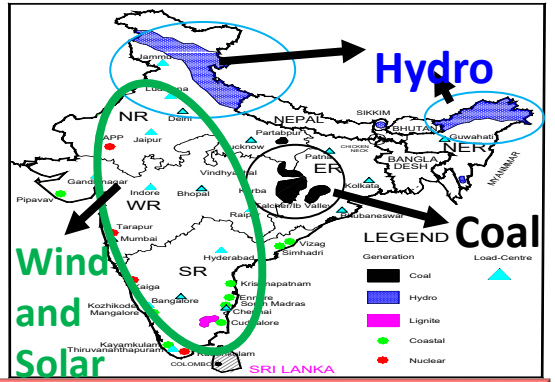
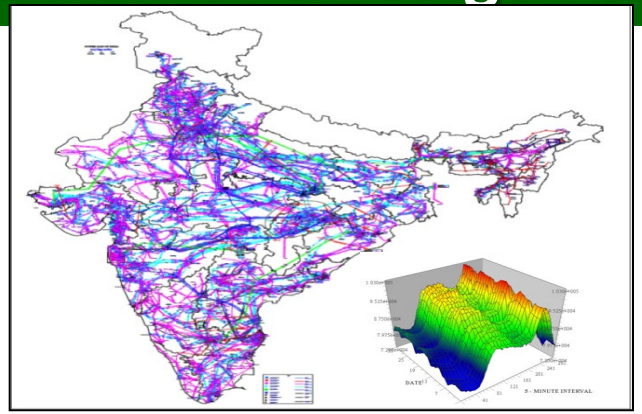
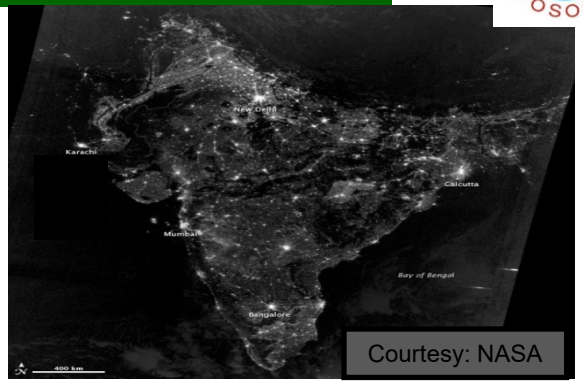
Indian Grid…Large Footprint







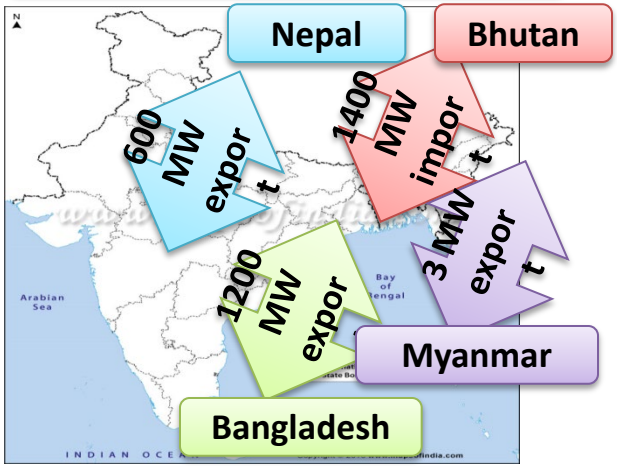
Indian Power System

- Generating Stations > 900 Nos.
- Generating Units > 2200 Nos.
- > 7000 Sub-stations,
- > 3100 transformers
- 11 Nos. HVDC Bi-pole/BtB
- > 100 nos. 765 kV lines
- > 1300 nos. 400 kV lines.

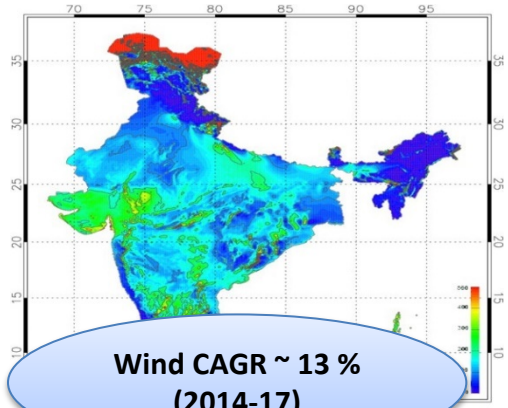
High growth

- **Demand met – 175590 MW on 18th Sep 2018**
- **Energy met – 3925 MU on 19th Sep 2018**
- **Hydro Generation – 741 MU on 31st Aug 2018**

International Interconnections



Renewables on the Rise…MW to GW



Wind CAGR ~ 13 %
(2014-17)

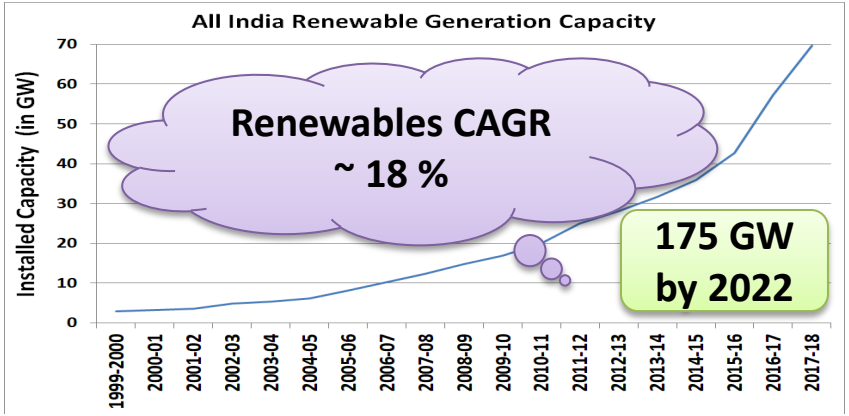
Wind Potential ~ 100 GW
(at 80 m hub- height)

Green Energy Corridors

National Offshore Wind Energy Policy & wind

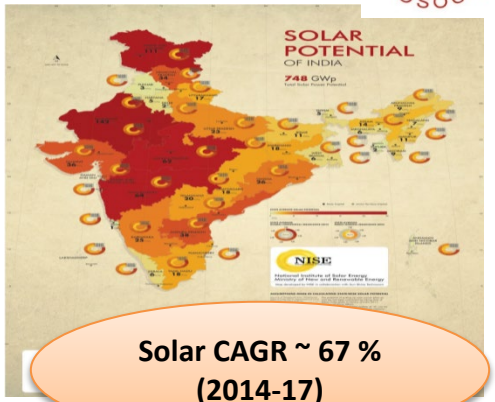
Wind Atlas

Wind Reverse Bidding
~ Rs. 2.43/kWh



Installed Capacity –as on 31 Dec'18

All India	349.28 GW
Thermal	223.02 GW
Hydro	45.39 GW
Nuclear	6.78 GW
RE	74.08



Solar CAGR ~ 67 %
(2014-17)

Solar Potential ~ 750 GW
(4-7 kWh per sq. m per day)

Solar Cities~ 60 Nos.

Solar Parks – 40 GW

Solar RPO ~ 8 % of total generation by 2022 (Excluding Hydro)

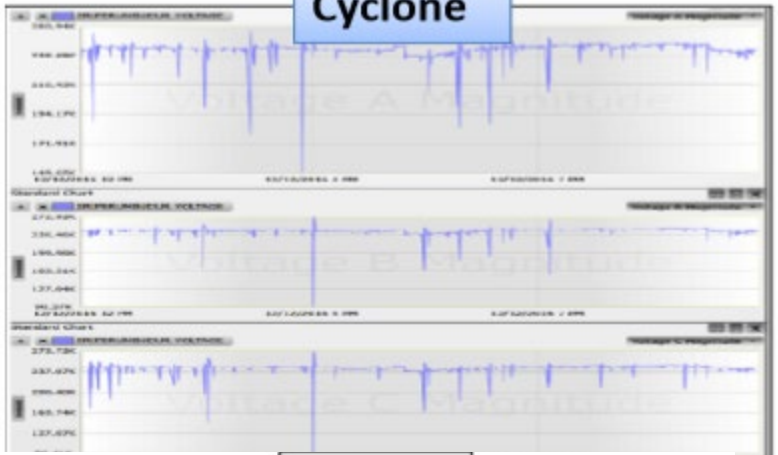
Solar PV Reverse Bidding
~ Rs. 2.44/kWh

Impact of Weather on Power System

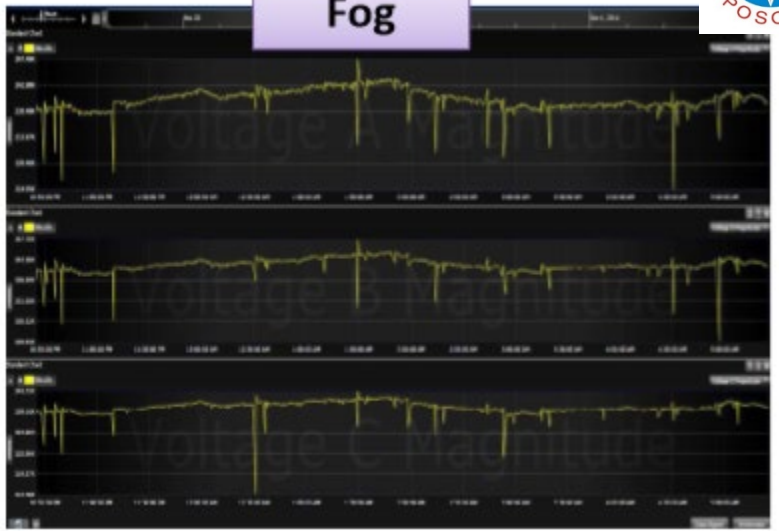
- **Peak Summer Period (April-June)**
  - High Temperature – Increase in Demand due to Weather beating Loads
  - Dust-storms - Load crash, High voltage
  - Agricultural Demand due to 'Kharif crop'
- **Monsoon Period (July-Sept)**
  - Widespread rains- sudden load crash & high voltage
  - Sudden hydro generation outage - due to high silt content
- **Winter Period (Dec-Feb)**
  - Agricultural Demand due to 'Ravi Crop'
  - Fog/smog
  - Demand due to use of Heating equipments
- **Cyclones**
  - Power outages, damage to transmission & distribution network
- Solar Eclipse
  - Impact on Solar Generation

Impact of Different Weather phenomena on Power system

Cyclone



Fog



Silt

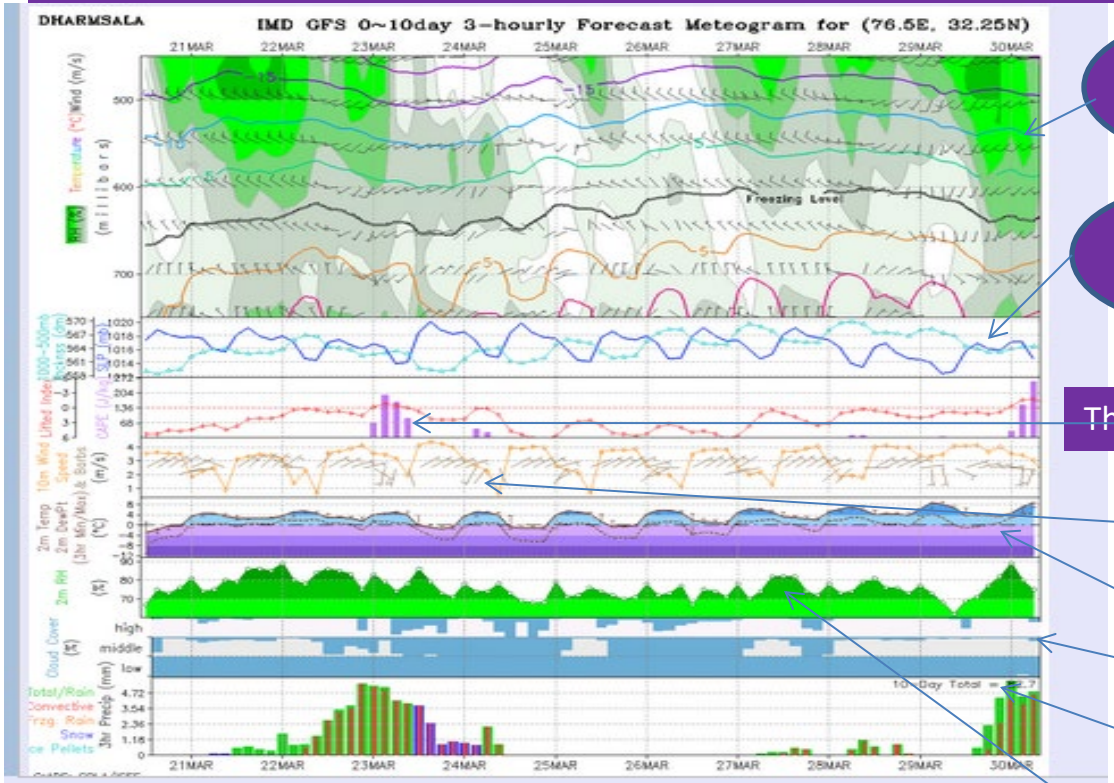
Minimizing Impact on Power System

- Prior knowledge of Weather Conditions
  - Demand estimation
  - Generation Optimization
  - Maintenance scheduling of generating units and transmission lines
  - Issuance of Advisory in case of warning
    - Power Generation Increase/Decrease
    - Assessment of Impact on Power Transmission lines
    - Simulation Studies
  - Better Plan for early restoration

Meteogram

- Inputs to Meteogram
  - Automatic Weather Stations,Satellite data ,Radar, Land station ..etc
- Meteogram provides Plots for Meteorological Variables
  - Rainfall,
  - Cloud Cover,
  - Temperature ,
  - Humidity &
  - Wind Speed & direction..etc
- It is 3 hourly forecast for 10 days.
- Each Meteogram Provides information for 10 kM radius
- Updated at 00:00 Hrs UTC and 12:00 Hrs UTC

Meteogram : Three Hourly Forecast for 10 Days



Relative Humidity

Sea Level Pressure

Thunderstorm Indices

Wind Speed & direction

Temperature

Clouds

Rains

Relative Humidity at 2 Meter

Available for 450 Locations in the Country

RADAR

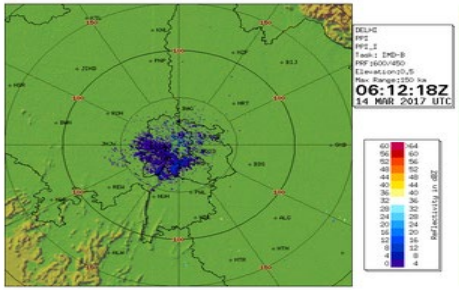
- The Doppler Weather Radar generates different displays and derived products of practical utility based on standard algorithms.
- These displays are updated @ every 10 minutes

Reflectivity (dBZ)

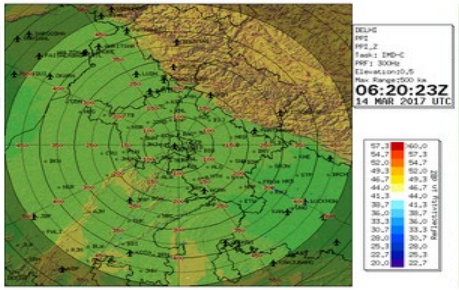
- The colors on the legend are the different echo intensities (reflectivity) measured in dBZ.
- "Reflectivity" is the amount of transmitted power returned to the radar receiver.
- Typically, light rain is occurring when the dBZ value reaches 20, 35-40 Moderate , 40-50 Moderate to Heavy 50-55 Heavy rain
- Hail is a good reflector of energy and will return very high dBZ values
  - Greater than 55

Products from Doppler Weather Radars

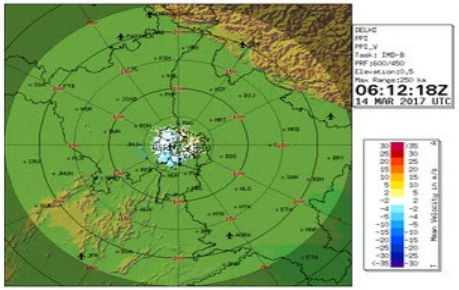
Plan Position Indicator (Z) - Close Range



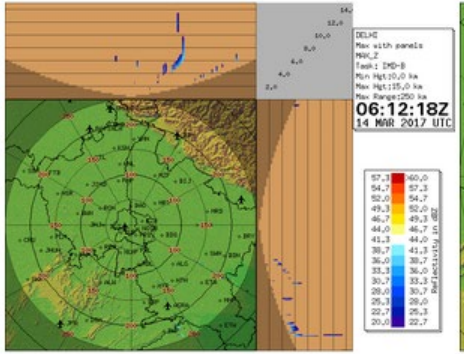
Plan Position Indicator (Z)



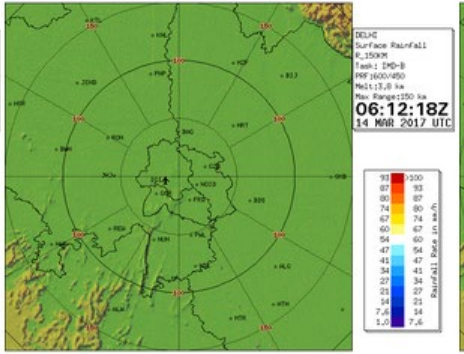
Plan Position Indicator (V)



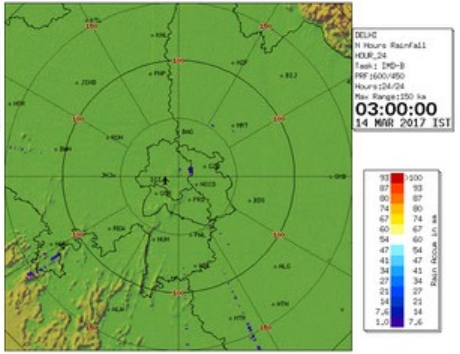
MAX (Z)



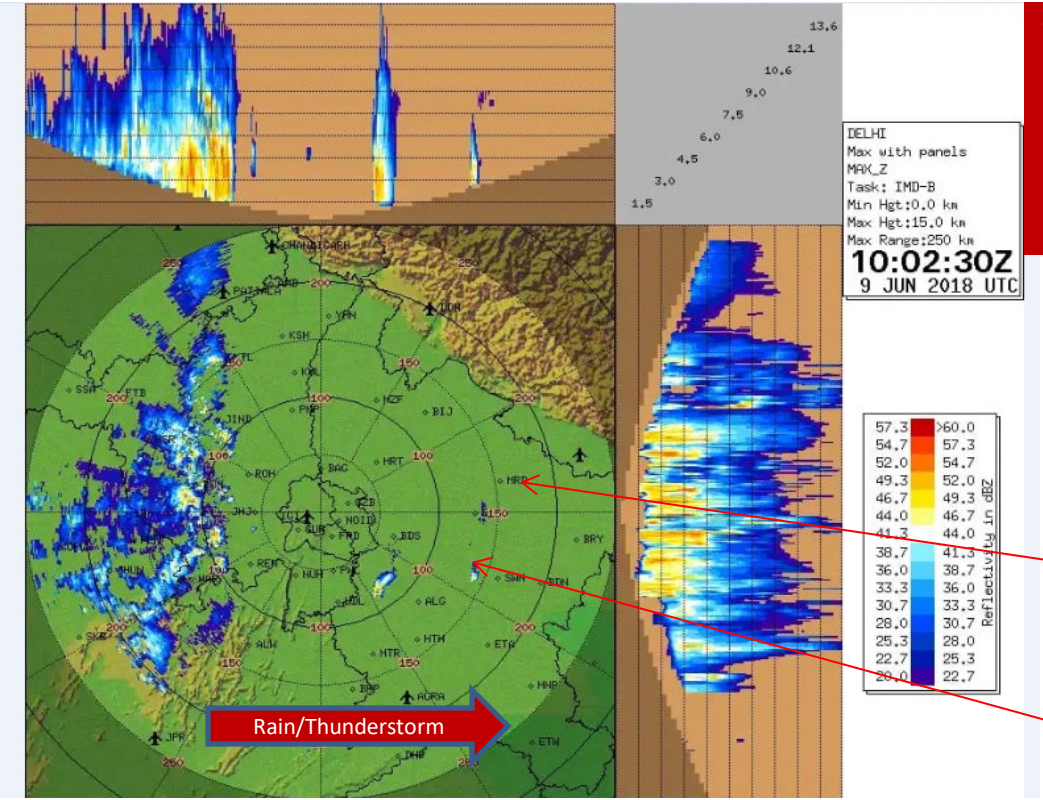
Surface Rainfall Intensity



Precipitation Accumulation



Radar Image for Rain/Thunderstorm Monitoring



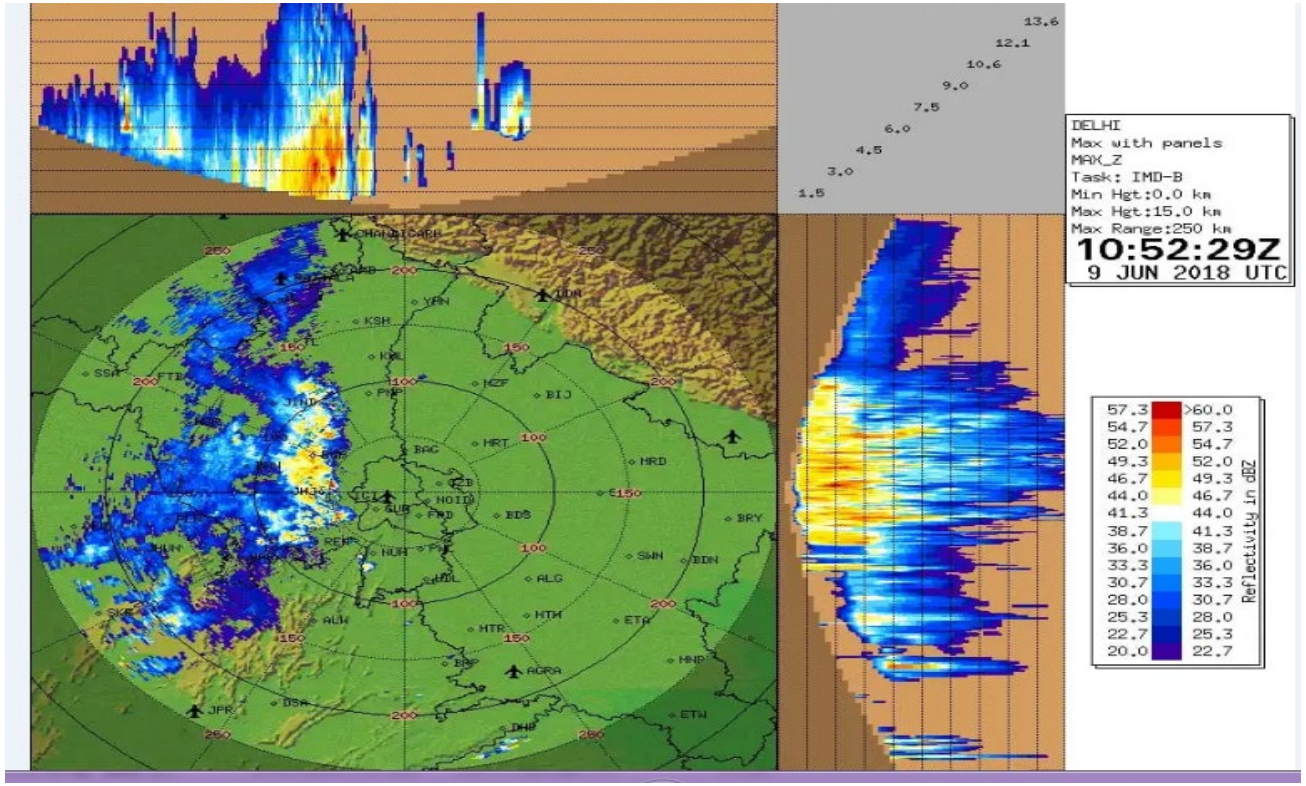
Thunderstorms:

- **A likely phenomena during summers**
- **Leads to Load Crash**
- **Excursion in Voltage and Frequency**

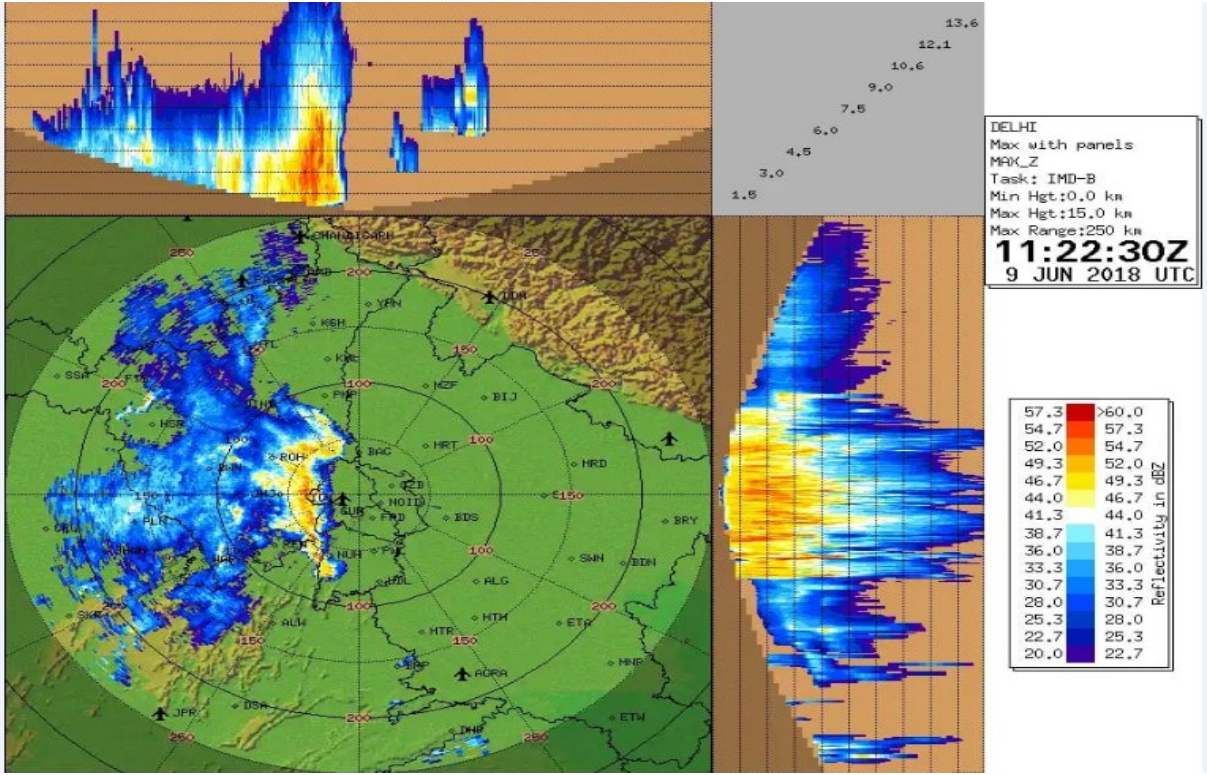
100 km Boundary

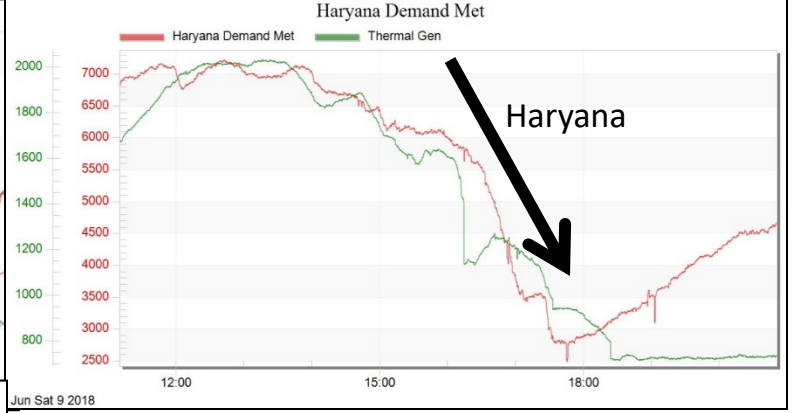
50 km Boundary

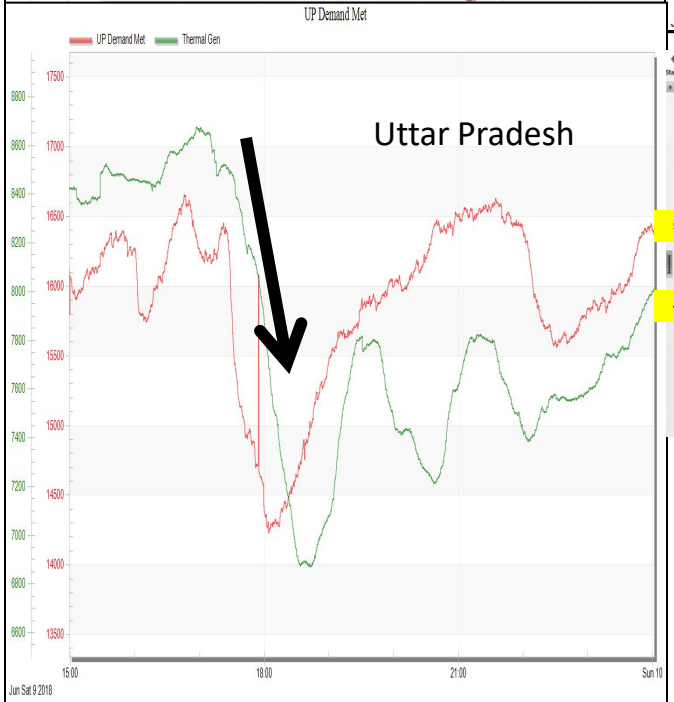
Radar Image for Rain/Thunderstorm Monitoring

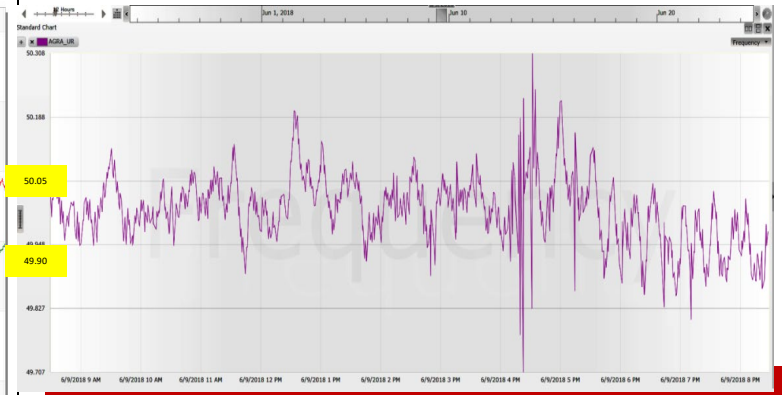


Radar Image for Rain/Thunderstorm Monitoring







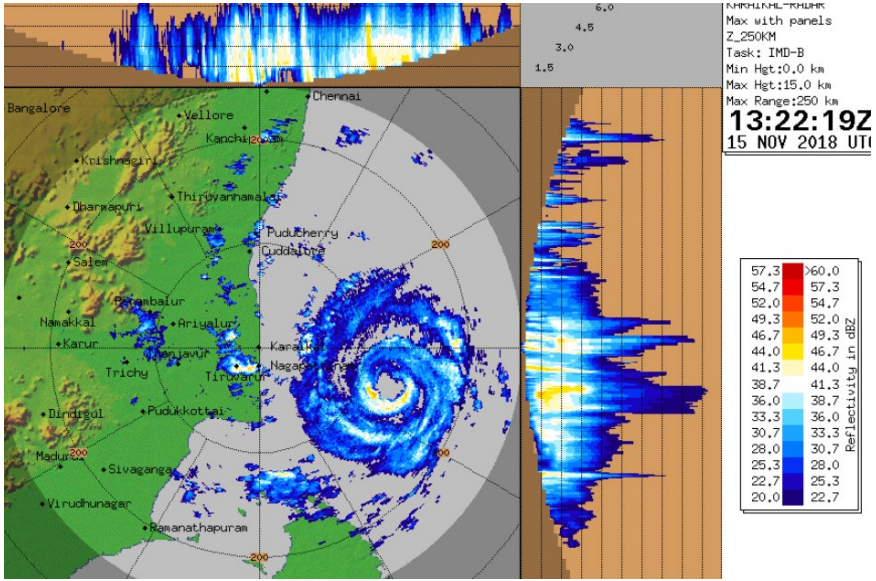


- Near Real time Radar image helped in Timely Reduction of Generation in State Control area/ISGS Generation, RRAS (Reserves Regulation Ancillary Services) Regulation leading to better Load Generation balance in the Grid

Cyclone Gaja

- Cyclonic Gaja made landfall in Nagapattinam district of Tamil Nadu around 1:40 am on 16th November 2018

- All the Control Centres referred the reports generated by IMD and closely monitored the RADAR/Satellite Pictures available on the Weather Portal



Gaga Cyclone:- Precautions Taken

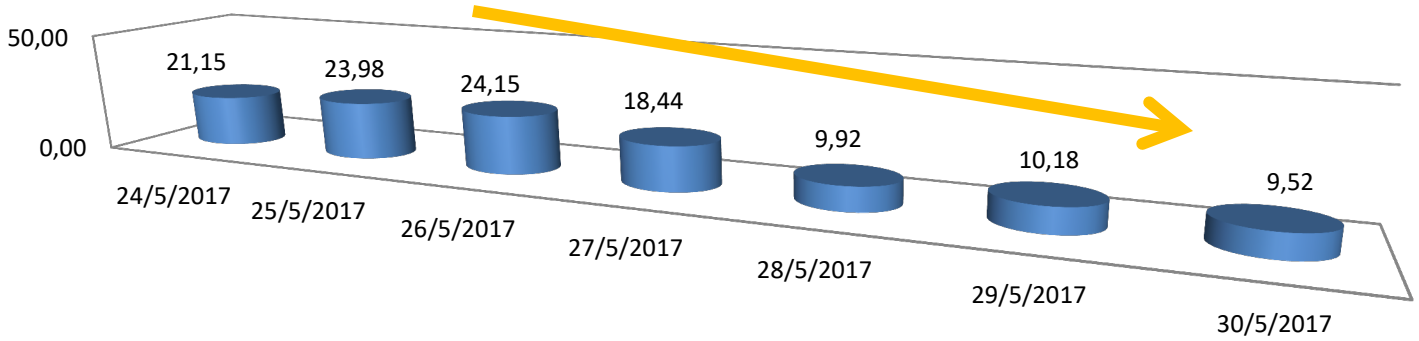
- System parameters of following Substations were closely monitored
  - i) 400kV Sriperumbudur S/s ii) 400kV Nagapattinam S/s
  - iii) 400kV SV Chattram S/s iv) 400kV ILFS S/s,
  - v) 400kV Kalivendapattu S/s, vi) 400kV Trichy S/s,
  - vii) 400kV Neyveli S/s viii) 400kV Pondicherry S/s
- Reactors were made available to control voltages
- All the outages were deferred in East Chennai, Nagapattinam area, Neyveli area and Pondichery area
- Followings units were hand tripped in anticipation of reduction in demand:
- 1. NCTPS -210 MW
- 2. NCTPS Stage-2 – 600 MW
- 3. STCMS (IPP) – 250MW

Close monitoring of cyclone helped in controlling the System parameters and restoration of power supply in the affected area.

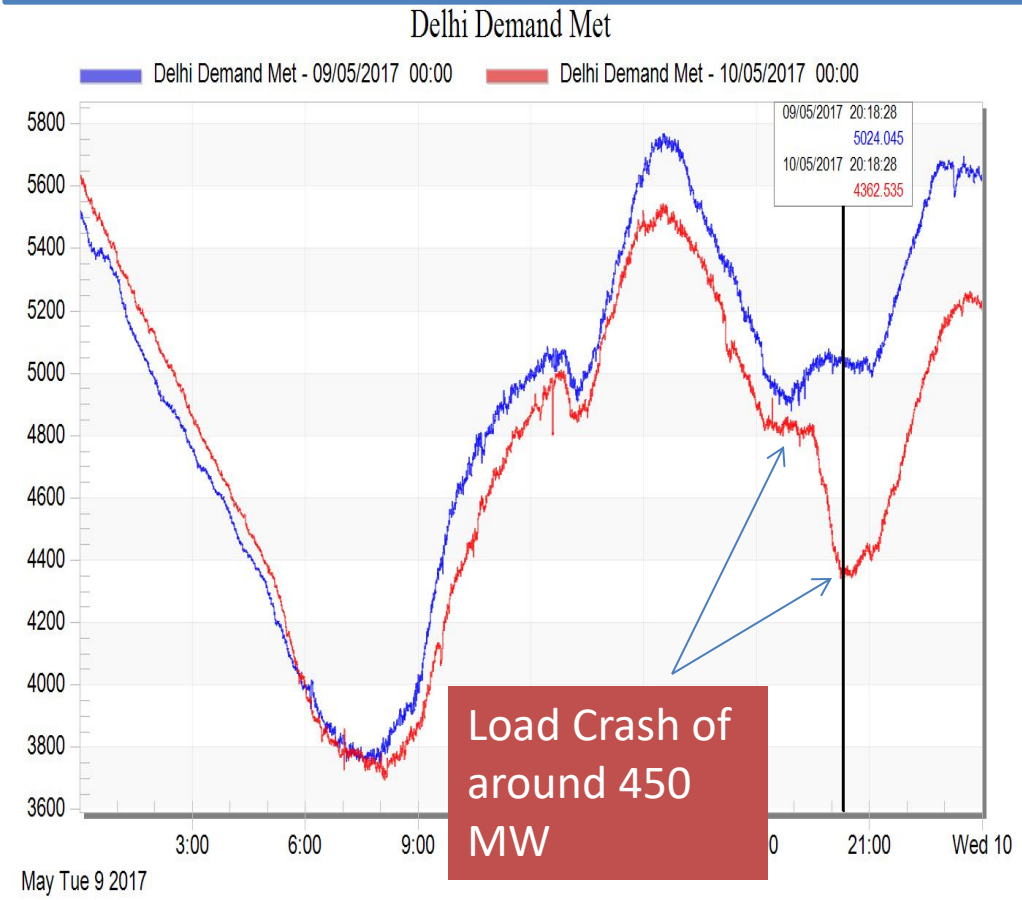
Demand Management Using Meteogram, Wind and Rain Forecast

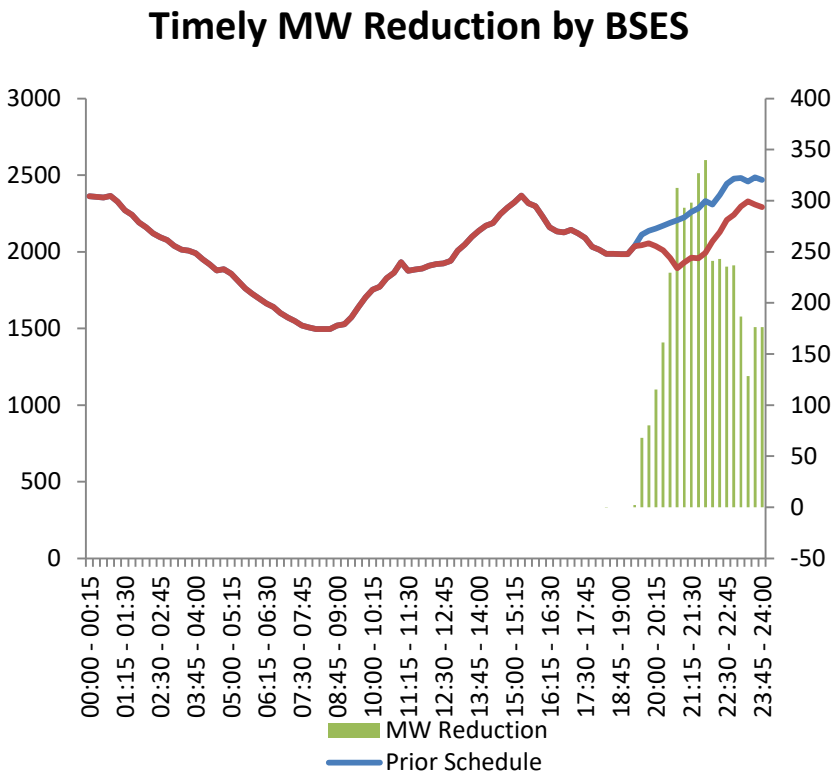
- Meteogram, wind and rain forecast for 27/28/29-05-2017 helped in better load assessment of UP control area by U.P. State Load Despatch Centre.
- As anticipated, UP demand went down from 19000 MW to 17000 MW due to change in weather conditions.
- Accordingly, STOA & purchase from Power Exchange of the order of 2000 MW was reduced. i.e Backing down of approximately 13 MU of costly thermal generation .

Total Power Exchange & Bilateral



Benefit achieved by BSES





Savings by BSES

S.no.	Date	Savings (Mus)
1	10/05/2017	0.24
2	31/05/2017	0.48
3	20/06/2017	1.49
4	30/08/2017	1.43
5	31/08/2017	1.26
6	22/09/2017	2.19
7	23/09/2017	1.87
	Total	8.96

Road Ahead

- RADAR/Satellite image may be layered with Topographical Maps, Transmission lines, Highways, State boundaries, Cities and Weather Warnings
- Rainfall estimate in catchment area of hydro plants for inflow forecasting /silt forecasting