Still out	Line tripped due to tower collapsed at Loc. no. 1 from Chamera-3 end
4	400KV-RANGPO-TEESTA-V-1	ER	04-10-2023	Still out	TEESTA-V is already under long outage
5	400KV-RANGPO-TEESTA-V-2	ER	04-10-2023	Still out	
6	220kV Manubolu-Sullurpet -2	SR	04-12-2023	21-12-2023	17
7	220kV Manubolu-Sullurpet -3	SR	04-12-2023	21-12-2023	17
8	220kV Tondiarpet-ETPS S/C	SR	04-12-2023	Still out	-
9	220kV Gummidipundi-Sullurpet S/C	SR	04-12-2023	02-01-2024	29
10	132 kV Panchgram-Srikona line	NER	14-01-2019	Still out	Reliability of the South Assam & Meghalaya power system has reduced.
11	132 kV Roing-Pasighat	NER	charged through ERS	Still out	Reliability of the Arunachal Pradesh power system has reduced.
12	132kV-Lekhi-Nirjuli-1	NER	28-06-2022	Still out	The line has been charged 132kV Pare-Lekhi-Nirjuli transmission line through the old 132kV LILO transmission line between NDTL and Lekhi substation on 11-07-2022. As per 203 rd OCCM Tower locations in spate of floods. Works stalled. Expected completion by March 2024.
13	132kV-Pare-Lekhi-1	NER	28-06-2022	Still out	The line has been charged 132kV Pare-Lekhi-Nirjuli transmission line through the old 132kV LILO transmission line between NDTL and Lekhi substation on 11-07-2022. As per 203 rd OCCM Tower locations in spate of floods. Works stalled. Expected completion by March 2024.
14	220 kV BTPS-Rangia	NER	21-06-2023	Still out	The 220 kV BTPS-Rangia line I and II has been charged through ERS tower on 29 th June and 05 th July 23 respectively.
15	132 kV Panyor HEP-PHEP & 132 kV Panyor-Chimpu line	NER	05-04-2023	Still out	Reliability of the Arunachal Pradesh and Assam power system has reduced

***Note:** As per regulation 5b of CERC (Standards of Performance of inter-State transmission licensees) Regulations, 2012, any line going under outage due to tower collapse should be restored back on emergency restoration tower within 12 days and on normal tower within 50 days in case of river bed.

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Logistics and Coordination

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

Future Initiatives for Grid Resilience

- Regulatory Framework for Reliability and Handling Low Probability High Impact events
- Weather Proofing - Analytics for Climate Information and Forecasting
- Storm Hardy Grid - Risk Assessment and Management for Adaptation Strategy
- Investment in Research and Deployment in upgrades to infrastructure
- Cross-sector collaboration for long-term infrastructure planning and cooperation for crisis response