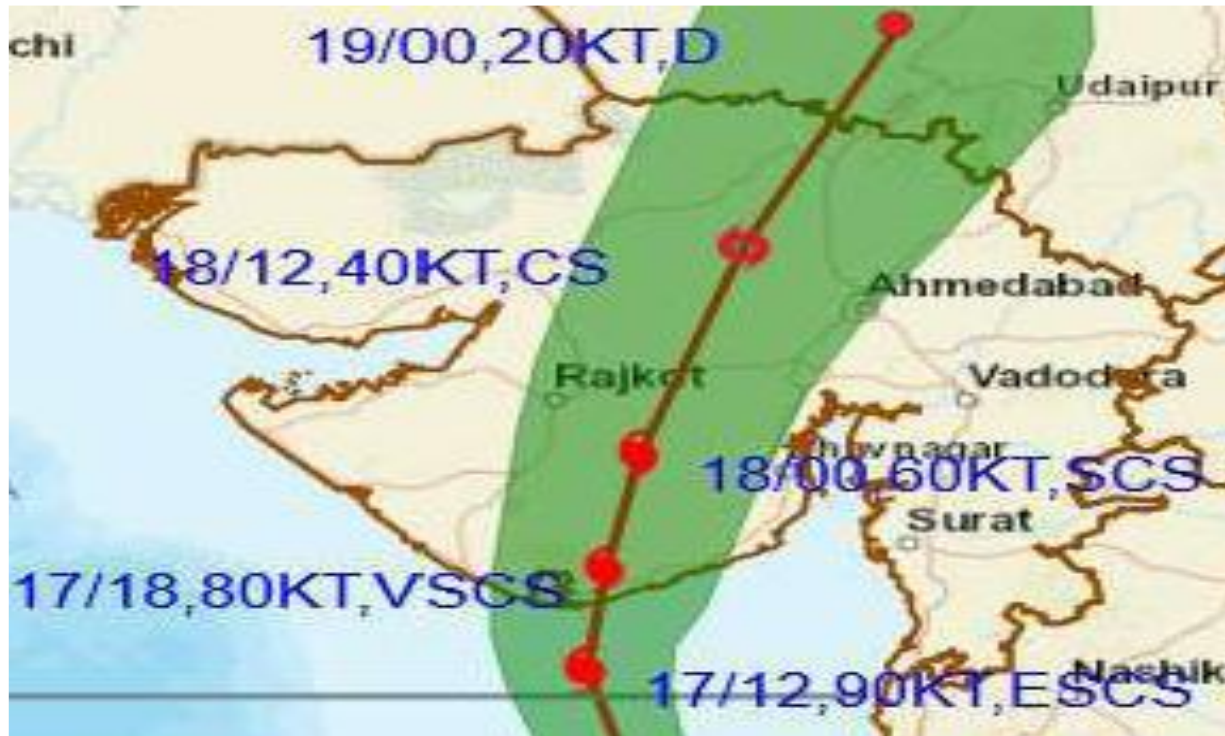

Impact of Weather on Power System Operation

Vijay Kodali
DGM(System Operation)
WRLDC, Mumbai

Grid Controller of India Limited (Grid-India)
[erstwhile Power System Operation Corporation Limited (POSOCO)]

Cyclone “TAUKTAE”

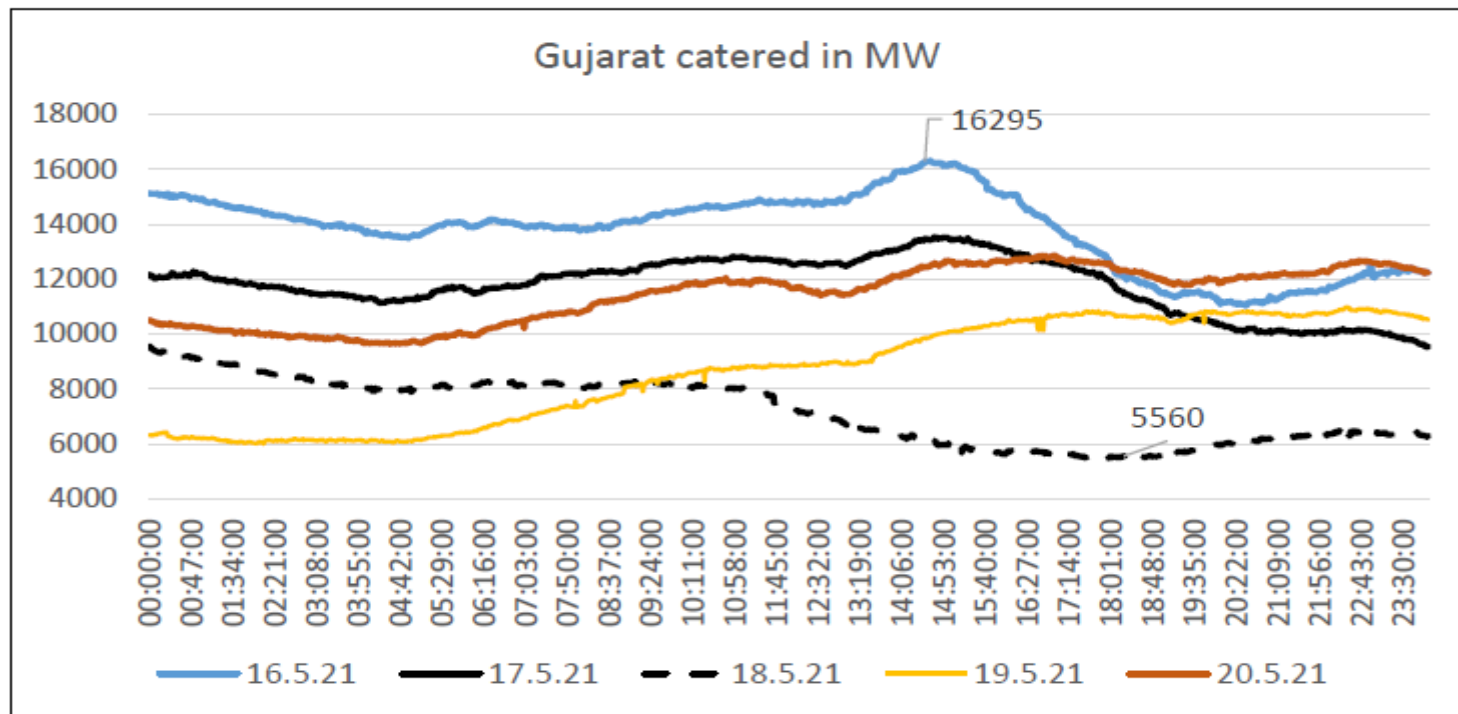
- ❖ The forecasted cyclone path by IMD



Cyclone “TAUKTAE”

❖ Demand pattern of Gujarat:

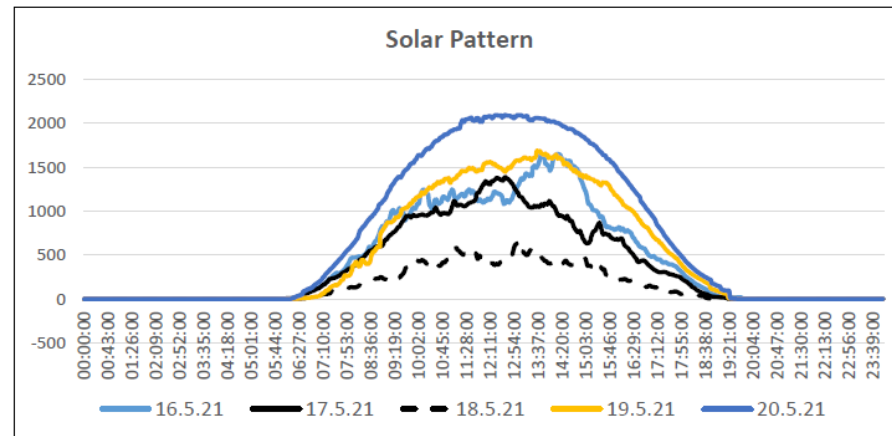
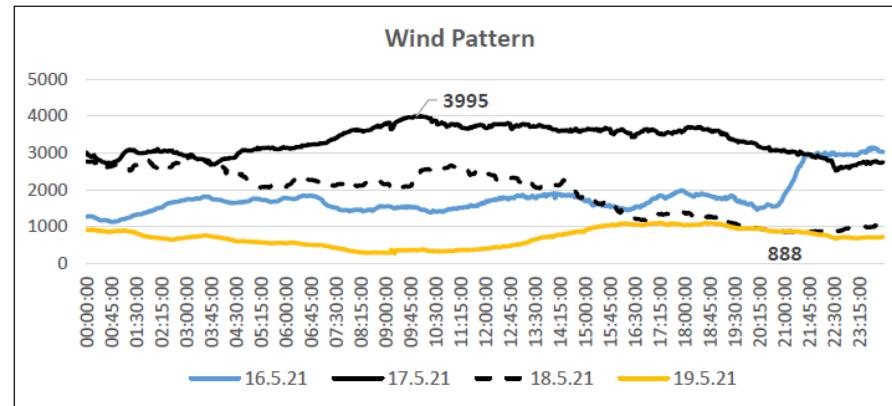
Load Patterns



Extreme Weather Events

Cyclone “TAUKTAE”

■ Variation in Wind and Solar Generation:



	17.5.21	18.5.21	19.5.21
Max wind in MW	4001	2951	1109
Min wind IN MW	2517	832	284
Max solar in MW	1389	677	1691

Cyclone “TAUKTAE”

❖ EHV Lines Affected

Voltage class	Tripped on 17.05.21	Tripped on 18.05.21
400 KV	4	18
220 KV	26	57
132 KV	8	22

EHV Substations Affected (66 KV and above)

Affected on 17.5.21	Affected on 18.5.21
94	136

Cyclone “TAUKTAE”

Photograph of Damages



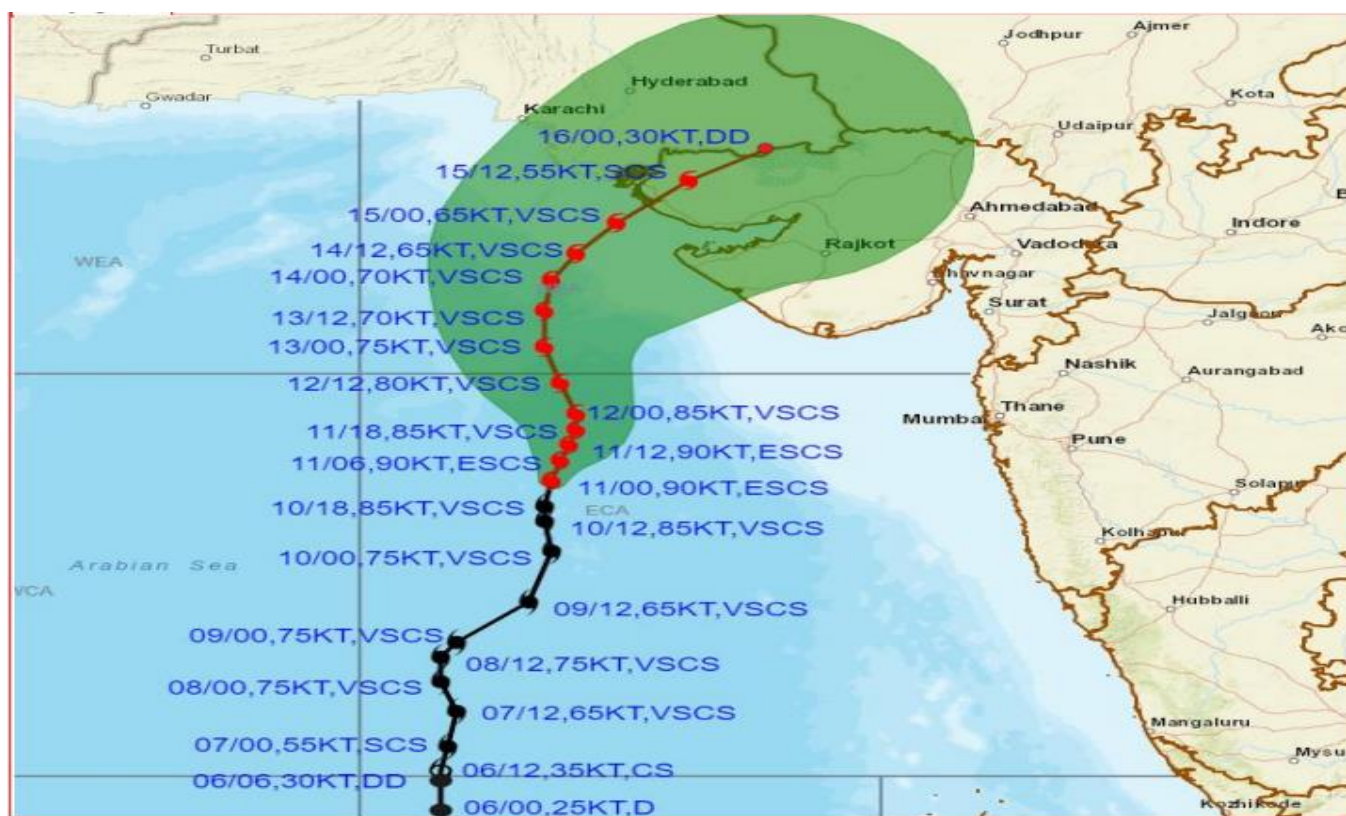
Extreme Weather Events

Cyclone “TAUKTAE”



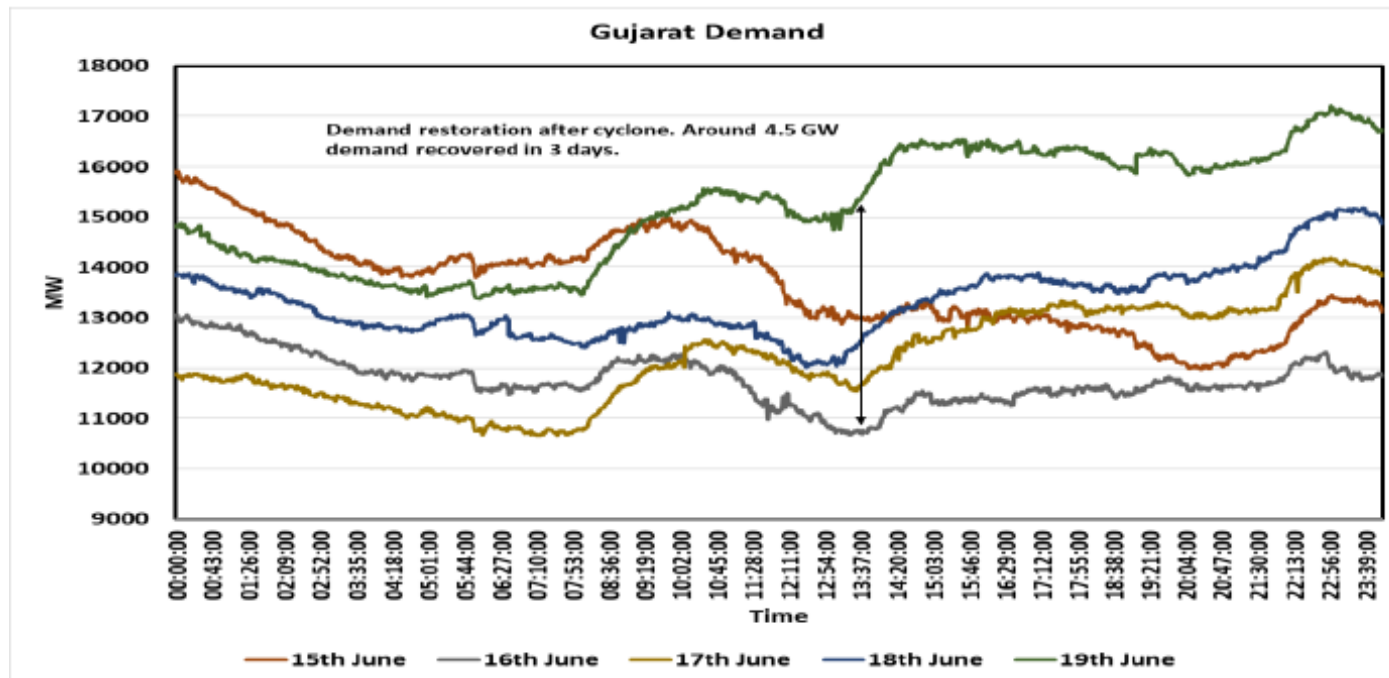
Cyclone “BIPARJOY”

- The forecasted cyclone path by IMD



Cyclone “BIPARJOY”

- ❖ Demand pattern of Gujarat:



Cyclone “BIPARJOY”

■ Details of Substations affected:

Substation Voltage level	Total Affected Substation
66 kV	271
132 kV	4
220 kV	7
400 kV	2
Total	284

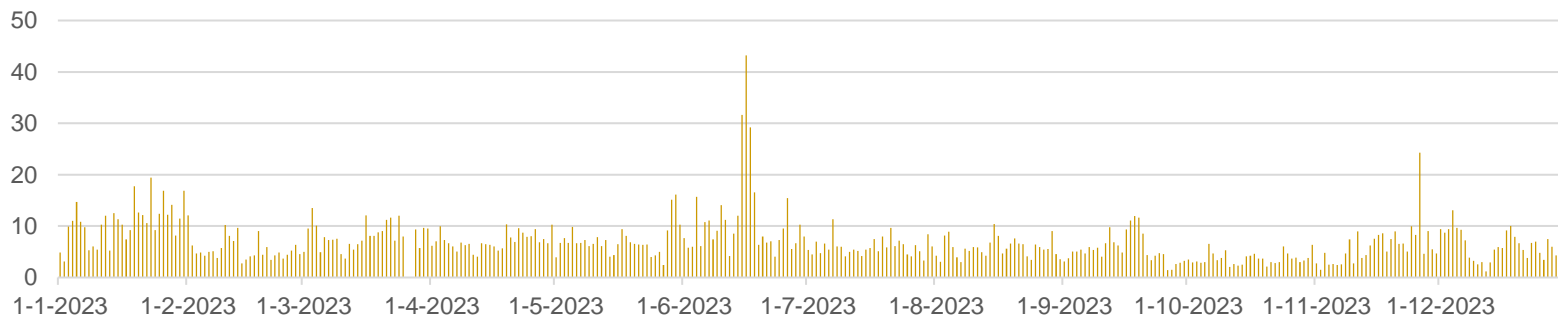
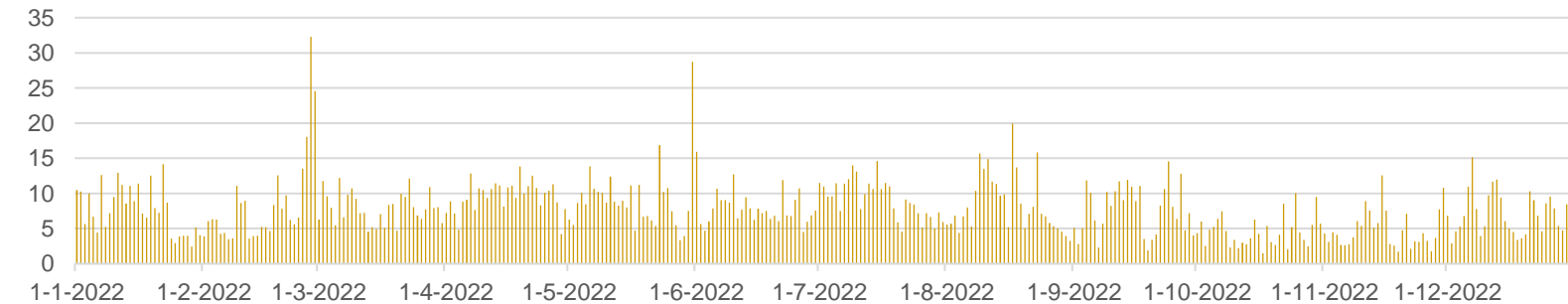
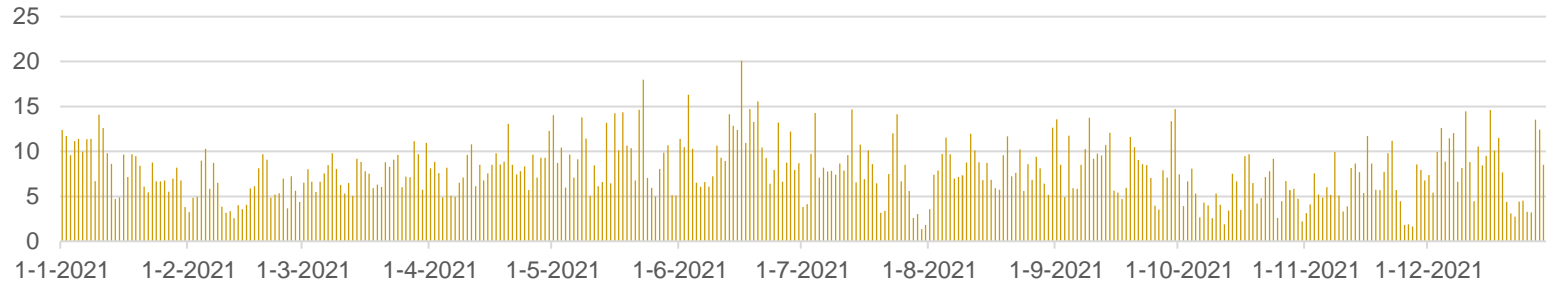
REMC

Installed capacity(in MW) monitored through REMC(as on 31.03.2024)

CONTROL AREA	SOLAR	WIND	Total
Gujarat	7030	7718	14748
MP	1657	2515	4173
Maharashtra	3426	5201	8627
ISTS	3810	4443	8254
WR Total	15924	19878	35802

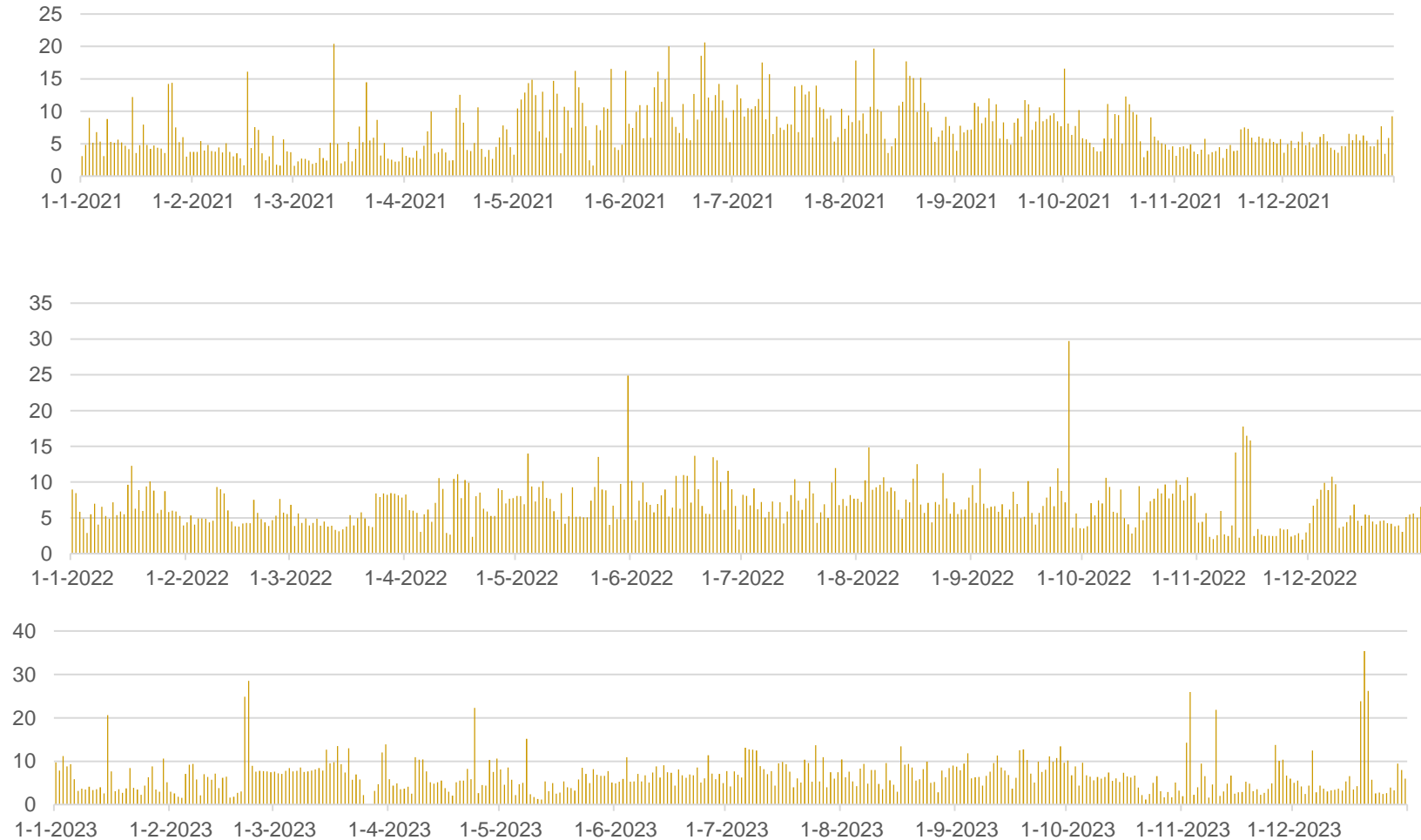
RE Errors-Wind(2021, 2022 & 2023)

NRMSE



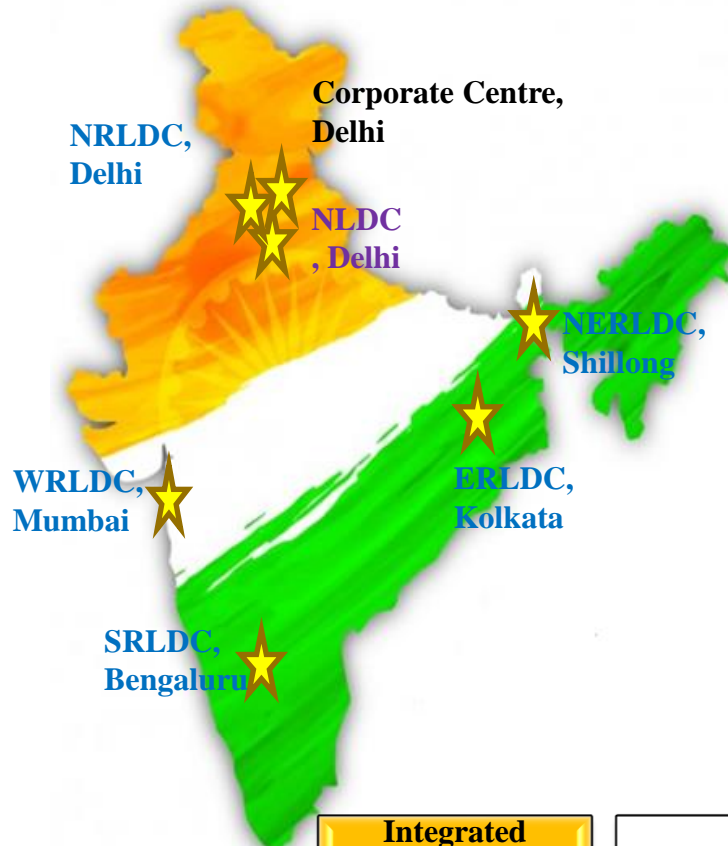
RE Errors-Solar(2021, 2022 & 2023)

NRMSE



Grid-India : Independent System Operator

Integrated National Power System Operation through Six Control Centres



*Map not to scale

**Integrated
operation of
National &
Regional Power
System**

**Fair, neutral and
accountable**

**Knowledge based
organization**

**Regulatory
oversight – Profit
not an objective**

**Financial &
Functional
autonomy**

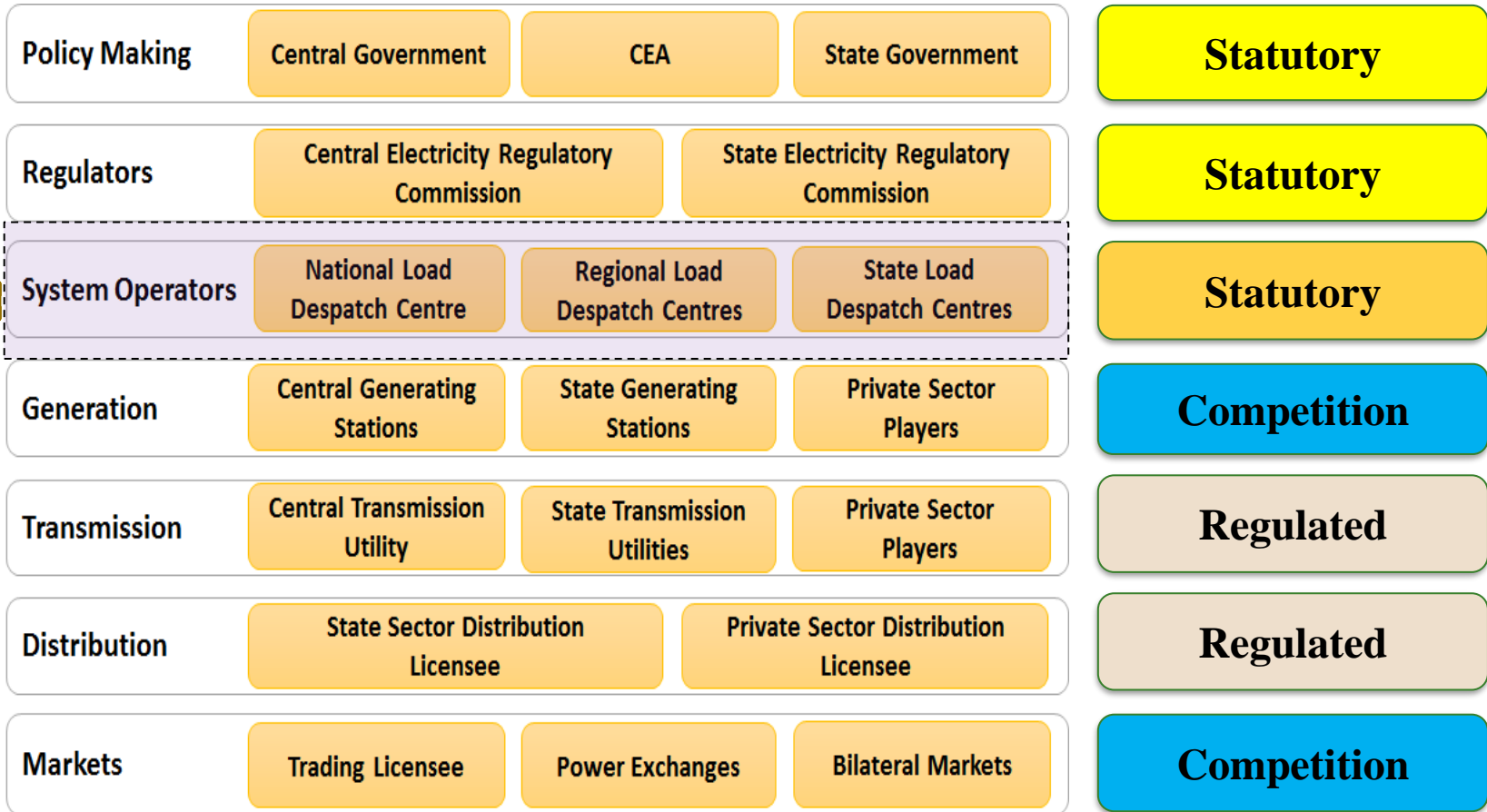
Vision:

To be a global institution of excellence for reliable & resilient power systems, fostering efficient electricity markets, promoting economy and sustainability.

Mission:

- Ensure Integrated Operation of the Indian Power System to facilitate transfer of electric power within and across the regions and trans-national exchange of power with Reliability, Economy and Sustainability.
- Facilitate competitive and efficient wholesale electricity markets and administer settlement systems.
- Promote innovation and adoption of latest technology with cyber security.
- Nurturing human & intellectual capital.

System Operation: 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

Load Generation Balance

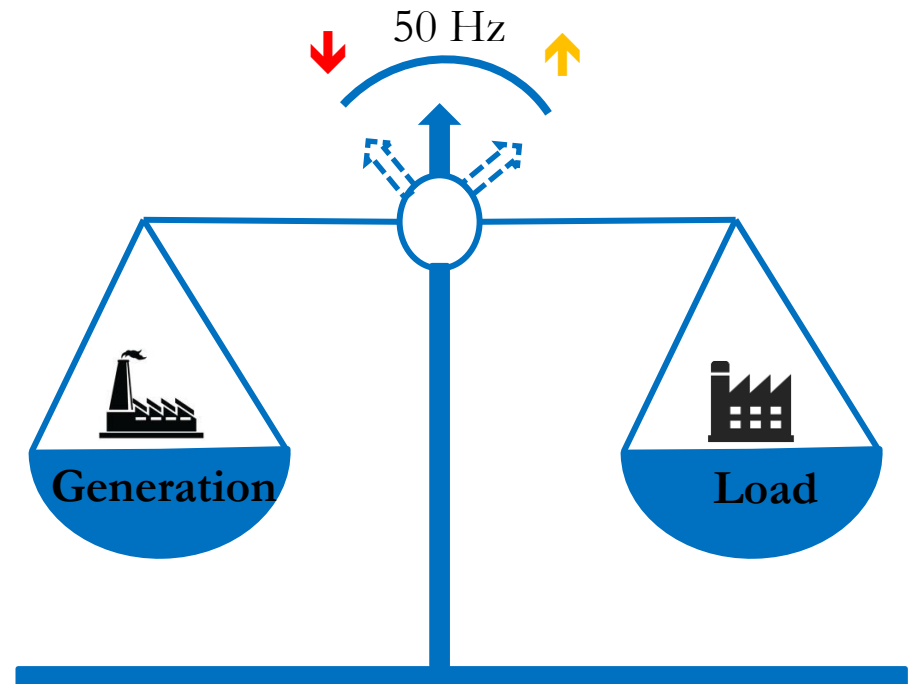
- Frequency is a key indicator
- Balanced System, **50Hz**
- Net Power Surplus → Frequency Increase
- Net Power Shortage → Frequency Fall

Change in load

- Bad weather conditions
- Disturbances
- Load change over boundary hours
- Housing/Industrial loads etc.

Change in generation

- Generator tripping – Faults/other reason
- Evacuation lines tripping on faults
- Variable renewable generation – Wind/Solar etc.



Impact of Weather on Power System



Summer Period (April-June)

- High Temperature – Increase in Demand
- Dust-storms - Load crash, High voltage, High frequency
- Low Reservoir Level

Monsoon Period (July-Sept)

- Widespread rains- sudden load crash & high voltage, High frequency
- Sudden hydro generation outage - due to high silt content
- Wet Coal, Flooded mines, low mining activities, Submerged Substation

Winter Period (Dec-Feb)

- Multiple element outage due to Fog/smog
- Low Demand, High Voltages

Renewable Generation

- Variation in Wind Speed and Wind Direction
- Variation in Irradiance due to Cloud Cover, Fog ,Astronomical events which makes it more intermittent.

Disruptive Weather (Cyclones, Solar Eclipse, Gusty Wind)

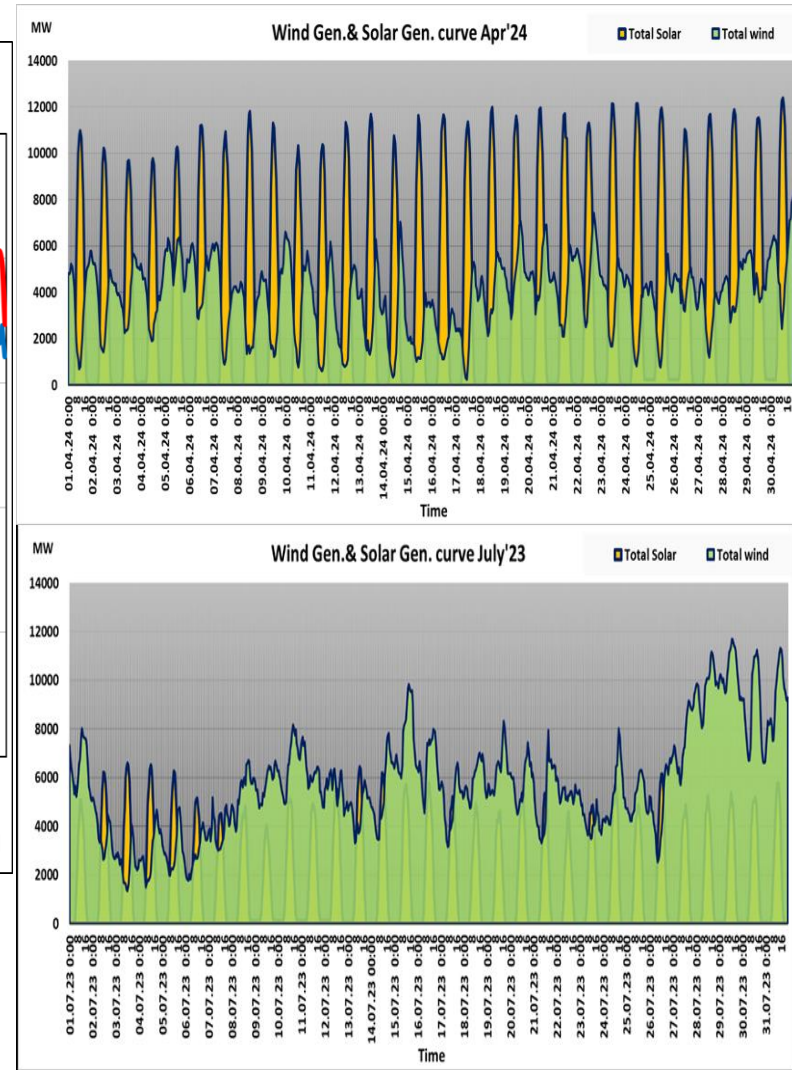
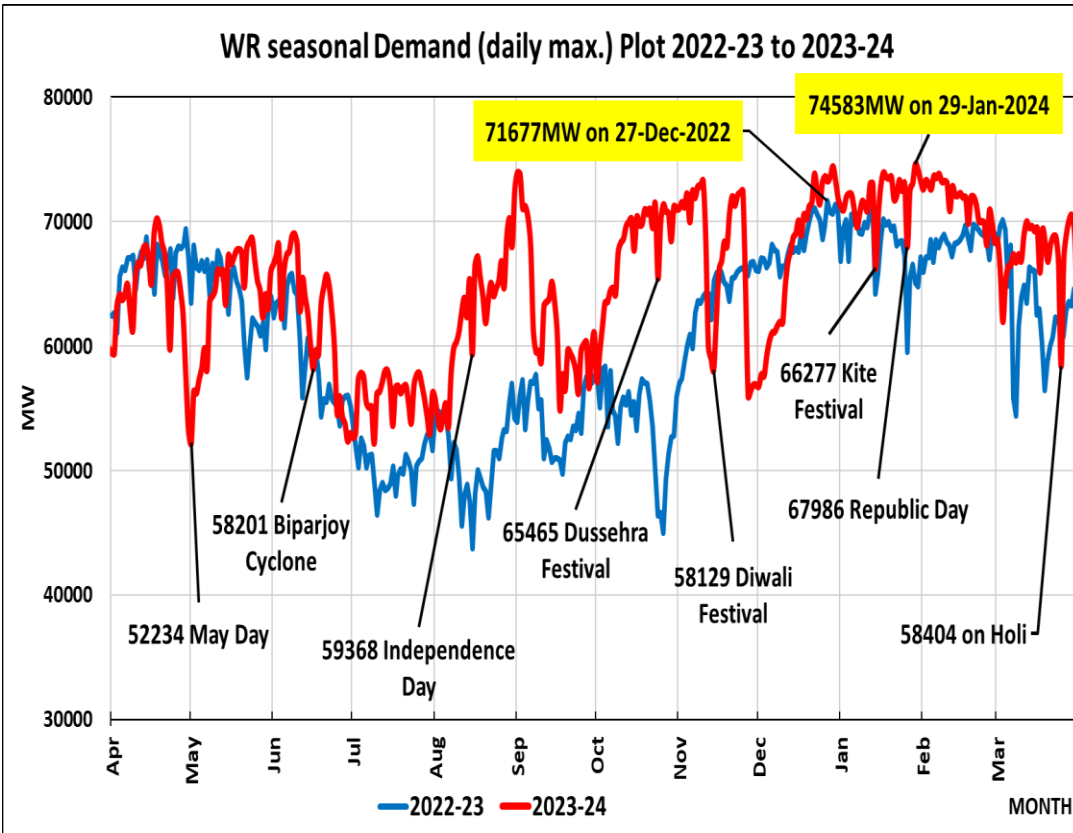
- Power outages, damage to transmission & distribution network
- Variation in Demand & RE Generation

Western Region Overview



- Western Region comprises of the States/UT:
 - Maharashtra
 - Gujarat
 - Madhya Pradesh
 - Chhattisgarh
 - Goa
 - UT of DD &DNH

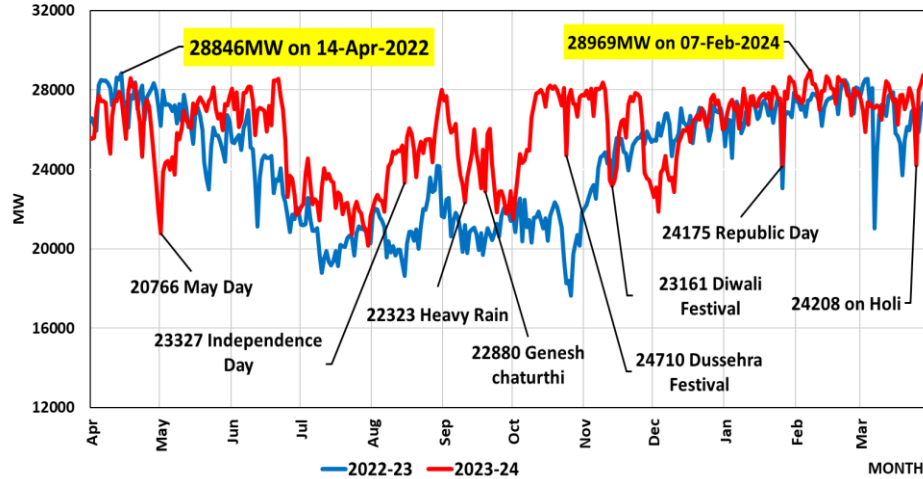
Seasonal Variation of Demand & RE Generation



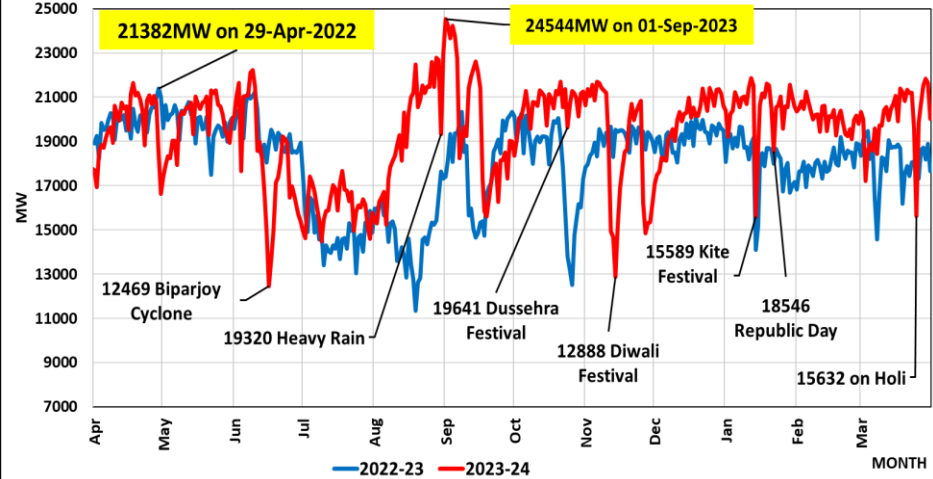
Seasonal Variation of Demand for WR States



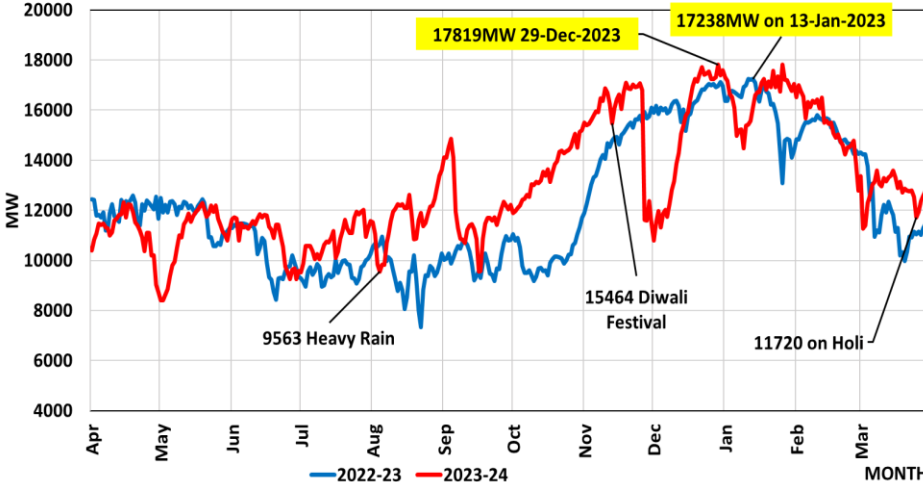
Maharashtra seasonal Demand (daily max.) Plot 2022-23 to 2023-24



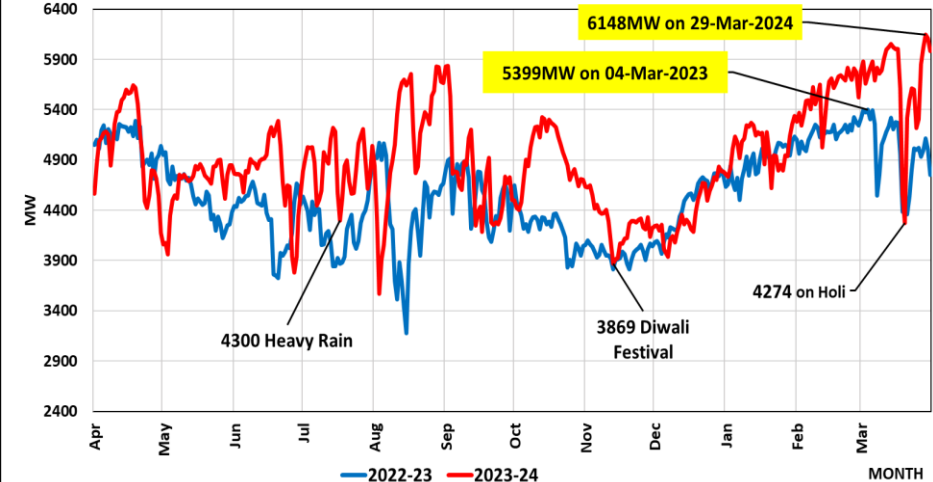
Gujarat seasonal Demand (daily max.) Plot 2022-23 to 2023-24



Madhya pradesh seasonal Demand (daily max.) Plot 2022-23 to 2023-24



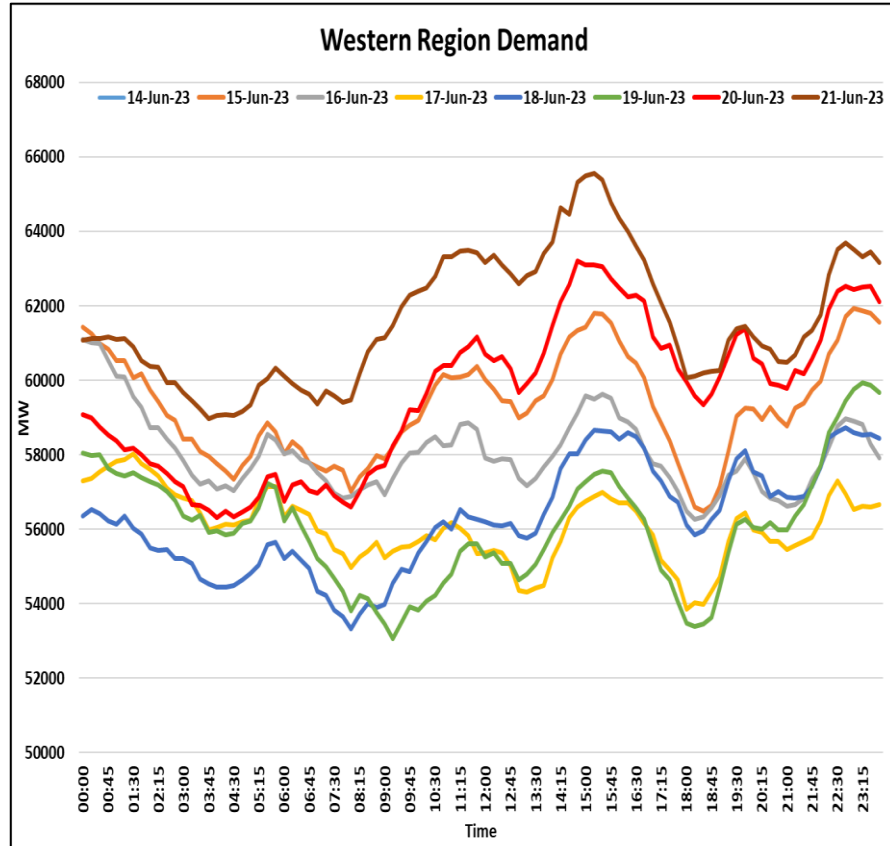
Chhattisgarh seasonal Demand (daily max.) Plot 2022-23 to 2023-24



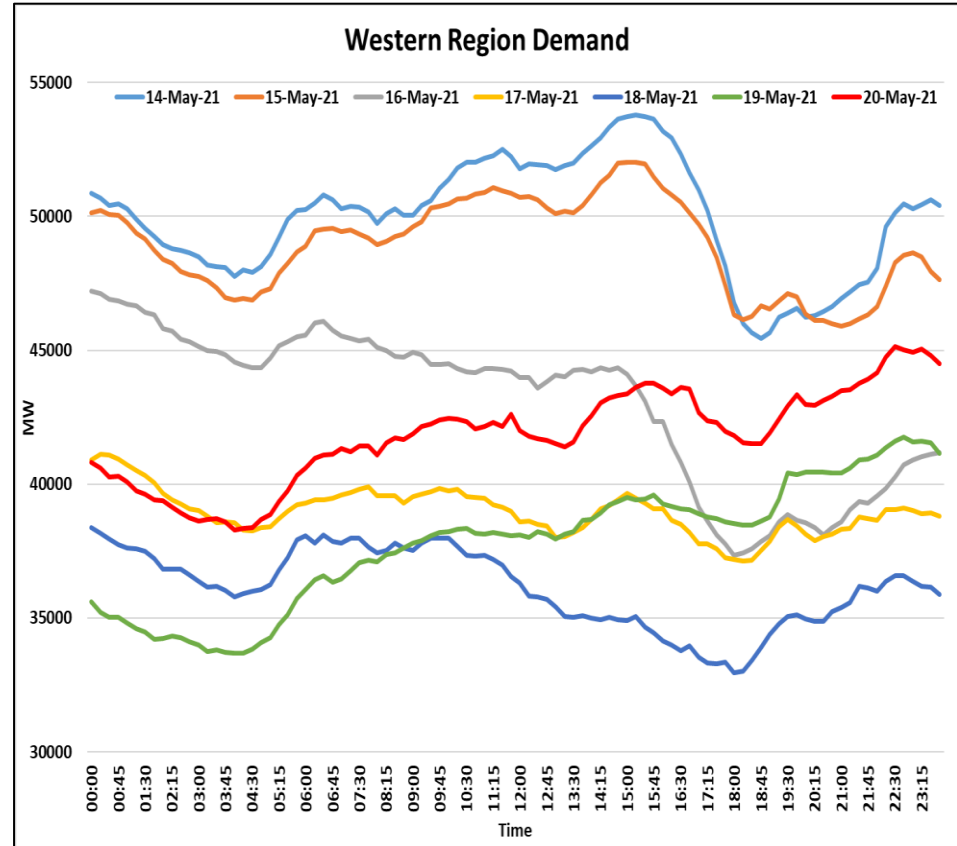
Impact of Cyclones



Cyclone Biporjoy- June 2023

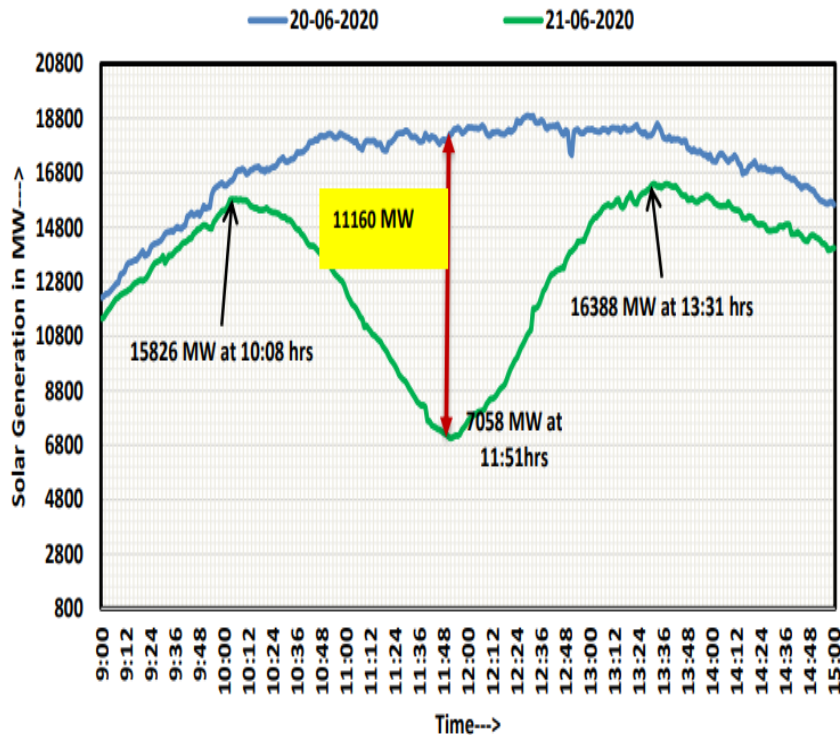


Cyclone Tauktae – May 2021

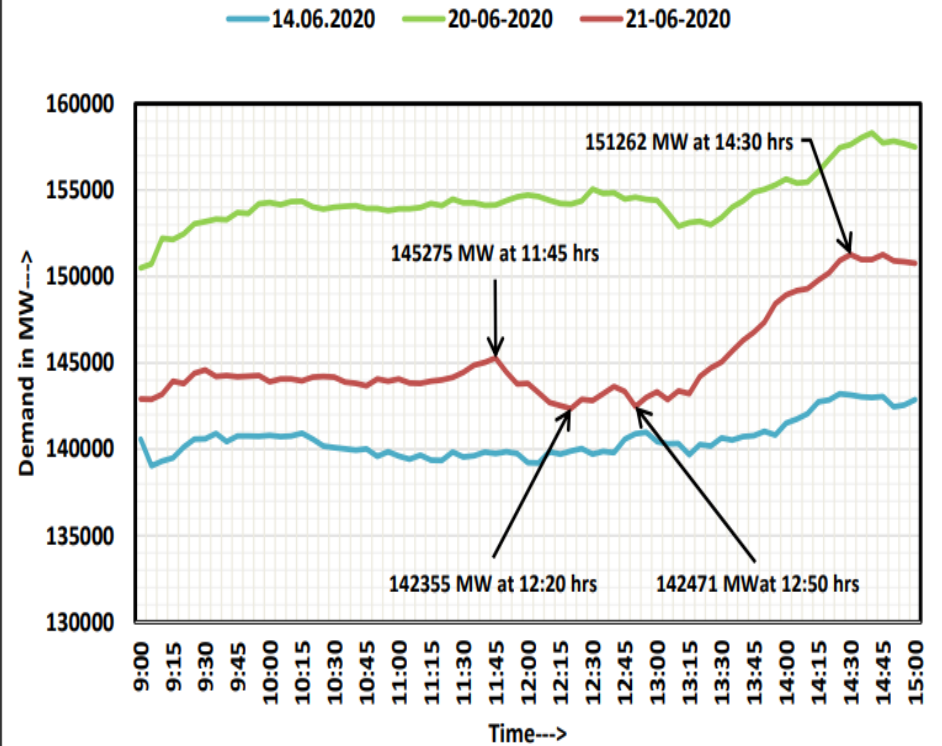


Impact of Solar Eclipse: 21 Jun 20

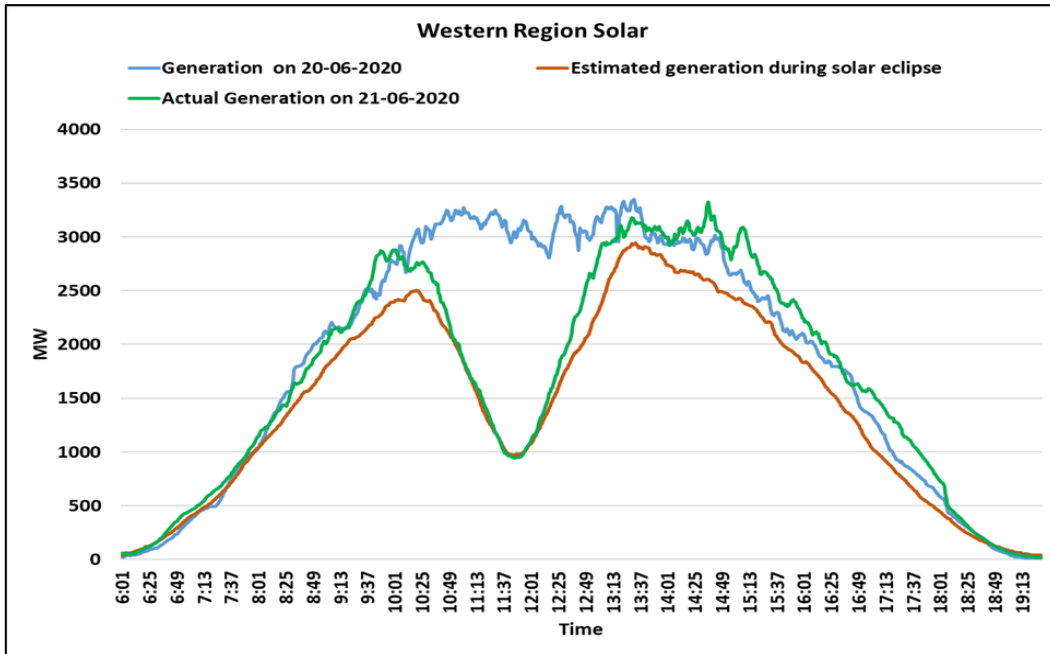
All India Solar Generation



All India Demand



Impact of Solar Eclipse in WR: 21 Jun 20



- **Solar Eclipse Type: Partial**
- **Solar eclipse Timing in Western Region:**
Start: 09:56 Hrs IST
End: 14:29 Hrs IST
- **Max. reduction in Solar Generation:**
2160MW at 11:38Hrs IST

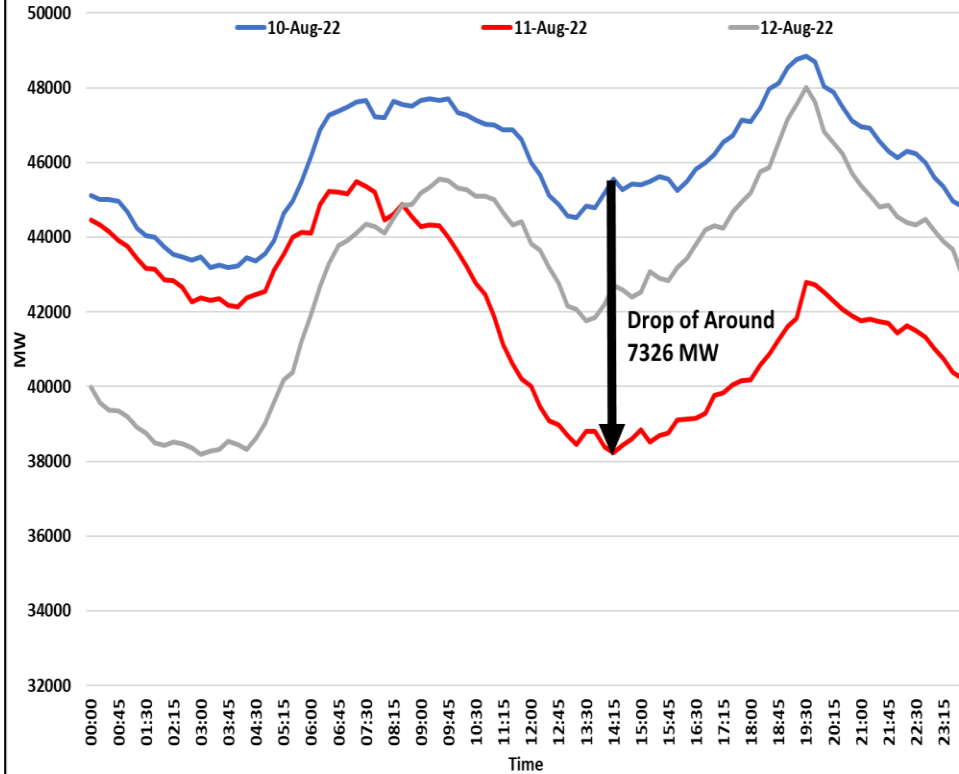
Actions taken:

- Thermal generation increased to 35108 MW from 33313MW during the start of solar eclipse.
- Gas generation increased to 3979MW from 3309MW during the start of solar eclipse.
- Hydro generation increased to 3741MW from 1687MW during the start of solar eclipse.
- **Reactive Power Management:** Reactors at ISTS level were taken into service wherever the voltages were expected to rise.

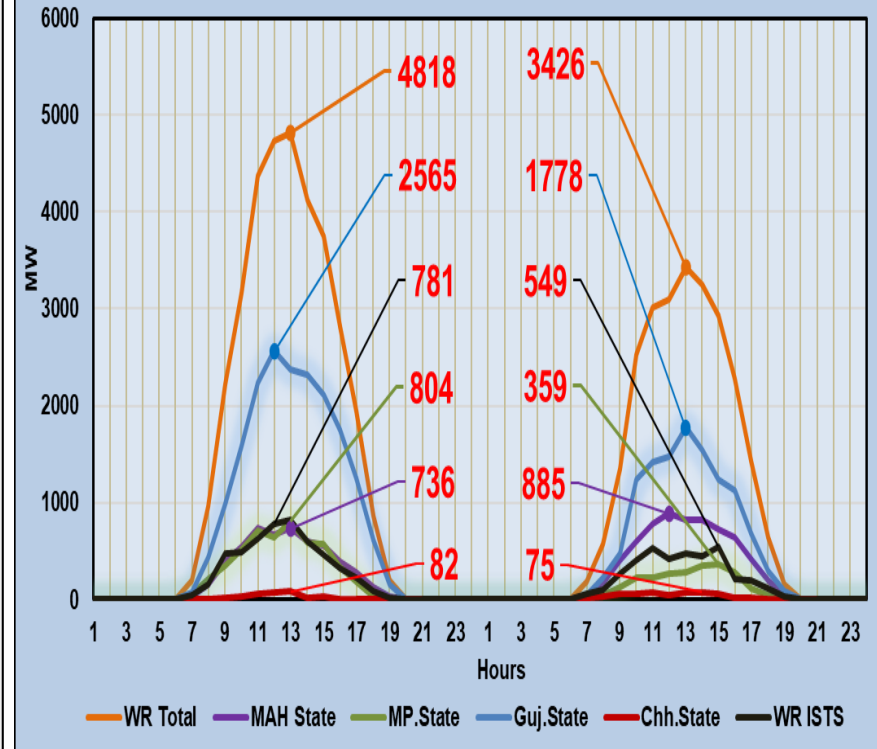
State /Region	Forecasted Max Reduction in Solar Generation (MW)	Actual Max Reduction (MW) during Solar Eclipse
Maharashtra	357	386
Madhya Pradesh	650	614
Gujarat	857	1004
WR ISTS	390	570
Western Region	2106	2160

Impact of Rains: 11 AUG 2022

Western Region Demand



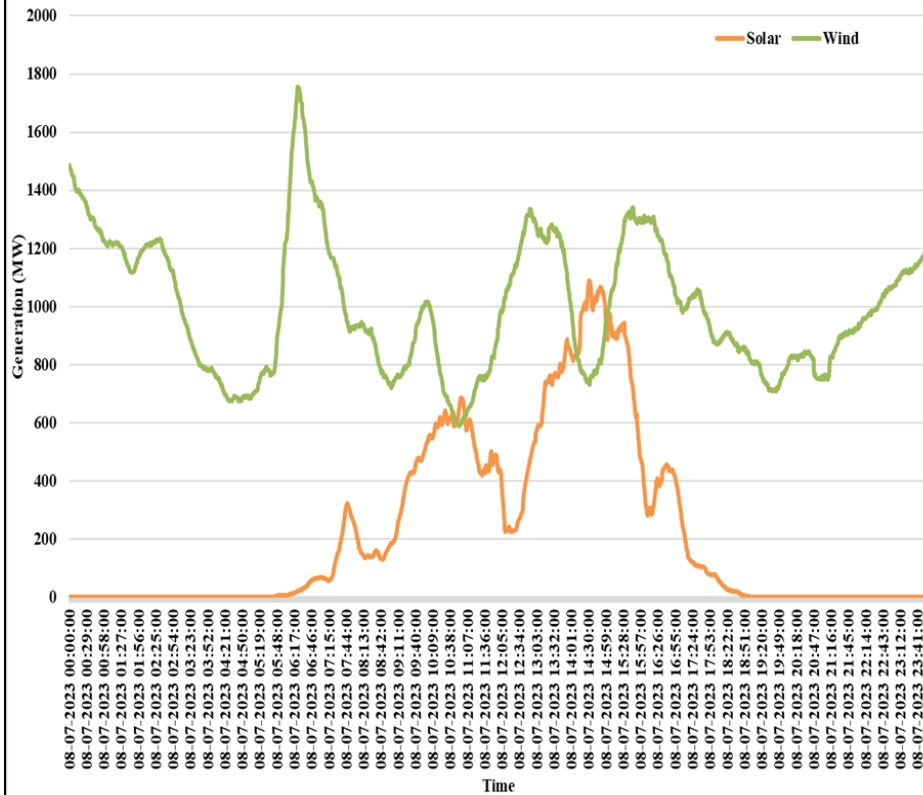
Solar Generation: 10.08.2022 & 11.08.2022



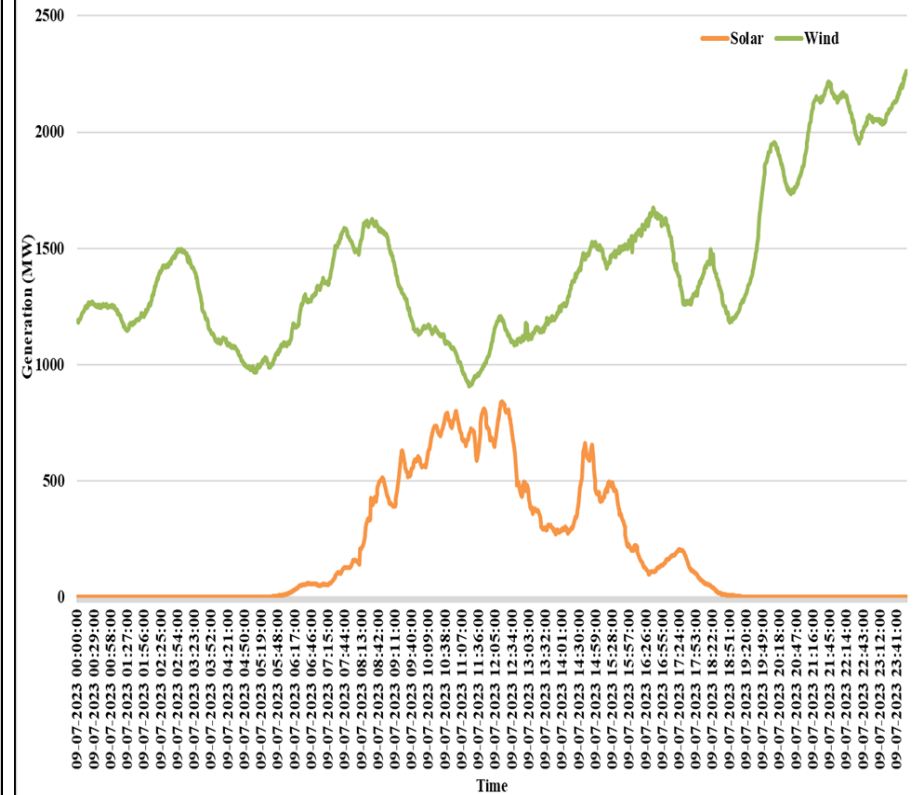
Impact of Rains: 08 & 09 Jul 2023



WR ISTS Wind & Solar Generation for 08 Jul'23



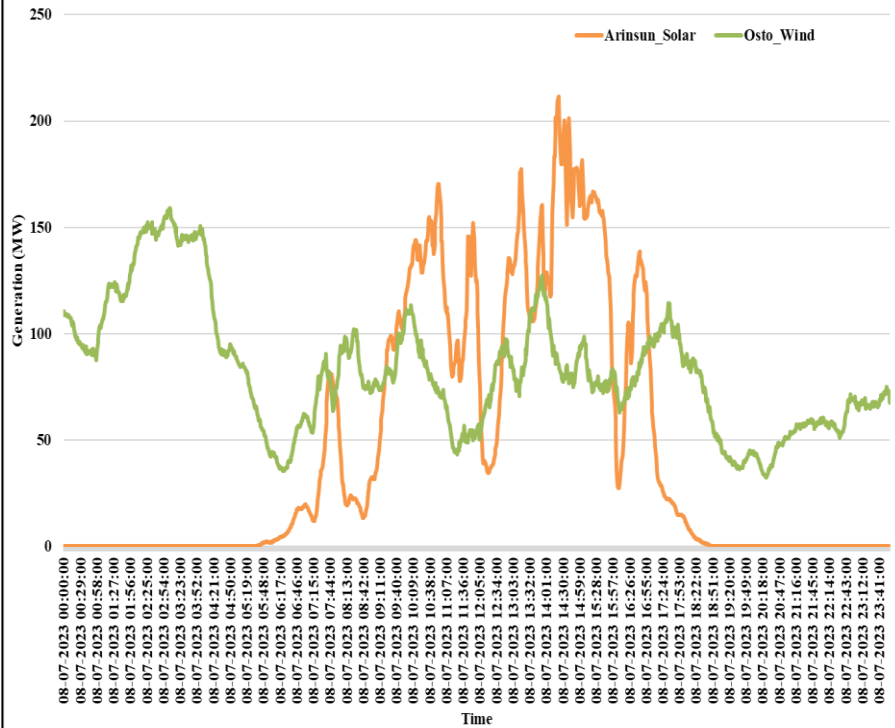
WR ISTS Wind & Solar Generation for 09 Jul'23



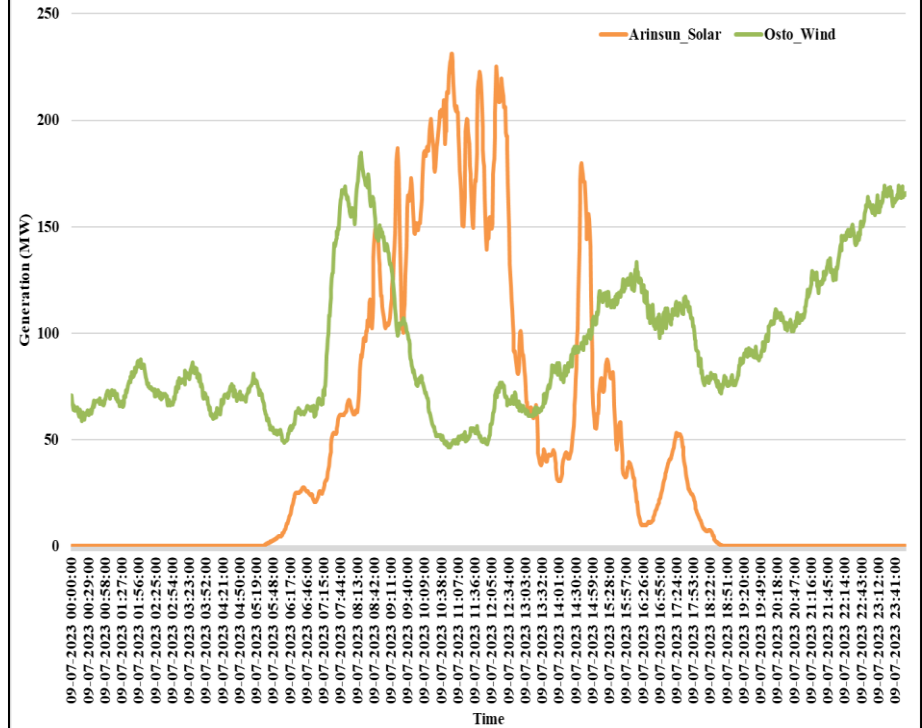
Impact of Rains: 08 & 09 Jul 2023



Arinsun Solar & Ostro Wind Generation for 08 Jul'23



Arinsun Solar & Ostro Wind Generation for 09 Jul'23



Use of Weather Variables in Power System



S.No	Demand Forecast	Wind Power Forecast	Solar Power Forecast
1	Temperature	Wind Speed	Solar Irradiance
2	Rainfall	Wind Direction	Relative Humidity
3	Relative Humidity	Pressure	Temperature

In the IEGC clause 31(2), demand estimation is mandated for SLDC and entities directly connected to ISTS line.

- Each SLDC shall forecast demand on an annual, monthly, weekly, and daily basis in MW and MWh for operational analysis and by using state of the art tools, weather data, historical data including special days.
- The demand estimation for day ahead, weekly ahead, month ahead shall be done with time block wise granularity. The demand estimation for year ahead shall be done with hour granularity.
- Based on the demand estimate furnished by the SLDCs and other entities directly connected to ISTS, RLDC will prepare the regional demand estimate and submit it to the NLDC. NLDC, based on regional demand estimates furnished by RLDCs, shall prepare national demand estimate.

Need for RE forecasting [IEGC 2023]



- As per IEGC 2023, Clause (3) sub clause (b) of Regulation 31 – “RLDC shall forecast generation from wind, solar, ESS and Renewable Energy hybrid generating stations that are regional entities and SLDC shall forecast generation from such sources that are intra-state entities, for different time horizons as referred to in clause (1) of Regulation 31 of these regulations for the purpose of operational planning.”

Weather Parameter received at WRLDC



S.No	Weather variable
1	Wind Speed
2	Cloud Fraction
3	Precipitation
4	Solar Irradiance
5	Relative Humidity
6	Temperature
7	Rainfall

PERIODICITY, RESOLUTION OF WEATHER FORECAST:

- *1 Revision per day at 15 minute resolution consisting of Current Day & 2 Day Ahead forecast data*

Weather data requirement



- Day ahead, week ahead and month ahead weather forecast data.
- Intra-Day weather forecast data with resolution of 15 minutes and periodicity of 3 Hrs.
- Bias correction of forecasted weather data through feedback of actual weather data.
- Actual Data of Weather after completion of Day with resolution of 15 minute.
- More accurate weather forecast data for special events like Cyclone so that impact on Power System asset like Transmission System can be predicted.

Thank You
