WELCOME
to

Fourth Meeting of the Technical Committee constituted by CEA for study of optimal location of various types of balancing energy sources/energy storage devices to facilitate grid integration of Renewable Energy Sources (RES) and associated issues

13-06-2017 (NRPC New Delhi)

Variability issue of RE Genertaion

- Deliberations on the adverse effects of variability of Wind and Solar generation and how to tackle the same.
- To give an assessment of loss of generation and of revenue, because of backing down of cheaper sources of conventional generation and losses due to Deviation Settlement Mechanism (DSM), purely on account of variability of renewable generation. Month wise data for 2016-17 and related details.

Constraints on T&D

- Whether any constraints on transmission or distribution (T&D) system have been faced? If so, necessary augmentation of T&D infrastructure which needs to be undertaken - scope and financial estimates for the same.
- To propose utilization of State's own balancing plants, wherever feasible.

Electric storage Needs and RE Integration issues

- An assessment of the quantum of electric storage system for balancing, which could be placed near the Renewable Energy (RE) generation sources.
- Details of issues in the Grid Integration of Renewable Energy Generation Sources (RES) in **Northern Region** and the possible solutions.

Telemetry and Communication, REMC

- Status of **Telemetry and Communication** system for Renewable Energy (RE) generators to SLDCs and data received through the same in a satisfactory manner on regular basis.
- Status of establishment of Renewable Energy Management Centre (REMC) in the state and its linking to SLDC.

Regulatory issues

Appropriate Commissions to offer their views on Regulatory issues and capex etc

Experience of Major Hydro Generators

M/s THDC, BBMB and SJVN Limited to share their experience on proposed method of utilization of their Hydro Plants as a balancing source(s) for Renewable Energy (RE) integration.

Thank You

- A detailed calculation of balancing requirement for all over India and possible options to meet the same.
  - Whether existing thermal plants will be able to flex and provide the flexibility or additional resources need to be installed.
- An assessment of existing and planned pumped hydro stations may be done. The costing for same may also be considered.
- A calculation on storage requirement may be carried out considering following
  - How much capacity is required
  - The technologies available for same
  - The requirement of space for placement of storage capacity
  - The financial implications and possible funding mechanisms
- International experience
- Whether plants proposed to be retired can be used for balancing requirement
- Comprehensive listing of available generators with their age, effeciency, whether they have space required to meet MOEF norms, costing to implement MOEF norms, cost of retrofitting for balancing (to decide if it is to be used for balancing or as a base load plant), whether the capacity is under retirement proposal.
- The above list should be considered so that when outage of plant is done, retrofitting for balancing as well as for MOEF norms should be done together.





एनटीपीसी
NTPC
A Maharatna Company

Adverse Effects of variability of Renewable Power

A K Sinha
AGM,NTPC Ltd

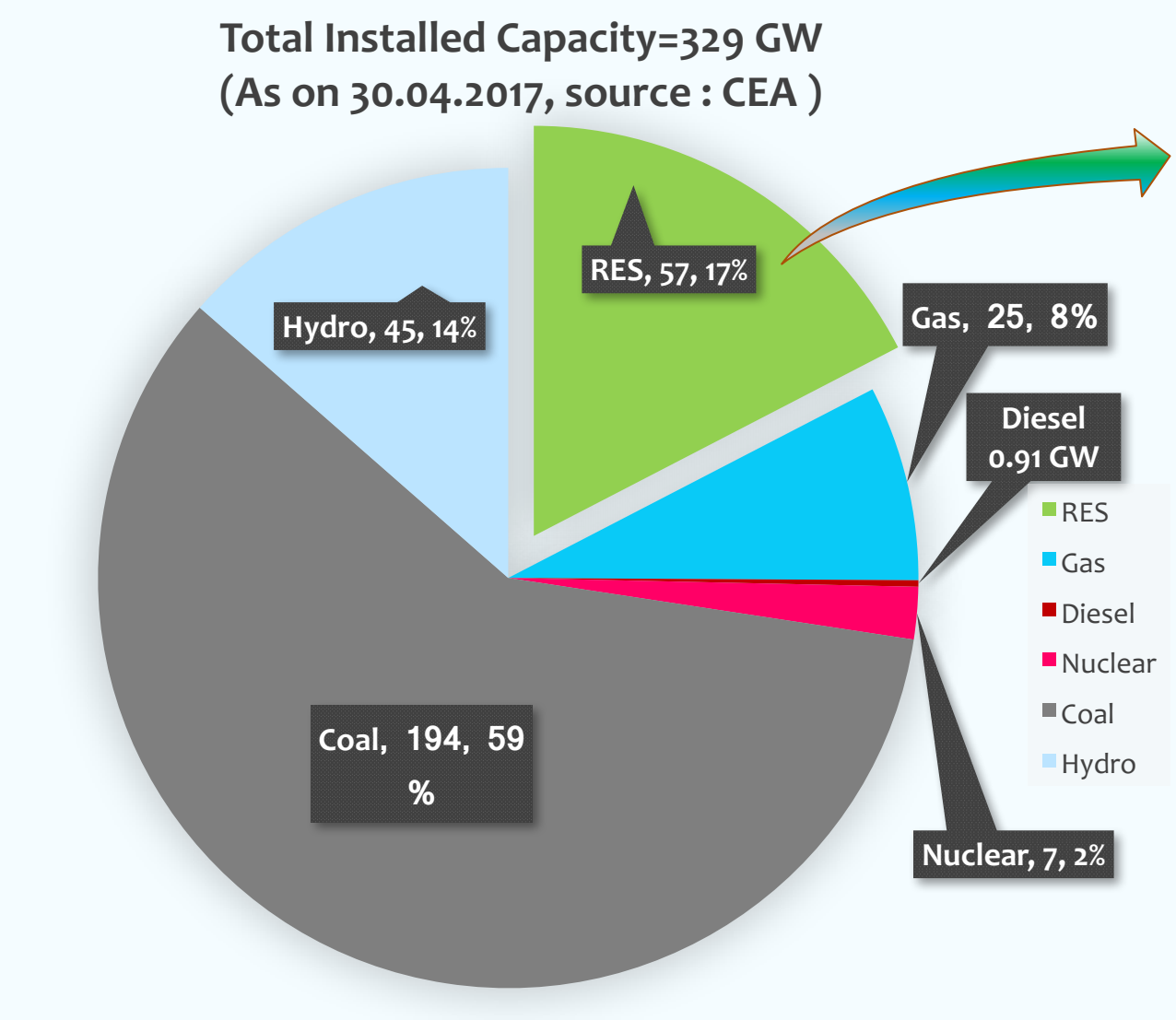


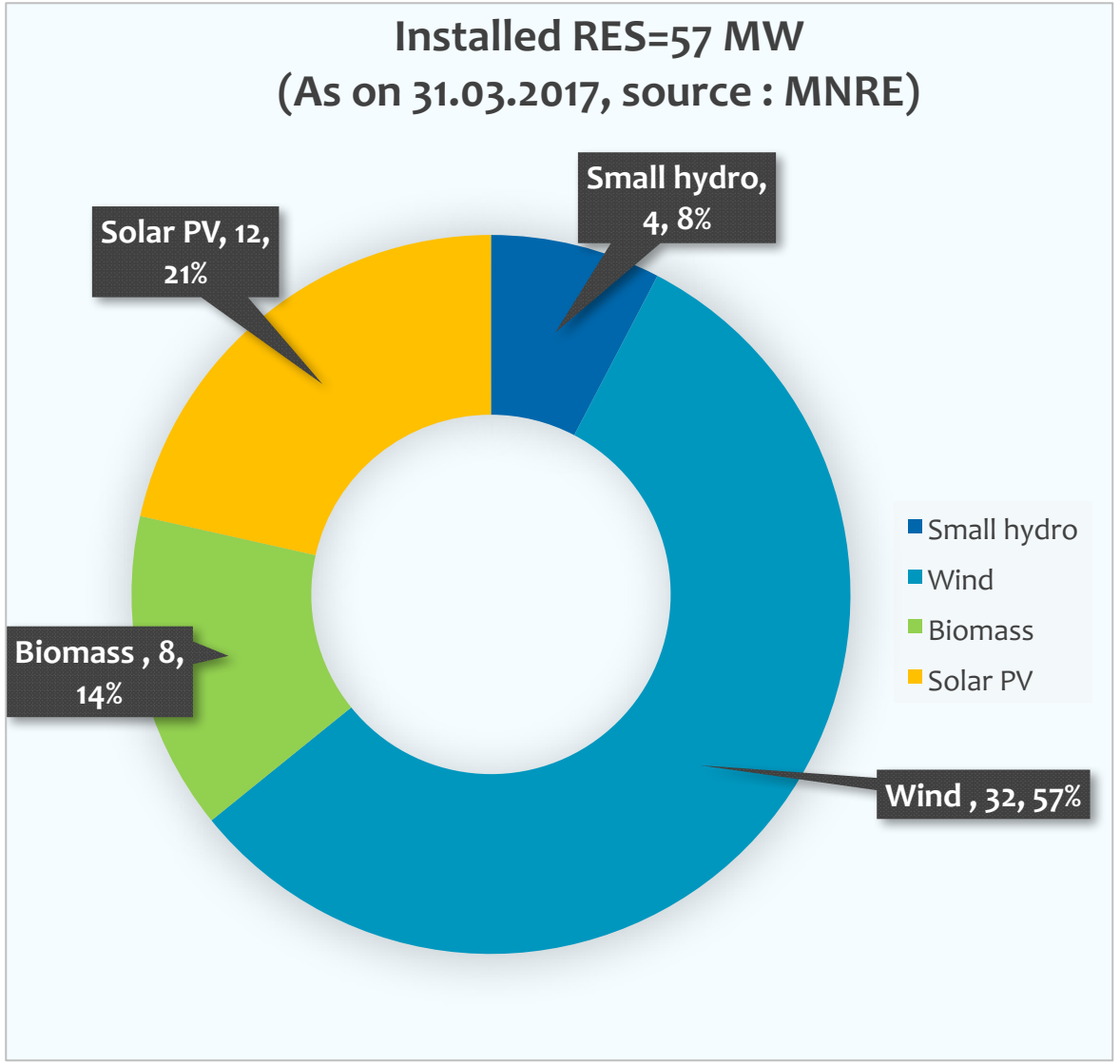


Contents

Renewable Integration Plan and its Impact

Present Installed Renewable Capacity

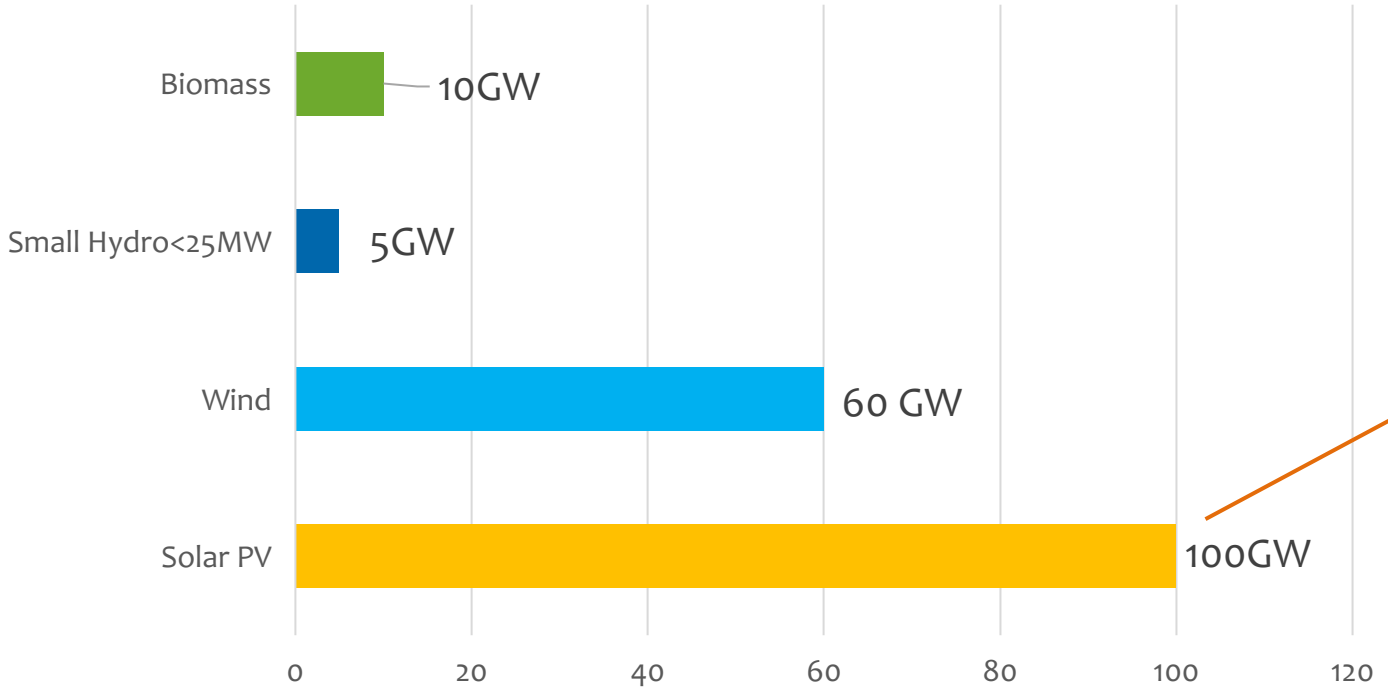




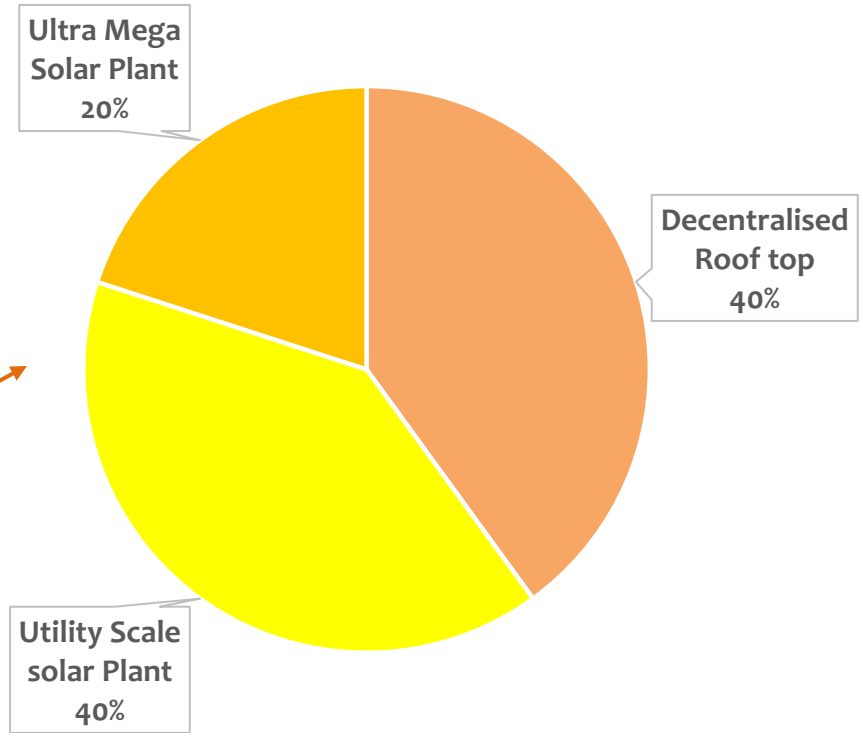
Future Renewable Integration Plan

India's Intended Nationally Determined Contribution (INDC) aims to base **40% of the total installed power generation capacity on non-fossil fuel resources by 2030** with international support on technology transfer and financing. This includes Government of India's ambitious target of achieving 175GW of RE by the year 2022.

175 GW Renewable Integration Plan by 2022

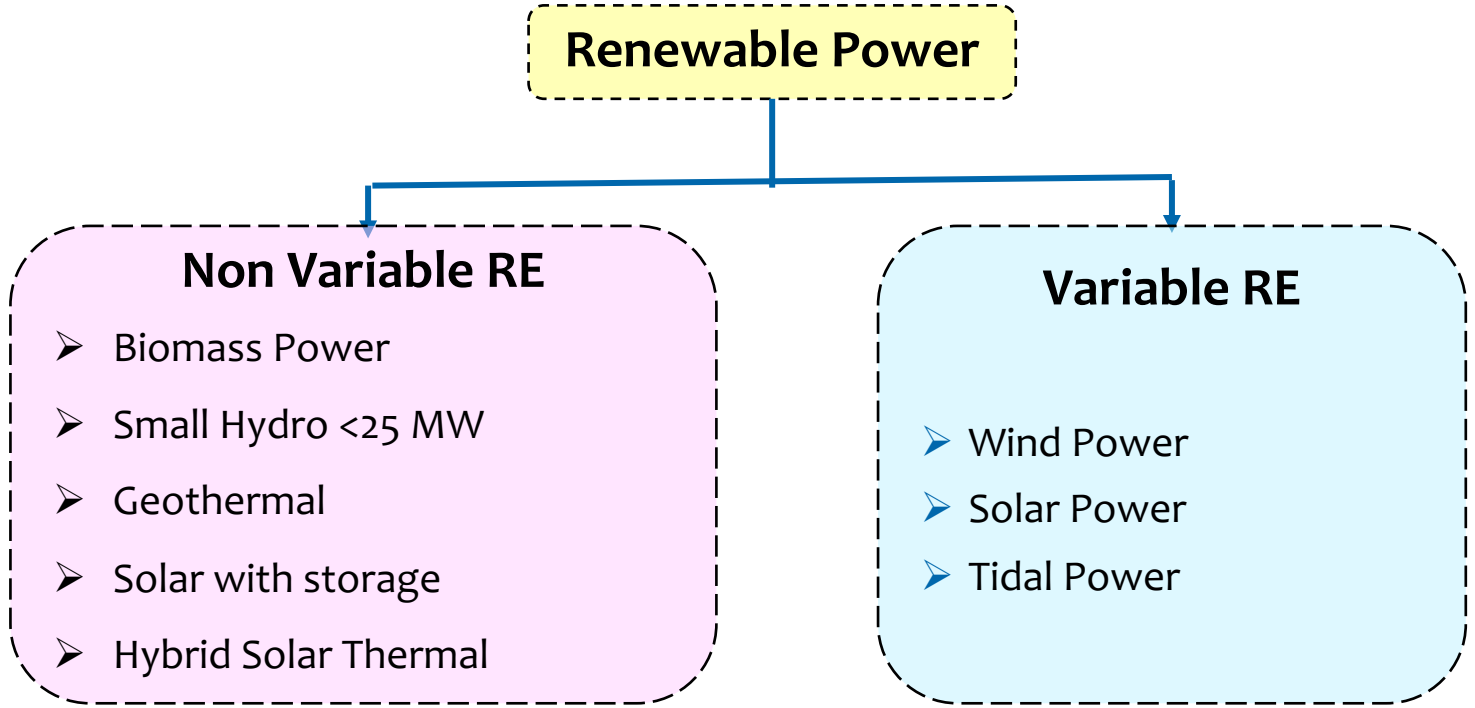


100 GW solar PV Integration plan



Variability of Renewable Power

Non variable renewable energy generation refers to sources of electricity that can be generated at the request of power grid operators or of the plant owner. Since wind power and solar power cannot be controlled by operators, so these are termed as Variable Renewable Energy (VRE) sources.



Peculiarities of Variable Renewable power

- Variability
- Uncertainty
- Geographically Confined
- Low inertia

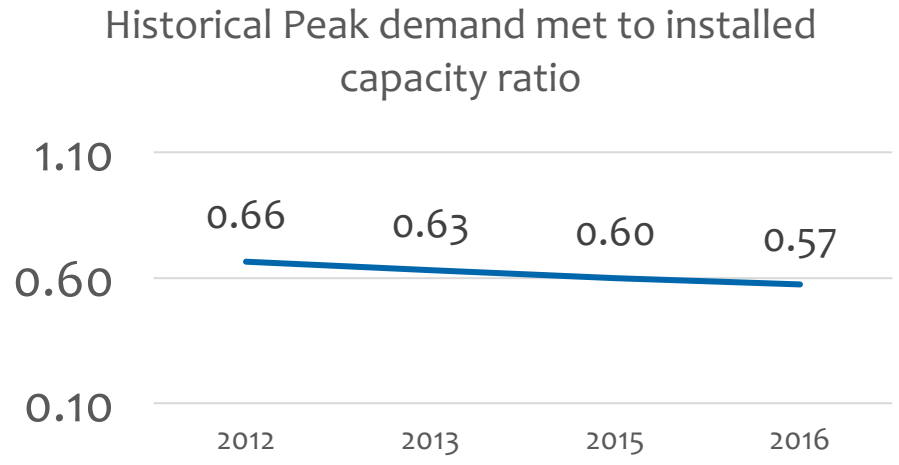
Impact on System

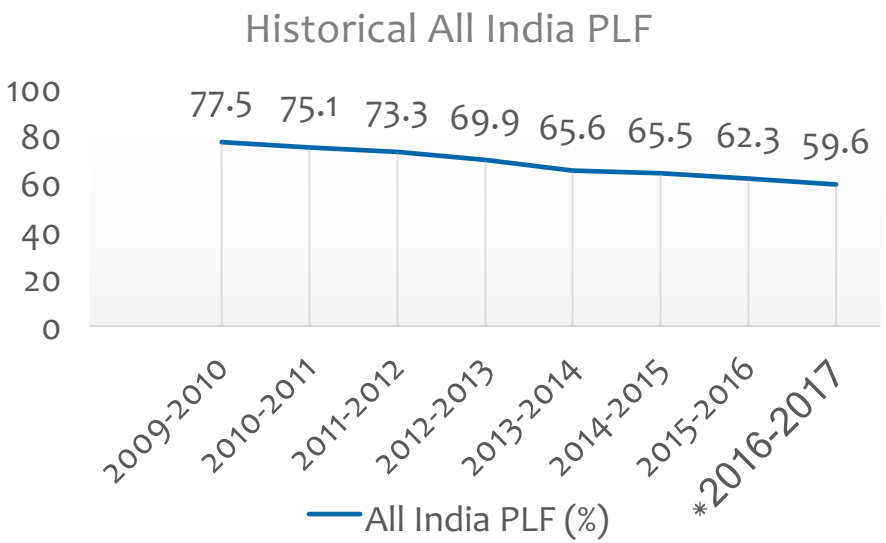
- Difficulty in load frequency control
- Difficulty in scheduling of tertiary reserves
- Requirement of enhanced transmission network and its under utilisation
- Increase in requirement of ancillary services and hence increased system operation cost
- Increase in transmission cost due to all above factors

Impact on existing Plant

- Lower PLF due to ducking of load curve
- High ramping requirement
- Two shifting and cycling of plants
- Increased forced outage and O&M cost
- Equipments life time reduction
- Poor heat rate and high Aux. Power

Today's Scenario: Cycling without Renewable Integration

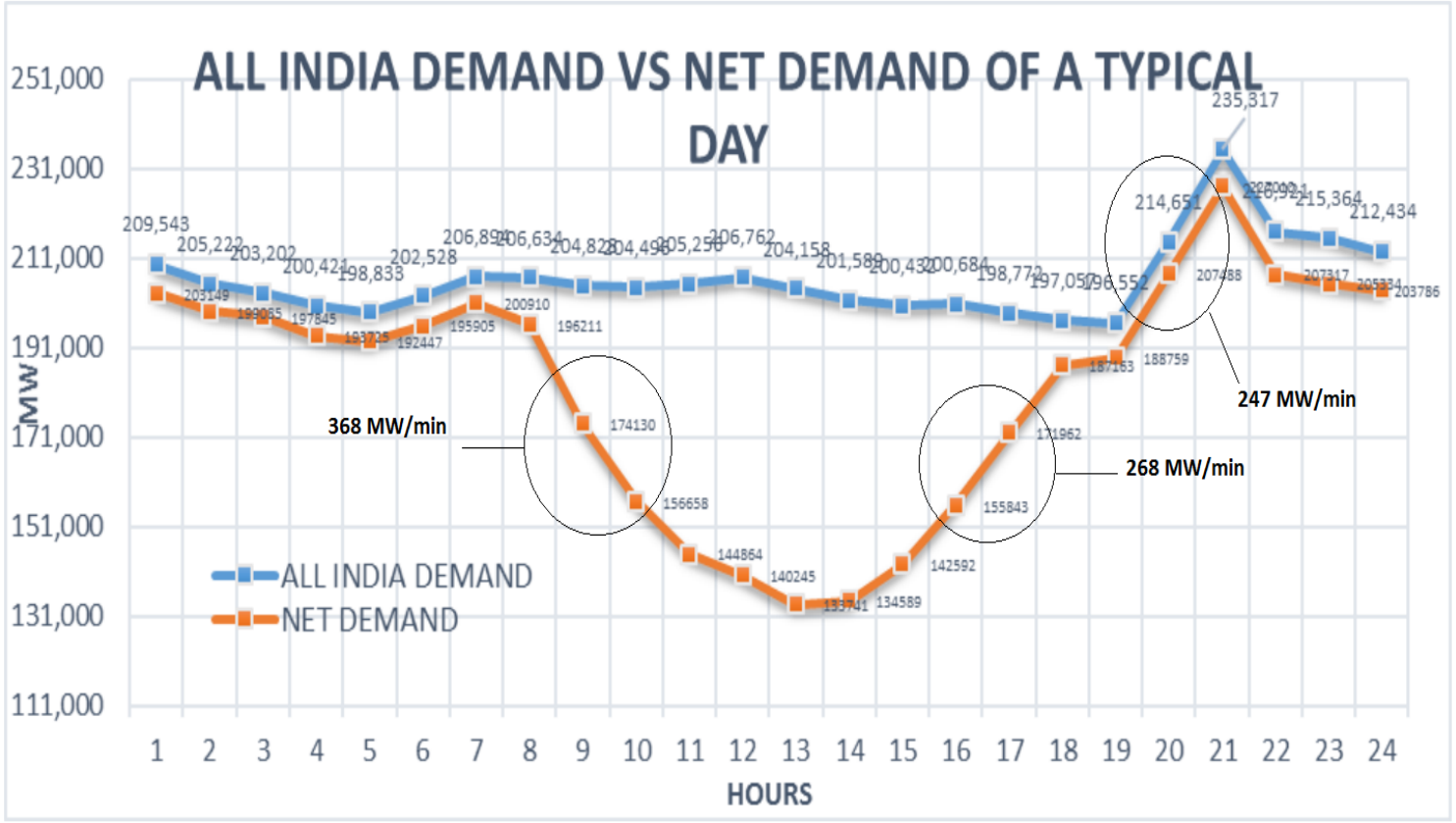




- In last five years, conventional capacity was added rapidly but in same proportion electricity demand did not rise, which caused lower PLF and lower peak to installed capacity ratio.
- It is likely to fall further due to rapid addition of RE.

Future Net Demand Curve (2021-2022)

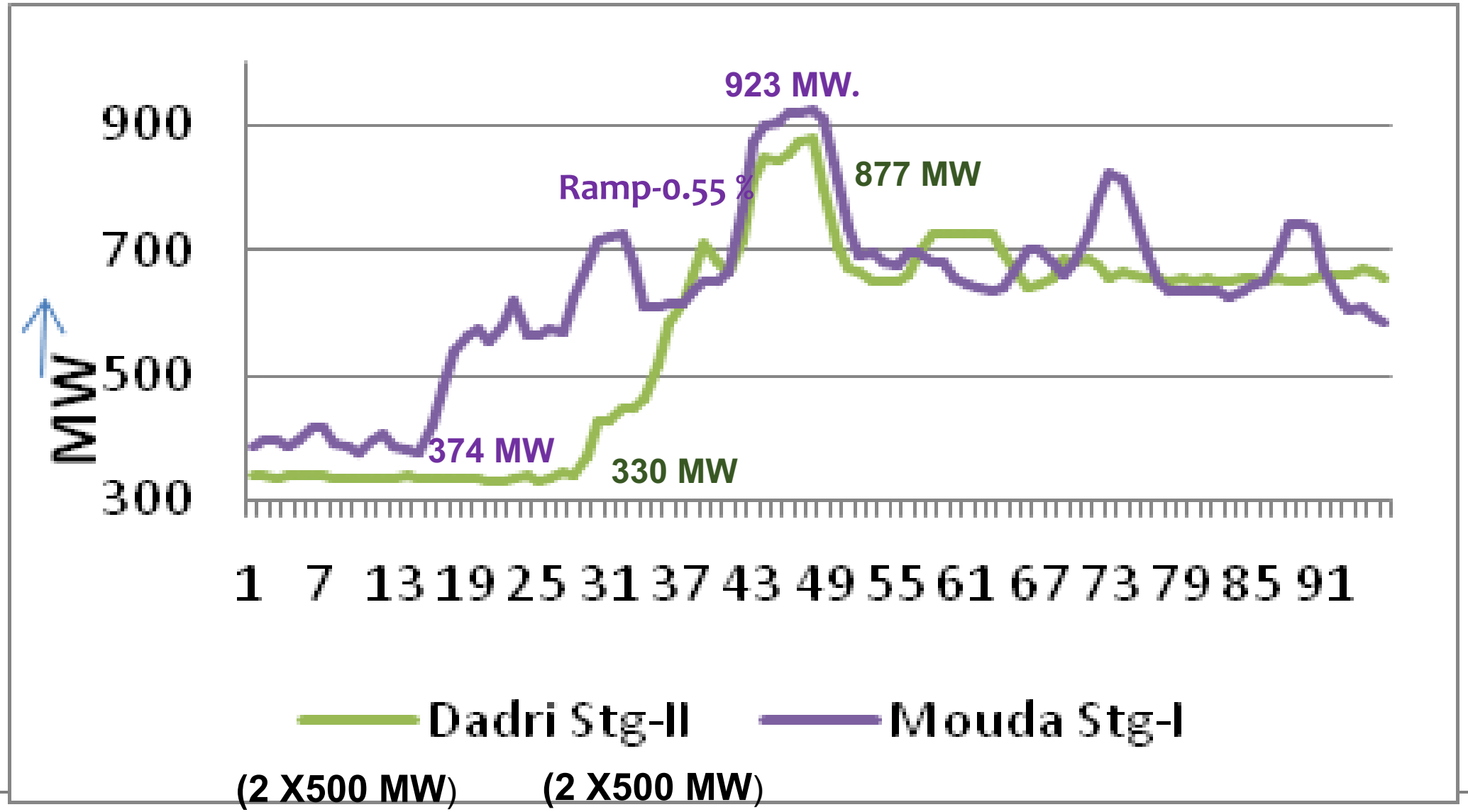
Source: CEA



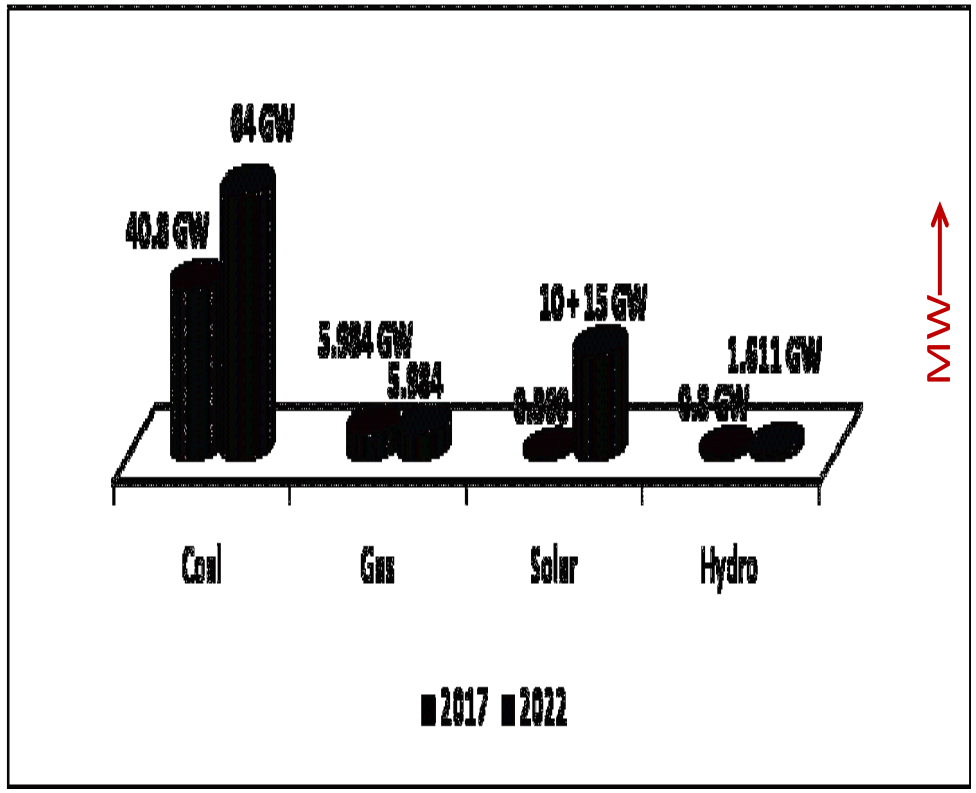
- Installed capacity ~ 523 GW *
- Peak hour ramp rate is 247 MW/min.
- Ramping down rate with sun rise is highest i.e. 368 MW/ min.
- Duck belly demand to peak demand ratio is 61% which will lead to partial loading and two shifting i.e. cycling of fossil based power plants and hence low PLF.

* Based on Draft NEP projections for 2021-22

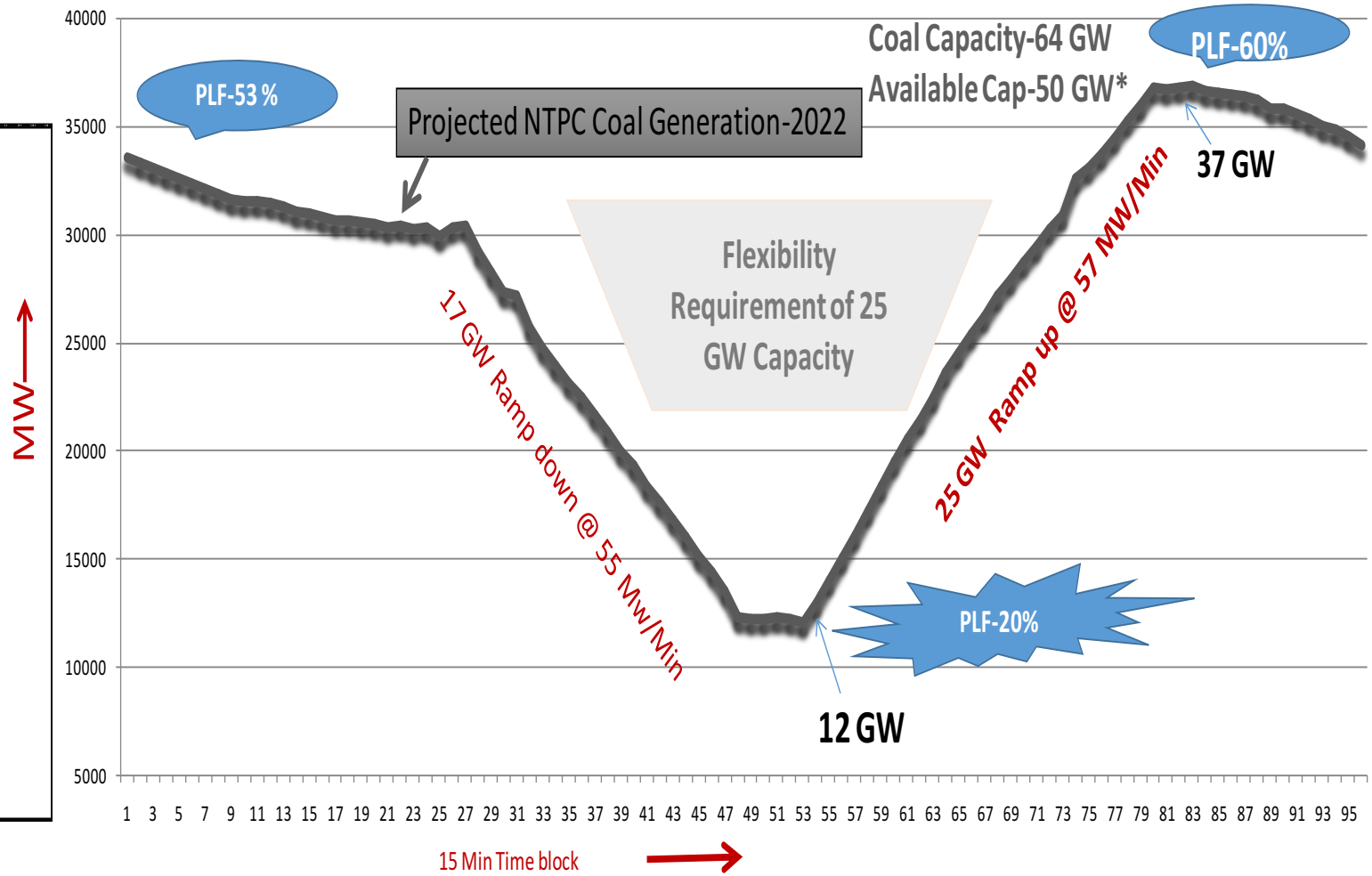
NTPC's present level of Flexible operation



Emerging Scenario for NTPC Group in 2022



Capacity Growth

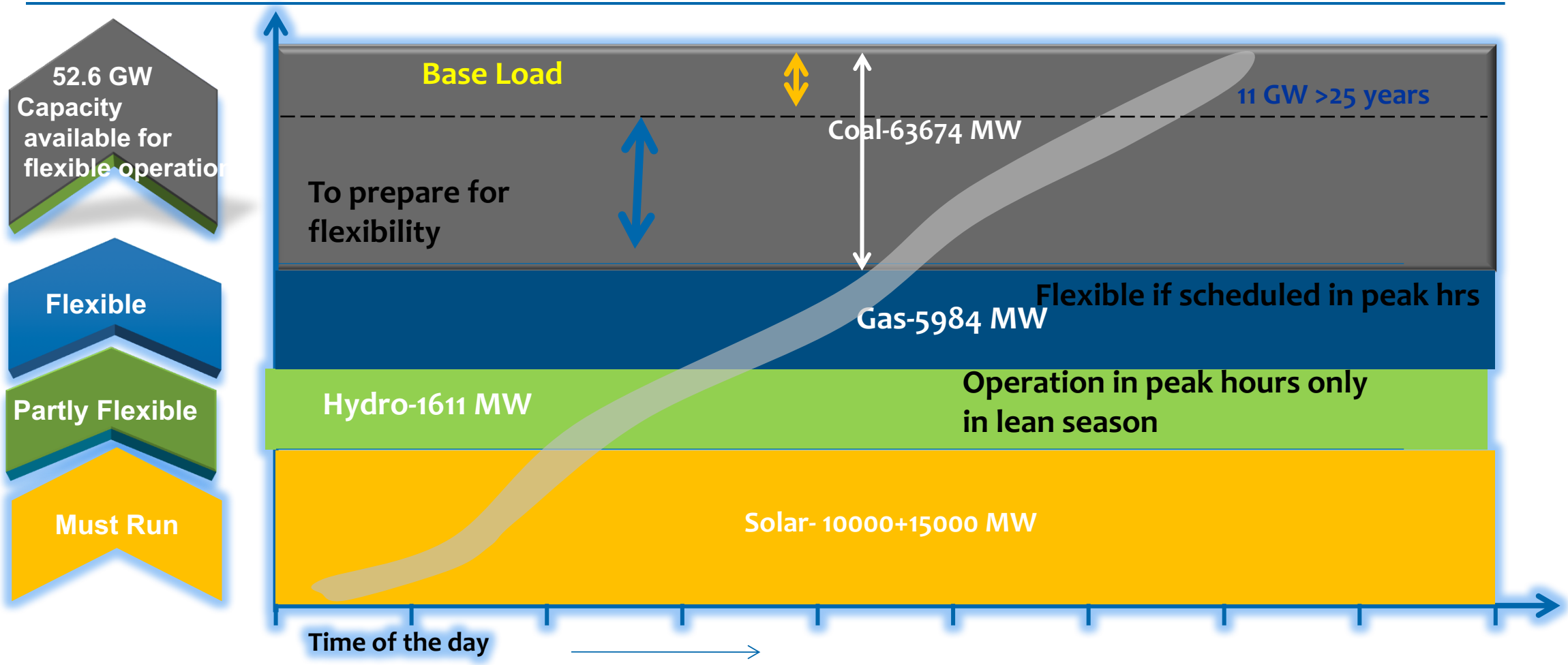


* Capacity <25 years old

Predicted Generation

Group NTPC's Approach towards Flexibility

OPTION-1



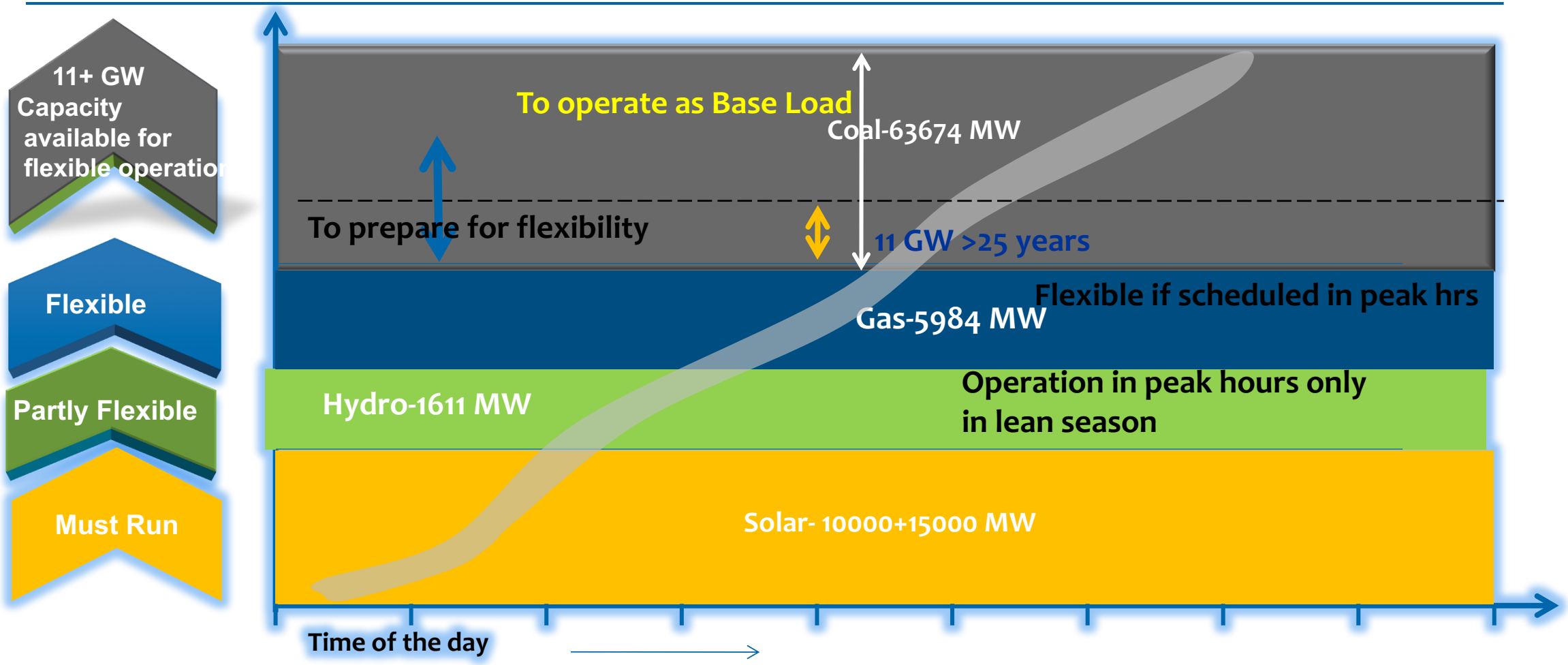
Maximum flexibility band available-Coal-25 GW(with minimum operation 55% PLF

Gas-5.5 GW

Hydro-1.6 GW

Group NTPC's Approach towards Flexibility

OPTION-2



Maximum flexibility band available-Coal-25 GW(with minimum operation 55% PLF
+ Gas-5.5 GW, Hydro-1.6 GW

Requirement for NTPC (2021-2022)

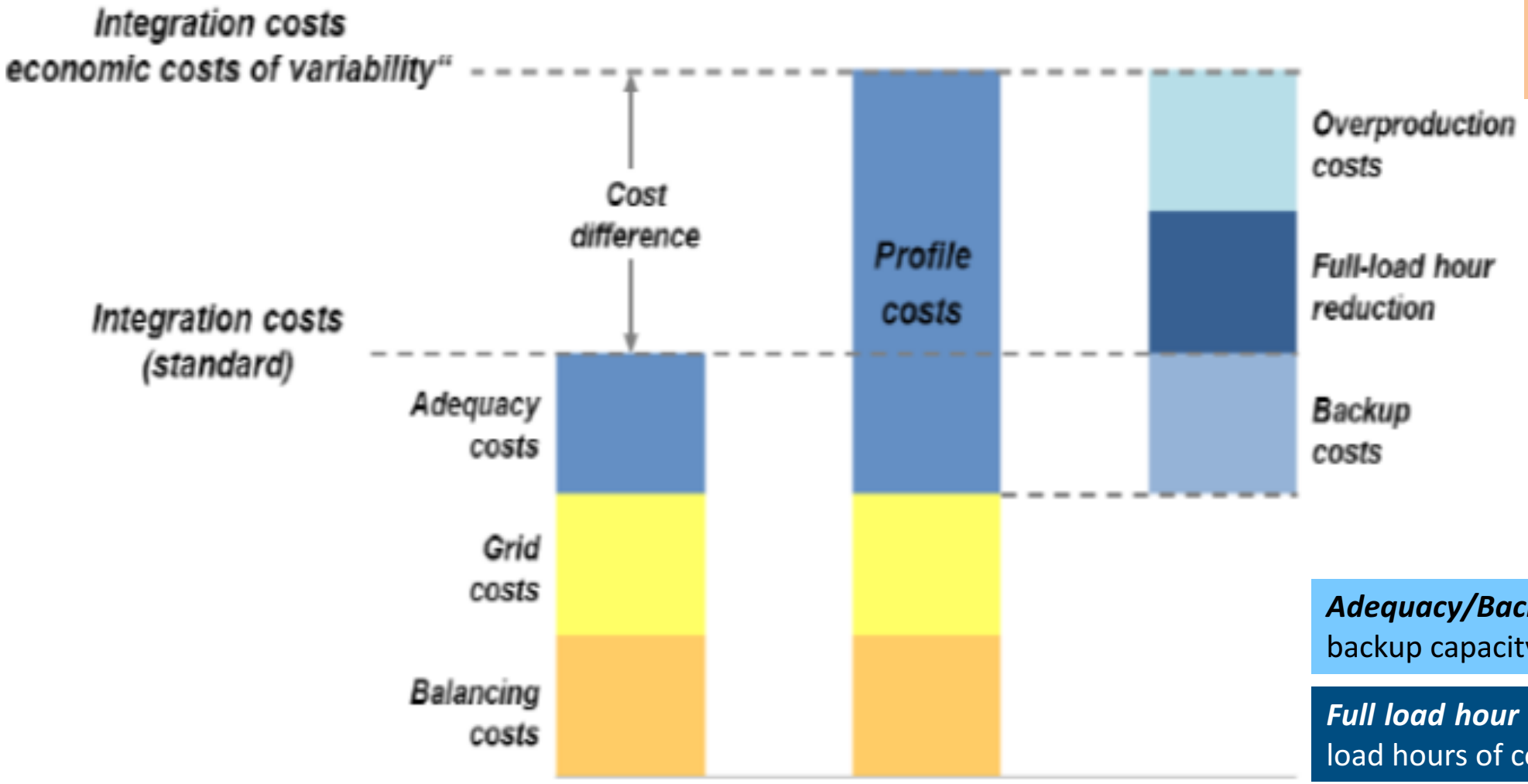
- With participation of all the Units of NTPC the ramp down @ 0.2-0.3 % and peak ramp up @ 0.15 % will be required
- At ramp rate of 1%, 21 % of the units will be required to participate during ramp down and 15 % units will be required during peak ramp up
- But some units will be required to ramp up/down at higher rates as per the merit order.
- Duck belly demand to peak demand ratio is 61% (difference of 20 GW) which will lead to partial loading and frequent start stops
- Even if all the units operate at technical minimum the gap of 20 GW will not be met i.e there will be frequent start/stop of some of the units

Cost of cycling to Generating Companies

- Modification cost required for making units cyclic ready
- Loss of useful life
- Increased O&M expenses
- Start up fuel cost
- Loss of availability due to forced outage
- Poorer heat rate
- Increased Aux. Power Consumption

Proper mechanism to recover these costs is necessary to maintain the financial sustainability of the Generating Companies.

Integration Costs : German Experience



Balancing costs –
Intraday adjustments against variations of RE

Grid costs –

- VRE source is located far from load centers investments in transmission might be necessary.
- Grid constraints are enhanced by VRE the costs for congestion management of power plants increase.

Adequacy/Backup costs – Due to need for backup capacity against low credible VRE

Full load hour reduction - **R**educes the full-load hours of conventional power plants

Source: Falko Ueckedt et al ; System LCOE : What are the costs of variable renewables ?

Design and Incentivize cost effective power system based on economic evaluation

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Cost Drivers

- Profile costs – because of variability
  - There is a requirement of back-up capacity
  - Decrease in full –load hours of capital intensive dispatchable power plants
  - Frequent Ramp up/down
  - VRE supply may exceed demand and thus over produce
- Balancing Costs- because of uncertainity.
  - Day ahead forecast errors cause unplanned intra day adjustments of dispatchable power plants and require operating reserves to respond within minutes to seconds
- Grid related costs
  - VRE located far off from load centres- requiring investments in transmission
  - Cost of congestion management

System Levellised Cost of Electricity: German Experience

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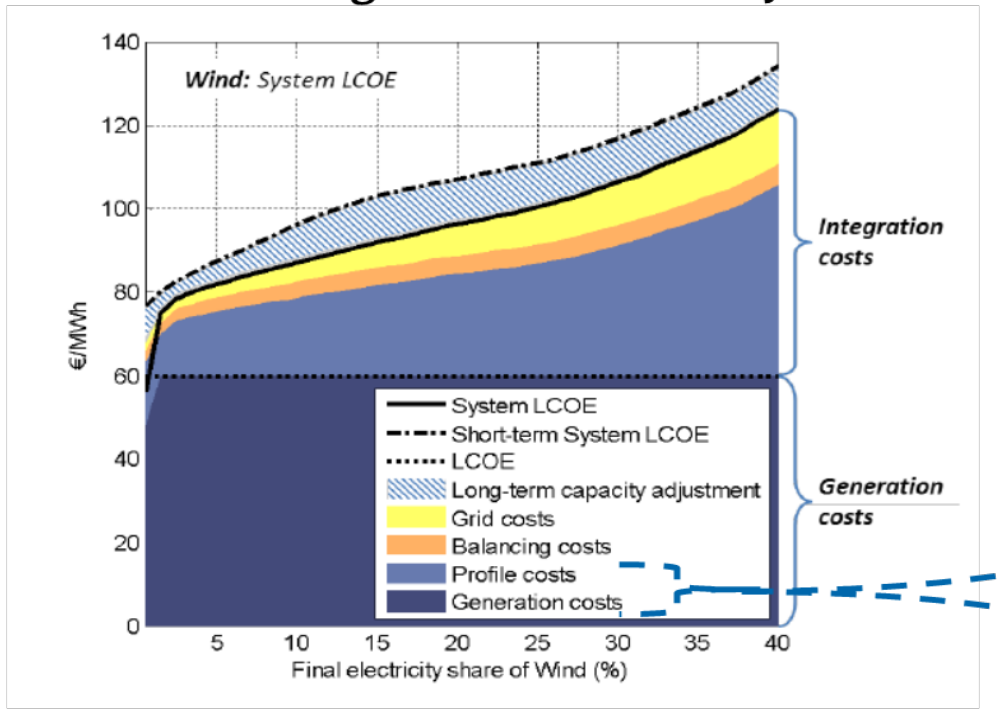
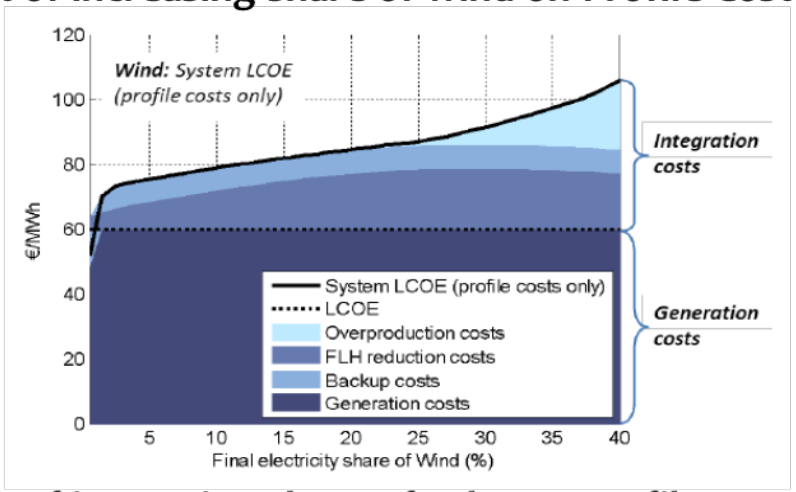
Effect of increasing share of wind on System LCOE



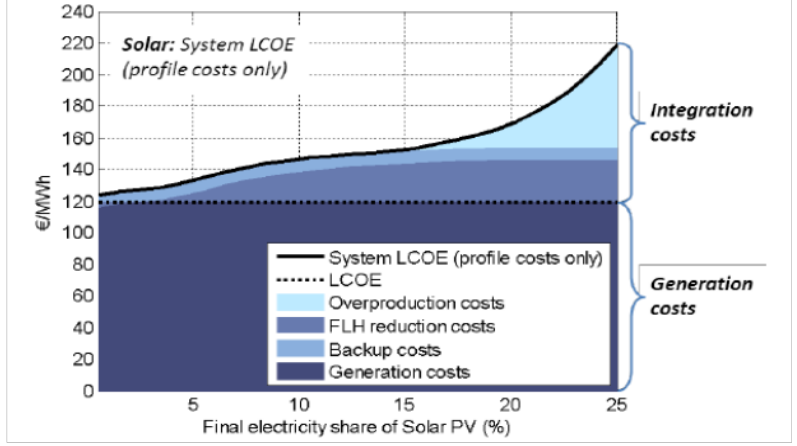
Typical costs (approx.), depending on grid penetration of VRE:
Grid Costs - 3 to 15 Euro /MWh
Balancing Costs - 3 to 6 Euro /MWh

	Solar	Wind
Present	3.6%	9.7%
2022	19.1%	11.4%

Effect of increasing share of wind on Profile Cost



Effect of increasing share of solar on Profile Cost



Grid & Balancing Costs are not considered in the above graphs

Source Weblinks –

(1) https://www.mcc-berlin.net/uploads/media/Ueckerdt_Hirth_Luderer_Edenhofer_System_LCOE_2013.pdf; (2) http://www.internationalenergyworkshop.org/docs/IEW%202013_4E1Ueckerdt.pdf

(3) http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP_Tech_Brief_Power_Grid_Integration_2015.pdf

System Levelised Cost of Electricity : Inference

- At high level of solar integration, for example at 25%, even if the solar tariff offered is ZERO, the cost at system level to the consumer is expected to be of the order of 10 Euro Cent per kWh (Rs. 7-8 per kWh)
- Similarly for wind penetration level of 40%, if the wind tariff offered is ZERO, the cost at system level to the consumer is expected to be of the order of 7 Euro Cent per kWh (Rs. 4 - 5 per kWh)
- Non variable renewable energy such as hydro, hydro with pumped storage, biomass, solar thermal, solar with storage, geothermal, waste to energy do not have such hidden system costs.
- The cost of electricity from common non variable renewable sources are as below:

S.No	Non Variable Renewable energy	Typical tariff (Rs./kWh)
1.	Biomass	7 -8
2.	Hydro/Small Hydro	4 – 6
3.	Geothermal	8-10
4.	Solar Thermal	12
5.	Solar with storage	12 - 14
6.	Pumped storage	7 - 9

- The cost to consumer from non variable RE is much less than the cost of solar and wind even with sharp fall in their prices. Therefore, they may be expedited to achieve full potential, in the benefit of consumers and existing infrastructure.

Impact on Coal/gas based Plant (Flexible Operation and Damage Mitigation)

It is Time For Flexible Generation Management

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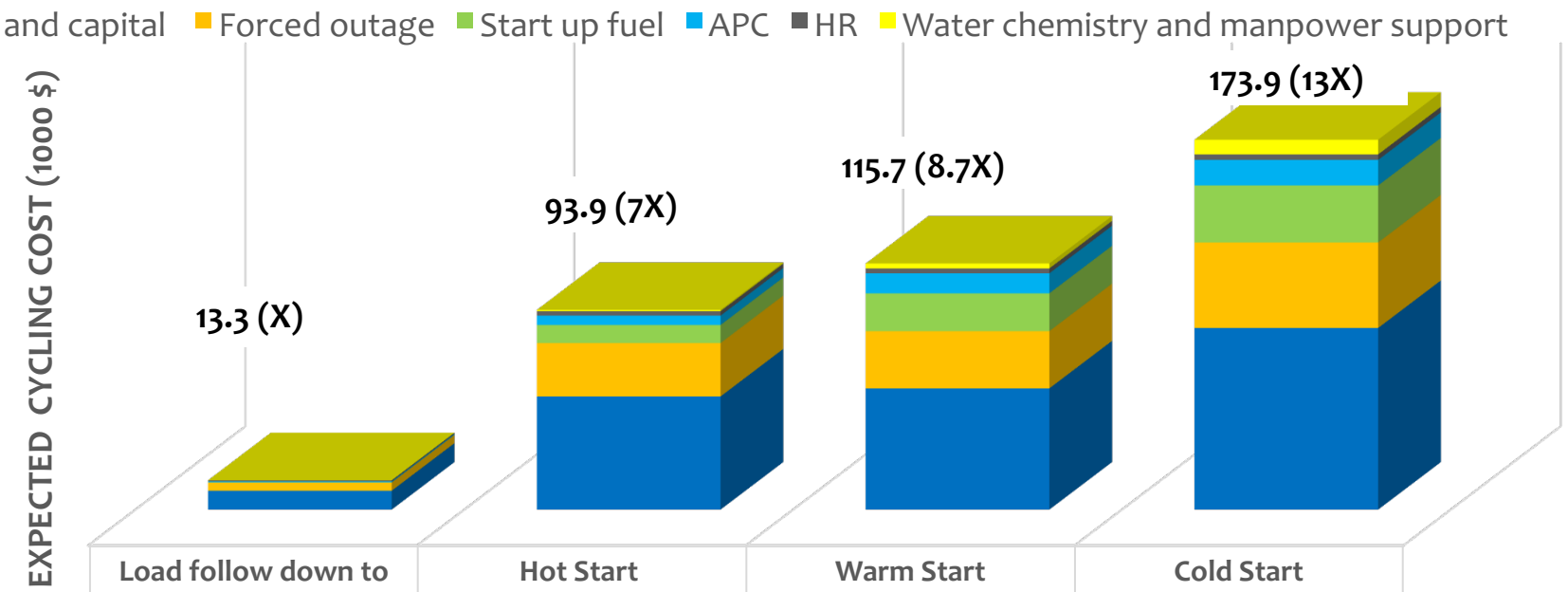
Actual Cost of Generation(Cyclic Load)= Cost of generation (Base load) + Integration Cost

- Time to learn how to minimise equipment damage and asses the true cost of cycling to find out actual cost of generation.
- True cost of operation arrives often years later. So, if cost of cycling is unknown making profits becomes a matter of luck rather than good management.
- Find out what, in terms of fuel cost and cycling cost , is the least expensive combination of units to meet system load?
- Knowing cycling cost would help in deciding either shut down unit (and incur cyclic damage) or to operate at minimum load.
- High fuel cost units(poor merit order) may require to cycle more than low fuel cost units, so they should be designed accordingly for heavy cycling duty. Old units with suitable cyclic modification, if required, can also be allocated for cyclic duty.

Comparison : Cost to Cycle a Unit, Per Operation

TYPICAL CYCLING COST FOR A 500MW COAL FIRED POWER PLANT (USA) (COST ARE SHOWN IN 2008 DOLLARS) ,SOURCE:-INTERTEK APTECH

Warm and cold starts are the most damaging for units. Whereas load following up to technical minimum is the least damaging.



	Load follow down to 180MW	Hot Start	Warm Start	Cold Start
Water chemistry and manpower support	0	0.6	2.3	6.9
HR	0.5	2.1	2.3	2.6
APC	0.5	4.4	9.4	12
Start up fuel	0	8.5	17.8	26.8
Forced outage	3.9	25.1	26.9	40.2
Maintainance and capital	8.9	53.2	57	85.4

Initiatives for Flexibilisation study

- Special task force has been constituted under the aegis of Indo-German Energy Forum (IGEF) – members : CEA, NTPC, POSOCO, EEC, VGB, GIZ and KFW
- Two of NTPC stations have been identified for pilot study (Dadri and Simhadri)
- The study covers the following –

  (A) Demonstration of technical and economic feasibility

  (B) Analysis of legal framework conditions

  (C) Capacity building of coal fired power plants operators
- Training programs, workshops with seminars already conducted
- Development of operator training concept is underway
- NTPC is also engaging an international consultant to study the cost and impact of cyclic loading on thermal units

Impact of Variable Renewables on Grid and its Mitigation

Renewables Integration into Power Grids

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The integration of a significant share of variable renewables into power grids requires a substantial transformation of the existing networks in order to:

a) Promote and prioritise non Variable RE such as Hydro, Biomass, Geothermal, Solar with storage, Solar Hybrid;

b) Establish an efficient electricity-demand and grid management mechanisms aimed at reducing peak loads, improving grid flexibility, responsiveness and security of supply in order to deal with increased systemic variability;

c) Improve the interconnection of grids at the regional, national and international level, aimed at increasing grid balancing capabilities, reliability and stability;

d) Introduce technologies and procedures to ensure proper grid operation stability and control (e.g. frequency, voltage, power balance) in the presence of a significant share of variable renewables leading to variation in equivalent grid inertia.

e) Introduce energy storage capacity to store electricity from variable renewable sources when power supply exceeds demand and aimed at increasing system flexibility and security of supply.

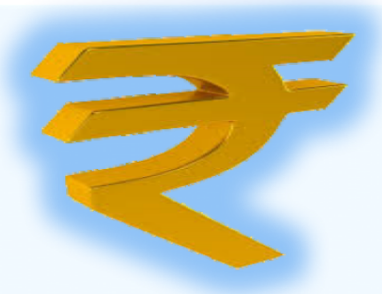
Strategy to Improve overall Grid Operation Efficiency

Upgradation of Grid technology	Centralized RE forecasting mechanisms need to be tightly integrated with system operations. Advanced decision-making and control systems need to be implemented that enable system operators to respond significantly faster to changed grid conditions.
Upgradation of Grid Protocols	Currently, in India, scheduling occurs on a day-ahead basis while dispatch occurs on a 15-minute basis. System operations technologies and protocols need to be updated to enable five-minute scheduling and dispatch of all resources connected to the grid and automated incorporation of RE forecasts. This will also lower ancillary service requirements and hence the over all cost to consumer.
Promote Flexible Demand & Supply Resource	Power systems, especially those with a high share of RE, require access to sufficient flexible resources (e.g. gas turbines, hydroelectricity, flexible coal units with AGC etc.) to ensure continued stability of the grid at each moment. India has 22% of total installed capacity of these flexible resources (gas and hydro power).
Expand Balancing Areas	More and more units should be brought under AGC, so that effective ramp rate requirement on individual units can be minimised and better load frequency control can be obtained.

Market Redesign

- For ancillary products like Peakers – active and reactive power support, frequency regulation, ramp rates, etc.
- Time of day metering: In order to promote consumption during RE peaking hours
- Incentivizing Storage : Pumped storage, Battery, Molten salt, etc.
- Balancing capacity charges for units earmarked for Flexibilisation

Policy Advocacy



Units catering to variable load requirement may be sufficiently compensated for increased retrofit cost, operation and maintenance costs through special tariff.

Cost of VRE is not a true indicator of the cost of electricity to consumer because it imposes additional cost on dispatchable generation. Keeping the affordability issue in mind, the targets for VRE integration should be decided. However, non-variable RE may be integrated on priority.

The policy should be oriented towards minimising **levelised system cost of electricity rather than looking at RE tariff in isolation**, ensuring grid stability and reduction in overall system operation cost in long run by reducing the extent of cycling on coal based generating stations as far as possible.

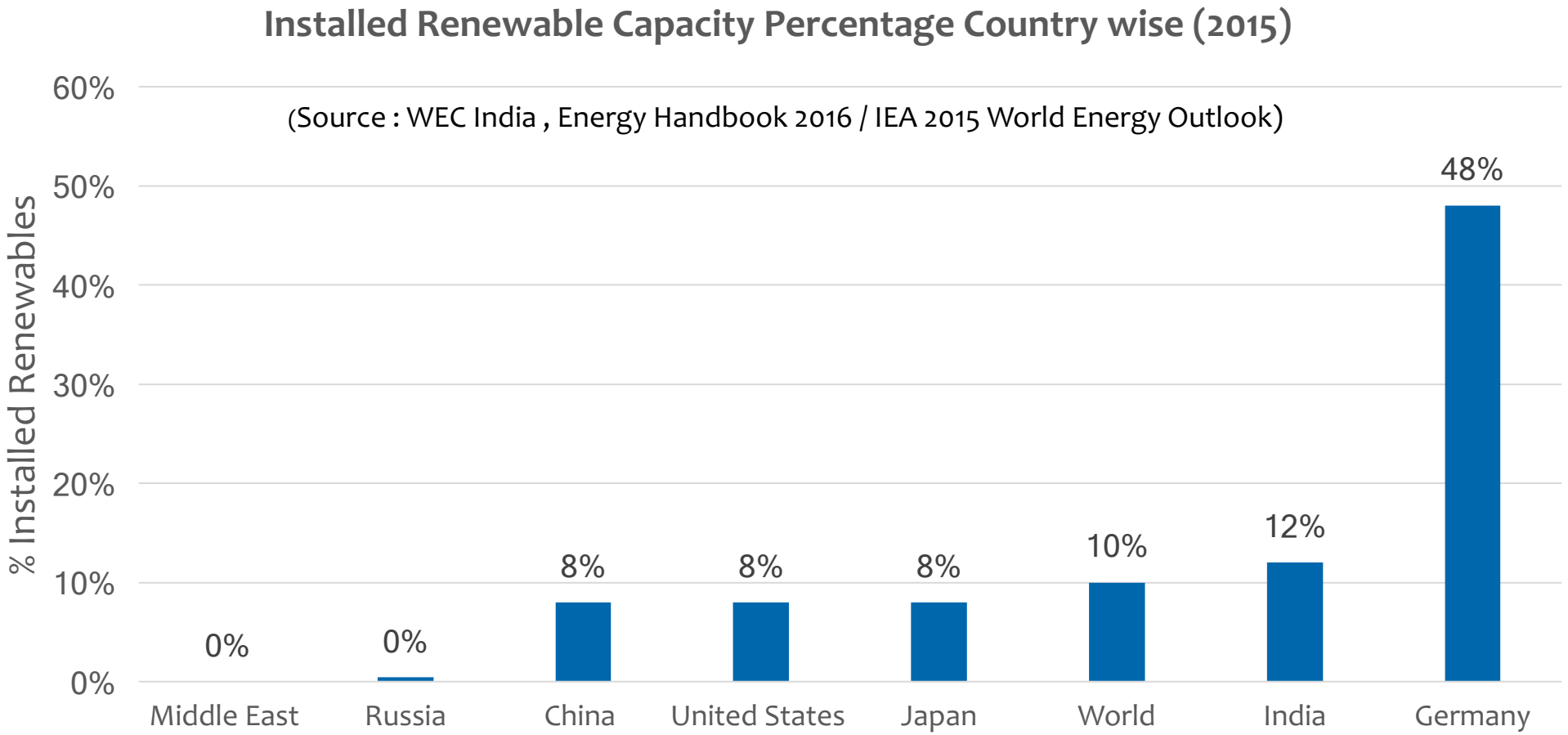
Conclusion

Integration of variable renewable energy (VRE) impacts both grid stability as well as other generating units connected to grid, thus increases cost of transmission and generation and finally cost to consumer.

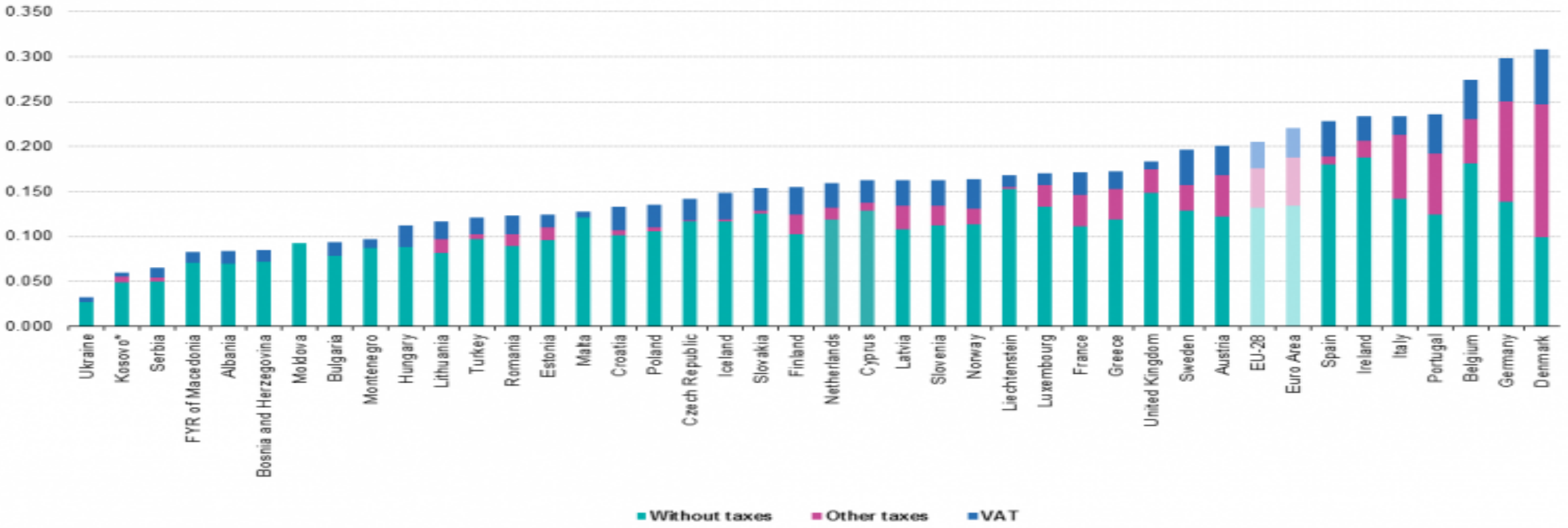
However , these cost can be reduced by adopting suitable operation practices, mitigation technologies, a better policy in picture, though it can not be eliminated totally. After all, we have to pay for better environment.

Thank You

World Renewable Scenario



*Renewable includes Solar, wind, biomass power and small hydro (<25MW).



*This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

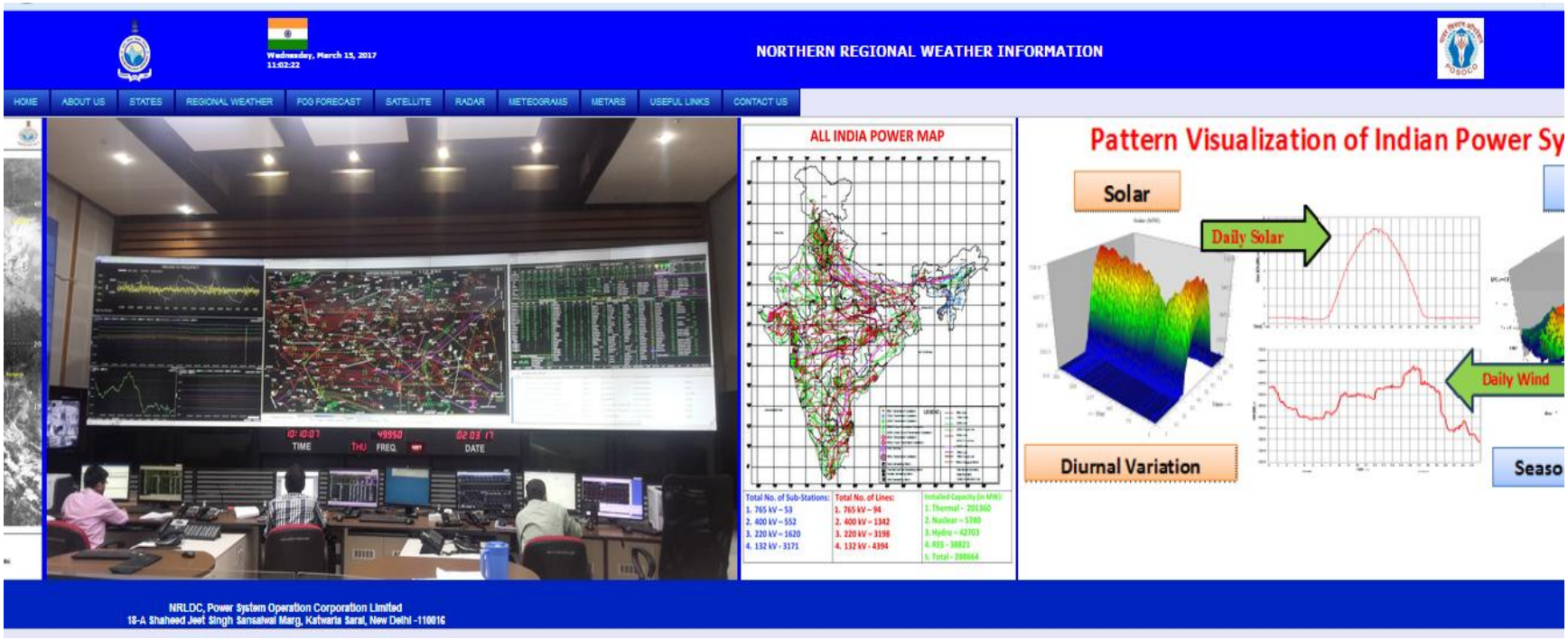
Source: Eurostat (online data code: nrg_pc_204)

Memorandam Of Understanding

MOU signed on 18th May,2015 between India Meteorological Department(IMD) and Power System Operation Corporation(POSOCO)

Objective of MOU: Weather information provided by IMD shall be used by the Power System Operators across India for better management of Indian Power System.

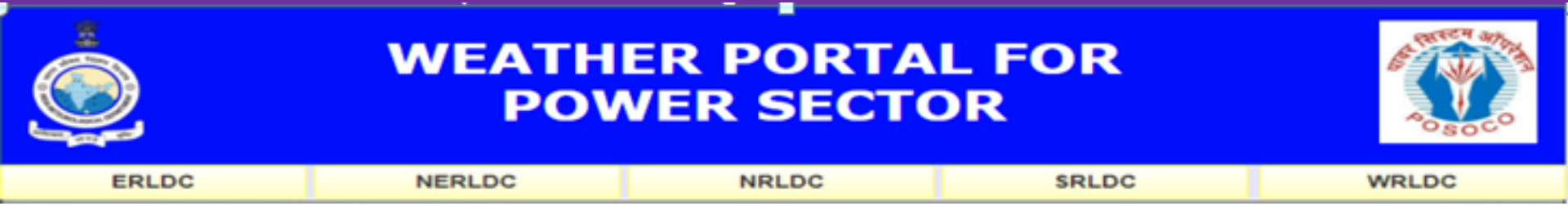
Weather Portal For Power Sector



Weather Portal for Power Sector has been developed using readily available products of IMD

Weather Portal For Power Sector

http://amssdelhi.gov.in/NRLDC/index.html



The Weather portals for all the 5 regions have been developed & made operational :

- NRLDC – on 14.03.2017
- NERDC – on 29.04.2017
- SRLDC – on 01.05.2017
- ERLDC – on 05.05.2017
- WRLDC – on 01.06.2017

Weather Portal for Power System- *Contents*

General Features

- Regional Weather Summary(Outlook for the next few days)
- Now cast
    - Forecast
    - Warning
- Radar data updating @ 10 min
- Satellite Images updating @ 30 min
- Meteogram- Forecast of Rainfall, humidity, Temperature, cloud cover, wind, wind direction, Thunderstorm (Lifted Index & cape) etc. in graphical representation(10 days in advance)

Regional Summary

DELHI REGIONAL EVENING INFERENCE DATED : 10/05/2017

REGIONAL INFERENCE

The upper air cyclonic circulation over Haryana and N/Hood extending upto 1.5 km above mean sea Level persists. The east-west trough from haryana to west Assam across Uttar Pradesh extending upto 0.9 km above mean sea level persists. The Western Disturbance as a trough in mid¬tropospheric westerlies at 5.8 km mean sea level roughly along Longitude 62.0°E and north of Latitude 25.0°N persists.

FORECAST VALID FOR NEXT 05 DAYS

No significant change in maximum temperatures over NW-India during next 2 days. Dust storm/Thunderstorm likely at isolated places over Rajasthan during next 48 hours.

FIVE DAYS RAINFALL FORECAST (FROM HOURS OF 10/05/2017 TO 0830 HOURS OF 15/05/2017)

MET SUB DIVISIONS	10/05/2017	11/05/2017	12/05/2017	13/05/2017	14/05/2017
JAMMU & KASHMIR	ISOL	ISOL	ISOL	ISOL	ISOL
HIMACHAL PRADESH	ISOL	ISOL	ISOL	ISOL	ISOL
UTTARAKHAND	SCT	SCT	ISOL	ISOL	ISOL
PUNJAB	ISOL	ISOL	ISOL	DRY	ISOL
HAR, CNG / DLH	ISOL	ISOL	DRY	DRY	DRY
WEST-U.P	ISOL	ISOL	DRY	DRY	DRY
EAST-U.P	ISOL	ISOL	ISOL	ISOL	ISOL
WEST-RAJ	ISOL	ISOL	DRY	DRY	DRY
EAST-RAJ	ISOL	ISOL	DRY	DRY	DRY

LEGEND: NO RAIN (DRY), VERY LIGHT RAIN / MAINLY DRY (M.D.), 1-25 ISOLATED (ISOL), 26-50 SCATTERED / A FEW PLACES (SCT), 51-75 FAIRLY WIDESPREAD / MANY PLACES (FWS), 76-100 WIDESPREAD / MOST PLACES (WS).

OUTLOOK FOR THE REGION FOR SUBSEQUENT TWO DAYS (FROM 15/05/2017 TO 17/05/2017)

Isolated to scatter Rain/Thundershowers likely over Western Himalayan region. Weather is likely to be dry over the rest of North-West India.

WARNING

10/05/2017	DAY-1	Thunderstorm accompanied with squall very likely at isolated places over Uttarakhand and East U.P. Gusty winds very likely at isolated places over J&K, Himachal Pradesh ,Punjab, Haryana, Chandigarh, Delhi and west U.P. Heat wave conditions very likely at isolated places over west Rajasthan.
11/05/2017	DAY-2	Thunderstorm accompanied with squall very likely at isolated places over Uttarakhand and East U.P. Thunderstorm accompanied with gusty winds very likely at isolated places over Haryana, Chandigarh, Delhi and west U.P.
12/05/2017	DAY-3	NIL
13/05/2017	DAY-4	NIL
14/05/2017	DAY-5	NIL

ENDS

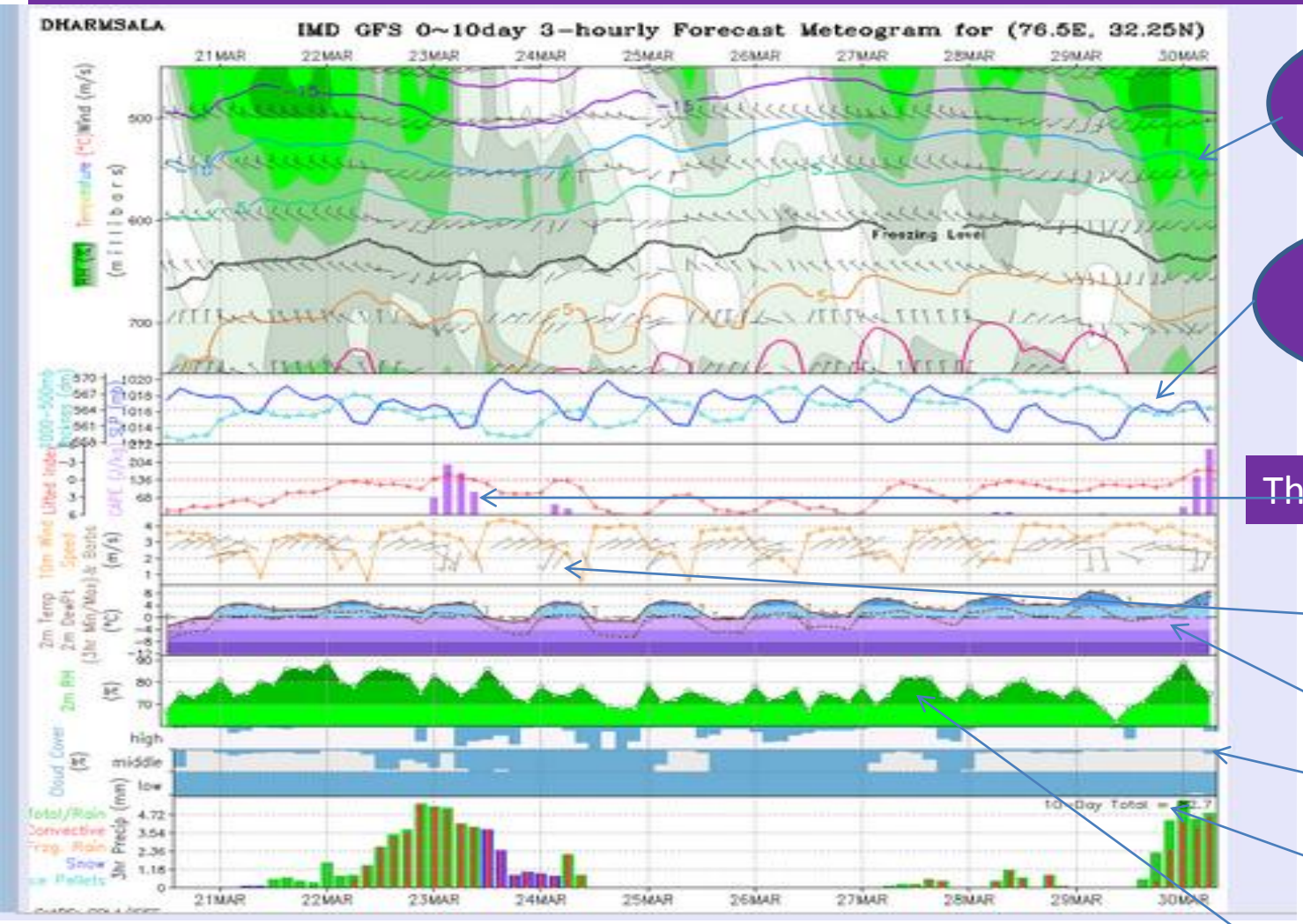
Weather info in UTC Time

- The world's weather communities use a twenty four hour clock, similar to "military" time based on the 0° longitude meridian, also known as the Greenwich meridian.
- Prior to 1972, this time was **called Greenwich mean time (GMT) but is now referred to as coordinated universal time or universal time coordinated (UTC). It is also known a "Z time" or "Zulu time".**
- **To obtain your local time(IST) here in the INDIA, We need to add 5 hours and 30 minutes from Coordinated Universal Time.**

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 at 10 Meter

Temperature

Clouds

Rains

Relative Humidity at 2 Meter

Available for 450 Locations in the Country

Indicator of Thunderstorms

- Lifted Index:
  - Value > Zero: Thunderstorms are unlikely
  - Value between 0 and -2 : Thuderstorms are possible with Good Trigger
  - Value between -3 and -5 : Thunderstorms are probable
  - Value more than -5 : Strong Probability of Severe Thunderstorm
- CAPE (**convective available potential energy) : Indicator of atmospheric Instability**
  - The purple bars indicate the CAPE value at the surface in units of J/kg.
  - CAPE is a measure of the buoyancy of a layer. The larger the CAPE, the greater the potential for severe weather.
  - Any value greater than 1000 J/kg indicates instability and the possibility of thunderstorms.
  - The base line for the bar graph of CAPE is 0

- Radar Transmitter transmits Electromagnetic Waves through directional Antenna in any given direction
  - Part of Energy is absorbed by the Atmosphere
  - Fraction of it is scattered back by the Targets and is received by the Receiver
- Received Power Depends Upon
  - Transmitted Power, Wavelength , Vertical and Horizontal Beam Width , Scattering cross section of targets ((Rain Drops,Snow ,Hail etc)
- Return Power provides information about weather Intensity and azimuth and Elevation of Antenna gives Location and Height of Cloud, Time taken by electromagnetic waves in to and Fro Journey gives range of the Target
- Doppler Weather Radar employ Doppler Principle to provide speed and direction of the Targets. (When the source for signals and observers are in relative motion then there is change in Freq observed by the Observer In case the source and Observer are moving closer ,Frequency increases and Vice Versa)

RADAR

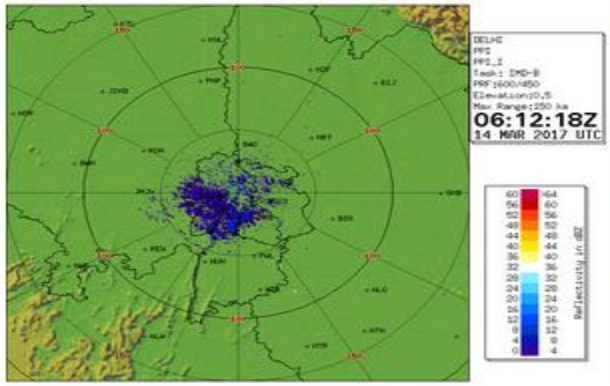
- The Doppler Weather Radar generates different displays and derived products of practical utility based on standard algorithms.
- These displays are updated @ every 10 minutes

Reflectivity (dBZ)

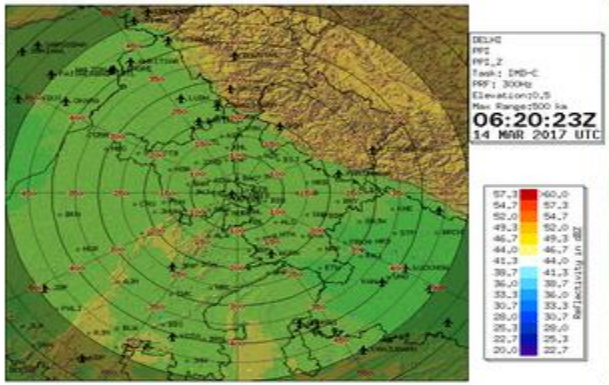
- The colors on the legend are the different echo intensities (reflectivity) measured in dBZ.
- "Reflectivity" is the amount of transmitted power returned to the radar receiver.
- Typically, light rain is occurring when the dBZ value reaches 20, 35-40 Moderate , 40-50 Moderate to Heavy 50-55 Heavy rain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

Products from Doppler Weather Radars

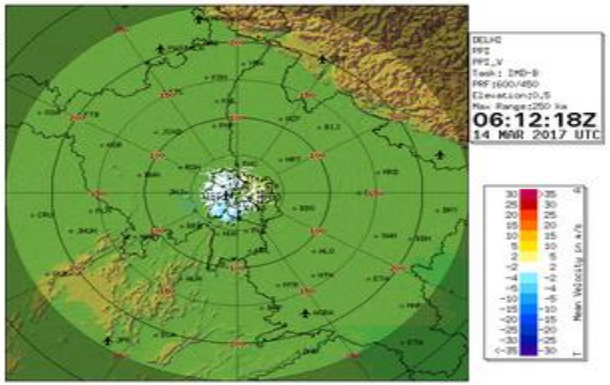
Plan Position Indicator (Z) - Close Range



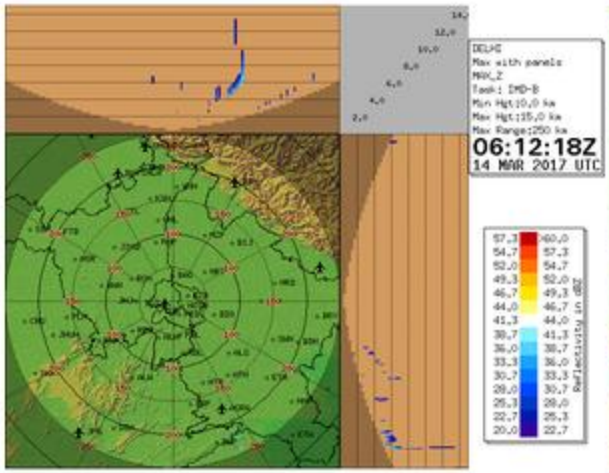
Plan Position Indicator (Z)



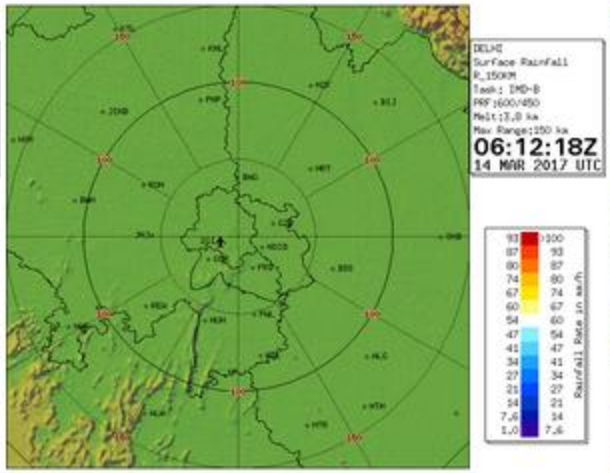
Plan Position Indicator (V)



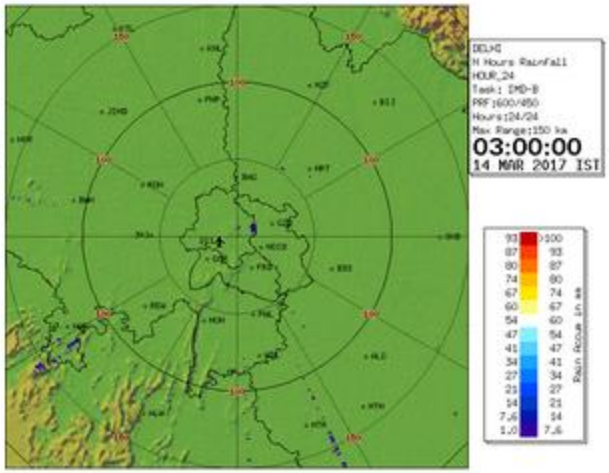
MAX (Z)



Surface Rainfall Intensity



Precipitation Accumulation



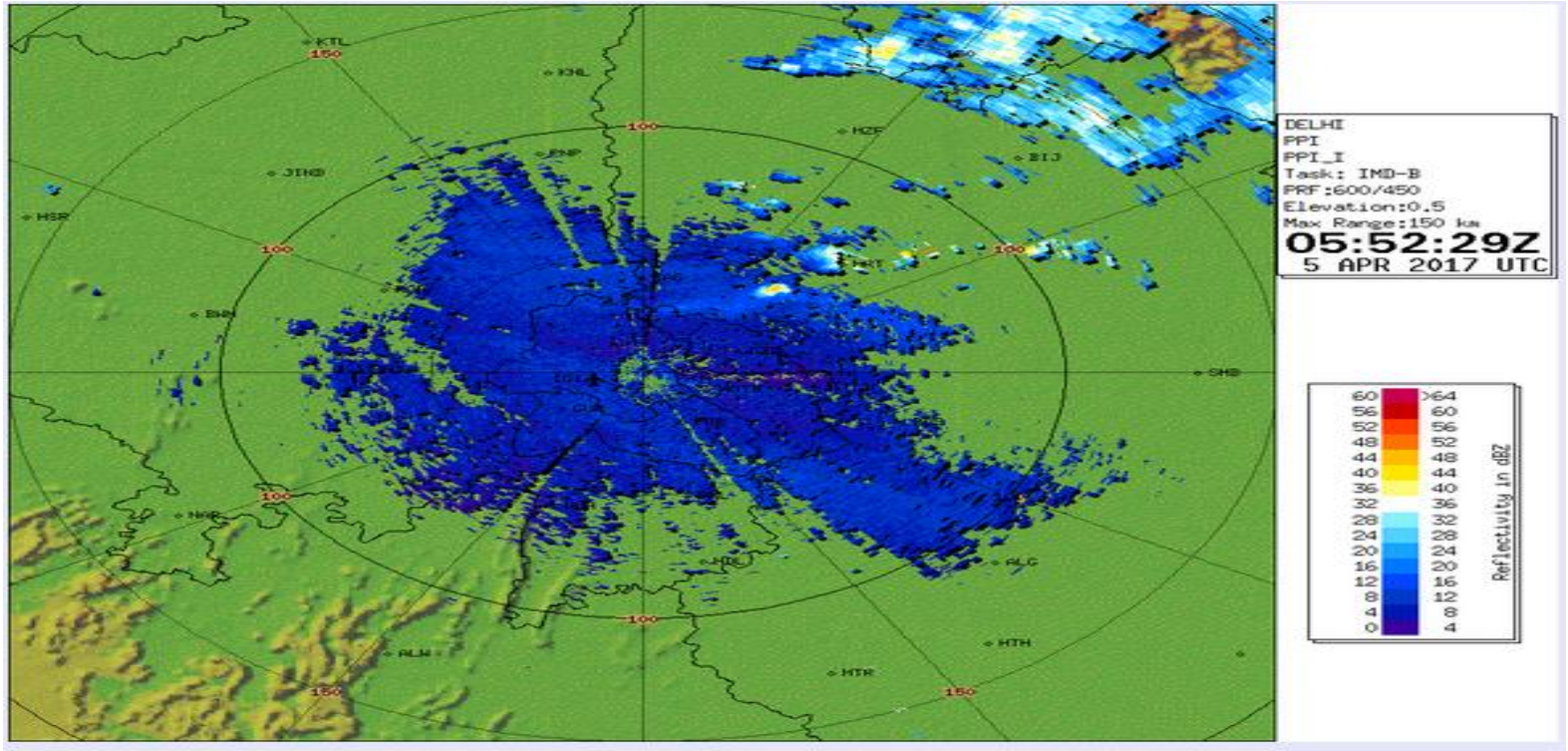
Various Elevation of Radar Images

- Presently IMD radar (Mausam Bhawan) have following elevation for scanning :
- 0.5 Degree
- 1.0 Degree
- 2.0 Degree
- 3.0 Degree
- 6.0 Degree
- 9.0 Degree
- 12.0 Degree
- 16.0 Degree &
- 21.0 Degree

Radar completed the process of scanning with all these elevation & sends the data within 10 Minutes.

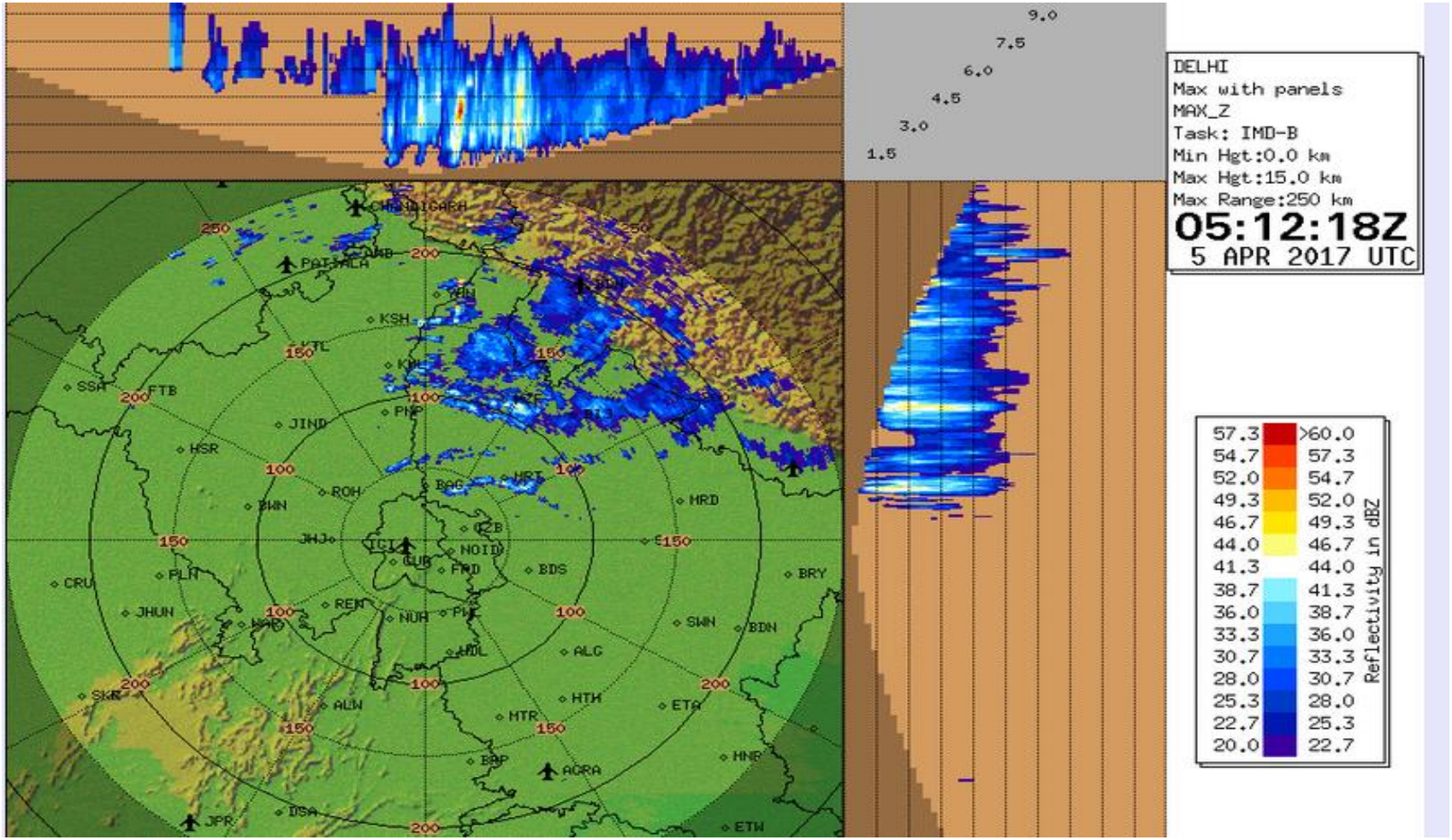
Plan Position Indicator

- Plan Position Indicator: A constant elevation surface data is presented as a cloud image around the Radar Station. The data depicted is on the slant range depending on the elevation

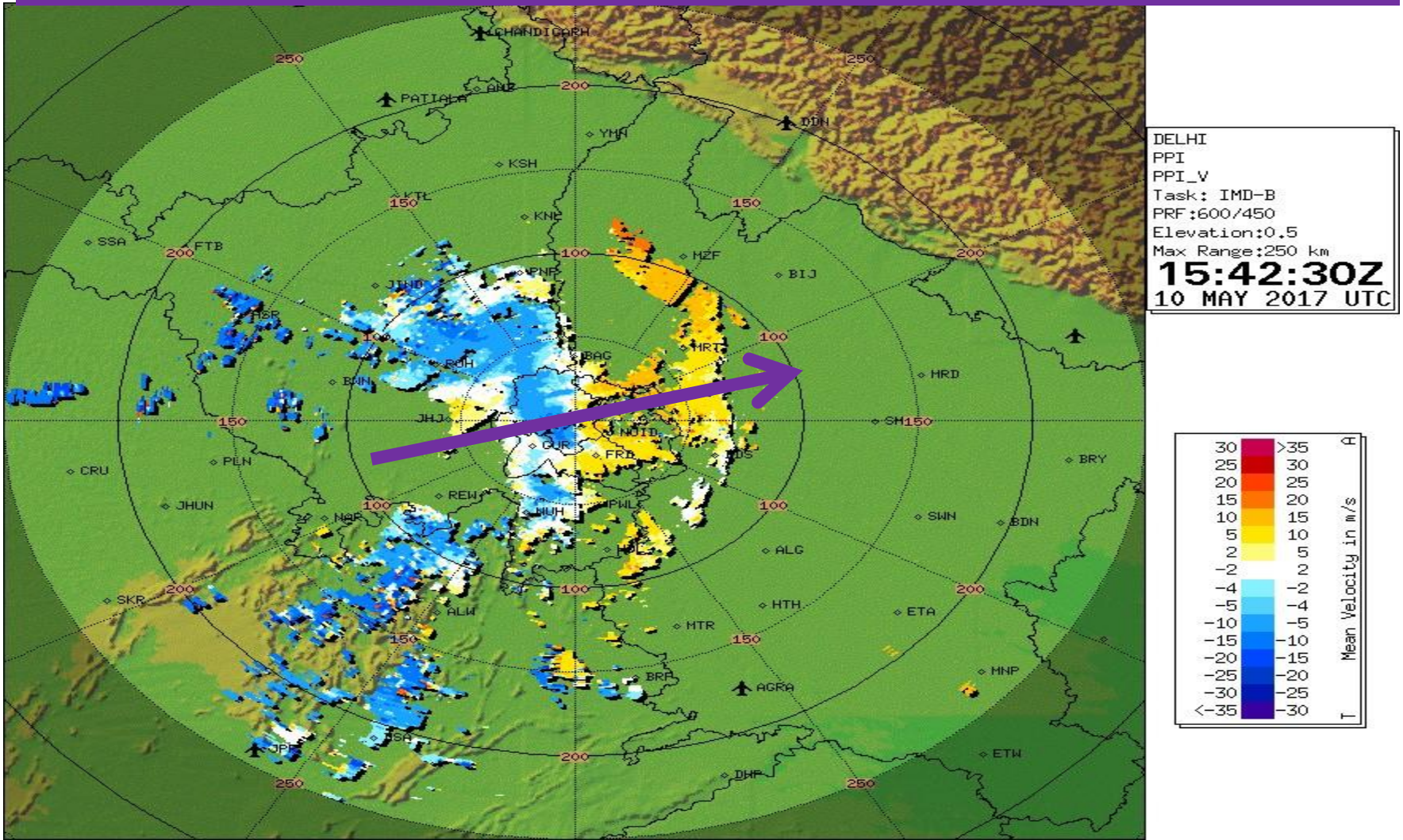


Range Height Indicator

This Product is same as conventional Radars . A Display is generated on the Range on the X-Axis and height of the Cloud Surface on Y-Axis

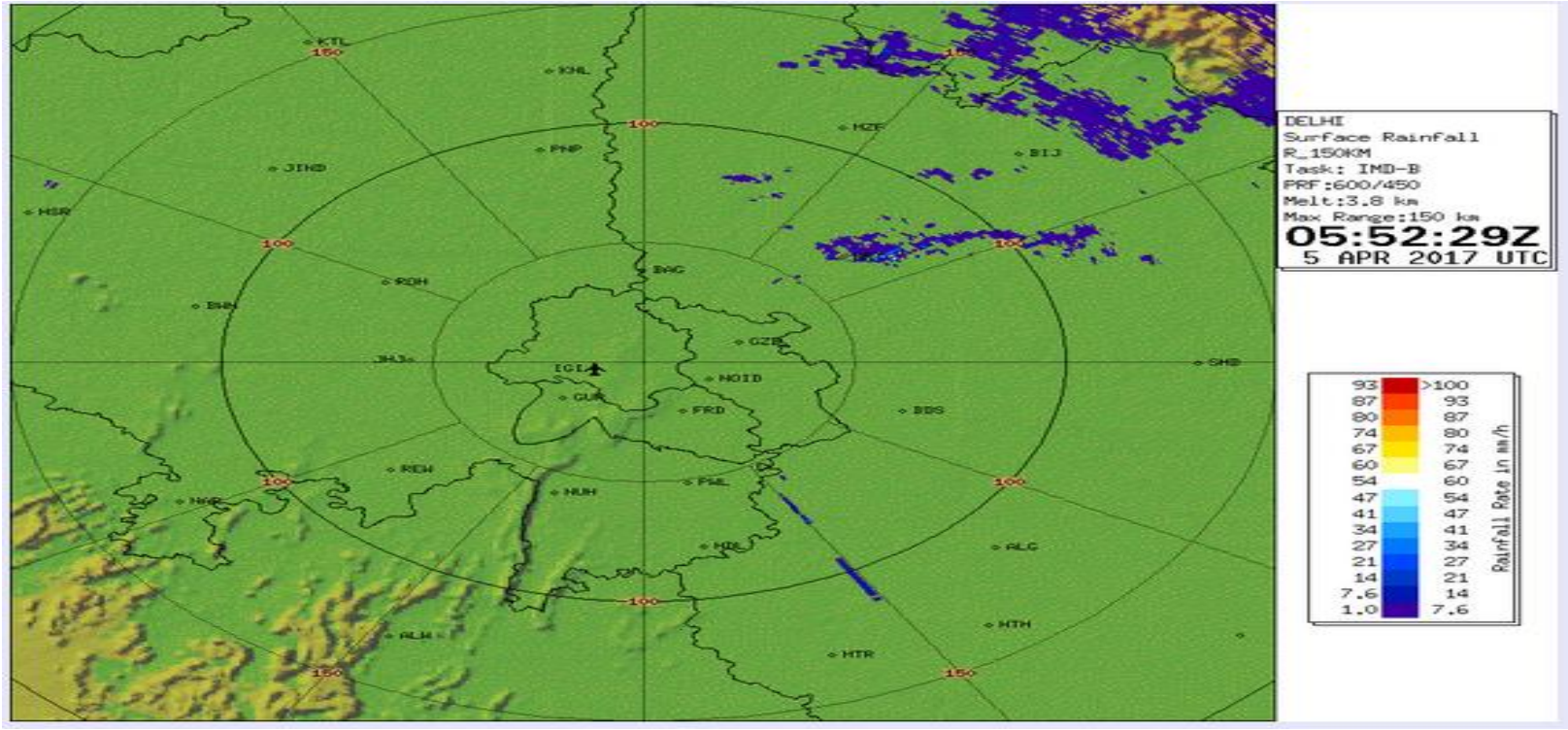


Plan Position Indicator (Mean Velocity m/s)



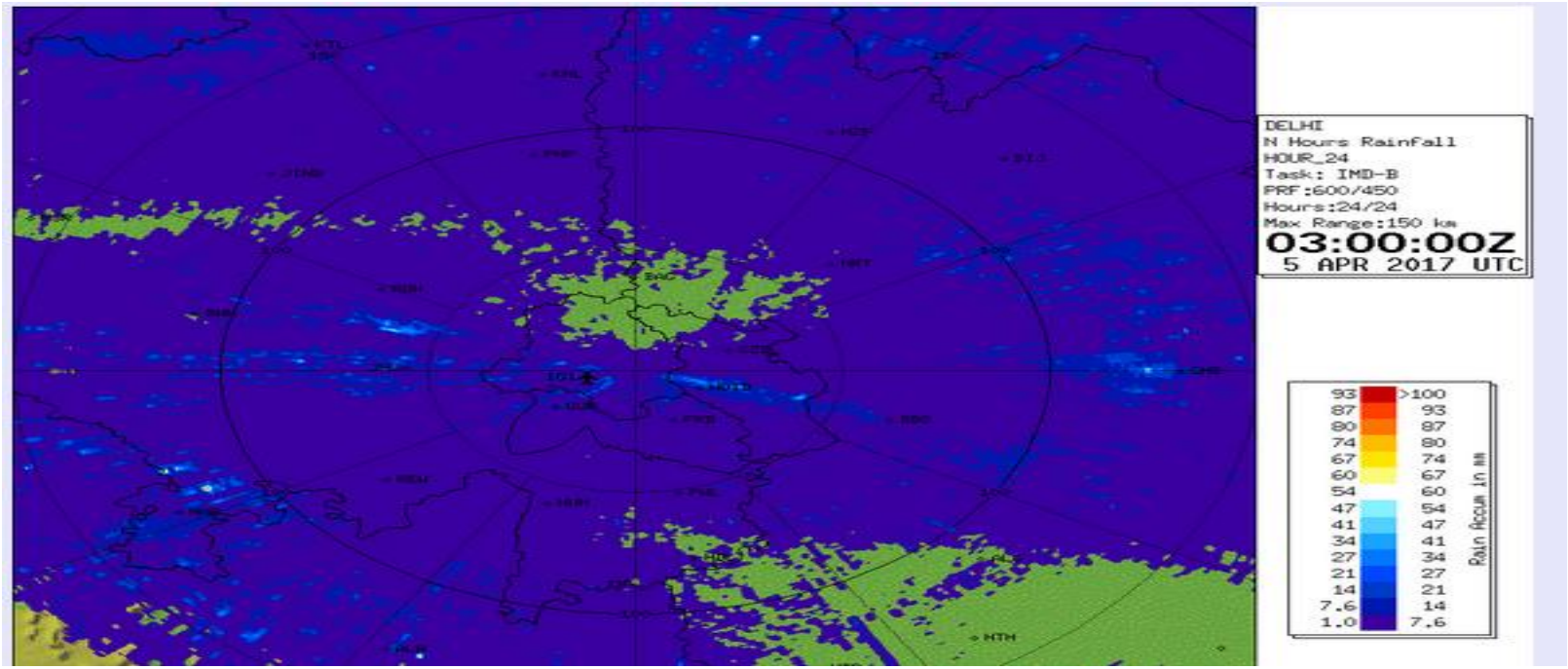
Surface Rainfall Intensity (mm/H)

- The SRI generates an image of the Rainfall Intensity in a user selectable surface layer with constant height above ground

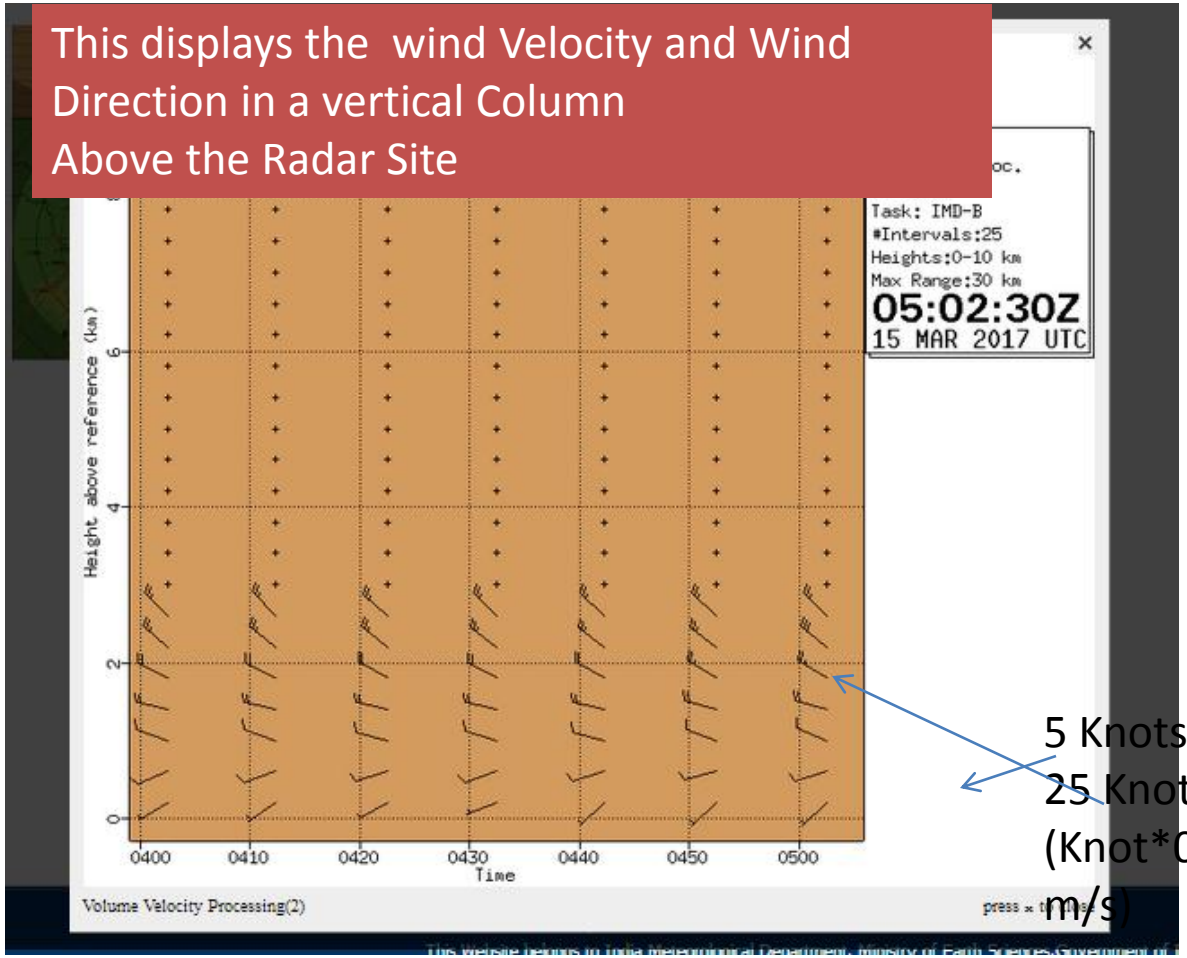


Precipitation Accumulation (mm)

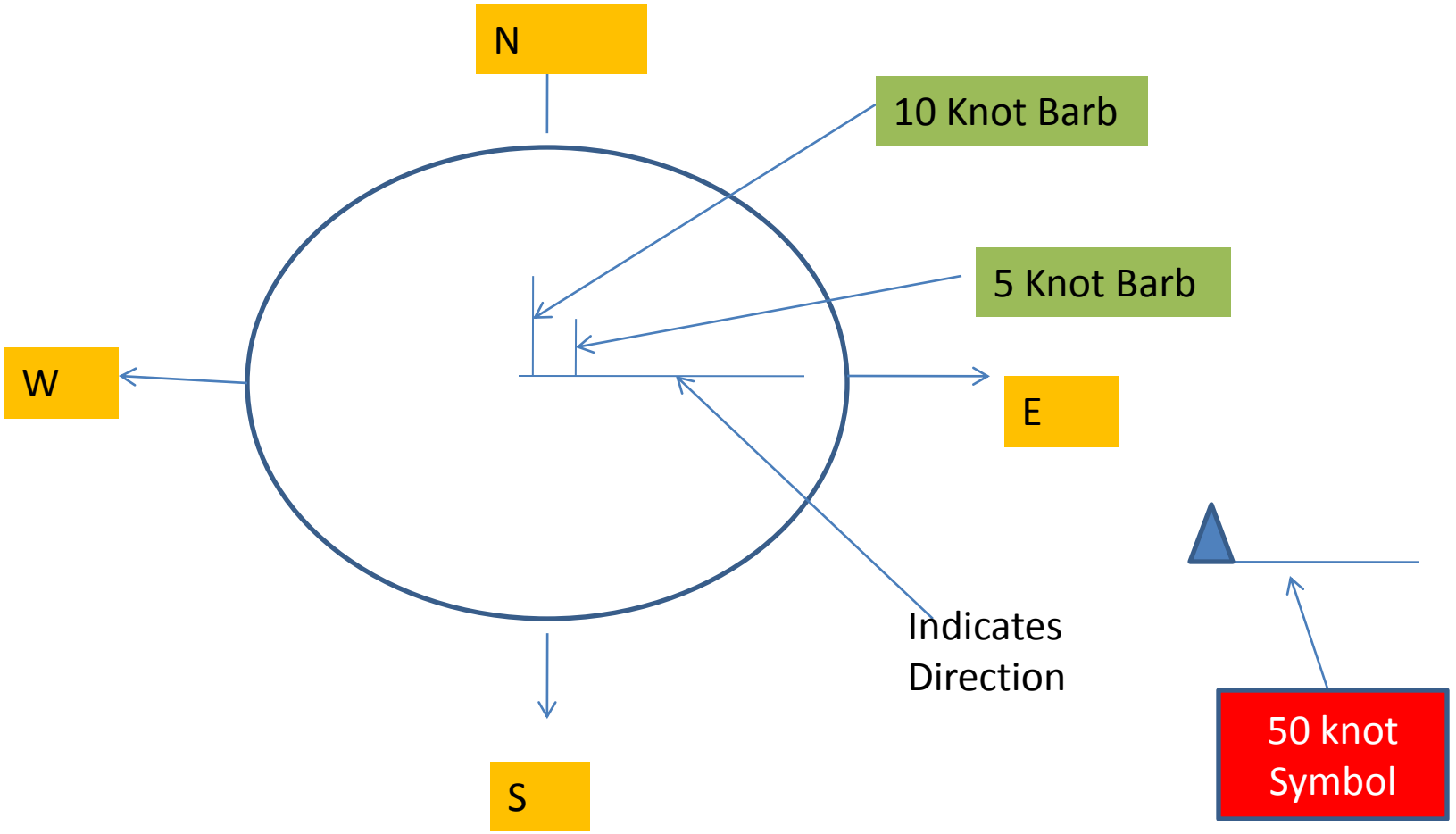
The PAC product is a second level product . It takes SRI products and Accumulates the Rainfall at a User definable Time Period
(It is 24 hours in our Case)



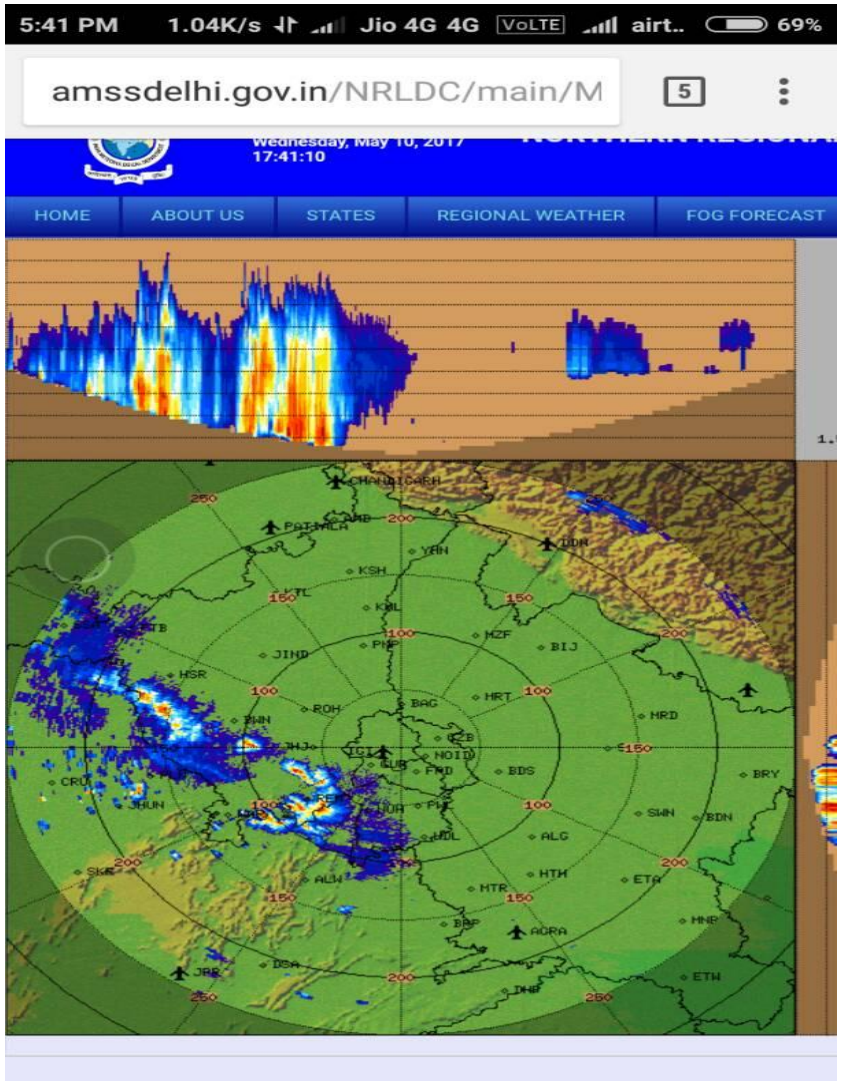
Volume Velocity Processing



Wind Direction and Speed of the Wind

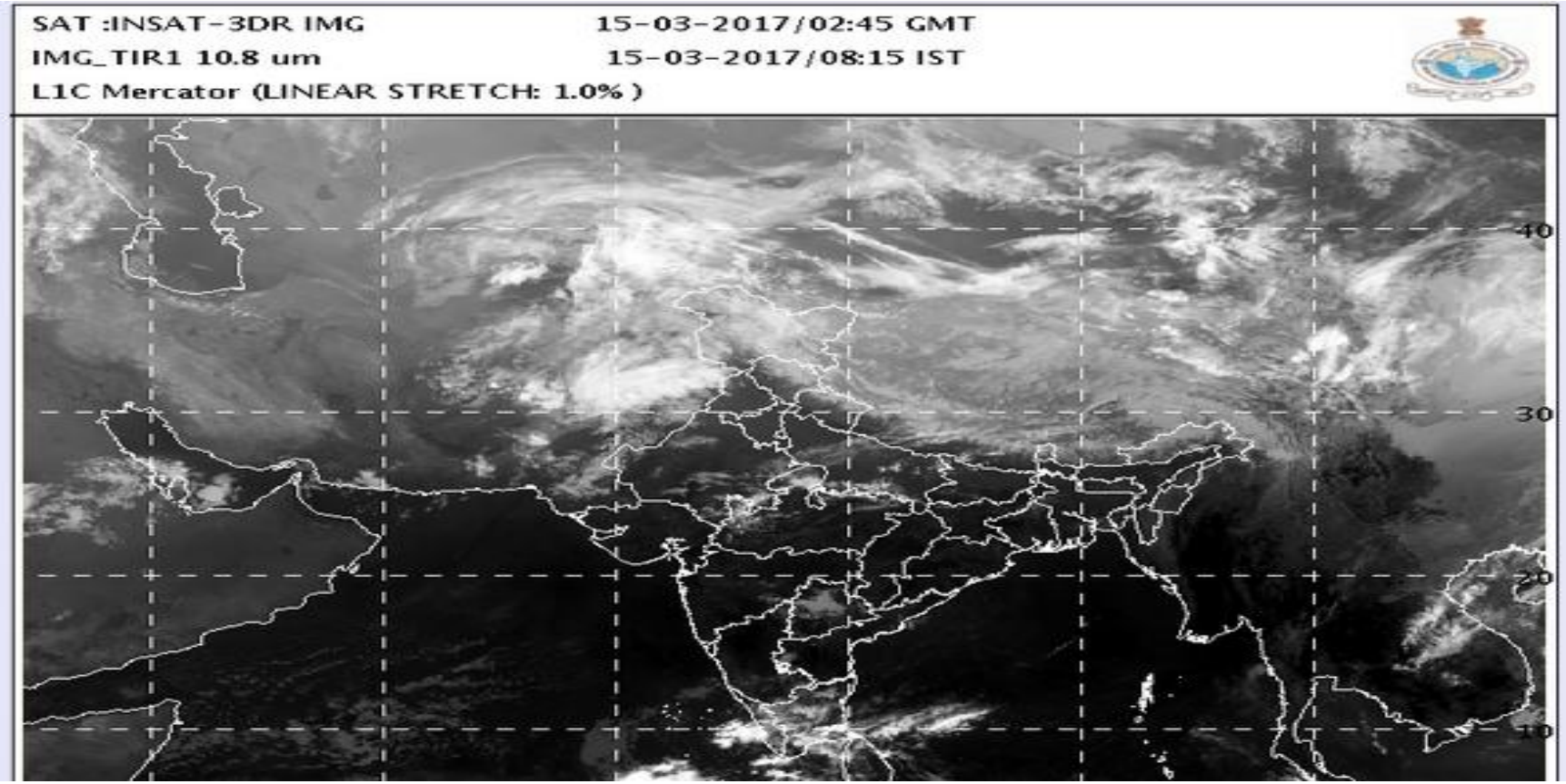


Radar Image



- It can be used for
  - Indentifying distance and height of Clouds (Kms)
  - Movement of clouds /Thunderstorm/Rains
  - Location of Rainfall and its intensity in mm/h
    - {Assessment of the impact and advance control measures required to maintain the Grid Security}
  - Total Rainfall in mm in the last 24 hours (mm)
    - Assessment of demand in next 24 hours
  - Wind speed and direction at the Location of Radar (knots)
    - load reduction due to factors, like, switching off of distribution lines to prevent collateral damage/distribution network outage

Satellite Image



Satellite makes measurement indirectly by sensing electromagnetic radiations coming from the surface below

INSAT 3D is being used to monitor the Weather . Image is updated every 30 minutes

Useful in tracking Cloud vector ,Cyclones etc.

Fog Forecast for Northern Region:
(Issued by RMC Delhi in Winters)

FOG FORECAST OF DELHI REGION

HOME

DATE : 14/02/2017 TIME OF ISSUE 14/0600 UTC 14/1130 IST

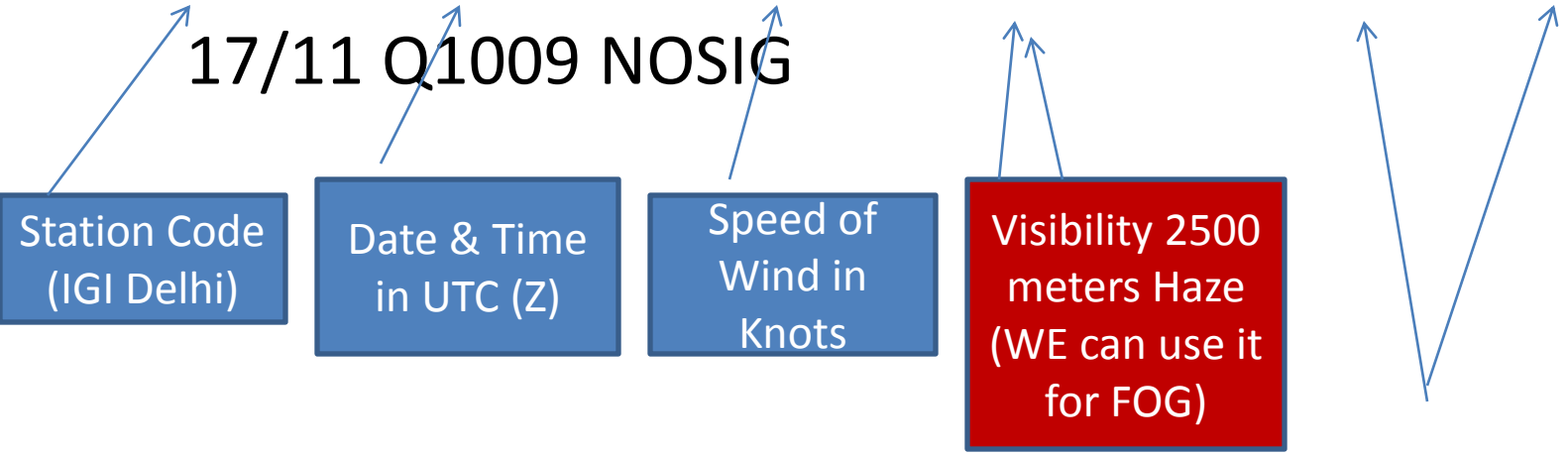
VALIDITY	VALID FROM DATE/TIME VALID UPTO DATE/TIME	FROM DATE/TIME TO
STATION	**FORECAST**	**OUTLOOK FOR NEXT SUBSEQUENT 12 HOURS**
(VIDP) I.G.I. AIRPORT, DELHI	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.
(VILK) LUCKNOW AIRPORT	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.
(VIJP) JAIPUR AIRPORT	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.
(VIAR) AMRITSAR AIRPORT	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.
(VEBN) BABATPUR AIRPORT	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.	FOG FORECAST IS TERMINATED W.E.F 14-02-2017 AND IT IS UPDATED WHEN REQUIRED.

METAR

- **METAR** is a format for reporting weather information.
  - A METAR weather report is predominantly used by pilots in fulfillment of a part of a pre-flight weather briefing, and by meteorologists, who use aggregated METAR information to assist in weather forecasting.
- METAR is the scheduled observation taken at the end of each hour.
- A typical METAR contains data for the temperature, dew point, wind direction and speed, precipitation, cloud cover and heights, visibility, and barometric pressure.
- A METAR may also contain information on precipitation amounts, lightning, and other information that would be of interest to pilots or meteorologists

Sample Metar Code

- VIDP 091730Z 09006KT **2500 HZ** FEW030 SCT100 17/11 Q1009 NOSIG



FEW030 SCT100- SKY Condition
FEW cloud at height of 3000 mtr and Scattered cloud at height of 10000mtr

17/11 – Air Temperature is 17Degree and Dewpoint Temp

Q1009- Pressure in hpa

NOSIG means that no significant change is expected to the reported conditions within the next 2 hours

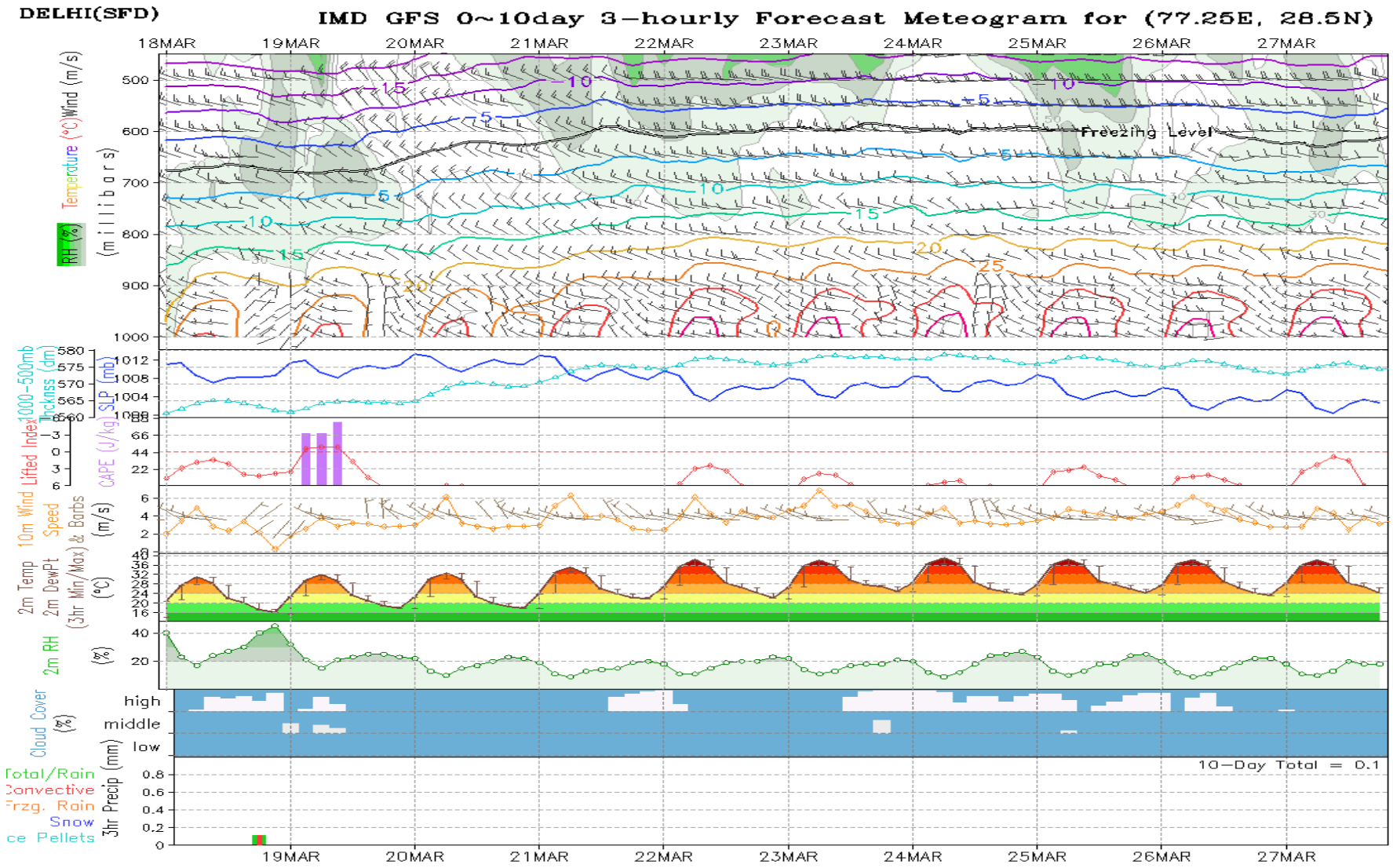
Case-I (BSES)

- BSES Rajdhani Power Limited (BRPL) has started using the products / features available on the website on regular basis.
- Weather information for Delhi's different location relevant to its license area viz. Mehrauli, Maharani Bagh, Badarpur, Najafgarh etc., Meteogram, Nowcast, Forecast and Warning.
- Radar products viz. MAX Z, Surface Rain Indicator, PPI, PPZ etc

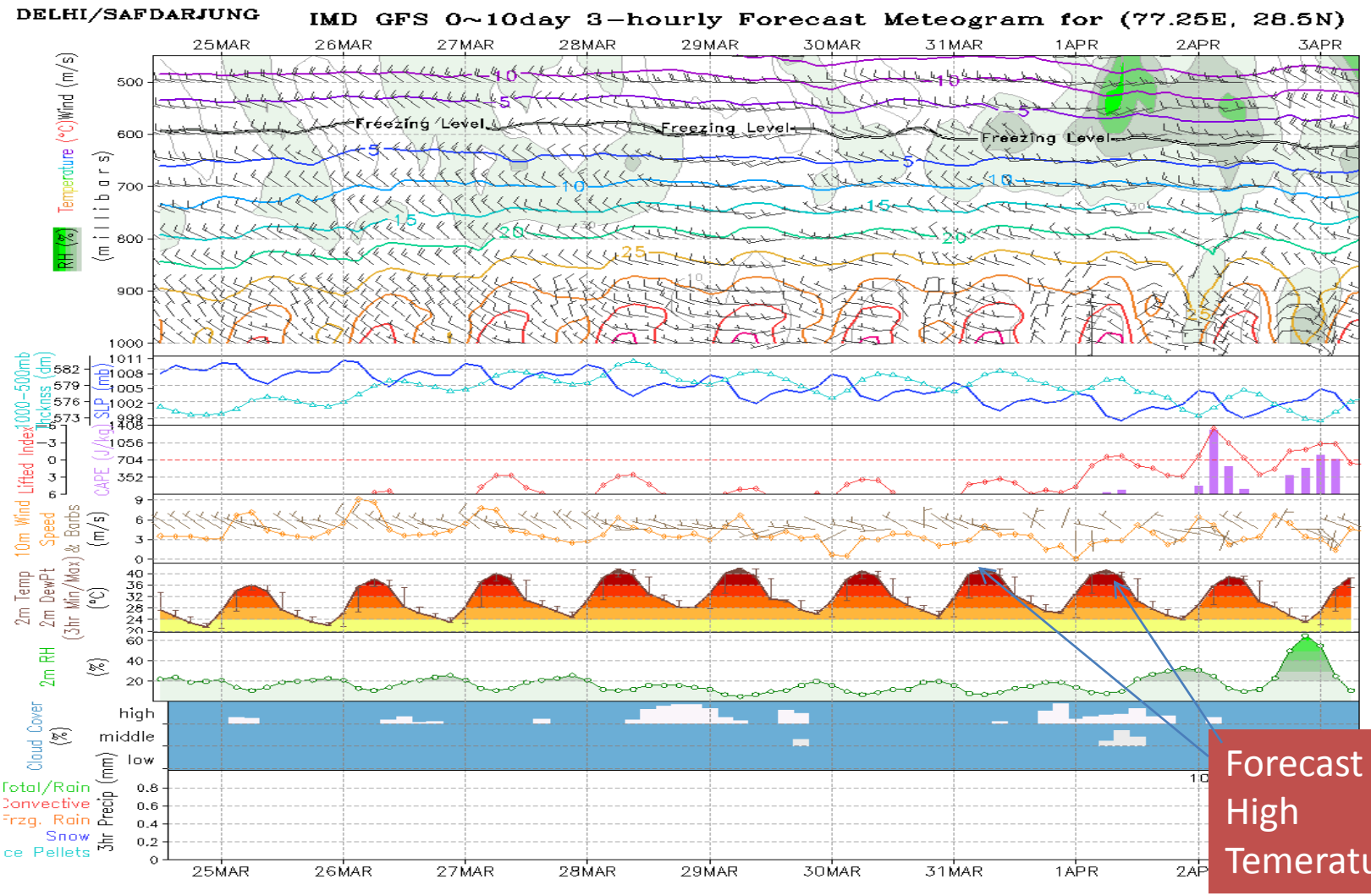
Case-I (BSES)

- The last week of March 2017 was predicted to be very hot and dry, which prompted units of Dadri TPS to be brought on bar to meet rising demand, in time.
- BRPL sent a note to Delhi SLDC along with the Meteogram predicting severe temperatures during last week of March 2017

Meteogram of Safadarganj : 19th March 2017

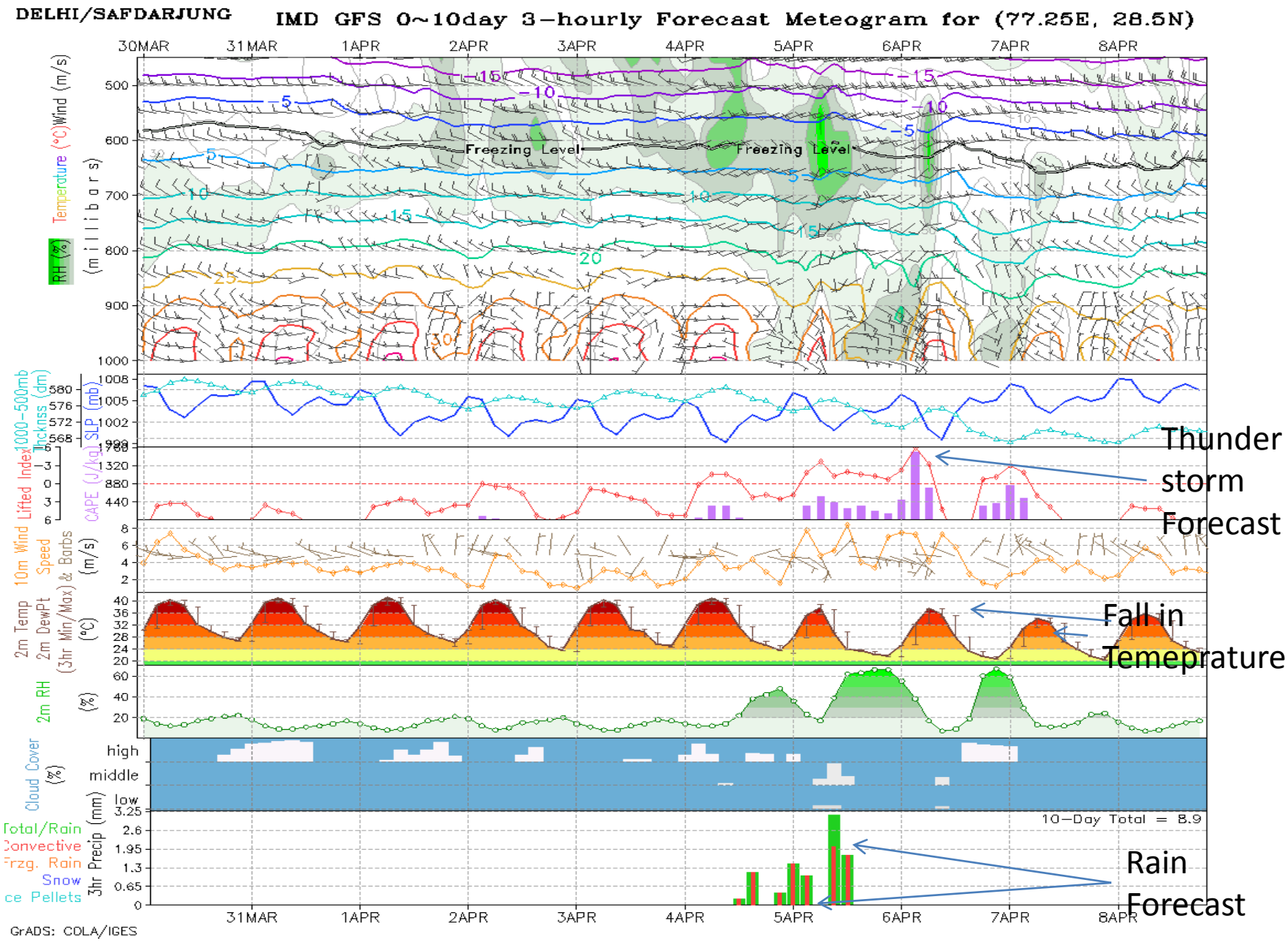


Meteogram of Safadarganj : 25th March 2017

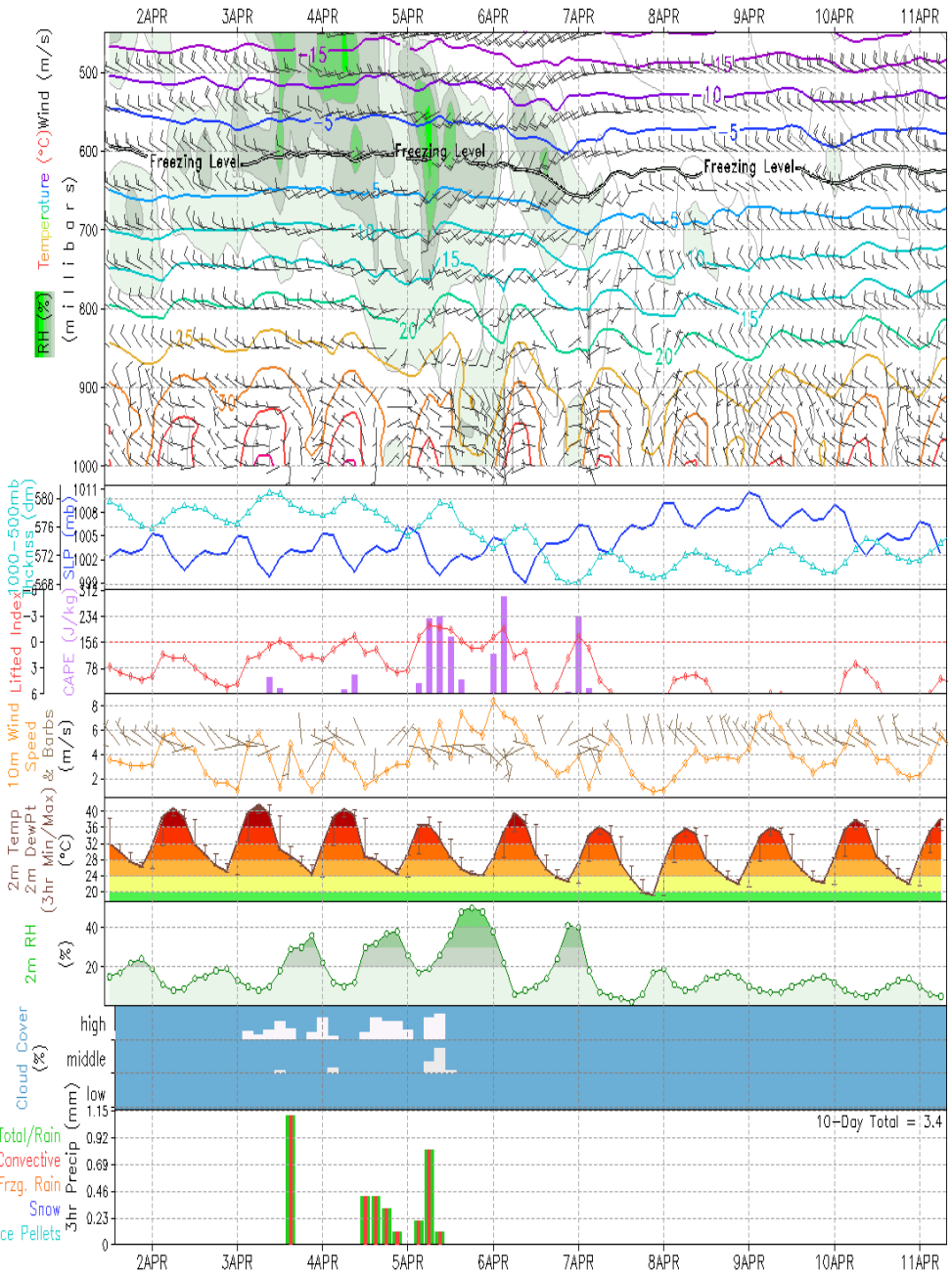


Case-I (BSES)

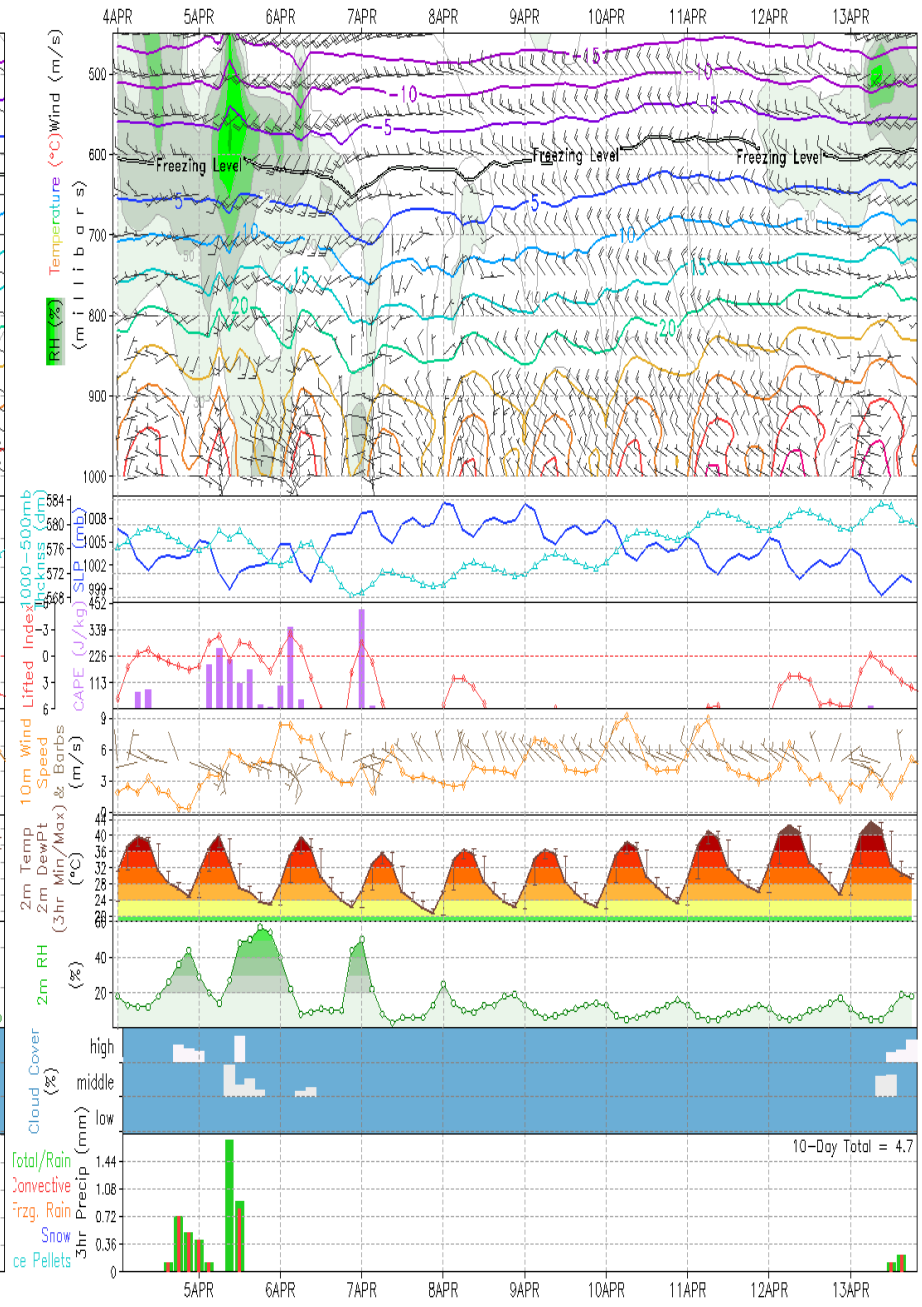
- The prediction of rainfall as well as fall in temperatures from ~ 40^{o}C after 4th Apr 2017 helped in concluding a fall in demand and therefore defer decision to switch on (bring to bar) another unit of Dadri TPS, which, would otherwise, have been brought to bar.
- The prediction of rainfall became stronger with each passing day


DELHI/SAFDARJUNG
IMD GFS 0~10day 3-hourly Forecast Meteogram for (77.25E, 28.5N)
30MAR
31MAR
1APR
2APR
3APR
4APR
5APR
6APR
7APR
8APR
Temperature (°C)Wind (m/s)
RH (%)
(millibars)
Freezing Level
Freezing Level
1000-500mb Thickness (dm)
SLP (mb)
Lifted Index
CAPE (J/kg)
10m Wind Speed & Barbs (m/s)
2m Temp
2m DewPt
(3hr Min/Max) (°C)
2m RH (%)
Cloud Cover (%)
high
middle
low
Total/Rain
Convective
Frzg. Rain
Snow
Ice Pellets
3hr Precip (mm)
10-Day Total = 8.9
GrADS: COLA/IGES
Thunder storm Forecast
Fall in Temeprature
Rain Forecast

DELHI/SAFDARJUNG IMD GFS 0~10day 3-hourly Forecast Meteogram for (77.25E, 28.5N)



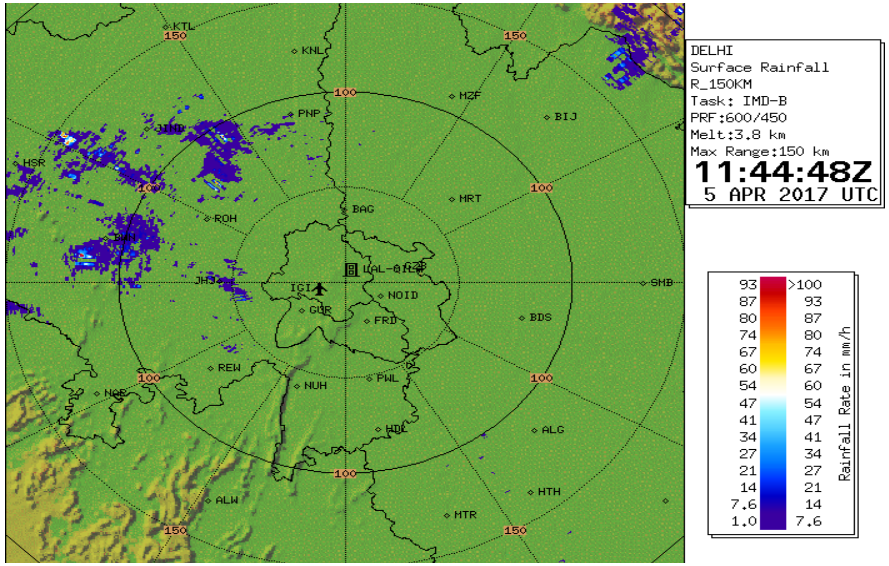
DELHI/SAFDARJUNG IMD GFS 0~10day 3-hourly Forecast Meteogram for (77.25E, 28.5N)

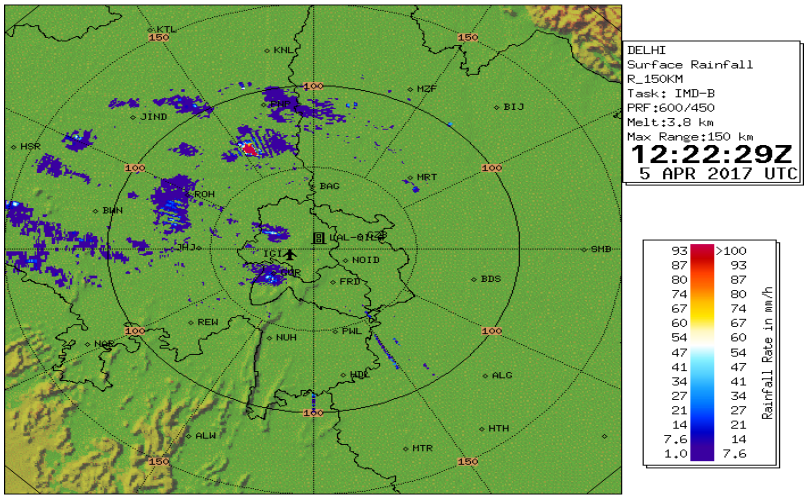


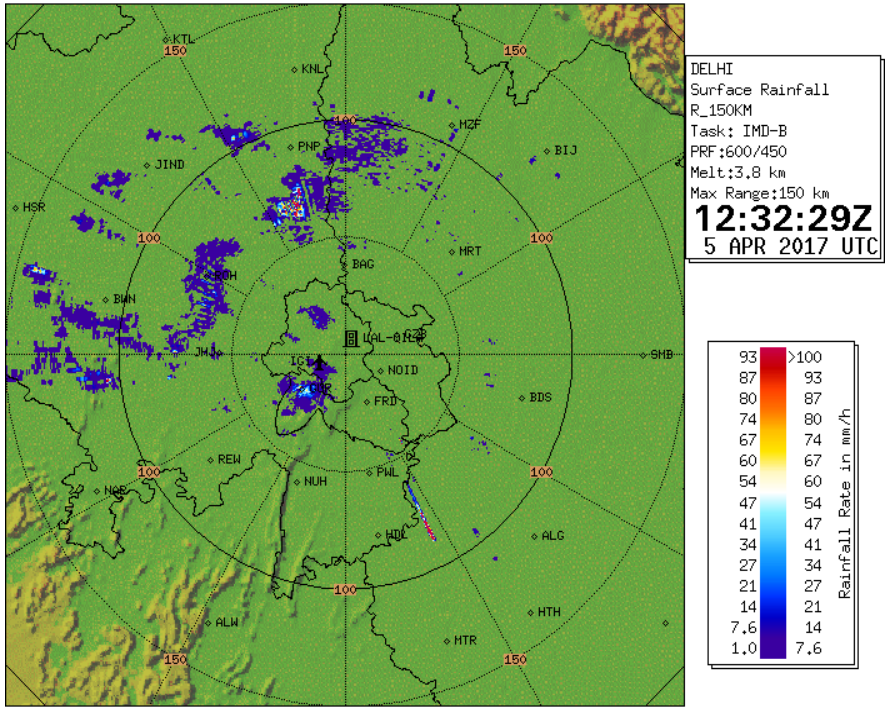
Real Time tracking through radar Images

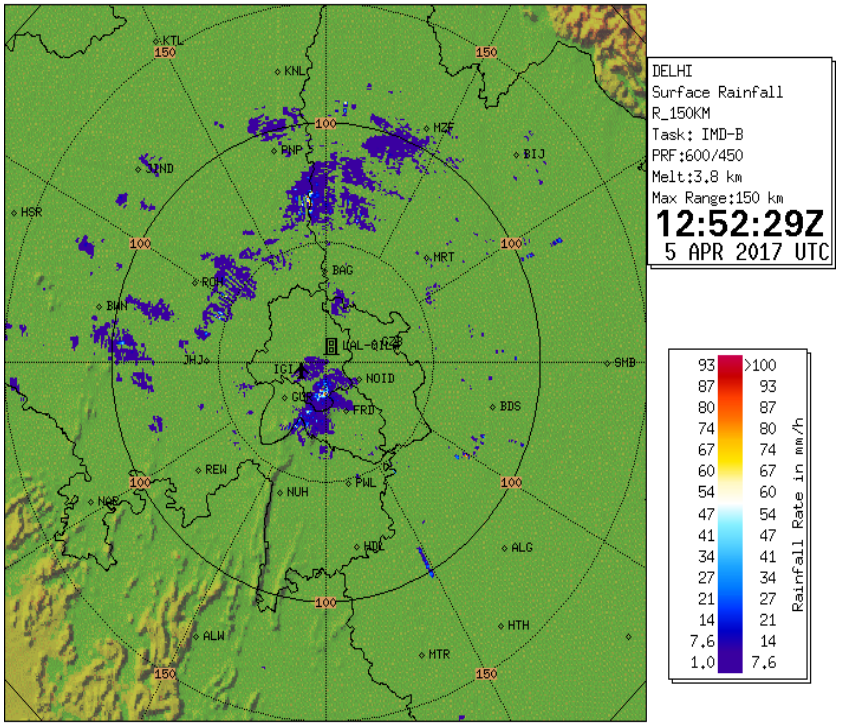
- ***Continuous tracking of rainfall movement on 4th and 5th April 2017 helped in predicting correct time and severity extent (about 60 MW),which led to lowering of Underdrawl in real time on the evening of 5th April 2017 starting around 18:00 hours. Rainfall accompanied with Thunderstorms hit Delhi around 17:00 hours that evening***.
- Earlier, rainfall / thunderstorms hit Delhi around 23:00 hours on 4th April 2017, for which clear prediction was available much earlier (> 3 hours ahead; As per IEGC, 6 fifteen minutes timeslots are needed for revision in schedule).
- Tracking of Radar image (updated every 10 mins) helped predicting more accurate timing of thunderstorm hitting West and South Delhi on 4th April night and again on 5th April evening

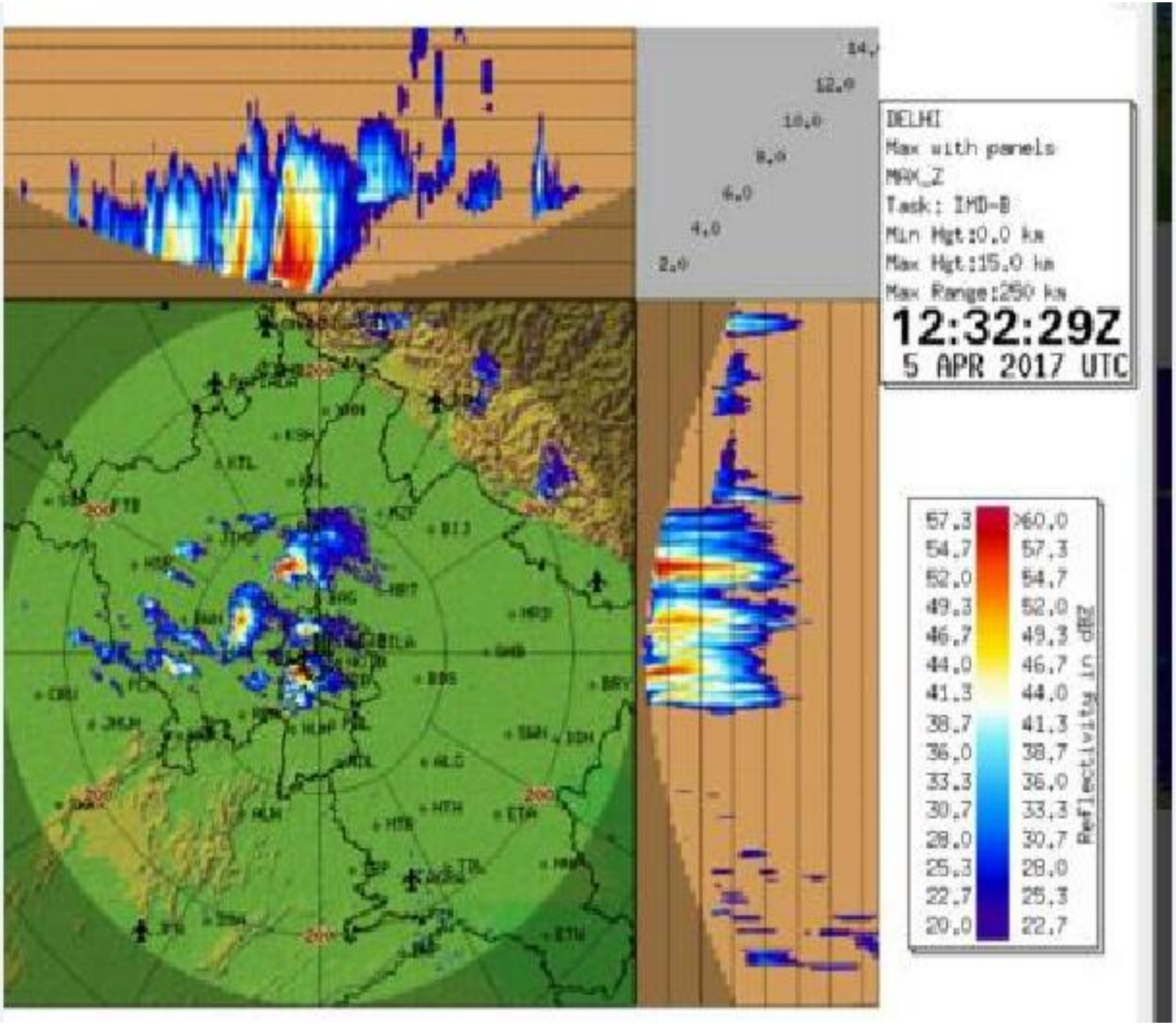
Tracking of Rainfall Movement on 5th April 2017










14.0
12.0
10.0
8.0
6.0
4.0
2.0
DELHI
Max with panels
MAX_Z
Task: IMD-B
Min Hgt:0.0 km
Max Hgt:15.0 km
Max Range:250 km
12:32:29Z
5 APR 2017 UTC
57.3 >60.0
54.7 57.3
52.0 54.7
49.3 52.0
46.7 49.3
44.0 46.7
41.3 44.0
38.7 41.3
36.0 38.7
33.3 36.0
30.7 33.3
28.0 30.7
25.3 28.0
22.7 25.3
20.0 22.7
dBZ
Reflectivity

Way Forward for Summer/Monsoon 2017

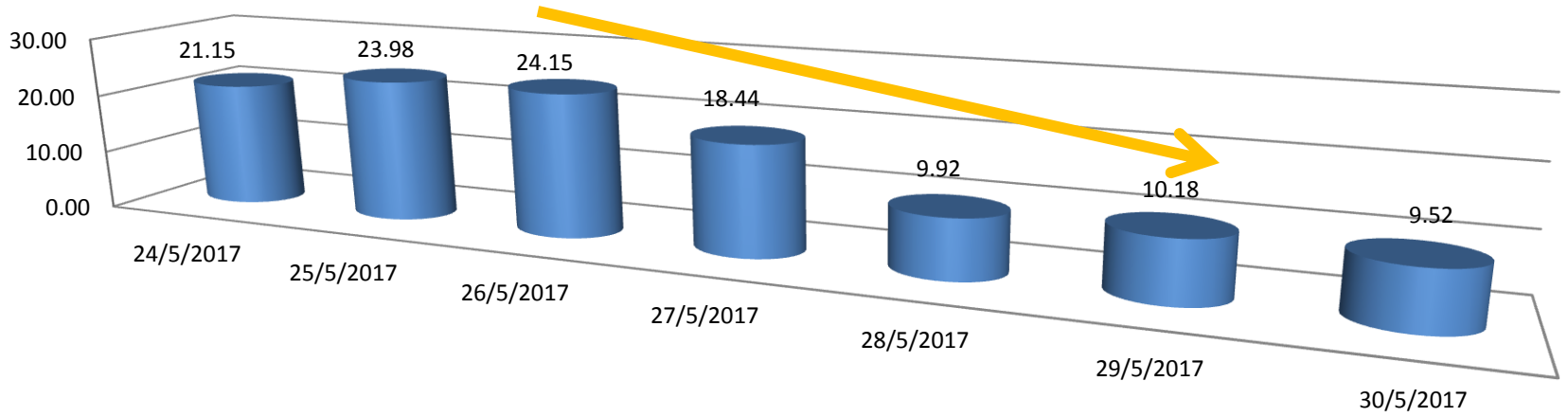
- Tracking of real time Thunderstorm / Rainfall movement shall help plan in advance to back down the generation in at least 1.5 hours in advance, to limit underdrawl.
- *The load fall gradients shall be different for different ambient weather conditions in May, June, July and August and thus, the historical load fall due to similar weather conditions as experienced during last summer, shall guide the percentage in coming months.*

Benefit achieved by Uttar Pradesh

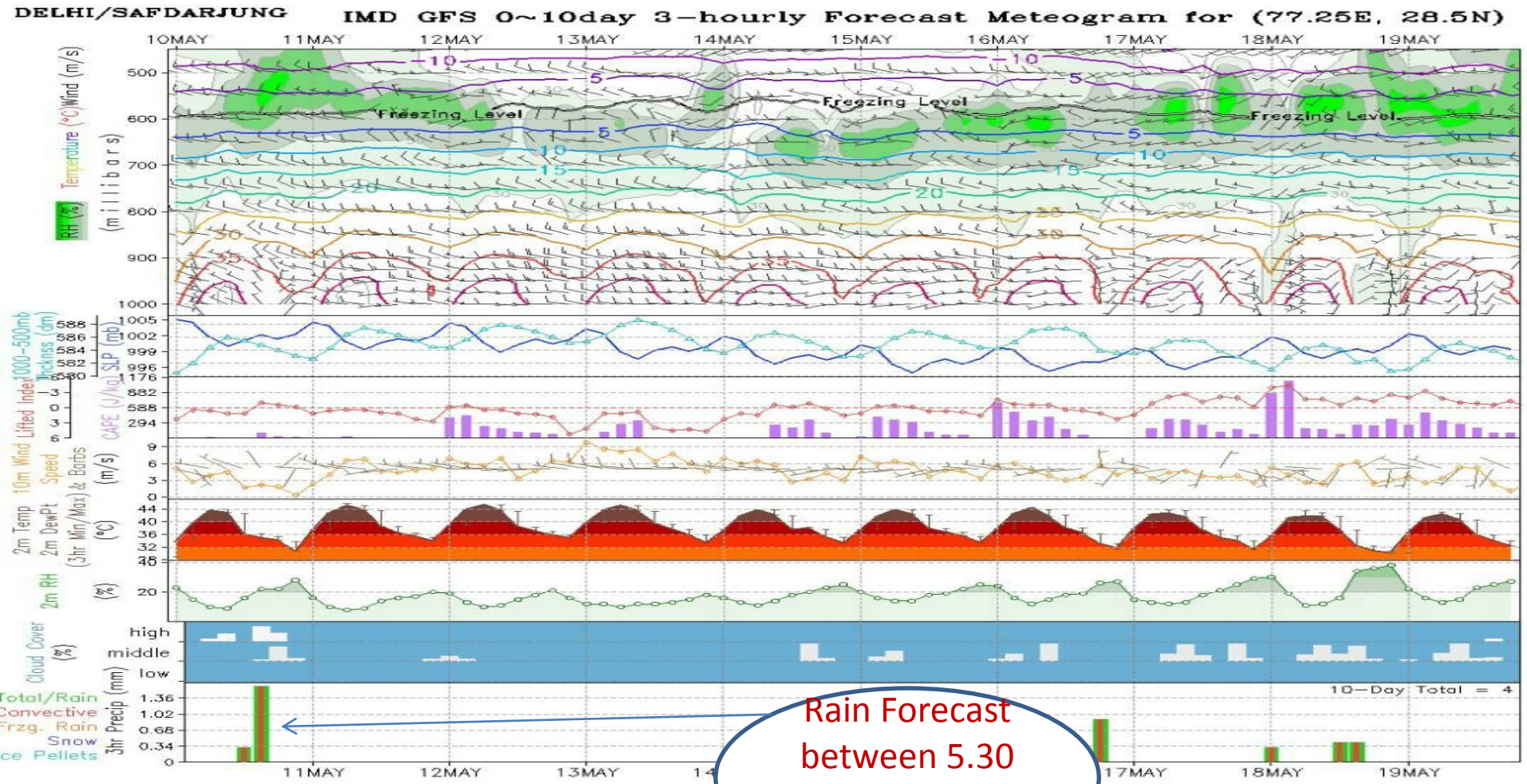
Case-2

- 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 .

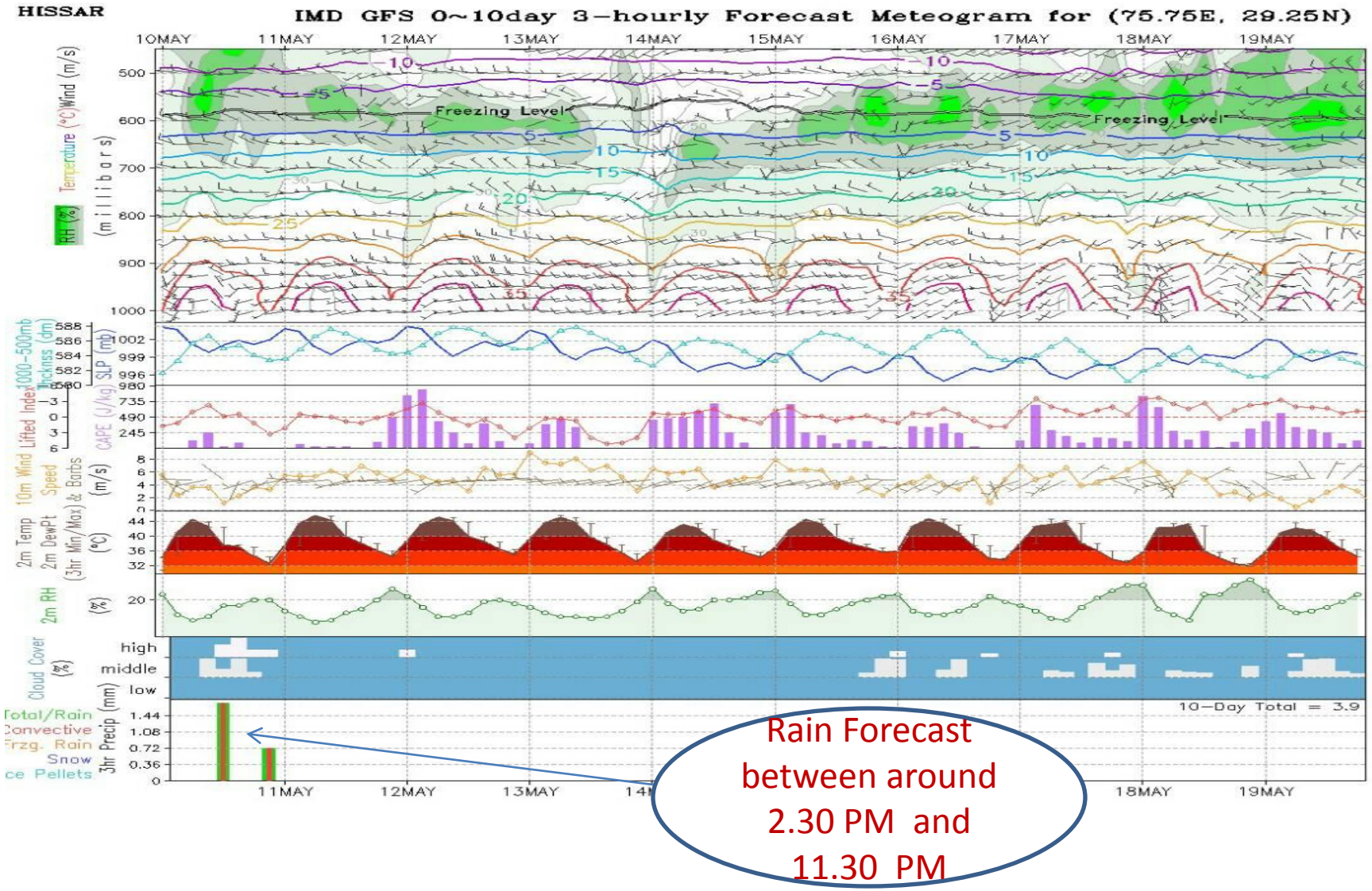
Total Power Exchange & Bilateral



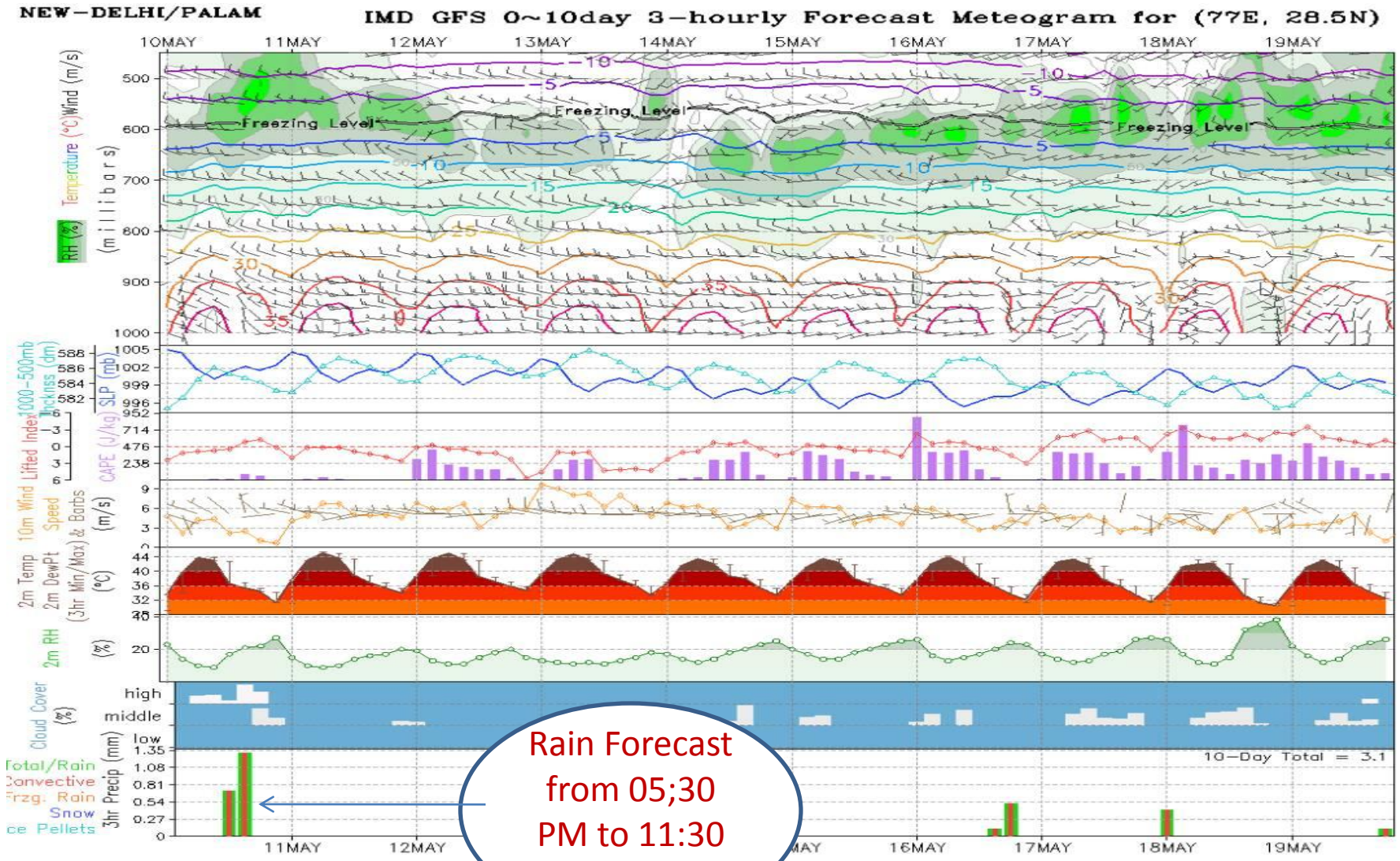
Weather Forecast for Safdarjung -10th May 2017



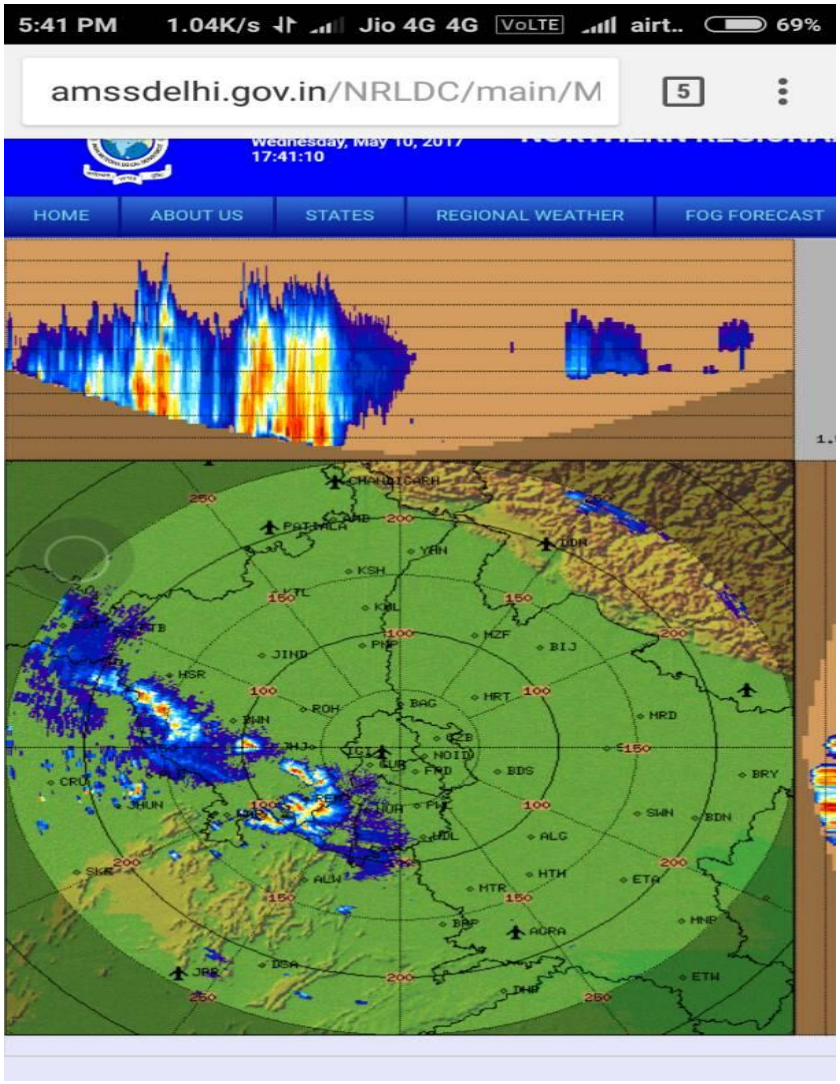
Weather Forecast for Hissar -10th May 2017

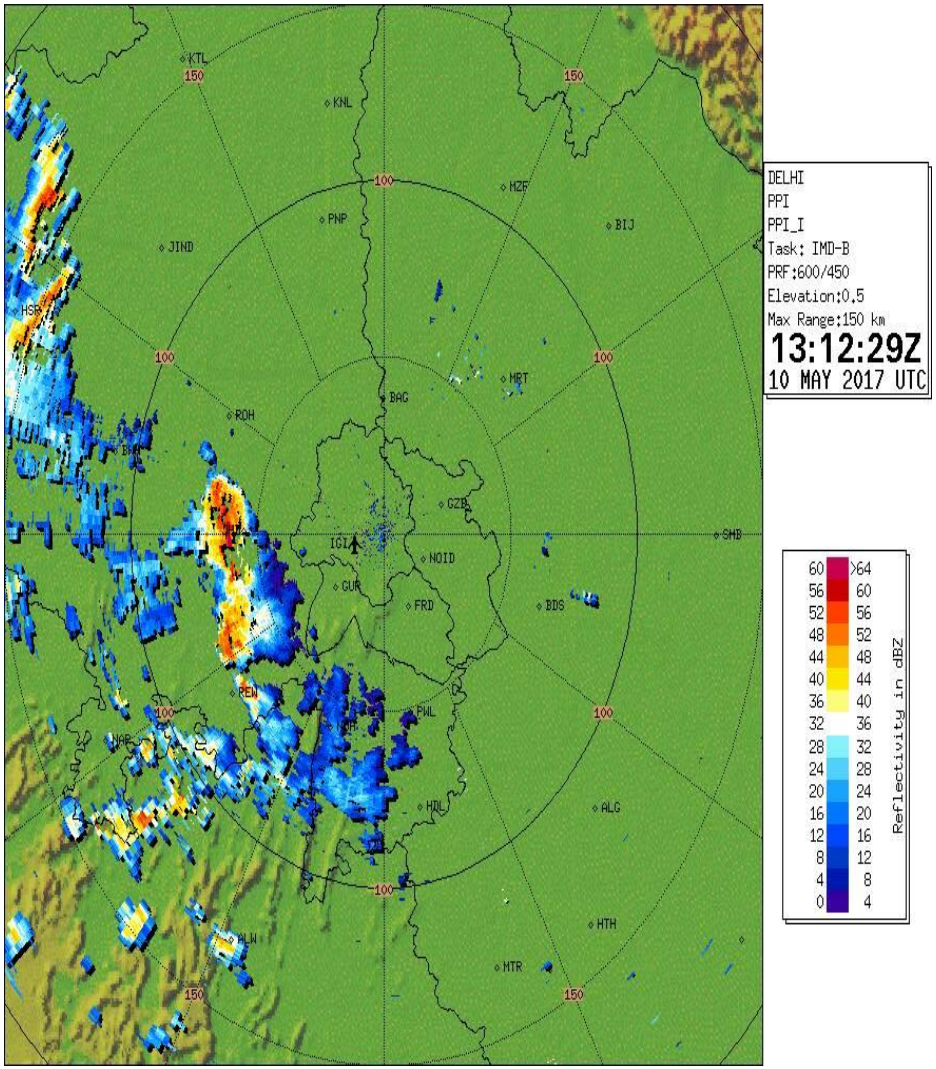


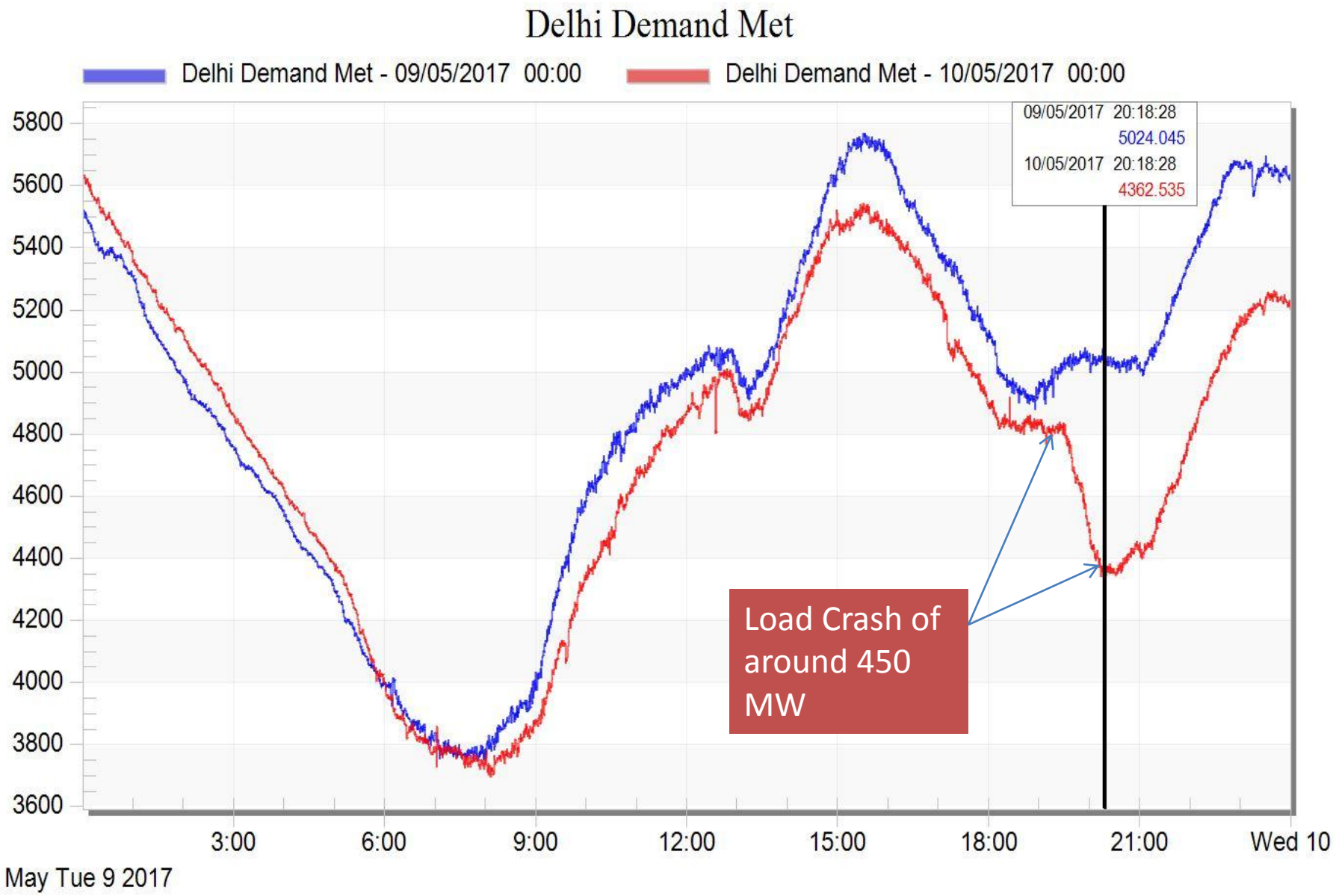
Weather Forecast for Palam



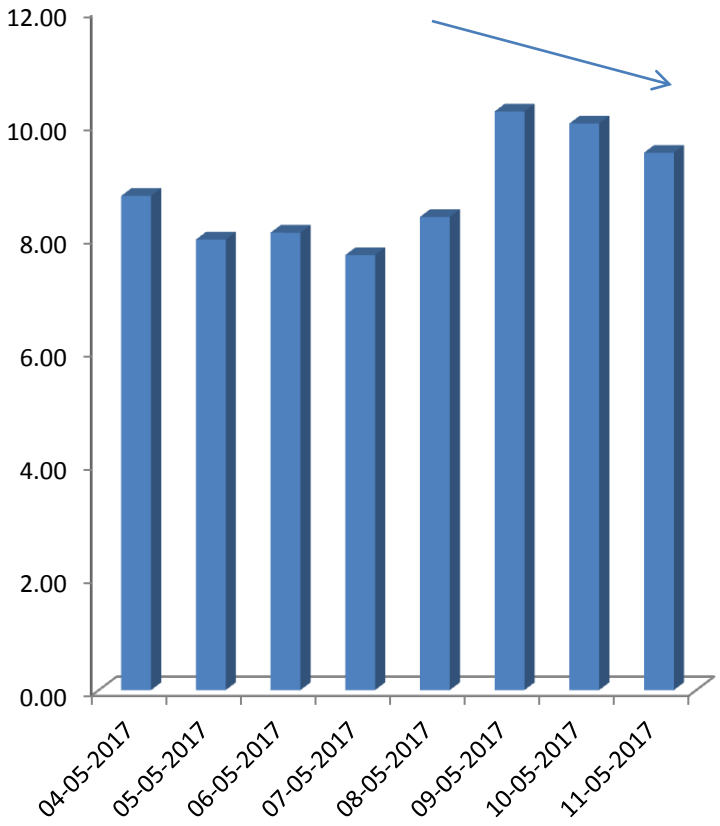
Radar Image


5:41 PM
1.04K/s
Jio 4G 4G
VoLTE
airt..
69%
amssdelhi.gov.in/NRLDC/main/M
5
Wednesday, May 10, 2017
17:41:10
HOME
ABOUT US
STATES
REGIONAL WEATHER
FOG FORECAST

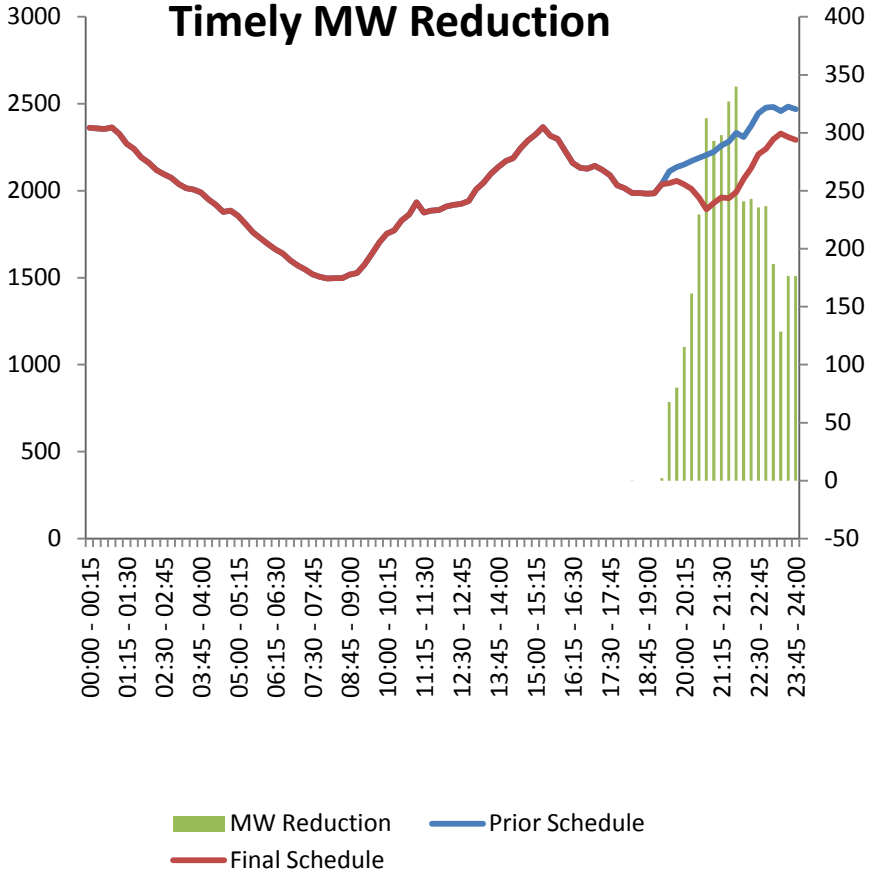

DELHI
PPI
PPI_I
Task: IMD-B
PRF:600/450
Elevation:0.5
Max Range:150 km
13:12:29Z
10 MAY 2017 UTC
Reflectivity in dBZ


Delhi Demand Met
Delhi Demand Met - 09/05/2017 00:00
Delhi Demand Met - 10/05/2017 00:00
09/05/2017 20:18:28
5024.045
10/05/2017 20:18:28
4362.535
Load Crash of around 450 MW
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
3800
3600
3:00
6:00
9:00
12:00
15:00
18:00
21:00
Wed 10
May Tue 9 2017

Total Power Exchange, IDT & Bilateral

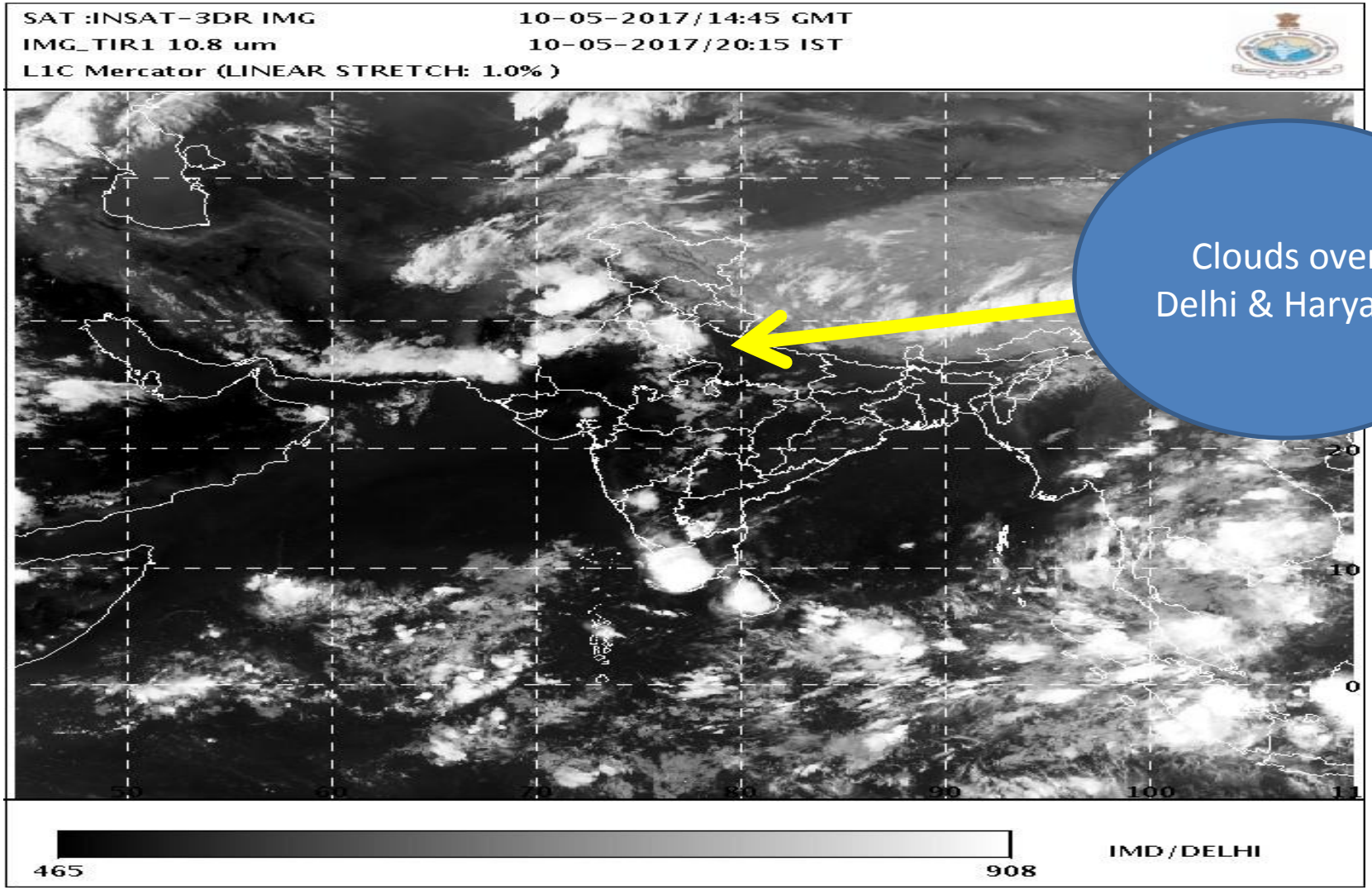


Timely MW Reduction

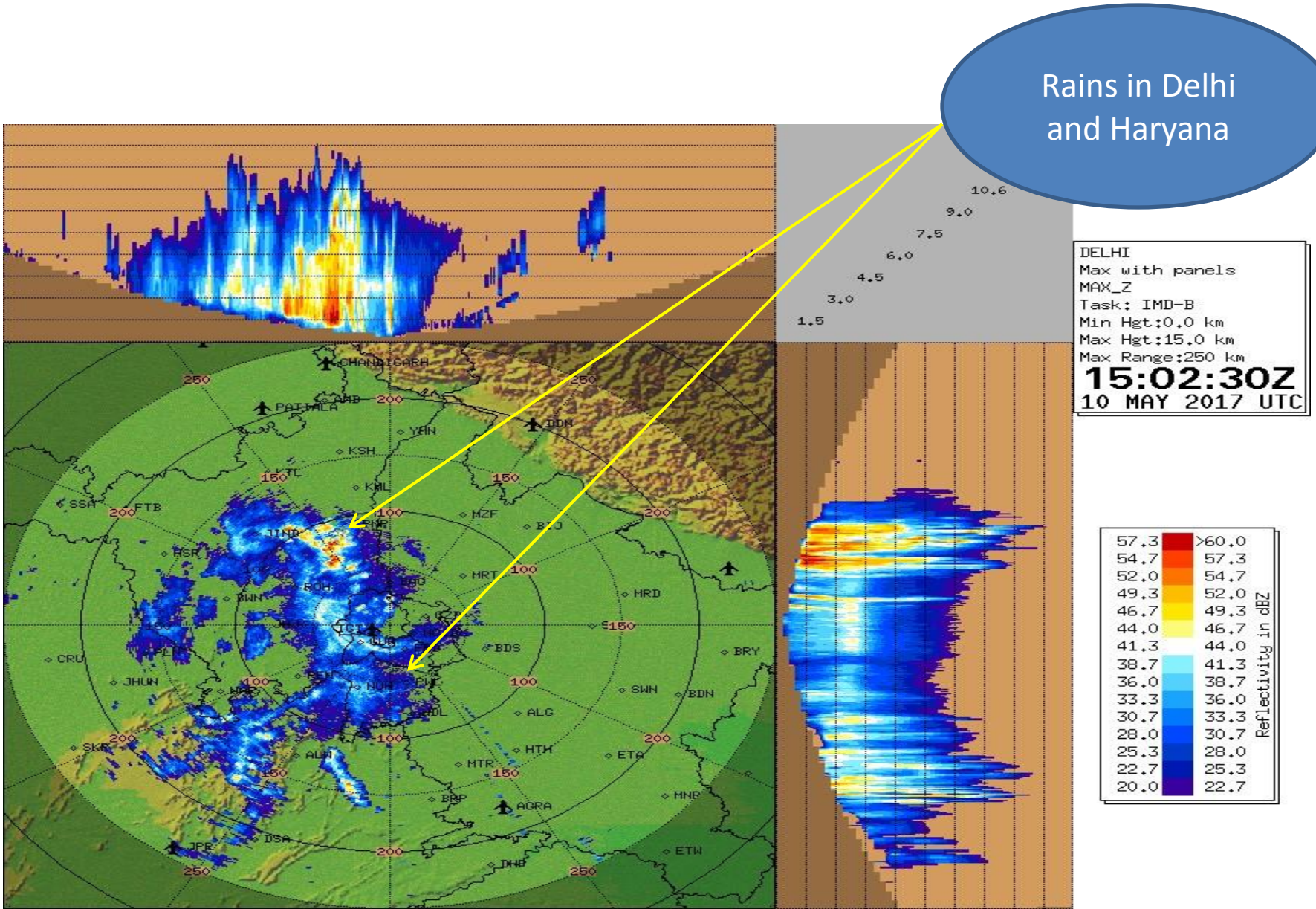


Total Mus reduced = 0.24 MUs

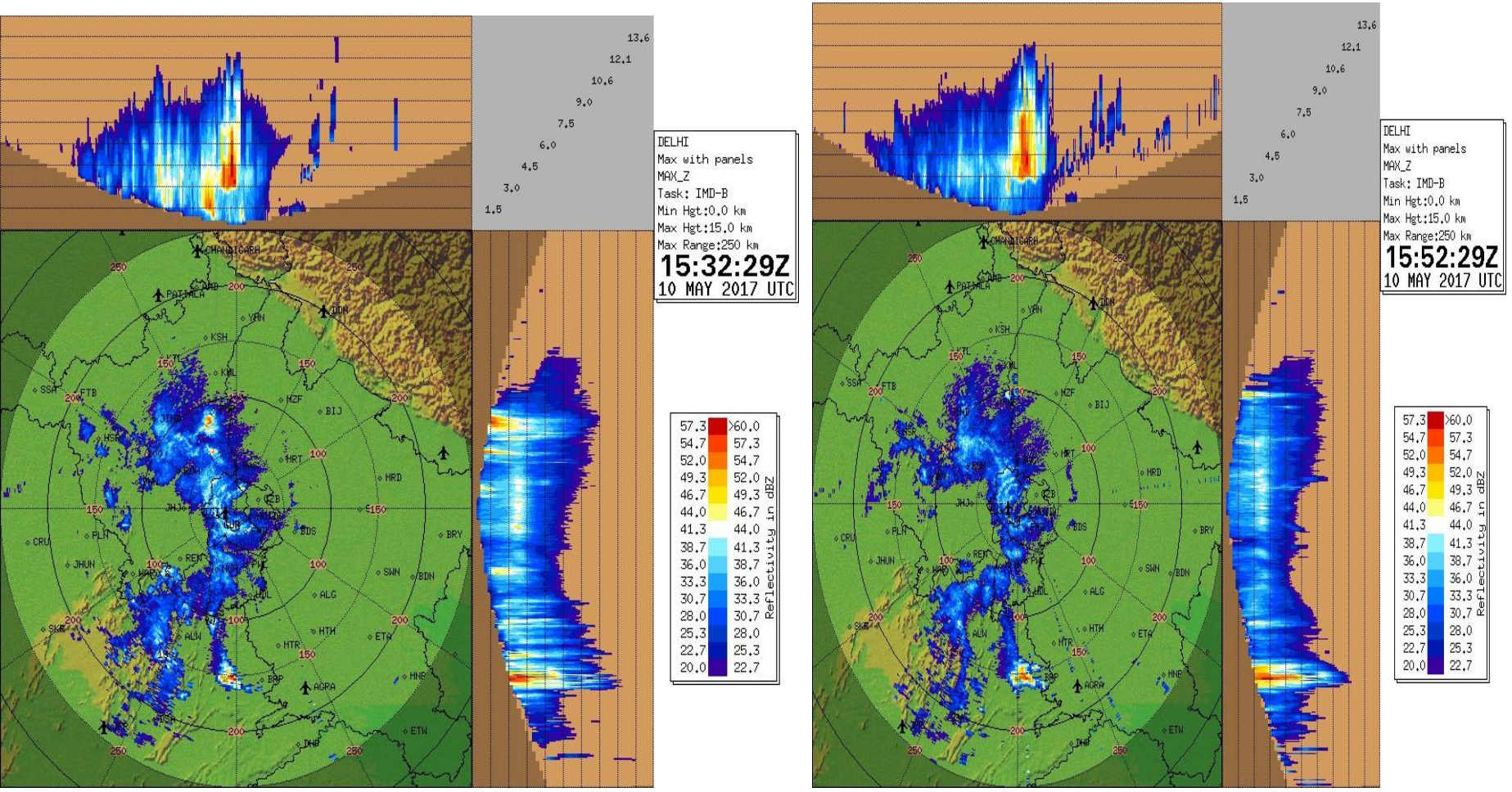
Satellite image at 20.15 Hrs



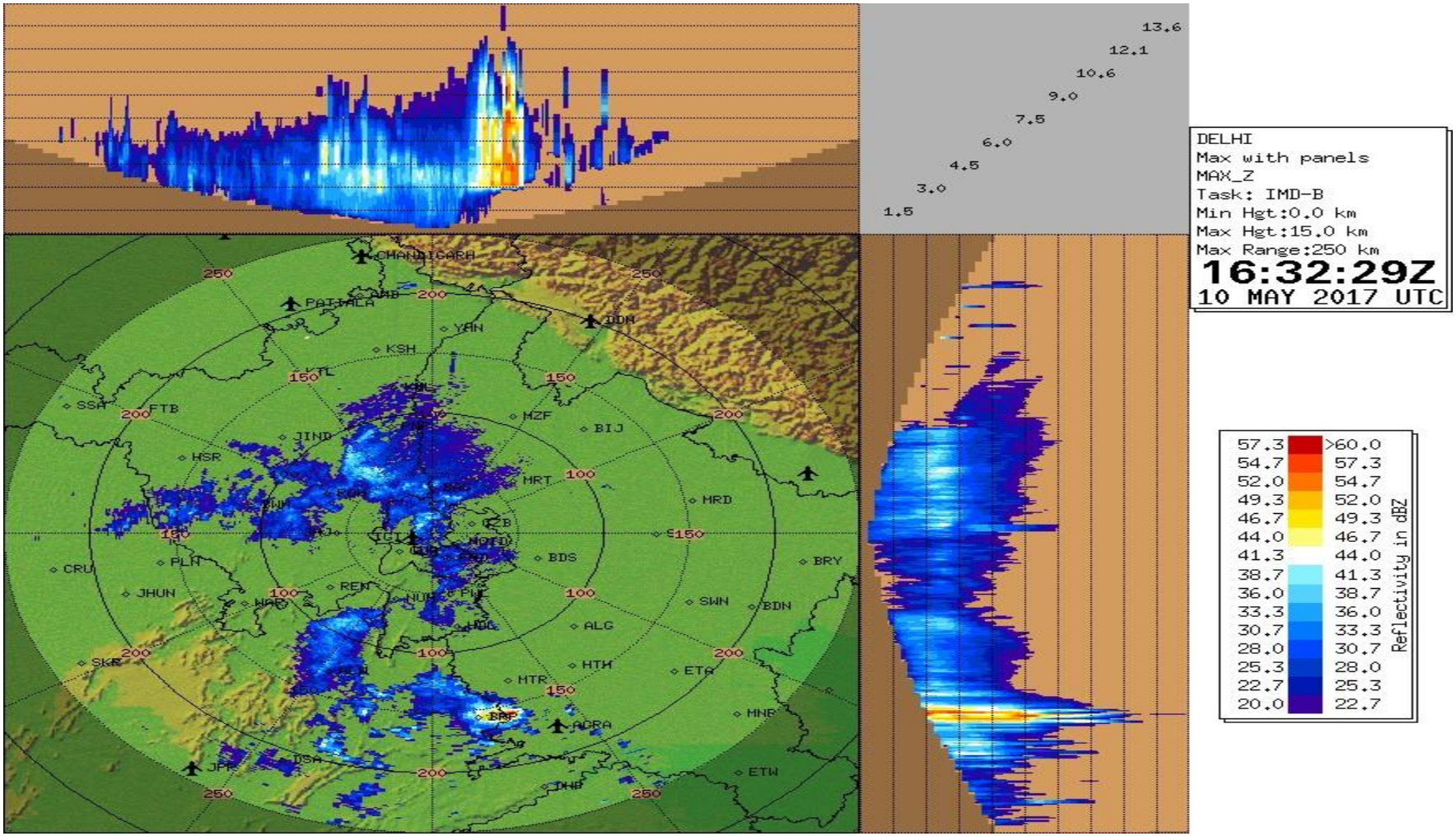
Radar image at 20:32 PM



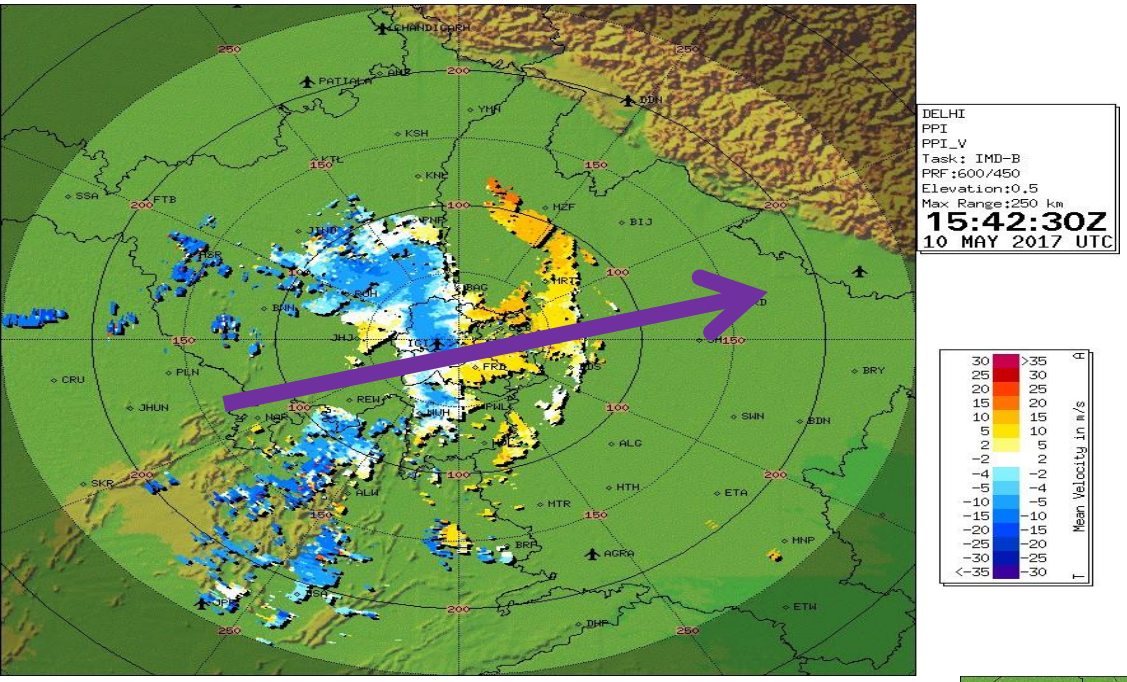
Radar Image at 21.02 PM and 21:22 PM

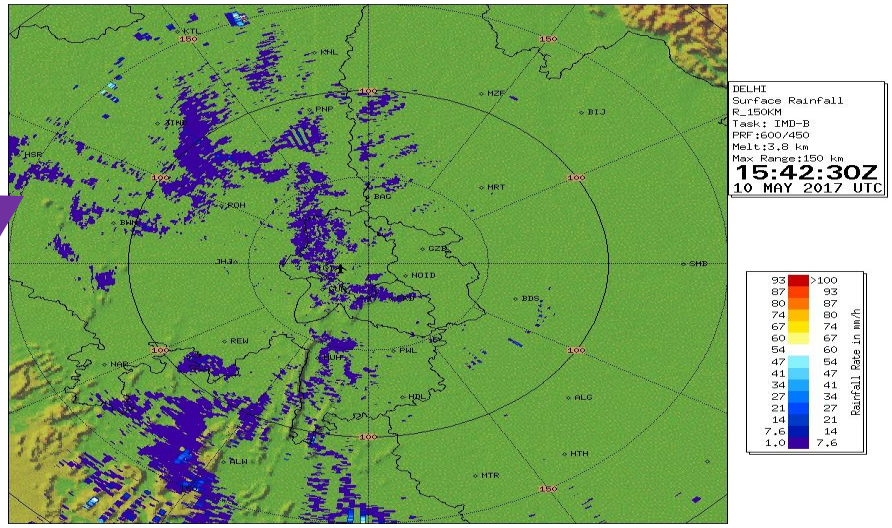


Radar Image at 22:02 Hrs



Cloud Movement





Rainfall in mm/Hr
(1.00-7.6 mm/Hr)

Way Forward

- ***Utilisation of Radar Products in Real time Grid Operation***

- Use of Mateogram/Weather data for short Term /Long Term Generation Planning/ Transmission outage Planning

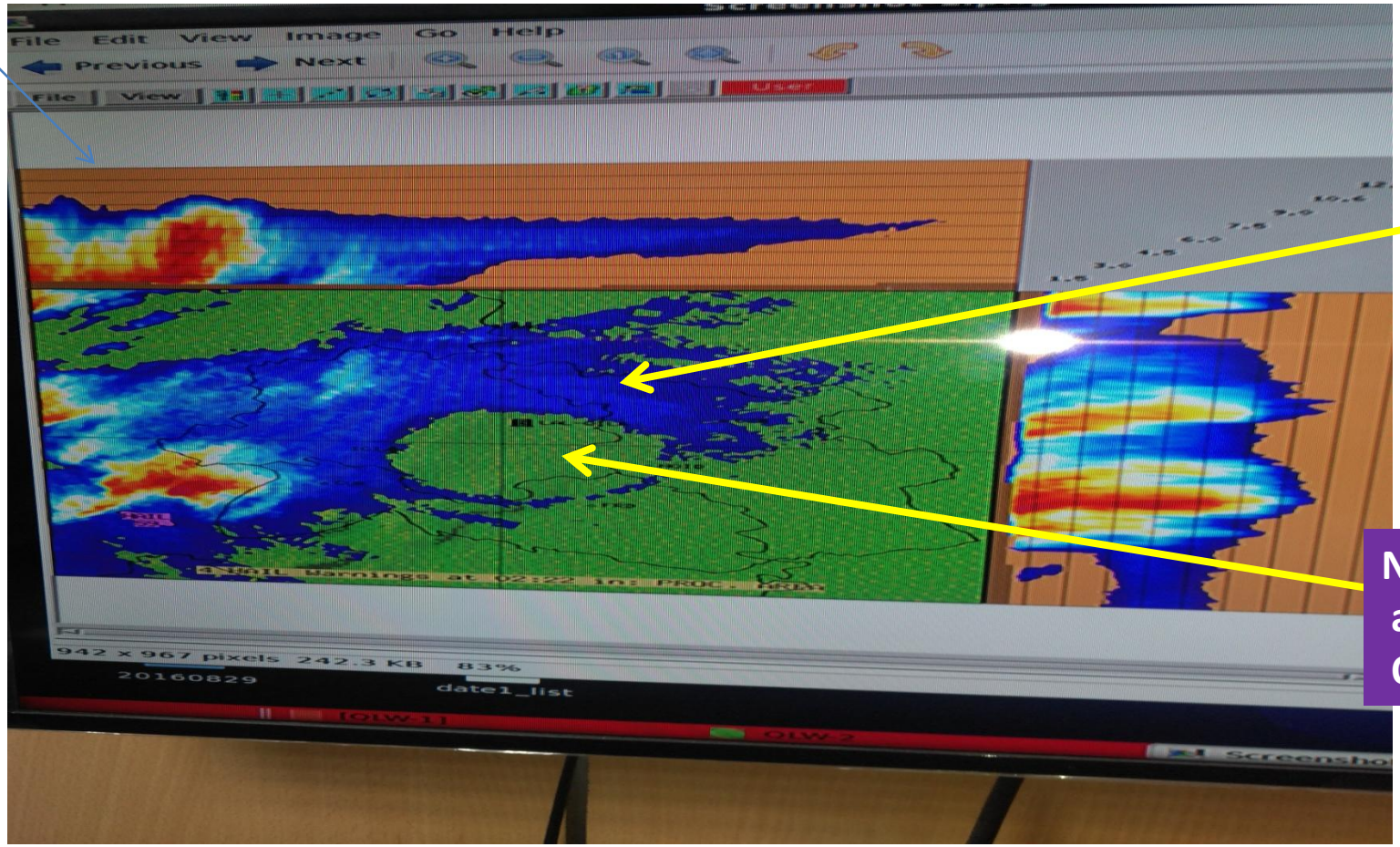
- Continual value addition based on availability of information at IMD end and the requirements for Grid Operation
  - Pop up of the Weather Warning on home page of respective region website.
  - Customization of Meteogram :
    - Reference Time in IST instead of UTC.
    - Marking of Time on Time axis
- Availability of meteogram information in tabular format / data format, to integrate with demand forecasting/EMS models/REMC
- Automation for the knowledge derived out of weather forecast and Real time weather information through RADARs & weather satellite.

Way Ahead Contd….

- Solar irradiance forecast & real time data to be made available on Web Portal to facilitate solar generation forecast
  - The Sample data of Outgoing Long Wave Radiation (OLR), Insolation has been provided by IMD for further study in forecasting of irradiation
  - Irradiance ,Temperature ,Humidity,, Wind Speed/Direction, is required at the Control Centre for forecasting the RE generation

- Ultimate aim is to provide weather layer superimposed on regional/national GIS displays with power system network, for forecast as well as real time weather information

Radar Picture of Delhi-26th January 2017



Rain/ Hailstorm

No rains around Lal Qila & Rajpath

THANKS

Team System Logistics

NRLDC

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09999039321
dkumarp@posoco.in

Fourth Meeting of CEA Technical Committee On 13.06.17 For Study Of Various Types of Balancing Energy Sources To facilitate large scale integration and associated issues

Presentation By-

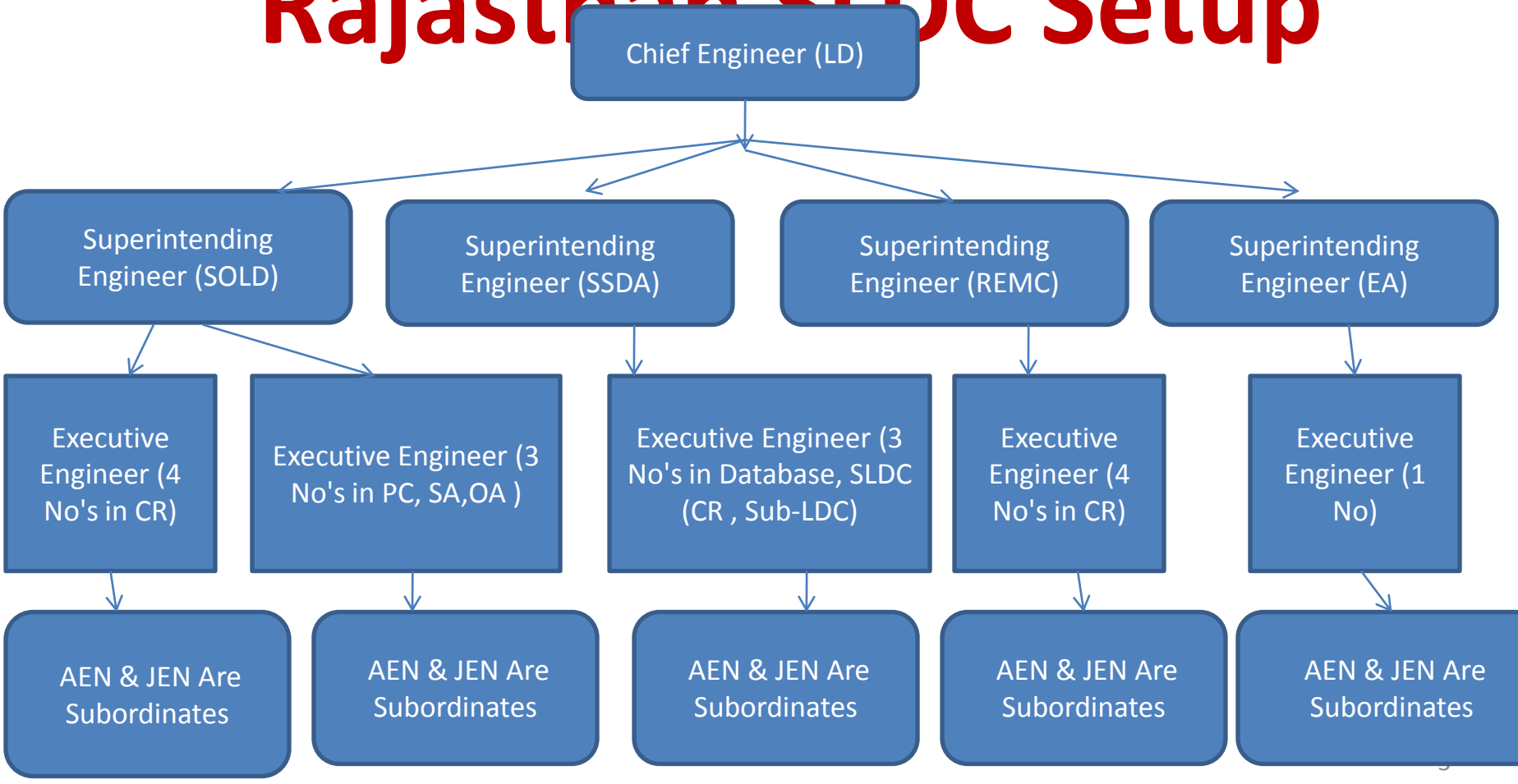
State Load Dispatch Centre

RVPNL, Jaipur, Rajasthan

INTRODUCTION

- The electricity system in India faces several challenges as the energy demand is expected to grow significantly while the energy resources in terms of fossil fuels are limited. The prime objective of Govt. of India is to build and efficiently deploy Renewable Energy for meeting the energy requirement of the country.
- To achieve the targets of RE generation fixed by Govt. of India in their plan for Rajasthan, promoting RE generation and to encourage and attract investors in this field , the Rajasthan Govt. has announced wind and solar policies.

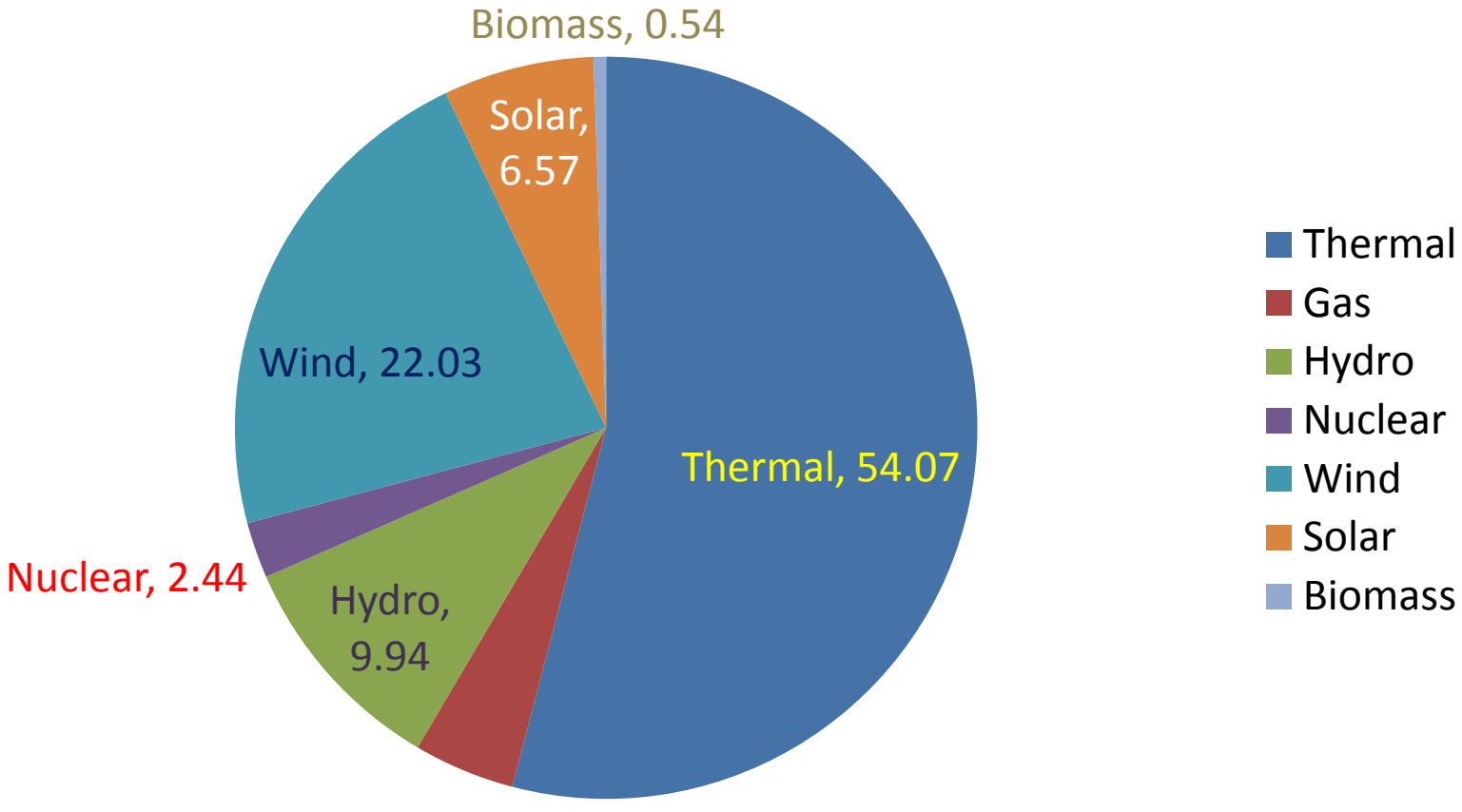
Rajasthan SLDC Setup



Rajasthan Installed Capacity As on 30.04.17

		ALL FIGURES IN MW			
	OWN	CENTRAL	PRIVATE SECTOR	TOTAL	% CAPACITY
THERMAL	5190.00	1394.41	3532.00	10116.41	54.07%
GAS	603.50	221.10		824.60	4.41%
HYDRO	356.85 HYDRO(MAHI+MMH) -163.85 CHAMBAL COMPLEX -193.0	1399.24 HYDRO PROJECTS - 732.06 BBMB COMPLEX - 660.44	104.00	1860.09	9.94%
NUCLEAR	200.00	256.74		456.74	2.44%
WIND	4121.20			4121.20	22.03%
SOLAR	1229.70			1229.70	6.57%
BIOMASS	101.95			101.95	0.54%
GRAND TOTAL(MW)				18710.69	

Installed Capacity

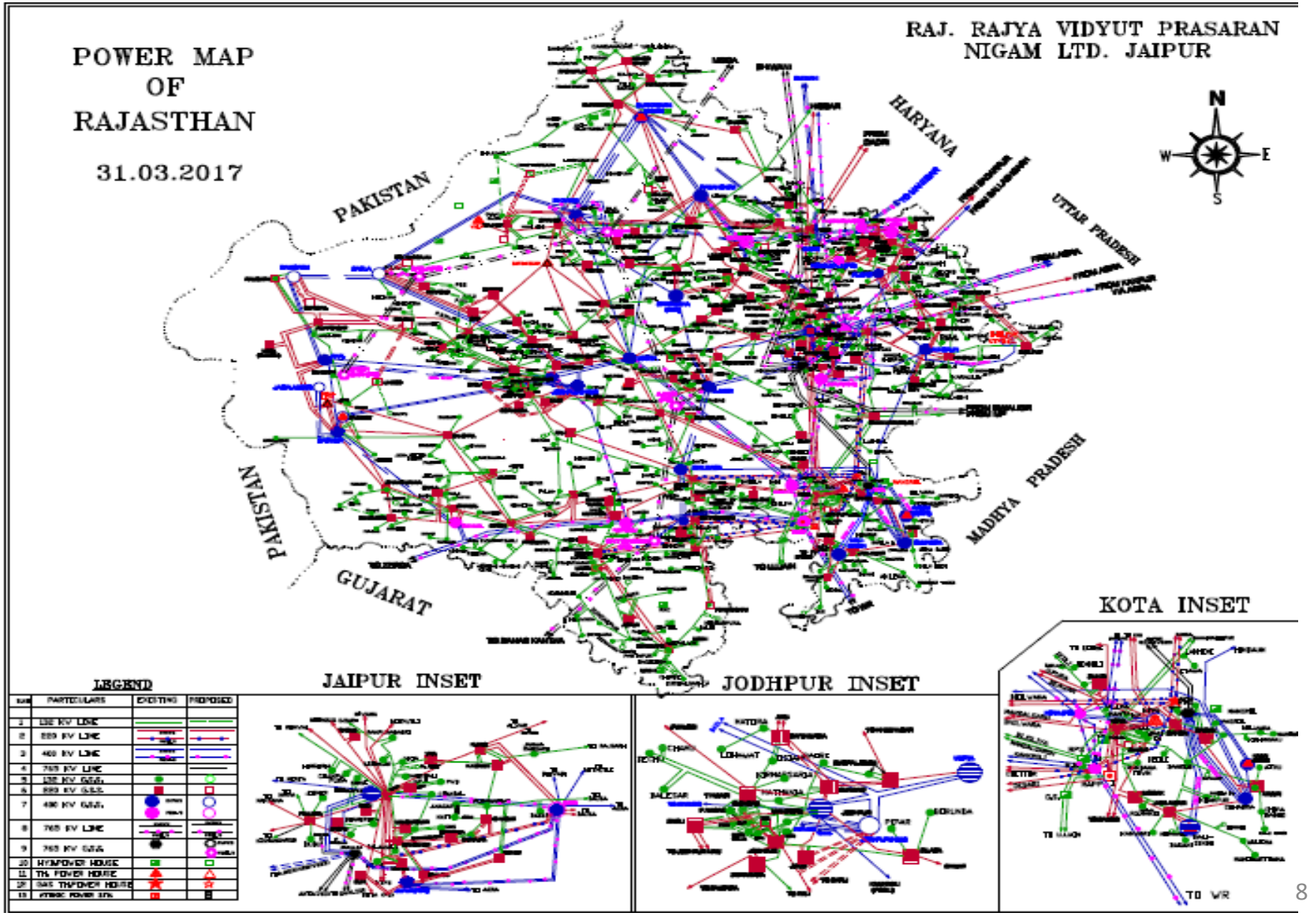


TIE LINES

VOLTAGE LEVEL	NAME OF LINES	
765 KV	PHAGI_GWALIOR_(D/C) PHAGI_BHIWANI_(D/C)	4
400 KV	HEERAPURA_BASSI (D/C) RATANGARH_SIKAR_(D/C) PHAGI_BASSI _(D/C) CHITTORGARH_RAPPC JODHPUR_KANKROLI(PG) MERTA_SHRICEMENT MERTA_KOTA(PG) CHITTORGARH_KANKROLI(PG)	11
220 KV		50
132 KV	A.THEDI_HISAR RAJGARH_HISAR	2
	TOTAL	**67**

EHV GSS & LINES

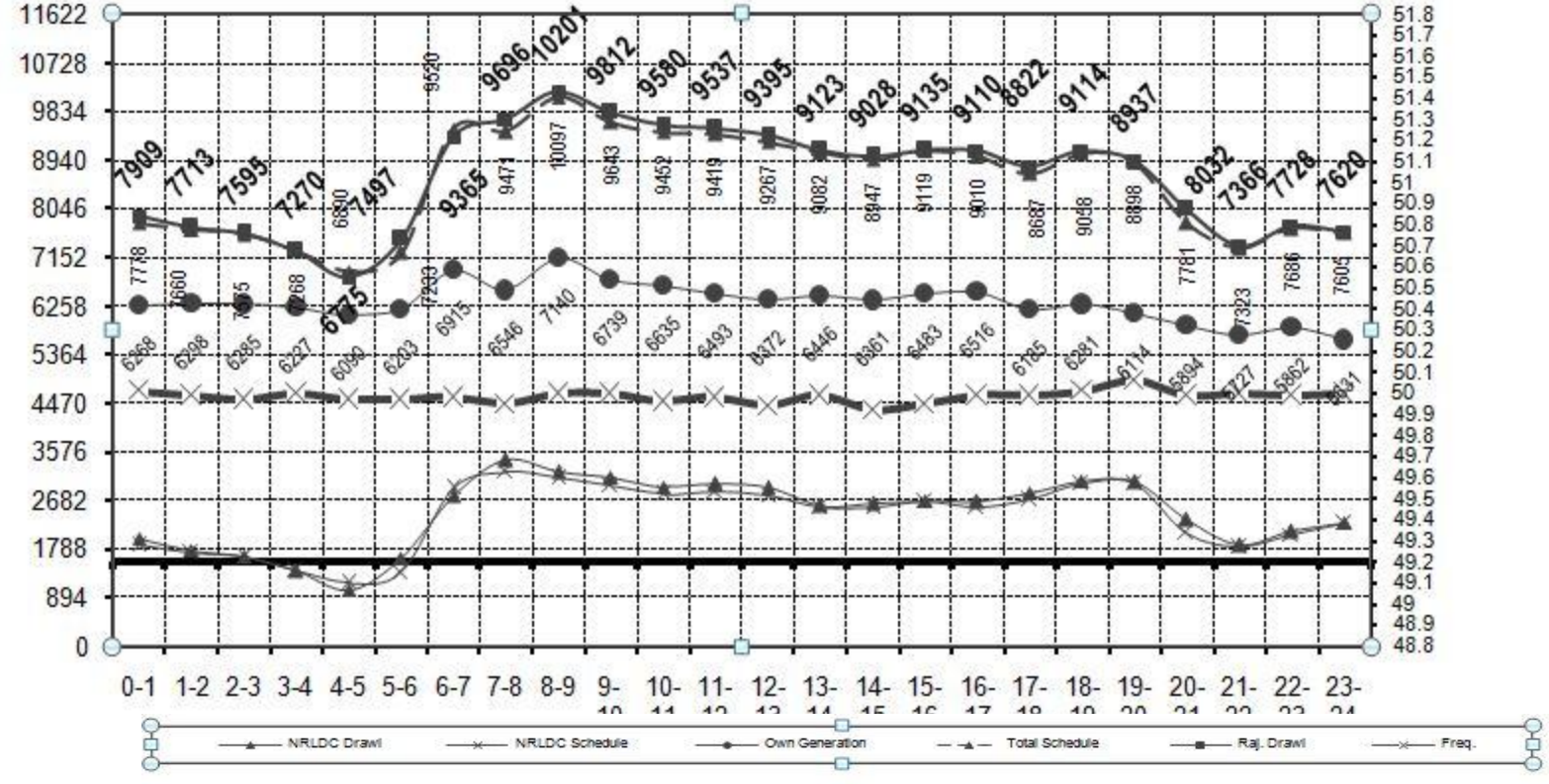
S.NO	EHV GSS	NO. OF GSS	EHV LINES (CKT. KM)	NO OF TRANSFORMER	TRANSFORMER CAPACITY (MVA)
1	765	2	425.5	12	7500
2	400	11	3937.33	25	7865
3	220	115	14225.43	244	27225
4	132	400	16443.87	1114	28957.5
Total		528	35032.13	1395	71547.5


POWER MAP
OF
RAJASTHAN
31.03.2017
RAJ. RAJYA VIDYUT PRASARAN
NIGAM LTD. JAIPUR
N
W
E
S
PAKISTAN
HARYANA
UTTAR PRADESH
MADHYA PRADESH
GUJARAT
PAKISTAN
LEGEND
JAIPUR INSET
JODHPUR INSET
KOTA INSET
TO WR

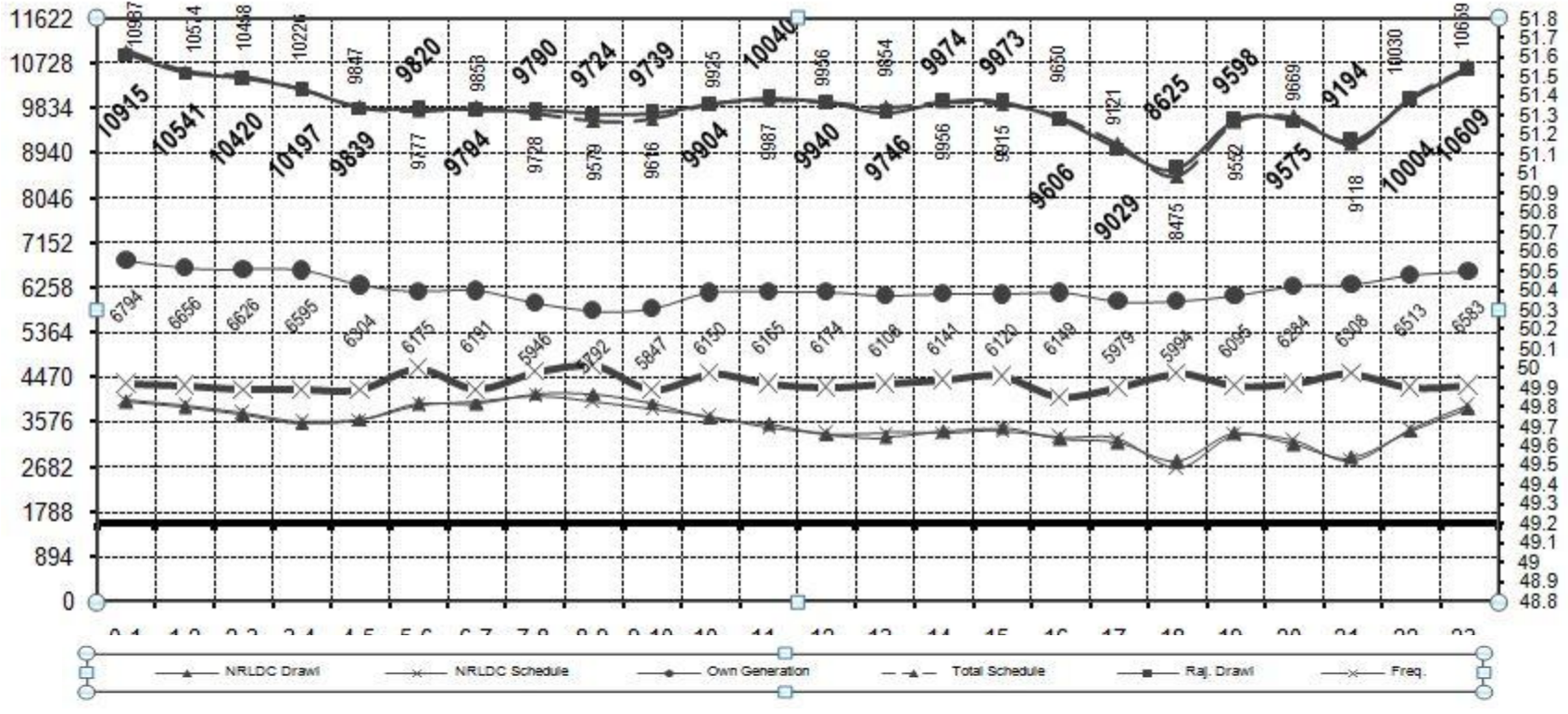
Max Consumption ,Peak Load and Wind for Financial Year 2010-11 To 2016-17

Financial Year	Max. Consu - mption (LU)	Date	Max Peak Load (MW)	Date	Block (HRS)	Max Wind (LU)	Date
2016-2017	2138.32	20.09.16	10348	25.01.17	08:15-08:30	**413.67**	06.07.16
2015-2016	2361.65	09.09.15	10961	09.09.15	00.30-00.45	**335.20**	04.07.15
2014-2015	2192.27	24.08.15	10642	31.12.14	09.30-09.45	**331.52**	15.08.14
2013-2014	1990.69	13.02.14	10038	19.02.14	08.30-08.45	**332.25**	27.06.13
2012-2013	1831.11	16.01.13	8515	10.01.13	08.00-08.15	**348.86**	25.01.12
2011-2012	1642.13	20.03.12	7605	06.03.12	06.30-06.45	**NA**	NA
2010-2011	1620.77	22.01.11	7442	06.02.11	12.15-12.30	**NA**	NA

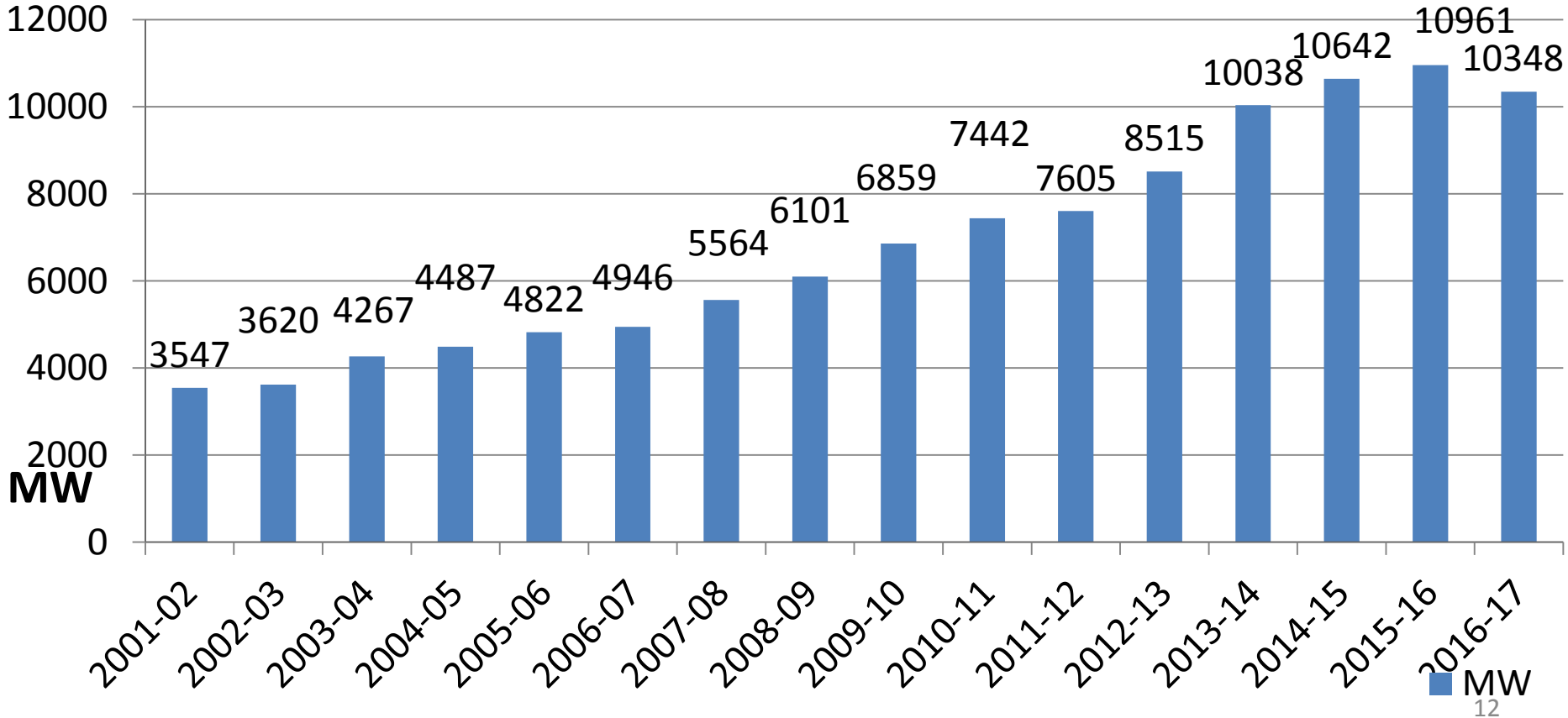
Load Curve of Rajasthan for 25 January, 2017



Load Curve of Rajasthan for 9 September, 2015



Growth of Maximum Demand Met(in MW)



Status of Wind Power Projects
Total Capacity Commissioned upto May 2017 : 4292.545 MW

S.No	Financial Year	Total Capacity of Wind Power Projects Commissioned (MW)	Cumulative capacity commissioned (MW)
1	2006-2007	111.75	464.645
2	2007-2008	70.45	535.095
3	2008-2009	199.6	734.695
4	2009-2010	350	1084.695
5	2010-2011	436.7	1521.395
6	2011-2012	545.65	2067.045
7	2012-2013	632.00	2699.045
8	2013-2014	98.80	2797.845
9	2014-2015	523.5	3321.345
10	2015-2016	685.5	4006.845
11	2016-2017	285.7	4292.545

RE Potential in Rajasthan

- Rajasthan has very huge potential of Renewable Energy Sources in western part which includes Jaisalmer, Barmer, Jodhpur & Bikaner districts .
- Wind Potential is also in Banswara & Pratapgarh districts of Rajasthan
- RREC has set the targets for solar and wind projects in Raajsthan about 27231 MW upto 2021-22

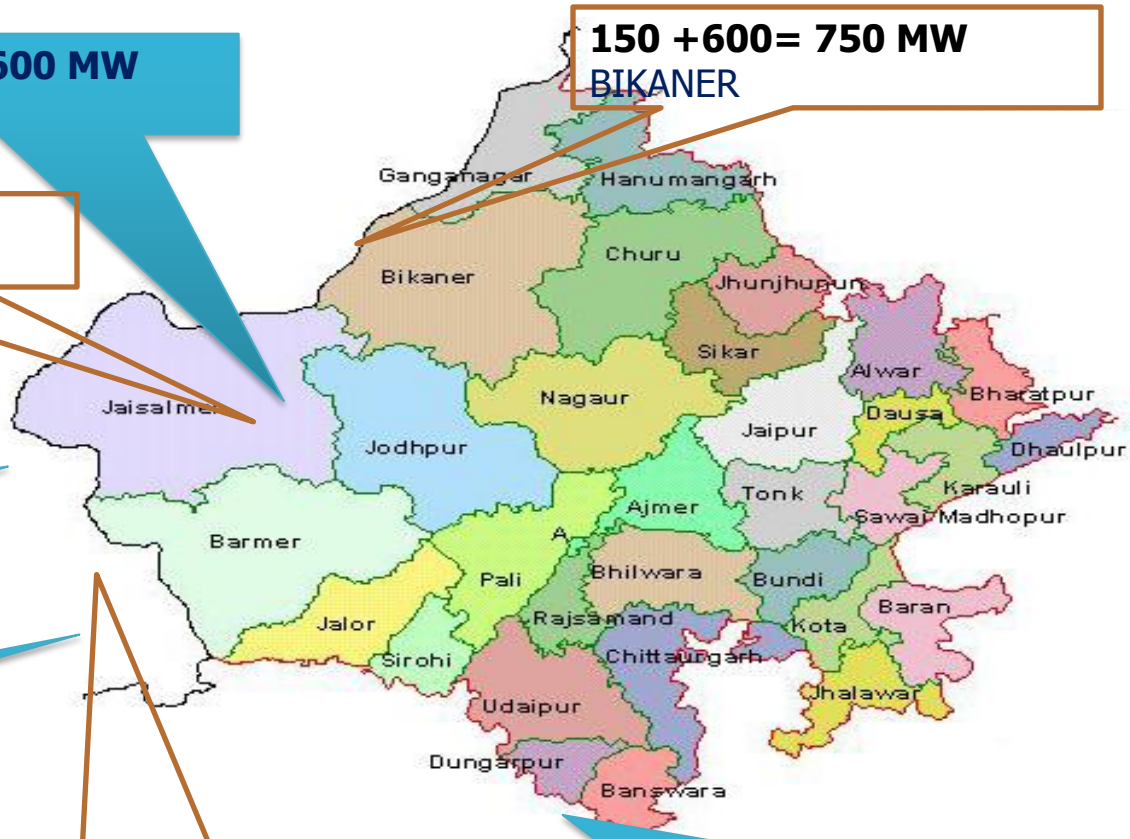
- RVPN will develop transmission system for evacuation of 13000 MW RE power. PGCIL will develop ISTS for evacuation of balance 14000 MW RE power which would be exported out side of state

Constraints on transmission and distribution system

During high wind injections, the loading on following lines are observed on the higher side

- 400 Kv Akal-Jodhpur
- 220 Kv Dhorimanna-Barmer
- 220 Kv Dhorimann- Rajwest
- 220 Kv Amarsagar-Phalodi
- 220 Kv Akal-Giral
- 132 Kv Jaisalmer-Chandan

Tentative locations of 13000 MW RE Projects



Renewable Energy Transmission:-
Green Energy Corridor Project

- Govt. of India is encouraging establishment of Renewable energy projects under clean energy development mechanism.
- MNRI under its grant scheme has approved solar parks at Bhadla in various phases.
- Details of funding of projects for strengthening the evacuation system for RE generation

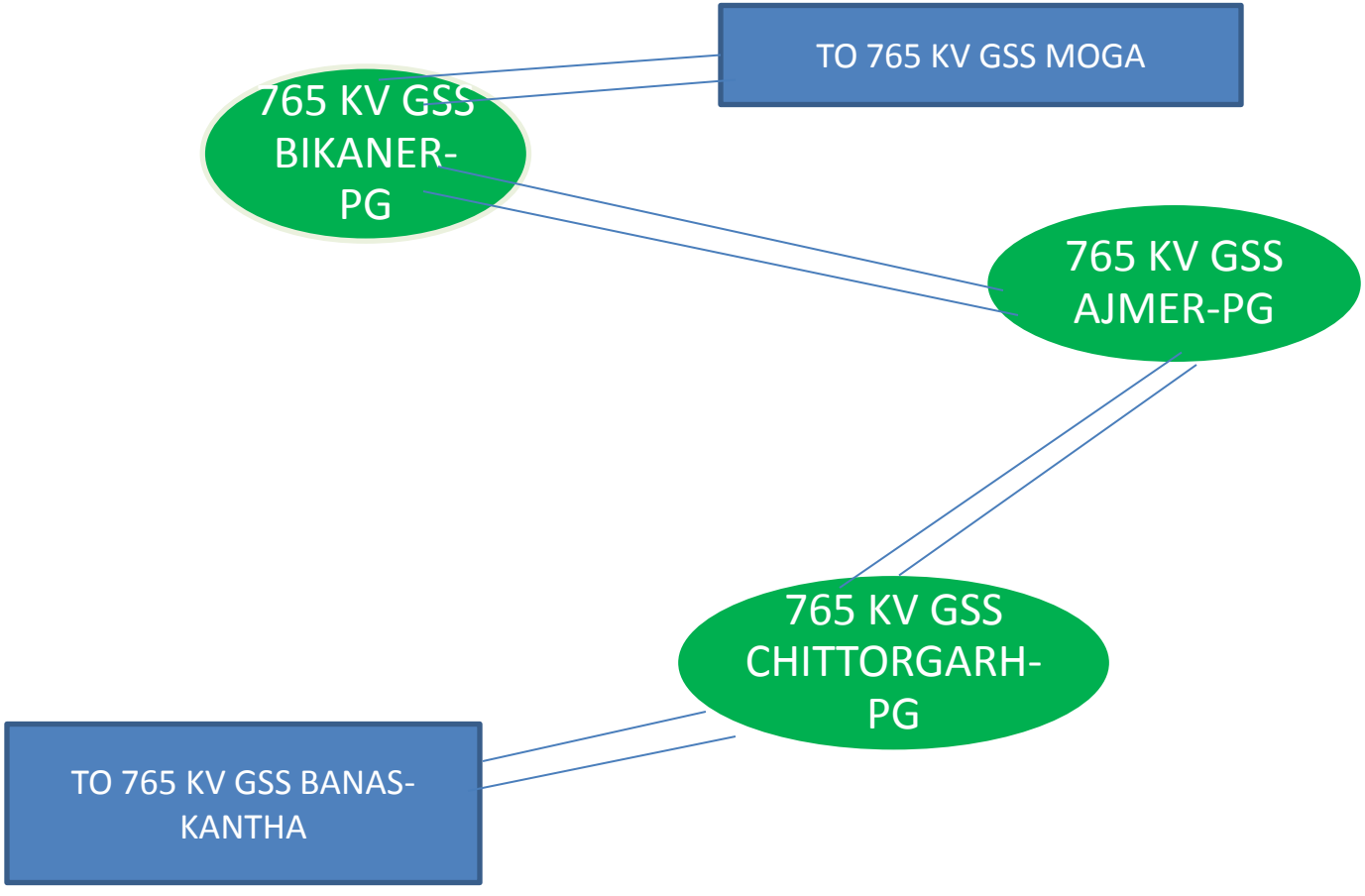
PRESENT FINANCIAL STATUS OF THE SCHEMES

S.No.	Details of the scheme	ADB funding	RVPN funding	Details of the scheme to be posed to KfW			Total amount in Rs. crore
				KfW funding	NCEF Grant	RVPN funding	
1.	Tranche-1	816.15	566.16	407.32	407.32	203.67	2400.62
2.	Tranche-2	25.00	1027.66	-	-	-	1052.66
3.	Tranche-3	25.00	127.69	-	-	-	152.69
4.	IDC (in schemes of Tranche-1,2 & 3 above)	-	658.97	-	-	-	658.97
5.	Taxes and duties	-	179.93	-	-	-	179.93
	Grand Total	**866.15**	**2560.41**	**1018.31 Crore**			**4444.87**

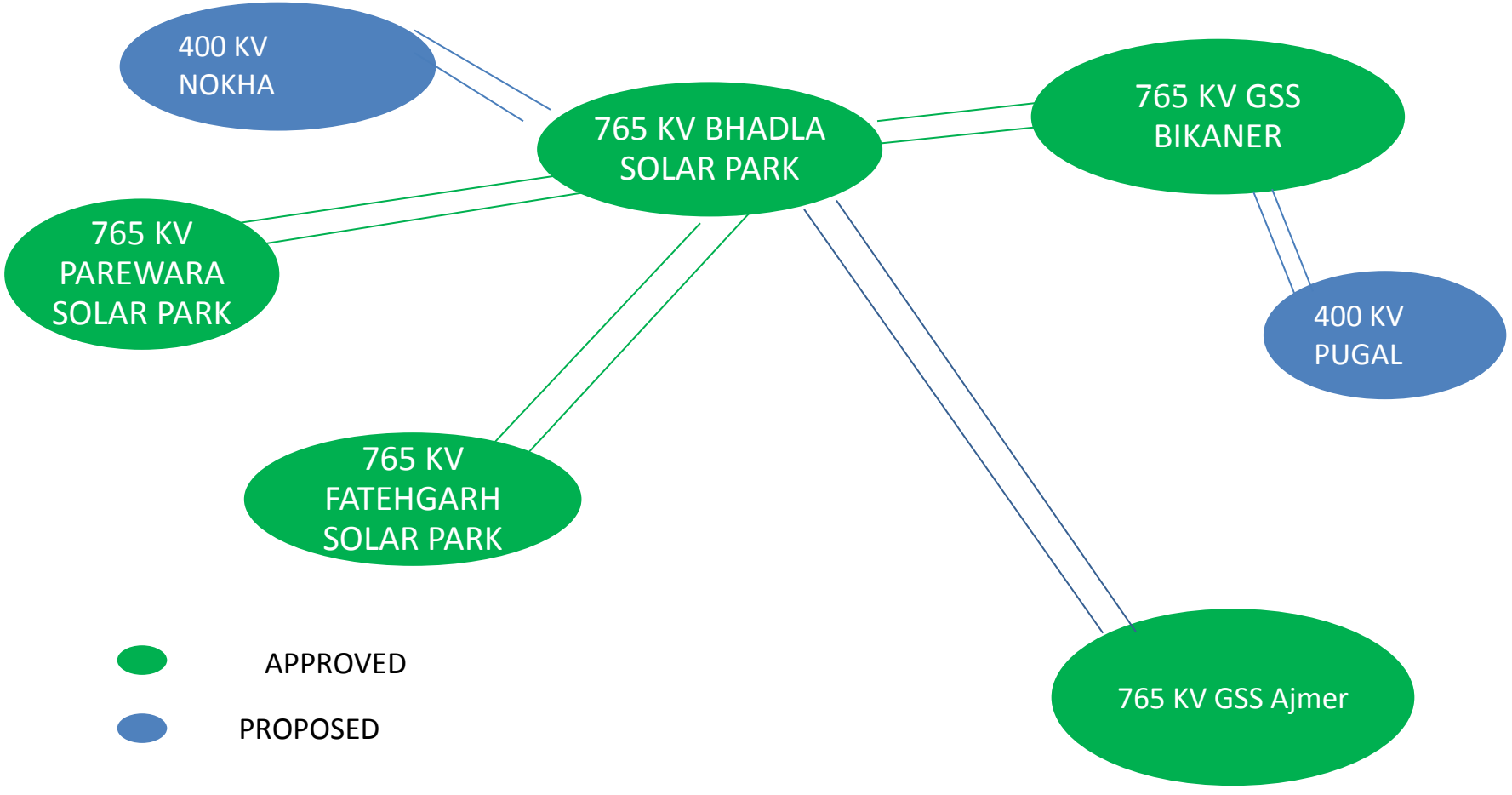
ABSTRACT

S. No.	Details of the scheme	Cost (Rs. Crores)
1.	ADB funding + Smart Grid	866.15
2.	KfW funding + NCEF Grant	814.64
3.	RVPN Funding	2764.08
	Grand Total	**4444.87**

GREEN ENERGY CORRIDOR (PHASE–I)



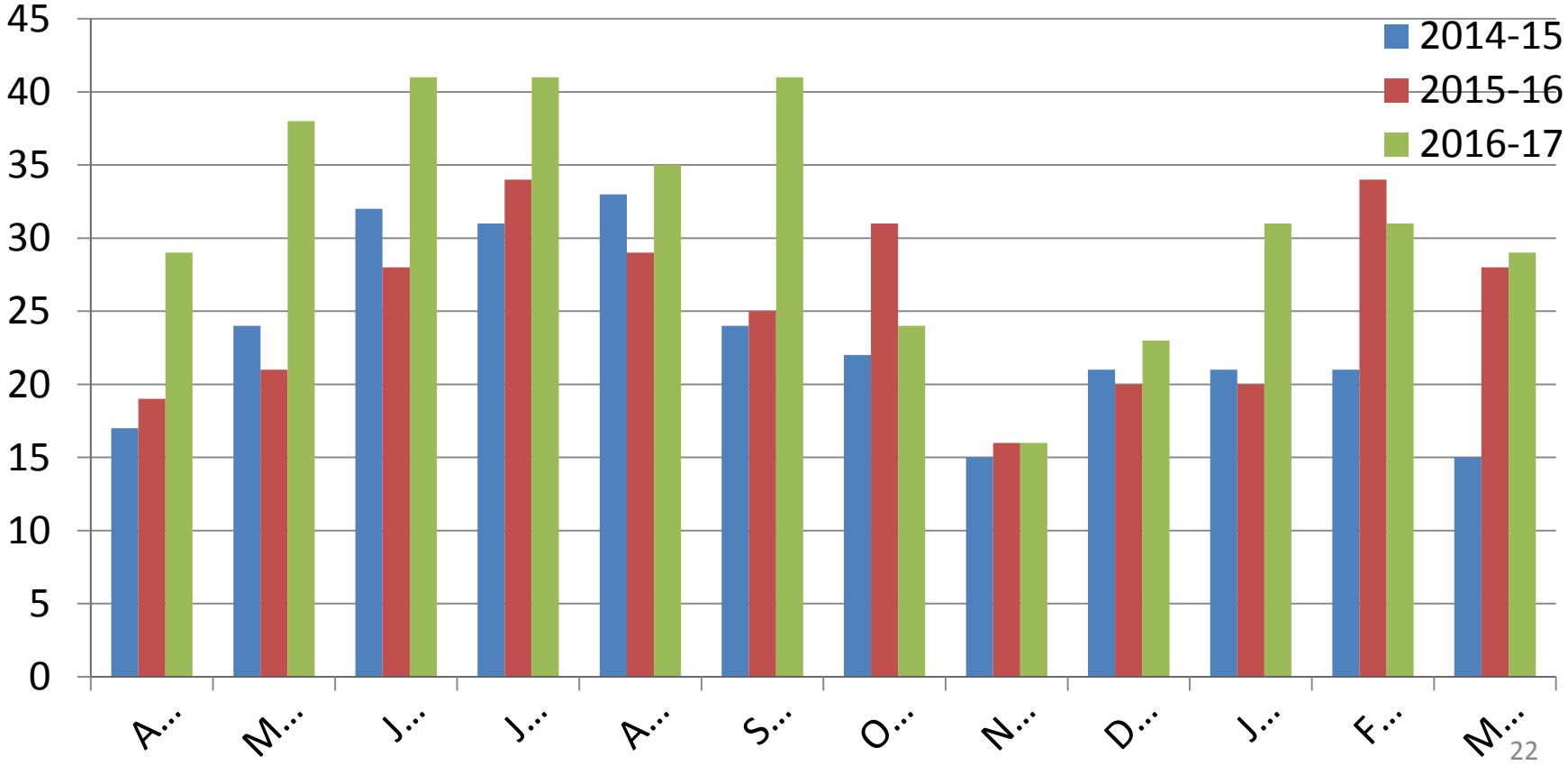
GREEN ENERGY CORRIDOR (PHASE-II)



Maximum Solar Generation (In LU)

	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
2014-15	21.15	32.07	22.04	20.52	21.62	22.55	20.5	17.3	15.72	16.21	18.27	20.66
2015-16	20.66	18.38	30.28	27.87	27.62	29.51	34.35	30.6	27.33	36.55	34.35	32.87
2016-17	34.18	35.43	33.78	31.95	30.61	53.57	35.49	31.36	29.07	33.36	26.09	29.1

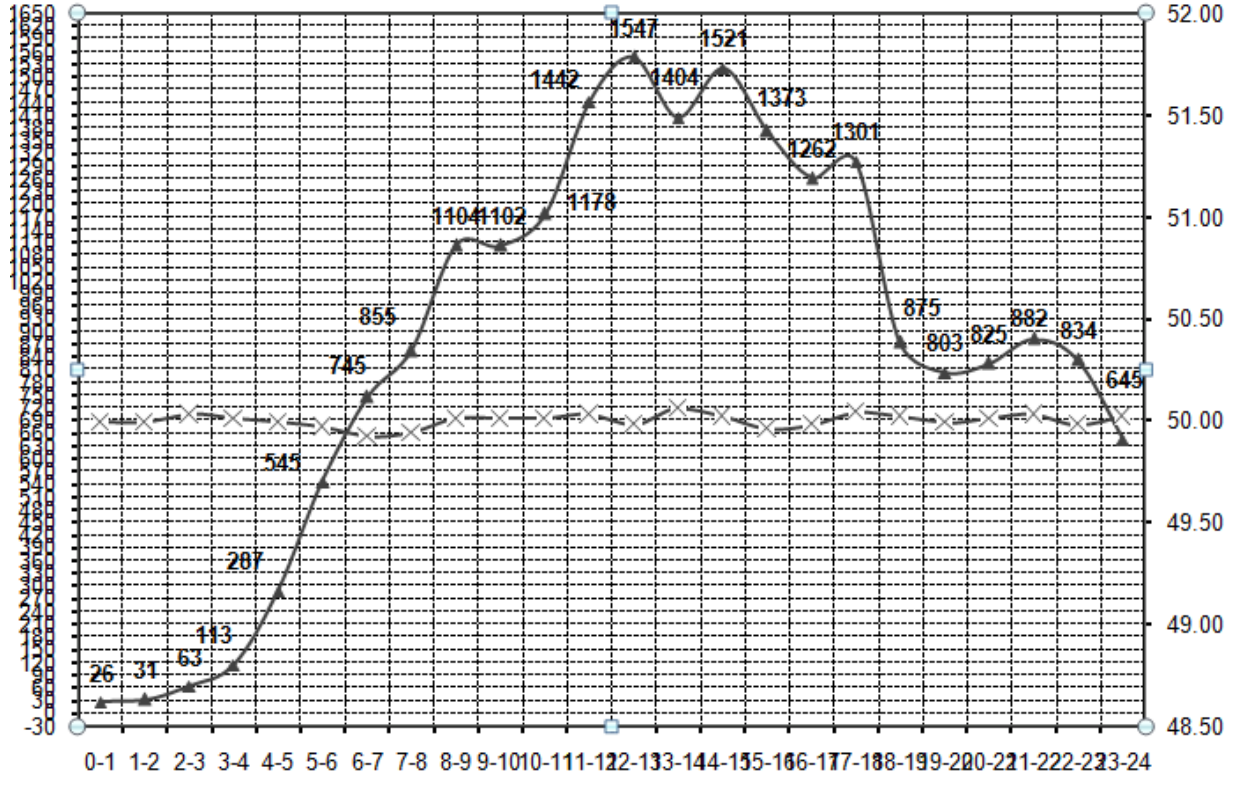
Month wise Max Wind Energy in a day (in MU)



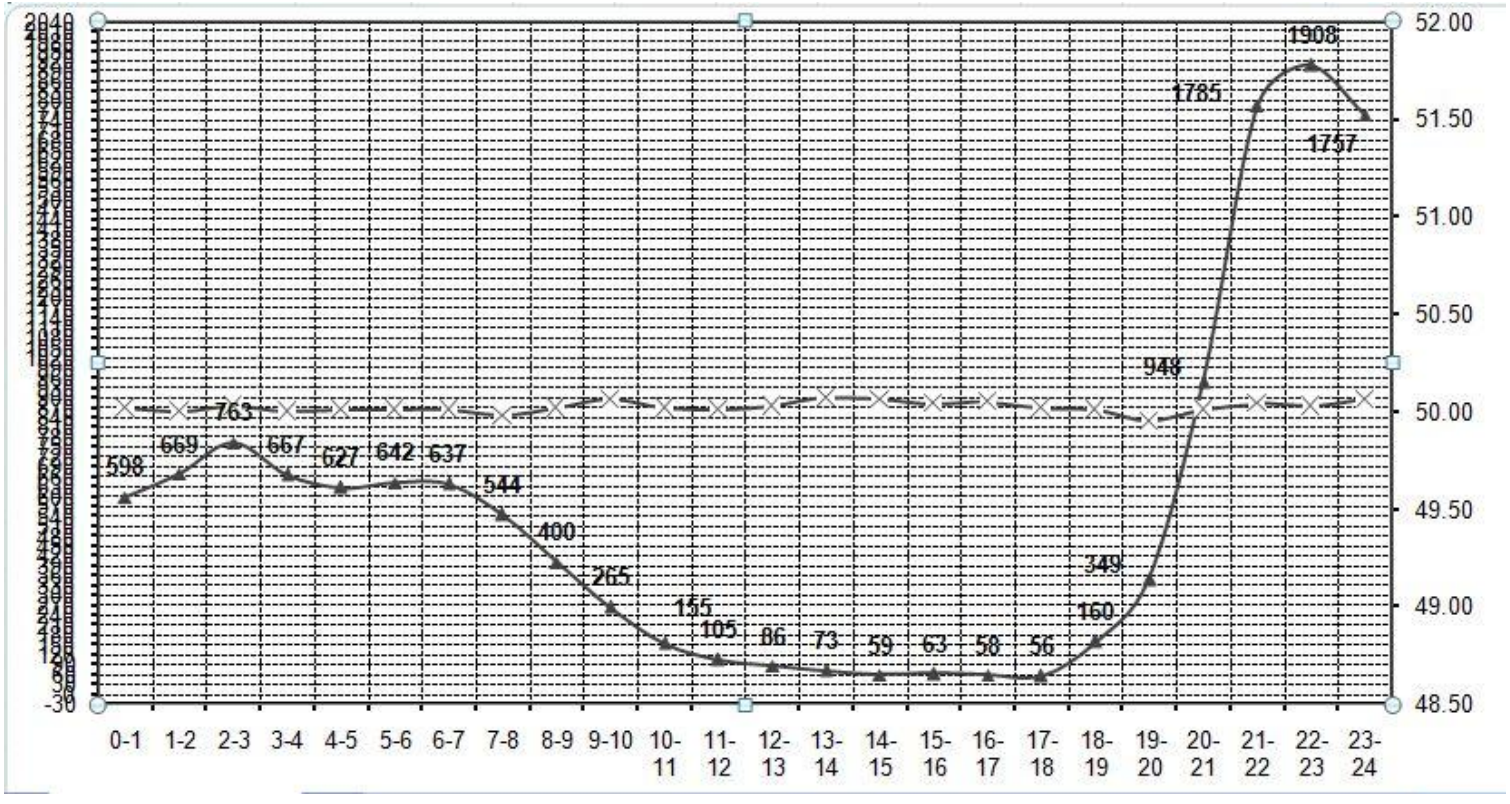
Variation of Winds

Year	No of days when variation between Max and Min generation is between 1000 and 1500 MW	No of days when variation between Max and Min generation is above 1500 MW	Maximum wind variation during a year	
			MW	Date
2013-14	31	--	1486	19.04.13
2014-15	21	--	1383	14.02.15
2015-16	61	1	1566	29.01.16
2016-17	145	26	1908	31.07.16

HOURLY AVERAGE WIND GENERATION



HOURLY AVERAGE WIND GENERATION for 31 July, 2016



Grid Integration of Renewable Energy Challenges

- RE is variable, uncertain and geographically concentrated in western part of state
- RE Generation in SCADA system for smooth grid operation
- Forecasting and Scheduling
- Balancing mechanism
- Sudden rise in wind energy injection -under drawl.

  Under drawl -restricted up to 250 MW.

  No charge receivable for underdrawl more than 250 MW at any frequency.

  Penalty when frequency > 50.10 HZ.

Grid Integration of Renewable Energy - Challenges

- Renewable energy -must run status .

  Management of deviation - DSM regulation

  High wind -backing down/box-up of generation ,surrender of CGS power (even of cheaper rate).

  During high wind injection , low demand and load crash due to rain -

  Wind generation also regulated for grid security.
- Sudden fall in wind energy injection -over drawl

  Management of deviation - DSM regulation

  purchase high cost power and/or load shedding.

  During less wind generation- overvoltage resulting into tripping

Grid Integration of Renewable Energy Challenges

- Uncertainty of RE Generation-
  Difficulty in meeting state demand
  Management of Deficit/Surplus power
  Frequent grid violation
  Frequent ramping up/down of thermal units
- Balancing-difficulty due to less Hydro-generation(356 MW) and it is agriculture based.
  Less and uncertain availability of gas.

CHALLENGES / BOTTLENECK IN PLANNING THE TRANSMISSION SYSTEM FOR RE PROJECTS

- Mismatch-

  Gestation period-Wind farms/Solar Parks

  3 to 4 months

  Construction of the transmission system

  2 to 4 years .

  Till the planned transmission system is commissioned, evacuation constraint is envisaged.
- RoW constraints
- Low Capacity Utilization Factor (CUF).

CHALLENGES / BOTTLENECK IN PLANNING THE TRANSMISSION SYSTEM FOR RE PROJECTS

- Potential far away from load centers – huge investment for evacuation
- Seasonal availability-wind & solar generation

  low PLF

  Consequently

  -transmission network sub-optimally utilized.

  -congestion in transmission/distribution network.

Balancing of Renewable Generation
Possible Solutions

- Difficulty to control Overdrawl/Underdrawl- Enhance gas & hydro sources.

  Financial Aid be facilitated by MOP .

- Compliance of DSM-

  Enhance OD/UD limit by CERC for rich RE generation and high demand states.

  Condition of change in direction(positive or negative) after 12 blocks be exempted or time period be increased.

- Use of pump storage hydro power plant .

Balancing of Renewable Generation
Possible Solutions

- High Wind Injection and low demand period- Consideration of Incentive to agriculture and bulk consumers to use energy.
- Parameters of power plants- Capable to increase sufficient variable range of generation without adverse effect.
- RE approvals/ connectivity- Strict compliance of regulation and system feasibility.

Balancing of Renewable Generation Possible Solutions

- Provision of data telemetry-Availability of RE generators telemetry data on voltage level 33kv and below.

- State Regulatory Framework:- RERC has notified draft Regulation on Forecasting ,Scheduling and Deviation settlement of Wind and Solar Generators , which are yet to be finalised in the State level.

- Compliance of Renewable purchase obligations- Mandatory with a provision of penalty .

  RERC directed all obligated entities to comply RPO.

- Positioning wind energy for the future by wind-solar hybrids- Wind solar hybrid system be used for better utilisation of grid infrastucture, grid stability and lower intermittency.

Status of establishment of REMC in the states and its linking to SLDC

- Renewable Energy Management Centre is being established by PGCIL as implementing Agency at SLDC under Green Energy corridor
- REMC circle comprising of team of engineers is functional since may 2016 and doing needful for establishment of REMC centre at SLDC ,Heerapura,Jaipur.
- Detailed project report (DPR) of setting up REMC has been commented upon and the same has been finalised.
- Specification of REMC has also been commented upon and the same has been finalised.
- NIB is under process with PGCIL (the implementing agency).
- Agreement executed between SLDC Rajasthan and PGCIL on dt. 29/05/17

Renewable Energy Management Centre (REMC)

- REMC , Equipped with advanced Forecasting Tools, Smart dispatching solutions & Real time Monitoring Of RE generation , can closely coordinate with the Grid Operations team for safe, secure and optimal operations of the overall grid.
- To fulfill above requirement ,MoP has taken step to establish 11 Nos. REMCs namely 07 Nos. in RE rich states (Rajasthan ,Gujarat, Maharashtra ,Tamil Nadu, Madhya Pradesh, Karnataka, Andhra Pradesh);03 Nos. in Regional LDCs (NRLDC ,WRLDC &SRLDC) and 01 No. in National LDC.

Functions:-

I. Forecasting of RE generation day ahead and intra-day etc.
II. Propagate RE related data to SLDC and coordinate for dispatching and balancing RE power
III. Central repository for RE generation data for MIS and commercial settlement purpose
IV. Coordination agency on behalf of SLDC for interacting with RE developers.

Status of REMC in Rajasthan

- New circle named “REMC circle “ has been created and has started functioning since MAY 2016
- DPR for setting up control room of REMC in Rajasthan has been finalised.
- Technical specification for setting up control room of REMC in Rajasthan has also been finalized.
- Tenders for the same has been called by the M/s PGCIL(Implementing Agency)

Work Execution

- Static data of wind farms and solar parks have been collected to facilitate forecasting of respective generation
- Daily generation injection into the grid is being collected for forecasting purpose/historical data.
- 43 Nos. of wind generating Farms are connected to 15 Nos. of STU pooling stations.
- 42 Nos. of solar generating firms are connected to 27 nos. of STU pooling stations.

Telemetry

- The telemetry data from 11 nos. STU pooling station are retrieved at SLDC.
- A tender is under process for providing communication infrastructure along with RTUs at the level of STU.

LVRT Protection for Wind

- In compliance to CERC order dt 05.01.2016 in petition No. 420/MP/2014 ,SLDC has requested wind generators connected at 132 KV Level and above to submit the LVRT capabilities status .
- In response 25 Wind generators have submitted the LVRT capabilities status.

Looking to anticipated large scale RE generation grid Integration ,the detailed action plan to work forward to implement forecasting, scheduling, data telemetering , infrastructure development , functioning of REMC, use of technology, transmission system development is essential to overcome related difficulties to meet RE targets and also to keep in view the security of the grid.

THANK YOU!!

Need of Hydro Power Revival and its Role as Balancing Energy Source

By

THDC INDIA LTD.

Balancing is Inevitable: WHY?

Intermittency of Wind and Solar

Wind and solar provide increased reliability risks.

Location Specific Potential, susceptible to congestion in existing transmission system

The bulk grid supports and is supported by conventional rotating generators (Coal, gas, hydro, nuclear) which provide "Essential Reliability Services" (ERSs).

Balancing is Inevitable: WHY?

Modern wind resources do not economically spin in synchronism with the grid so they are electrically decoupled from the system. Solar generation does not involve rotating machinery. Thus, both do not inherently provide ERSs.

Wind and solar can be made to provide approximations of ERSs, but that may require significant increased costs and reduced generation output.

As the penetration level of asynchronous generation increases, this will either increase cost, limit operational flexibility, degrade reliability or most likely result in a combination of all three factors

Hydro Power and Energy Security

Hydropower is mature and cost competitive renewable energy source

World's largest source of renewable energy, accounting for almost fifth of Global Electricity

Development of Hydro projects is important to meet the objectives on sustainable development and for energy security.

Critical Role of Hydro Power

Availability

Meet Peak Demand

- Quick ramp up and Ramp Down

Sustainability

Contribution to Irrigation & Drinking Water

- Clean Power
- Flood Mitigation

Affordability

Long Operating Life

- Cost reducing overtime

Role of Tehri Power Complex in Northern Grid

- Tehri Power Complex consists Tehri HPP(4X250MW), Koteshwar HEP(4X100MW) and Tehri PSP(4X250MW). Tehri HPP & Koteshwar HEPTehri are in operation and PSP scheduled for commissioning by FY 2019-20.
- The live storage capability of Tehri Hydropower Plant facilitates the Grid to optimize use of variable RES over both shorter and longer periods.
- Upcoming Tehri PSP having variable speed Asynchronous machines will enhance energy storage capacity of Northern grid.
- Given large inertia, Tehri Power Plant strengthens the transient stability of grid.
- Tehri Plants are operating on least forced outage, which shows high reliability. In last five year we successfully limited the forced outages within 0.4% by adopting best O&M practices.

Tehri Hydro Power providing full range of Grid Stabilising Service

- Peaking Power Station
- Quick start capability
- Black Start Capability
- Regulation and Frequency response
- Voltage support by Synchronous Condenser Mode
- Supply of Power as per requirement

63 MW Wind Power Project at Devbhumi Dwarka, Gujarat

Salient Features of the Project

Location	Village Bhanvad and Kandorna, Distt. Devbhumi Dwarka, Gujarat
Nearest Town	Khambhalia, 15-20 KM
Nearest Railway Station	Khambhalia Railway Station, 20 KMs
Nearest Airport	Jamnagar Airport, 50 -60 KMs
No of Wind Turbines	30 (21 at Kandorna Site, 09 at Bhanvad Site)
Capacity Utilisation Factor	26.04 %
Annual Energy Production	2.28 GWh/ MW (Total approx. 144MU)
Tariff	Rs. 4.19/ kWh (PPA signed with GUVNL)
Project Life	25 Years

Location of the Project

- Project site -60 km. from Jamnagar in south west direction.
- District: Devbhumi Dwarka
- Approx. 10-15 km from Khambhalia
- Nearest airport –Jamnagar / Rajkot

THDC's 63 MW site

Status of the Project

- Project commissioned on 31.03.2017.
- Project implemented in a record time of 04 months at a project cost of Rs. 415.5 crores.
- PPA for off take of entire power from the project signed with Gujarat Urja Vikas Nigam Limited (GUVNL) on 03.01.2017 at a fixed Tariff of Rs 4.19/kWh
- THDCIL has setup its transit office-cum-accommodation for the project at nearest town- Khambhaliya.
- Project is eligible to receive Generation Based Incentive (GBI) to the extent of Rs. 63 Cr. from Govt. of India.
- Generation from the project up to June’17 (upto 11.06.17) is 26.52 MU

50 MW Wind Power Project at Patan, Gujarat

Salient Features of the Project

Name of Wind Farm, State	Patan Wind Farm in Gujarat
Villages / Taluka / District	Vahedpura, Ved, Amrapur, Anvarpura/ Sami, Santalpur / Patan
Nearest Airport, distance from project	Ahmedabad, 200 Kms.
Wind Park Capacity	300 MW
WTG Model	G97 – 2.0 MW
Rated Capacity of WTG	2000 KW
Rotor Diameter	97 M
Hub Height	90 M
Annual Energy Generation	110.5MU
No. of WTGs installed;	25 Nos. x 2MW; Total = 50 MW
Pooling Sub-Station (PSS)	220/33KV SS at Amarapur
Grid Sub station	Tharad, approx. 90 Kms. From Amrapur PSS.
Tariff	Rs. 4.15 / Kwh (PPA signed with GUVNL)

Salient Features of WTG

	General Data	
1	WTG type and make	Gamesa G97- 2MW, Horizontal axis wind turbine with variable rotor speed
2	Wind speed at rated output (m/sec)	14
3	Cut in wind speed (m/sec)	3
4	Cut out wind speed (m/sec)	25
5	Tip speed (m/sec)	55.83
6	Survival wind speed (m/sec)	52.5
7	Tower height (m), Type, no. of section	90.3m, conical barrel tube, 4
8	Rotor speed	19
9	Maximum operating temperature. (^{0}C)	+45^0
10	No. of blades	3
11	Rotor diameter (m)	97
12	Length of rotor blade (m)	47.5
	Generator	
1	Make and Rated power output (KW)	ABB make, 2070KW
2	Type	Asynchronous (variable speed machine)
3	Output voltage and RPM	690 Vac., Speed range: 900-1680rpm
4	No. of poles	4
5	Current (Amps.)	1966.3
6	Frequency	50Hz
	Yawing system	
1	Type	Yaw ring with friction bearing
2	Gear ratio	1:940
3	Rated capacity of yaw motor (KW)	2.2
4	No. of yaw motor	4
5	No. of yaw brakes	8
	Gear box	
1	Type	Planetary
2	Gear ratio	1:106.793

Status of the Project

- The Project was commissioned on 29th June 2016, 2 months ahead of the schedule. The project cost is Rs 315 Cr.
- The expected Annual generation from the project is 110.5 MU with 25.22 % capacity factor.
- The Power Purchase Agreement (PPA) for the project has been signed with Gujarat Urja Vikas Nigam Limited (GUVNL) at a fixed tariff of Rs. 4.15 / unit for 25 years of life of the project.
- The Wind Project has been registered with IREDA for availing Generation Based Incentive (GBI) of Rs 50 Cr for the project. GBI claim of Rs 2.8 Cr under process at IREDA.
- The generation from Patan Wind Power Project up to June'17 (upto 11.06.2017) is 85.78 MU.

Indian Power Sector

Installed Capacity: 319.60GW

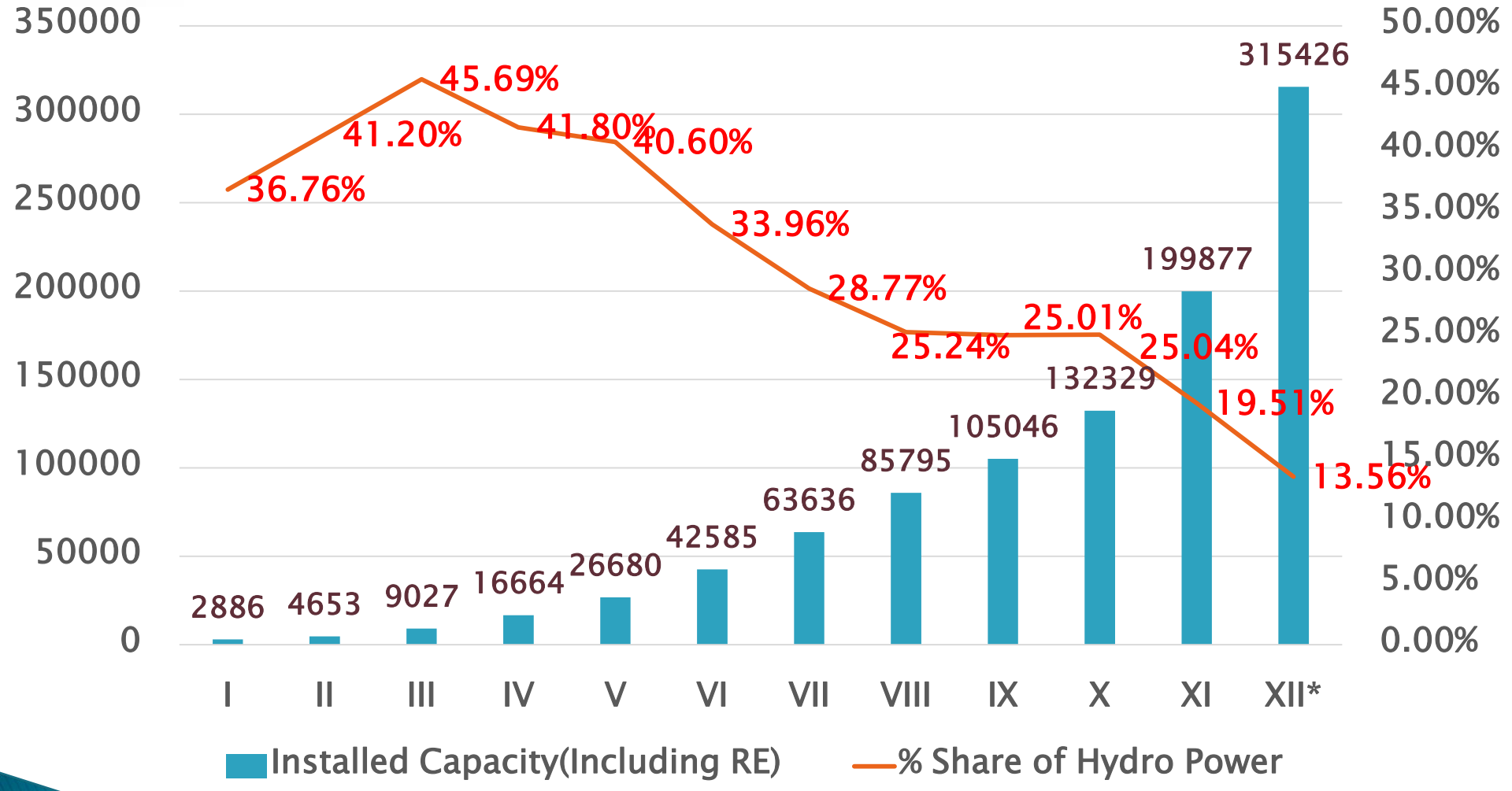
- Thermal:218330MW
- Hydro:44478MW
- Nuclear:6780MW
- RES:50018MW

Position in World

- Third Largest Producer
- Forth largest Consumer of Electricity

Source :CEA

Trends of Hydro Power Share in Indian Power Sector



Source :CEA

Major Reasons for Slippage of Projects from 12th Plan

- **Slow Progress of Civil works**
- **Poor geology**
- **Law and Order issue**
- **Funds Constraints**
- **Contractual Issues**
- **Environment Issues**
- **Local Issues**
- **Unfavorable weather Conditions like heavy monsoon, floods,cyclons etc.**

Source: Draft NEP prepared by CEA

Current Issues & Challenges

- Land acquisition Issues
- Environment and Forest Issues
- Rehabilitation & Resettlement Issues
- Enabling Infrastructure
- Law & Order / Local Issues
- Technical Challenges
- Natural Calamities

Source: Draft NEP prepared by CEA

Conclusion

- Following strategies are proposed to be adopted to revive Hydro Power sector:
  - Need to achieve adequate Hydro mix
  - Preferential Treatment should be ensured for development of Hydro Projects
  - Declaring all Hydro Power as renewable energy shall definitely act as a catalyst in revamping Hydro Sector
  - Providing Hydro power purchase obligation within currently mandated Non Solar RPOs to qualify for dispatch priority
  - Providing interest subvention during construction and post COD to all Hydropower projects
  - Excluding cost of enabling infrastructure from Project cost
  - Create a hydro power development fund.
  - Softening lending terms and conditions for Hydro projects by engaging bankers and financial institutions.

Thank You

Battery Energy Storage System in Puducherry

Power Grid Corporation of India Limited

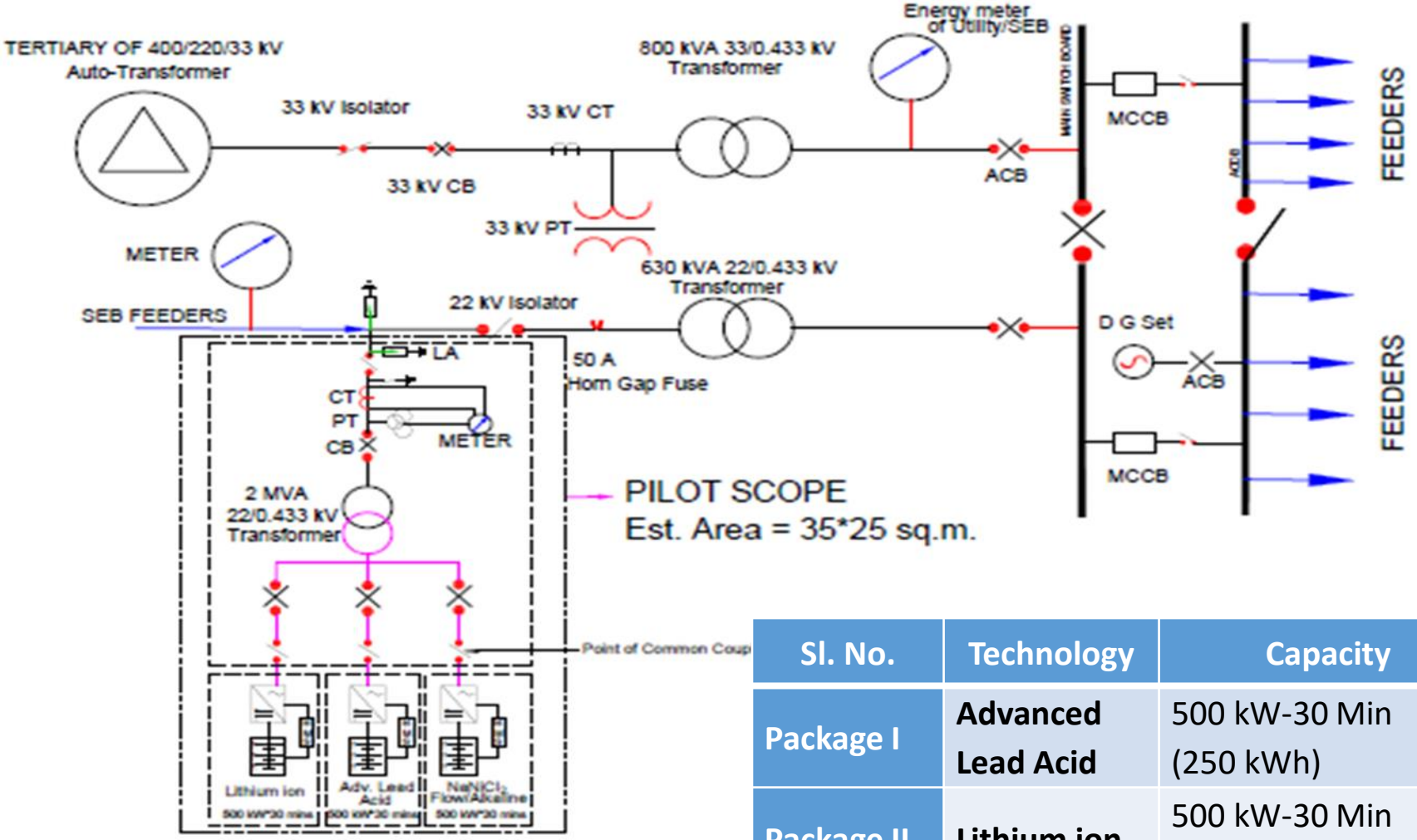
Drivers for Pilot Project on Energy Storage

- Balancing support needed for high Degree of Renewable Penetration (175 GW) by 2022
- Very less existing capacity of Grid scale energy storage in the form of Pumped Hydro storage
- High gestation period for Pumped hydro storage
- No experience of grid scale energy storage apart from Pumped Hydro

Why Battery Energy Storage Pilot ?

- Quicker installation period
- Higher ramp rate
- Lower response time
- Modularity in size
- Flexibility in transportation
- Options of many Chemistries

Size of the Pilot Project

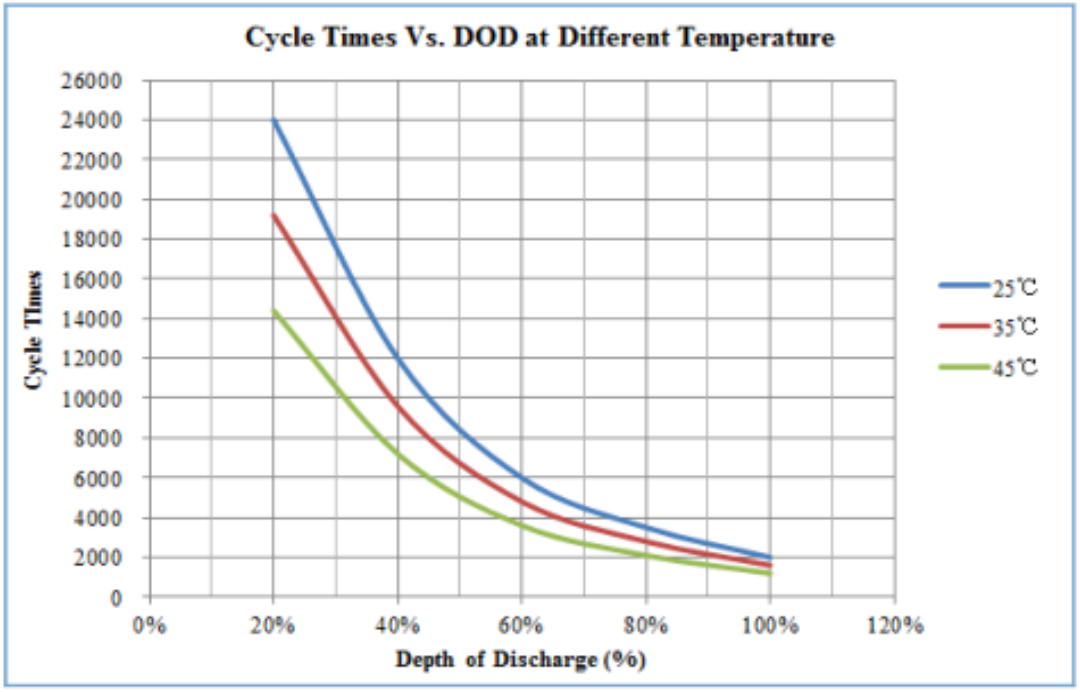


Sl. No.	Technology	Capacity
Package I	**Advanced Lead Acid**	500 kW-30 Min (250 kWh)
Package II	**Lithium ion**	500 kW-30 Min (250 kWh)
Package III	**Flow**	250 kW-4 hours (1000 kWh)

Technical Specifications

Parameters	Li-ion Battery	Advanced lead Acid Battery	Flow Battery
Charging rate	3 hrs. from rated DoD to Full Capacity	3 hrs. from rated DoD to full capacity	5 hrs. from rated DoD to full capacity
DC-DC Round-trip efficiency	>90%	>80%	>75%
Service Life	10 years	10 years	10 years
Life-cycle	4000 cycles (900 MWh)	3000 cycles (675 MWh)	3000 cycles (2700 MWh)

Lithium Ion Cycle Life

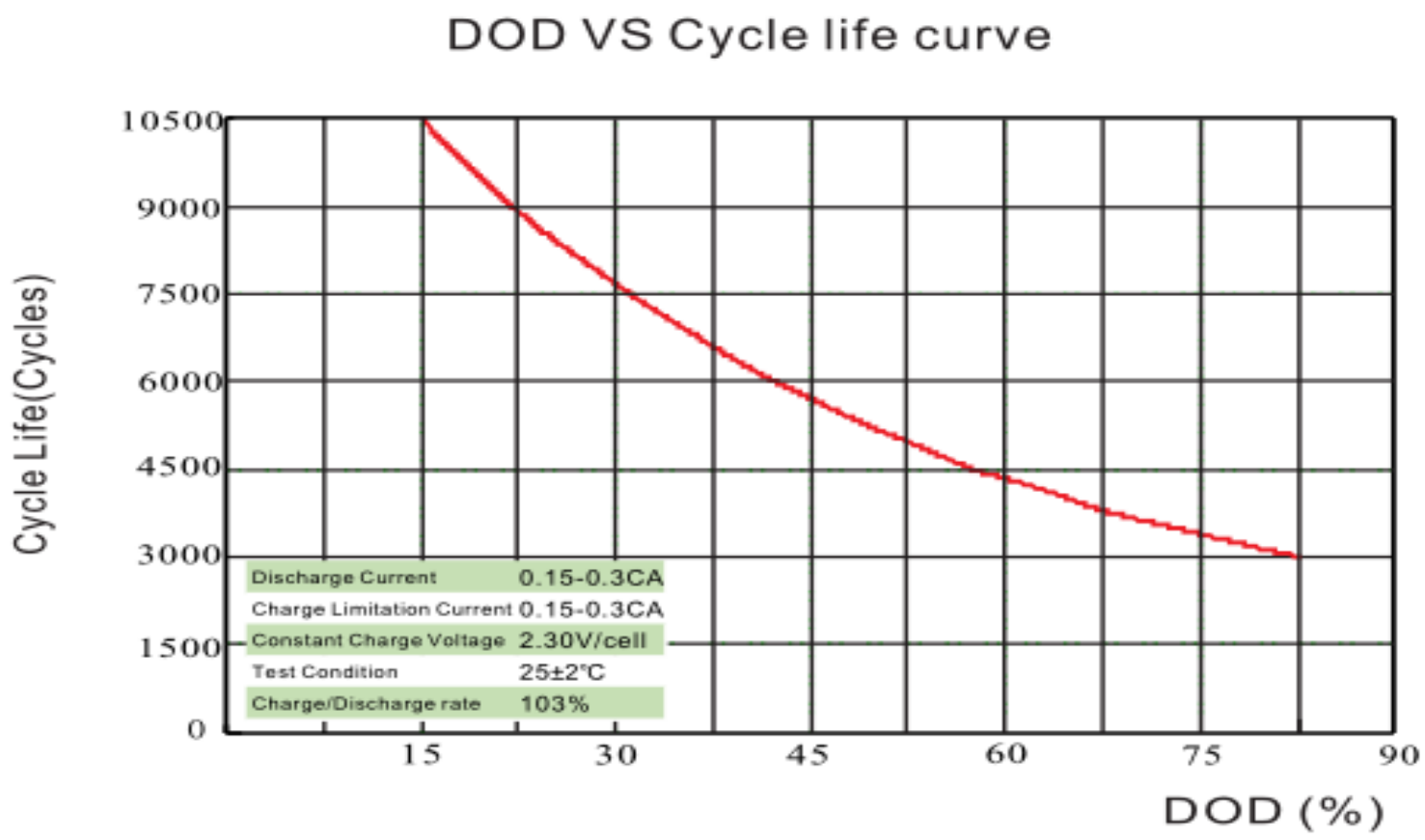


Graph 1 - Cycle life vs. DOD of NLC Series with Ideal Charge Mode

Table 1 Data of Cycle Number

Temp. (℃)	Depth of Discharge (%)				
	100%	80%	60%	40%	20%
25	2000	3500	6000	12000	24000
35	1600	2800	4800	9600	19200
45	1200	2100	3600	7200	14400

Advanced Lead Acid Cycle Life



Note: Application on single cell.

System Configuration: Adv. Lead Acid

Internal Chemistry: Cathode-PbO_2, Anode-(Lead+Carbon),Electrolyte-H_2SO_4

Details of Each Cell: 2V, 600 Ah

Configuration: Two strings are connected in parallel, each string comprises of 300 cells connected in series (total 600 cells)

PCS Efficiency: 96%

Total Capacity of Battery: 691.2 kWh (useful Capacity at 2C was found 384 kWh)

Rated DoD: 65.1%

System Configuration: Lithium Ion

Internal Chemistry: Cathode- Lithium Iron Phosphate, Anode- Carbon & Electrolyte - Lithium Hexafluorophate and solution of carbonates

Details of Each Cell: 3.2 V, 80 Ah.

Configuration: Battery Module -2 cells in parallel, 6 such units in series (19.2 V, 150Ah). One String-36 modules in series. (432 cells, 691.2 V & 150 Ah), 4 such strings in Parallel (1728 cells, 691.2 V, 600 Ah)

PCS Efficiency: 96%

Total Capacity of Battery: 398 kWh(useful capacity at 2C 357 kWh)

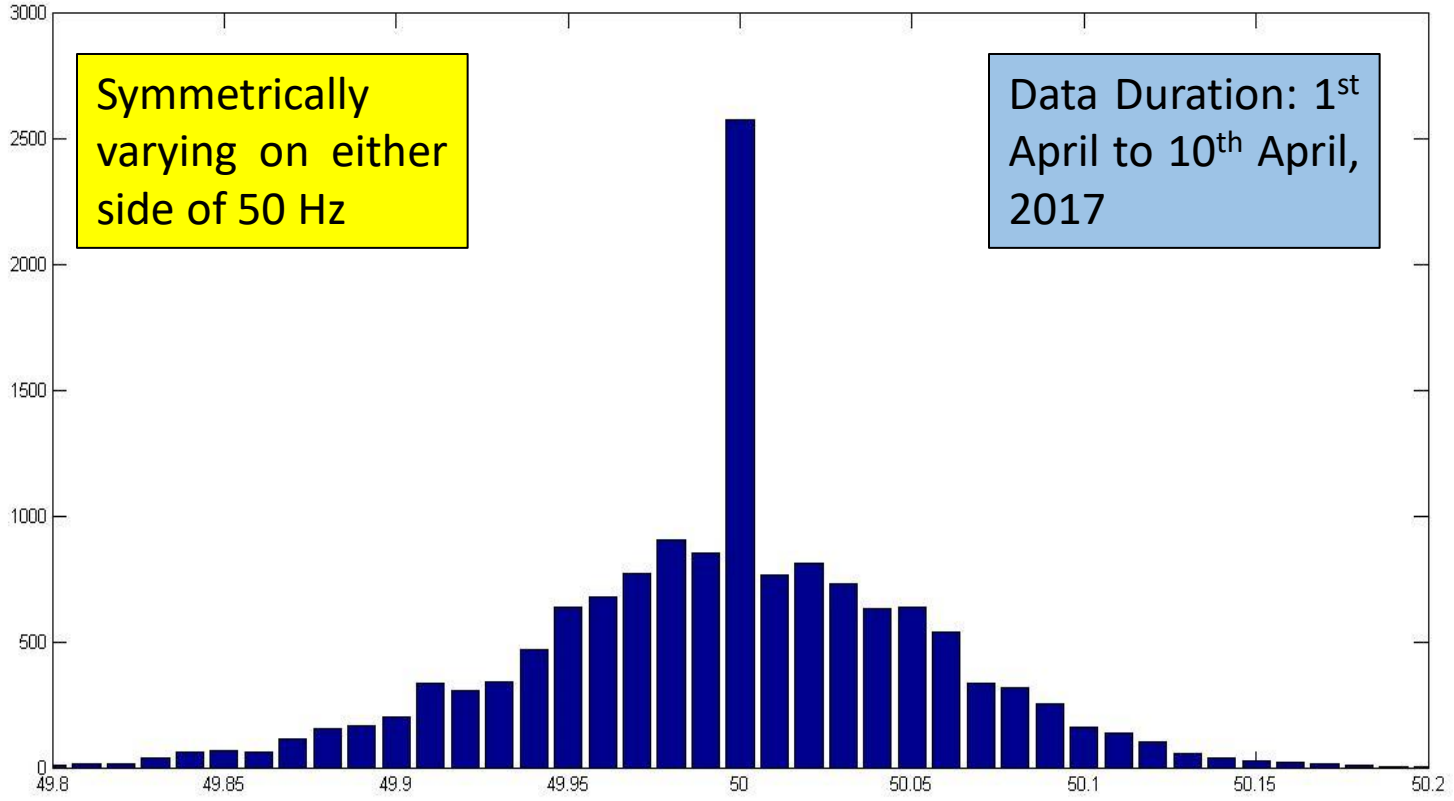
Rated DoD: 70%

Learnings

- Preparation of Technical Specification
- Life cycle of the battery
- Global standards for safety, testing etc.

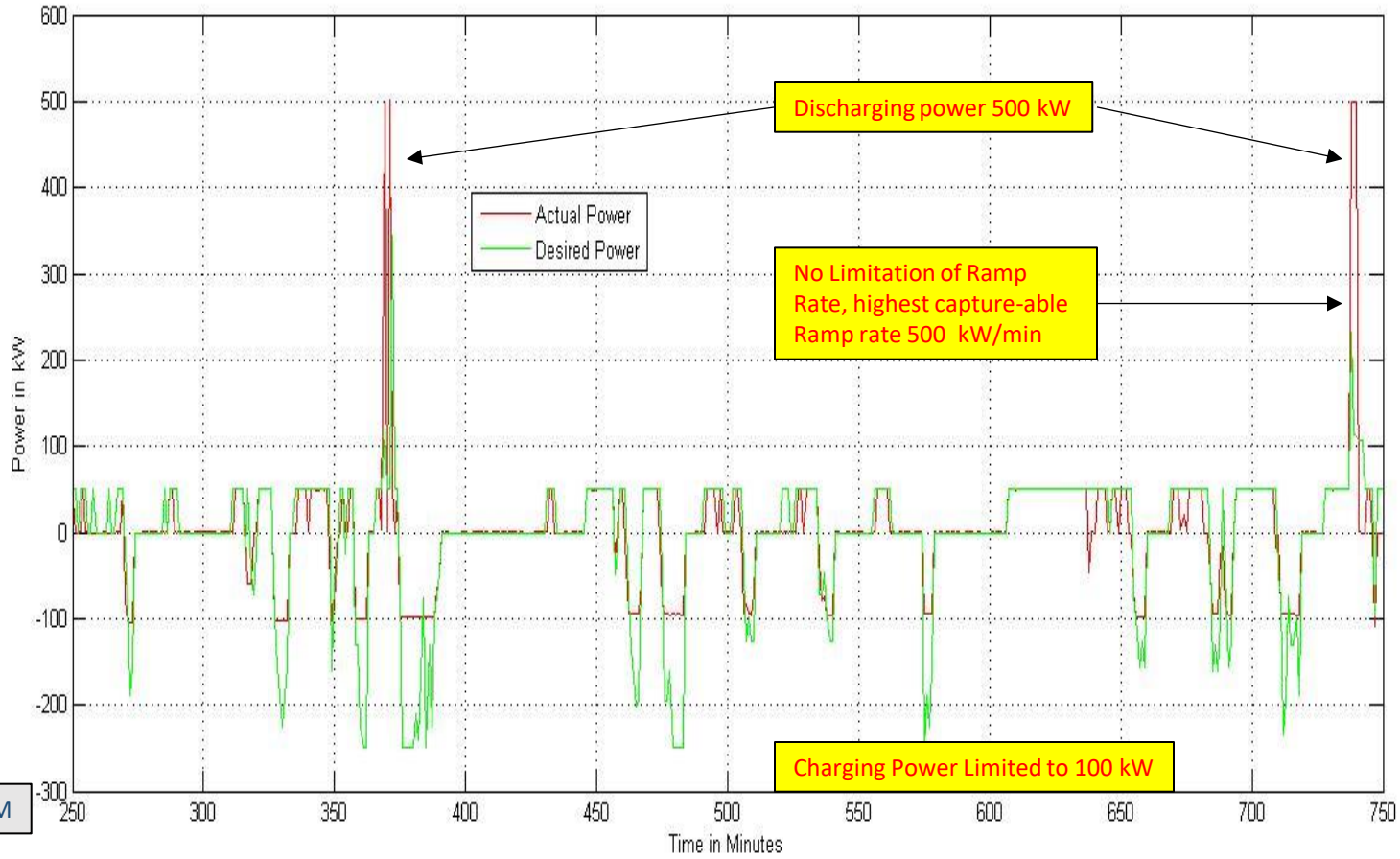
Parameter	Advanced Lead Acid	Lithium Ion
Delivered Size	250 kWh, 500 kW	250 kWh, 500 kW
Design Sizing	691.2 kWh	398 kWh
Nos. of Cells	600 nos.	1728 nos.
Rated DoD	65%	70%
Battery Footprint	One 40 ft. and one 20 ft. Container **Area Foot print: 45 sq. m.**	One 40 ft. Container **Area foot-print: 30 sq. m.**
Cost	-	1.5 times than Advanced Lead Acid

Histogram of Frequency of Indian Grid



Total Data Points	Number of 50 Hz points
14400	2572 (17.8%)

Power Desired and Power Actual: Analysis on Data of 1st April, 2017

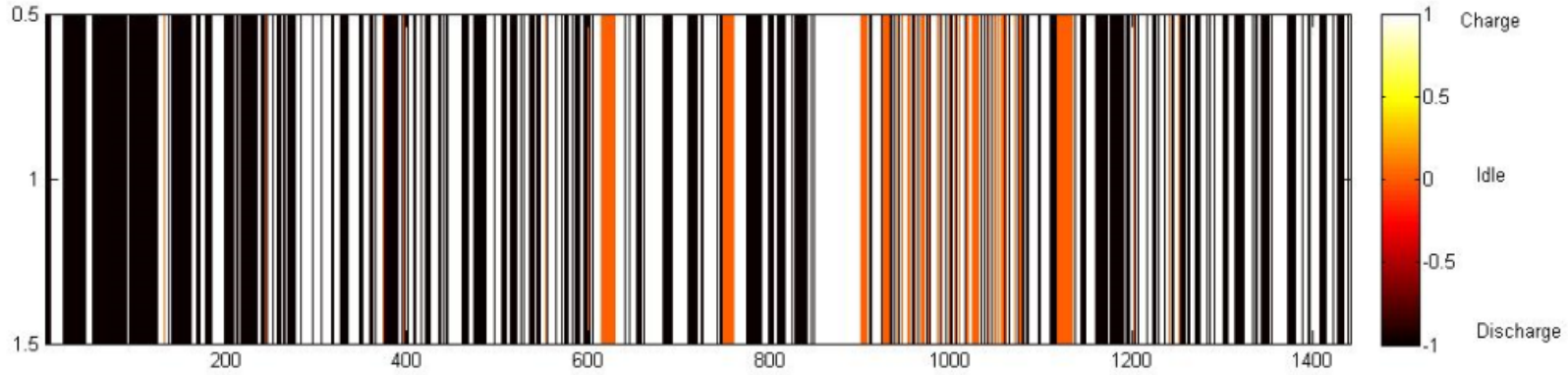


4.10 AM

12.30 PM

Charging and Discharging Characteristics should be symmetrical as the frequency histogram is symmetrical

Charge, Discharge and Idle Time of Battery: 1st April 2017



Discharging of Battery during night

Charging and idling during afternoon

Discharging of Battery during evening

Charging Time	Discharging Time	Idle Time
45.63%, 11 hrs	46.04%, 11 hrs	8.33%, 2 hrs

Frequency Regulation Operation

Frequency Regulation Operation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Power Grid Corporation Of India Ltd
Puducherry
प्रायोगिक परियोजना
Pilot Project
बैटरी ऊर्जा भंडारण प्रणाली
Battery Energy Storage System


Narada
Exicom
litlium-ion battery Energy Storage System
पावरग्रिड


Narada
Exicom
Advanced Lead Acid Battery Energy Storage System


Narada
Exicom
Storage Capacity: 250kWh
Rated Power: 500KW


Narada
Narada
Narada


पावरग्रिड