



भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
नवीकरणीय ऊर्जा उद्भव विकास प्रभाग
Renewable Energy Source Development Division
*** ** ***

No. CEA/Plg/RES-30/2017

Dated: 14-07-2017

विषय: नवीकरणीय ऊर्जा स्रोतों के ग्रिड में एकीकरण को सुविधाजनक बनाने के लिए विभिन्न प्रकार के ऊर्जा स्रोतों / ऊर्जा भंडारण उपकरणों के अनुकूलतम स्थापन के अध्ययन और संबंधित मुद्दों के लिए सीईए द्वारा गठित तकनीकी समिति की चतुर्थ बैठक का कार्यवृत्त (मिनट्स) .

Subject : **Minutes of the Fourth Meeting of the Technical Committee constituted by CEA for study of optimal location of the various types of balancing energy sources / energy storage devices to facilitate grid integration of Renewable Energy Sources and associated issues – reg.**

महोदय/Sir,

Minutes of the **Fourth Meeting** of the Technical Committee on the subject held on **13th June, 2017 at NRPC, New Delhi**, under the Chairmanship of **Member (Planning), CEA**, are enclosed herewith for your kind information and further necessary action.

Copies of the presentations made during the meeting are being sent on emails only.

एन आर पी सी, नई दिल्ली में 13 जून, 2017 को सदस्य (योजना), के. वि. प्रा. की अध्यक्षता में आयोजित उपरोक्त विषय पर तकनीकी समिति की चतुर्थ बैठक के मिनट्स (कार्यवृत्त) आपकी जानकारी और आवश्यक कार्रवाई हेतु संलग्न हैं।

बैठक के दौरान की गई प्रस्तुतियों की प्रतियां केवल ईमेल पर भेजी जा रही हैं .

कृपया पत्र की पावती दें/ Kindly acknowledge the receipt of the letter.

भवदीय/Yours faithfully

अशोक कुमार राजपूत/(Ashok Kumar Rajput)

Chief Engineer(RES Dev.)

Convener and Member Secretary

Email: ceaopmwind@gmail.com

Phone : 011-26714324 /26732257 (M) – 9868202176

1. Sh. Hanumantharayappa, Chief Engineer, Elecyc, (Planning & Co- ordination), KPTCL
2. Sh. P. Suresh Babu, Chief Engineer, SLDC & Telecom, TSTRANSCO
3. Sh. B.B. Mehta, Chief Engineer, State Load Despatch Centre, Gujarat
4. Sh. A K V Bhaskar, SE, State Load Dispatch Centre, A.P. Transco
5. Sh. P.A.R. Bende, Chief Engineer, SLDC, MPPTCL
6. Sh. Manoj Kumar, General Manager (BD&JV), NHPC Ltd.
7. Sh. Atulya Kumar Naik, AGM (Power Systems), SECI
8. Dr. P.C. Maithani, Adviser and Sh. J. K. Jethani, Scientist-D, MNRE
9. Dr. Subir Sen, COO (CTU-Pig & SG), CTU/Powergrid
10. Sh G. Chakraborty, DGM, NLDC (POSOCO)
11. Sh. S.S. Mishra, AGM (PE-Solar), and Sh. A.K. Sinha, AGM (OS-SIIS), NTPC Limited
12. Chief Engineer (IRP), CEA
13. Chief Engineer (PSP&A-I), CEA
14. Chief Engineer (PSP&A-II), CEA
15. Chief Engineer (HE&TD), CEA
16. Chief Engineer (TE&TD), CEA
17. Chief Engineer (GM), CEA
18. Chief Engineer (FM), CEA
19. Chief Engineer (F&CA), CEA
20. Secretary, CERC, New Delhi.
21. Member-Secretary (NRPC, WRPC, SRPC, ERPC & NERPC)

Copy for kind information to:

- 1) PPS to Secretary (Power), New Delhi
- 2) PPS to Secretary (MNRE), New Delhi
- 3) PPS to Joint Secretary (R&R), Ministry of Power, New Delhi
- 4) Joint Secretary (Dist), MoP, New Delhi
- 5) SA to Chairperson, CEA,
- 6) SA to Member (Hydro), CEA
- 7) SA to Member (GO&D), CEA
- 8) SA to Member (Power System), CEA
- 9) SA to Member (E&C), CEA
- 10) SA to Member (Thermal), CEA
- 11) Sr.PPS to Member (Planning), CEA

Minutes of the Fourth Meeting of the Technical Committee held on 13th June, 2017 under the chairmanship of Member (Planning), CEA for study of optimal location of the various types of balancing energy sources / energy storage devices to facilitate grid integration of Renewable Energy Sources (RES) and associated issues

The **fourth meeting** of the Technical Committee constituted by CEA for study of optimal location of the various types of balancing energy sources / energy storage devices to facilitate grid integration of Renewable Energy Sources (RES) and associated issues was held under the Chairmanship of **Shri Pankaj Batra, Member (Planning), CEA**, on **13th June, 2017 (Tuesday) at NRPC, New Delhi**. The meeting was organized for deliberating specifically the issues concerning the **States of Northern Region**. List of participants is at **Annexure-1**.

Shri A K Rajput, Convener and Member Secretary of the Committee and Chief Engineer (RES), CEA welcomed **Member (Planning), CEA** and all the participants. He made a special mention about inviting **BBMB, SJVN and THDC India LTD (THDC)** for the meeting. He stated that these PSUs having Hydro Power Plants located in Northern Region (NR) have been invited to share their experiences that how these hydro resources, including the Pumped Storage Plant (PSP) could be optimally utilized for balancing power requirement in view of the increasing penetration of Renewable Energy Generation Sources (RES). Brief agenda for deliberations in the meeting was presented.

Member (Planning), CEA and Chairman of the Committee was requested to address and guide the participants.

Shri Pankaj Batra, Member (Planning), CEA stated that along with various issues of RE integration in the grid, the Committee is also deliberating on the issue of optimal use/location of the various types of balancing energy sources / energy storage devices so that variability of RE generation could be tackled in a smooth fashion. There could be various types of balancing sources including the Battery Energy Storage system (**BESS**). BESS of adequate capacity could be installed near the RES pooling station to relieve the transmission system. Depending upon the feasibility, balancing power could be sourced from storage / pondage type of hydro power plants, gas based power plants and also from thermal power plants (TPPs) depending upon response time.

Pumped storage power plants (PSPs) offer the unique advantage of acting as a load in the pump mode by raising the water to upper reservoir during times of surplus power and running in generating mode during times of deficit power situation in the grid, similar to BESS.

The Chair stated that a Policy Note on Gas has also been sent to MoP for use of the stranded gas based power plant capacity for “**balancing power**” needs. One start-stop cycle of the gas based plants affects its life by about 10 Equivalent Operating Hours (EOH), so instead of running all gas plants during peak time and shutting them down all during “off peak” hours, some plants could be used for balancing during the day i.e. in “load following mode,” providing various outputs.

The Chair stated that the ramp rate for gas based plants could be about 10% per minute as compared to 1-1.5% per minute of rated capacity of thermal

power generating units. This flexibility could be utilized for ramping requirements. If required, existing thermal power units can also be made to operate in flexible manner through appropriate retrofitting. The Committee has to assess whether balancing requirements could be met within the State Level, or Regional Level or by utilizing the balancing resources of the entire country or also of neighboring Countries like Bhutan and Nepal, which have substantial hydro resources/reserves. There is a need to socialize the cost of balancing, otherwise RE rich States may be discouraged to put more RE capacity in the system, which is essential from clean energy point of view. Under the “Green Corridor Development (**GCD**)” plans transmission system strengthening has been planned and in some states, the work has started. **The Chair** stated that before actual implementation of the transmission system strengthening, a cost benefit analysis of strengthening of transmission system versus establishment of local storage device near RE generators pooling station should be carried out, to optimize the transmission system needs.

Member Secretary, NRPC shared his experience of Sardar Sarovar Hydro Project (SSHP). He mentioned that about 75% of energy used for pumping is recovered when required during generation. Formation of Joint Venture (JV) by different entities is also a good option for establishment of PSP, and balancing power requirement could be shared by the entities. He also stated that accuracy of forecasting and existence of scheduling for renewables is important in managing the variability of RES.

SE (REMC, Rajasthan) stated that for promoting RE generation and to attract investment in this field, the Rajasthan Govt. has announced Wind and Solar policies. He made a presentation, highlighting the composition of generating sources, poor availability of gas for gas based plants, generation availability from RE sources and operational aspects of RES in the state. He stated that Rajasthan is working out arrangements for improved availability of data from RES on a regular basis at the pooling station and transmission of their data to SLDC. Rajasthan has huge potential of Renewable Energy Sources in its western part, but the load center is in the eastern part. Rajasthan Renewable Energy Corporation Limited (RRECL) has set the targets for solar and wind projects in Rajasthan of about 27231 MW upto 2021-22. RVPN will develop transmission system for evacuation of 13000 MW RE power. PGCIL will develop Inter-state Transmission System (ISTS) for evacuation of balance 14000 MW RE power which would be exported. Work of establishment of Renewable Energy Management Centre (REMC), at the State Load Despatch Centre (SLDC) has been initiated. During periods of high wind power injections, the loading on some of the lines are observed on the higher side. Challenges faced by them during system operation are:

- a) RE is variable, uncertain and geographically concentrated in western part of the state, load centres are in the eastern parts.
- b) Availability of data from RES in real time mode is of vital importance for smooth operation of the grid.
- c) Forecasting and Scheduling regulations are not in place in the state.
- d) Balancing mechanism needs improvement.
- e) Sudden change in wind energy injection leads to under drawl (UD)/over drawl (OD) situation.

- f) Frequent ramping up/down of thermal units is resorted to, causing excess wear and tear.

In Rajasthan total installed capacity as on 30th April 2017 is 18710.69 MW of which 4121.20 MW is wind and 1229.70 MW is solar. Annual capacity utilization factor (CUF) of Wind power stations is 25%. He stated that in case of Rajasthan, for RE balancing, Hydro Power is not preferred as its generation is based on irrigation requirement. Gas also has issues if used as balancing source, because gas availability is a constraint. In Rajasthan Gas is arranged through monthly or yearly contracts .

Rajasthan stated that the Gestation period for Wind farms/Solar Parks is 3 to 4 months and Construction of the transmission system takes 2 to 4 years, till the planned transmission system is commissioned, evacuation constraint is envisaged. At the same time there are right of way (RoW) constraints also. Transmission network is sub-optimally utilized and also congestion is faced in transmission/distribution network. It was also stated that in order to control Over-drawl/Under-drawl, there is a need to enhance gas & hydro based generation.

Financial Aid should be facilitated by MOP for the balancing power needs. For compliance of deviation settlement Mechanism (DSM), he suggested for enhancement of OD/UD limit by CERC for the states rich in RE generation and the states having high demand, condition of change in direction (positive or negative) after 12 blocks be exempted or time period be increased.

For Balancing of Renewable Generation, the following options were presented by Rajasthan:

- a) During High Wind power Injection and low demand period- Consideration of Incentive to agriculture and bulk consumers to use energy.
- b) To utilize variable range of thermal generation units, without adverse effect.
- c) For RE approvals/ connectivity - Strict compliance of regulation and adequate evacuation system.
- d) Availability of RE generators telemetry data especially at voltage level 33 kV and below.
- e) Rajasthan Electricity Regulatory Commission (RERC) has notified draft Regulation on Forecasting, Scheduling and Deviation settlement of Wind and Solar Generators, which should be finalized soon.
- f) Promote wind-solar hybrids for better utilization of grid infrastructure, grid stability and lowering of intermittency.

The presentation made by Rajasthan is at **Annex-A**.

Representative from **PGCIL** mentioned that voltage profile of transmission system in Rajasthan is a major issue and also the old wind turbine installations are not Low Voltage Ride Through (LVRT) compatible.

The Chair stated that Rajasthan should suggest location of Energy Storage Systems where congestion is maximum, so that a pilot project can be taken up. It was also suggested that action need to be taken by Rajasthan for

availability of data at RE generating pooling stations and transmission of the same to SLDC.

Referring to establishment of communication network for data availability **CE(PCD), CEA** informed that Government of India is setting up **National Optical Fiber Network (NOFN)** to provide connectivity to 2.50 lakh Gram Panchayats (GPs) spread over 6600 Blocks in 641 Districts across the Country. Minimum 100 Mbps bandwidth at each Gram Panchayat is proposed. The NOFN Scheme is being implemented through **BBNL (Bharat Broadband Network Limited)**, which has been set up as a Special Purpose Vehicle (**SPV**) by Government of India. The programme has been divided in two phases, with a target to cover 1.0 lakh Gram Panchayats in First phase and 1.5 lakh Gram Panchayats in Second phase. So far, work in Phase-I is almost complete. Phase-II of 1.5 lakh Gram Panchayats are targeted for completion by December, 2018. The implementation of Phase-II of **BharatNet** (erstwhile NOFN) is being envisaged through participation of States Governments. States would prepare Detailed Project report (DPR) and accordingly fund would be released to the State Govts. It was also clarified that while laying optical fiber from a Block to Gram Panchayat (GP), in case substation is located in between, then the optical fiber can be routed through the substation. If, while laying underground optical fiber cable, right of way (ROW) is an issue then electric poles can also be used for stringing aerial fiber. He stated that Andhra Pradesh was planning to lay 61,000 kms of optical fiber underground cable in association with NOFN (National Optical Fiber Network) using **USOF** (Universal Service Obligation Fund). The estimated cost is Rs 4700 Cr (Rs 3800 Cr from Central + Rs 900 Cr from State).

CE(PCD), CEA suggested that the State Govt while connecting Block with GPs may consider integrating Discoms electrical network. Even in case, the Discoms' 11 kV or 33 kV or 66 kV substations do not fall in the route, the connectivity to such substations could be made from nearest fiber **POP** (Point of Presence), by laying incremental fiber. In this way, though the State Discoms may incur some additional cost, but it would benefit them to have fiber connectivity at most of the locations, which in turn could be connected to the nearest 132 kV level. As MOP is envisaging complete optical fiber connectivity at 132 kV and above voltage level, dovetailing of Discoms' electrical network with BharatNet fiber network would help the State Power System to have fiber connectivity up to distribution level.

The Chair stated that considering the importance and need of reliable communication, particularly when large numbers of renewable energy sources are being integrated into the grid, a separate meeting only on data communication aspects will be held.

CE (IRP), CEA gave a presentation highlighting the different aspects of RES penetration in the Indian grid in 2021-22 scenario. He suggested that, in order to develop a better understanding of the impact of RES in the state grid, the RE rich States of India should develop the following:

- i) The **Hourly Load Curve** for the entire year
- ii) The **Hourly Generation Profile** of wind and solar in the state for all the 8760 hours(24X365) of the year.
- iii) The **Net Load Curve** and **Duck Curve** for each day of the year.
- iv) The **ratio of minimum load and maximum load** of the net load curve for each day of the year and thereafter, identifying the **critical**

period in the year when the backing down requirement would be maximum.

- v) The **expected daily and yearly contribution of energy** by the different categories of RES.
- vi) **Hourly/sub-hourly Ramping Duration Curve** for the whole year.
- vii) A separate **Generation Duration Curve** for both solar and wind for the year.
- viii) **Distribution Curve for Daily Peak Generation** for Solar and Wind
- ix) The **Combined Solar and Wind Generation Distribution Curve** for the whole year.
- x) **Segregation of the entire year suitably into different seasons** and finding out the **critical days in each season** and during generation planning for the critical period.

He suggested that, by analyzing the above curves, the State will be having a better visibility regarding the roles and impact of RES at different times of the year. This would also help in doing advance planning by the states.

The Representative from **NRLDC** apprised the group about the weather forecasting system and portal developed with the help of India Meteorological Department (IMD). MOU to this effect was signed on 18th May, 2015 between India Meteorological Department (IMD) and Power System Operation Corporation (POSOCO) with the objective that "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 has been developed using readily available products of IMD for all 5 regions of the Country. Meteogram is used for forecast of rainfall, humidity, temperature, cloud cover, wind, wind direction, thunderstorm etc. in graphical representation (10 days in advance). It is 3 hourly forecast for 10 days. Each Meteogram provides information for 10 km radius and is updated at 00:00 Hrs and 12:00 Hrs universal time coordinated (**UTC**). **To obtain local time (IST)** in India, we need to add 5 hours and 30 minutes to the Coordinated Universal Time. There is a need to customize the portal for indicating Indian Standard Time (**IST**).

RADAR: Radio Detection and Ranging system is also being used for prediction of weather conditions. The Doppler Weather Radar generates different displays and derived products of practical utility based on standard algorithms. These displays are updated @ every 10 minutes.

The 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

The presentation made by NRLDC is at **Annex-B**.

THDC made a presentation on "*Need of Hydro Power Revival and its Role as Balancing Energy Source*." They highlighted that in view of intermittency of RE, balancing power needs are inevitable. It was stated that the bulk grid supports and is supported by conventional rotating generators (Coal, gas, hydro, nuclear) which provide "Essential Reliability Services" (ERSs). 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. Hydropower is mature and cost

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

THDC presented the Role of Tehri Power Complex in Northern Grid with following highlights:

- Tehri Power Complex consists Tehri HPP(4X250MW), Koteshwar HEP(4X100MW) and Tehri PSP(4X250MW). Tehri HPP & Koteshwar HEP Tehri 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 with least forced outage, which shows high reliability. In last five years, they successfully limited the forced outages within 0.4% by adopting best O&M practices.

THDC also presented the salient features of two of its Wind power installations located in Gujarat.

To revive Hydro Power sector, the following suggestions were made by **THDC**:

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

They informed that PSP is to be commissioned by 2020, which can be used for balancing of RES. He said that hydro can play a critical role in balancing as it can ramp up quickly and is also environmentally sustainable. He said that Tehri is a storage type hydro plant. In the rainy season, it overflows and Koteshwar is a downstream dam used as pondage. He also informed that capital cost of Tehri PSP is as low as Rs.1.9 crore/MW. FRL- for dam is 830 m and MDDL is 740 m. This helps the plant to store energy during off-peak hour and generate when required. The machine can have finer control of frequency and high inertia helps to provide transient stability to the grid. The presentation made by THDC is at **Annex-C**.

The Chair informed that Hydro, as balancing source, will be used during summer and winter since in the monsoon season it may be overflowing. He requested THDC to do a study on the coordinated operation of reserves for the Tehri Complex.

Representative from **BBMB** informed that there are downstream constraints to supply water to Anandpur Sahib canal. They have 155 MW installed generating capacity on canal which is must run. The views of BBMB is at **Annex-D**.

The Chair made a remark that the CERC Regulations states that in the case of a pumped storage plant, energy had to be supplied by the beneficiary for pumping to the extent of its share, 75% of which could be retrieved by the beneficiary, during a period of its choice. However, it was not clear for how much time the pumped water could be stored. He also mentioned that the evaporation and transportation losses need to be considered. He suggested a **specific meeting to discuss the issues of operationalization of PSPs be scheduled separately**. He also suggested that in order to compensate for spinning reserve, in ancillary services Regulations, some incentives need to be given to the generators who are participating in balancing services.

Formation of a Committee under **Member Secretary NRPC, CEA** alongwith concerned hydro plants for **integrated operation of reservoir was suggested**. The Representative from **NTPC** made a presentation on study of thermal plant flexible operation. He mentioned that 25-30 parameters need to be considered and their weighted average can give an idea about the suitability of the plant to be used for balancing. He stated that old plants can be used for flexible operation after retrofitting. Boiler will need more changes as compared to turbine. Thicker water tubes mean more stresses therefore thinner tubes are required. The minimum load for which a subcritical plant can be used for flexible operation will depend on the quality of coal being used. For thermal power units, minimum cycling cost is incurred for "load following" and maximum cost for "cold start." This analysis is based on a study carried out in Germany on German machines. He also requested for details of simulator available with various stakeholders, so that specific changes can be made to incorporate balancing features for training of operators, under the capacity building programme.

NTPC stated that there is Cost of cycling to Generating Companies and proper mechanism to recover these costs is necessary to maintain the financial sustainability of the Generating Companies. The presentation made by NTPC is at **Annex-E**.

Making a presentation on the pilot project in Puducherry, **PGCIL** representative brought out a comparative study of **Li-Ion battery, Flow battery and Advanced Lead Acid battery** on various parameters. The presentation made by PGCIL is at **Annex-F**.

The Representative from CERC wanted the following to be addressed:

- 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.
- International experience may be assessed

- Whether plants proposed to be retired can be used for balancing requirement

PSERC representative put forward his concern about higher cost of power for some states. He stated that states which are contributing more in Hydro power need to be compensated. The penalties faced by states for short lifting of coal also need to be considered.

Representative from **MP SLDC** suggested that new plants to be constructed in the same place replacing the old ones.

Summing up the discussions, **Member (Planning), CEA** stated that the concerns of all the states will be taken care of, but they should also try to look at the bigger picture since a comprehensive approach is required. In the long run, RES is the best solution for our energy mix. The best part is that the demand is growing in our country, so with economies of scale and increasing competition, between different energy sources, the cost of RES generation would drop, while that of coal and associated labour will continue to increase. He stated that **Demand response** is one of the best methods for balancing renewable generation. As an example he stated that Mumbai uses demand response in a pilot project. For automated demand response use of smart meters would be required.

The Meeting ended with the vote of thanks to the chair.

Annex-I

List of Participants- Fourth Meeting of the Technical Committee held on **13th June, 2017** under the chairmanship of Member (Planning), CEA for study of optimal location of the various types of balancing energy sources / energy storage devices to facilitate grid integration of Renewable Energy Sources and associated issues

4th Meeting of the Technical Committed on Optimal Location of Balancing Sources Participant List						
S.N	Name	Desgination	Office Address	Ph.No./Fax No	Mobile No	Email Id
1	Sh. Pankaj Batra	Member (Pgl)	CEA	011-26732202	9350981062	pan-batra@hotmail.com ,
2	A.K.Rajput	Chief Engineer	CEA	011-26732020	9868202176	rajput.ashok@gmail.com ,
3	L.Satyanarayana	Dy.Director	CEA	011-26732256	9818327046	lsn262003@yahoo.co.uk
4	Sneha	AD	CEA	011-26732255	9013213867	snehabit@gmail.com
5	Hoshiyar Singh	D.E.O	CEA		9911118997	hoshiyarsingh393@gmail.com
6	Rakesh Singh Powar	DD	THDC India Ltd.		7895507755	rakeshpanwarzero@gmail.com ,
7	Alok Kumar	CE	NRLDC		9999039321	alokkumar73@gmail.com ,
8	Paresh Khandelwal		NRLDC		9599225907	presh26d@gmail.com ,
10	Manoj Sardana	Dpty Director	THDC India Ltd.	011-24366117	9650493650	manoj_sardana@yahoo.com ,
11	Neeraj Verma	DGM	THDC India Ltd.	0135-2473433	9997999111	neeraihdcc@gmail.com
12	Tarun Mukhija		SECI	011-71989283	8881100009	tarun.mukhija@seci.co.in ,
13	Atulya Kumar Naik	Addl. Gen. Manager (PS)	SECI	011-71989214	9717954896	aknaik@seci.co.in ,
14	Kashish Bhambhani		Power Grid Crop.		9971399117	kashish@powergridindia.com ,
15	Rajesh Kumar		Power Grid Crop.		9811397471	rajeshkumar@powergridindia.com ,
16	G. Chakrobarty	Dy.GM	POSOCO		9433041815	gchakrobarty@posoco.in ,
17	Ammi R Toppo	Director	CEA			ceirpcea@yahoo.com ,
18	Er. Asha Saini	CE/SO	BBMB		9417216058	ceso@bbmb.nic.in ,
19	Anil Gatum		BBMB		9417216047	dirpr@bbmb.nic.in ,
20	Sanjay Kr. Sharma	Joint Director	DERC		9717694965	jdps@dere.gov.in ,
21	parshant Kumar	Joint Director	DERC		9810866555	jdft@dere.gov.in ,
22	Er. S.K. Jain		PSERC Chandigarh		9646118103	directorreg@psercchd.com ,
23	Mohan Salm		SLDC MPPTCL Jabalpur		9425805027	mohansalm@yahoo.com ,
24	U.K.Nand		NHPC, Fridabad		9810603804	ukn@nhpc.nic.in ,
25	Manoj Kumar		NHPC, Fridabad		7579455850	mkumar@nhpc.nic.in ,
26	Rajesh Dangi	Director/Engg.	JERC, Gurgoan		8725011401	directore@gmail.com ,
27	S.K. Gupta		SECREM & RVPNL Jaipur		9414063333	skvijay012@gmail.com ,
28	Shilpa Agarwal	joint Chief (Engg)	CERC	011-23353503	9650992680	shilpadce@yahoo.com ,
29	Vikram Singh	Director	CEA	011-26109168	9868893051	vikramsinghfm@gmail.com ,
30	Joydeb Bandyupadhyay	CE	CEA	011-26132220	9990158192	ceirpcea@yahoo.com ,
31	MAKP Singh		NRPC		9425066437	makpsingh@yahoo.com ,
32	Manish Gaur	AEN (REMC) RVPN	REMC,RVPN,Jaipur		9414014304	id.gaur@gmail.com ,
33	Smjash Ayush Yanmar		CEA		7838308846	smyash.ayush.verma@gmail.com ,
34	Dr. L.D.Parpney	CE	CEA		9968308829	ldparpney@gmail.com ,
35	T. Venkateswaser	Director	CEA		8800688776	venkat_talluri@nic.in ,
36	A.K.Sinha	AGM	NTPC		9650992971	anjansinha01@ntpc.co.in ,

List of Addresses - Members of the Technical Committee and other concerned

Sl. No.	State/Utility	Name of the Nominated Officer	Designation, Address & Contact details	Mobile No.
1.	Karnataka	Sh. Hanumantharayappa	Chief Engineer, Elecy, (Planning & Co-ordination),Karnataka Power Transmission Corporation Ltd. (KPTCL), Room No.209, 2 nd Floor, Kaveri Bhavan, Bengaluru-560009. ccepn@gmail.com , Fax.No.080-22292204. Ph.: 080-22210416	9448363092
2.	Telangana	Sh. P. Suresh Babu	Chief Engineer, SLDC & Telecom, Room No:611, A Block , TSTRANSCO, Vidyut Soudha, Khairatabad, Hyderabad- 500 082. cesldctelangana@gmail.com , Ph. : 040-23317645	9440679432
3.	Gujarat	Sh. B.B. Mehta	Chief Engineer ,State Load Despatch Centre, Gujarat Energy Transmission Corporation Limited, 132 kV Gotri Sub Station Compound, Near T.B. Hospital, Gotri Road, Vadodara – 390 021 celd@gebmail.com , Tel.No.0265-2353171	9879200736
4.	Andhra Pradesh	Sh. A K V Bhaskar.	SE, State Load Dispatch Centre, A. P. TRANSCO, Hyderabad akvbhaskar@gmail.com , Ph:040-66175195 Fax: 040-66175194	9490153116
5.	Madhya Pradesh	Sh. P.A. R. Bende	CHIEF ENGINEER (LD) STATE LOAD DESPATCH CENTRE, OFFICE OF MPPTCL, NAYAGAON, RAMPUR, JABALPUR – 482 008 (M.P.) (0761)2970089 Fax: (0761) 2664343/2970119 sldcmpjbp@gmail.com , parbende@gmail.com ,	9425805264
6.	Rajasthan	Sh S K Gupta	Sh S K Gupta SE (REMC), Rajasthan Rajya Vidyut Prasaran Nigam Ltd., Heerapura GSS, Ajmer Road, Jaipur Tel. No. 0141-2251601 9414061519 ce.ld@rvpn.co.in , aks4Oaks@gmail.com , se.remc@rvpn.co.in , Tel. No. 0141-2251601	9414063333 8233664841 9414061519
7.	Maharashtra	Dr. S.S. Kulkarni	Chief Engineer (SLDC), Maharashtra State Electricity Transmission Co. Ltd., Mumbai cesldc@mahasldc.in , Tel. No. 022-27601931	9819363329
8.	Tamil Nadu	Er. A. Axilium Jayamary,	Director /Operation, TANTRANSCO directoropn@tnebnet.org ,	044-28521088
		Sh. P.R. Muralidharan	Superintending Engineer, Renewable Energy Management Centre, SLDC, Chennai-260002	9445377059

			seremc@tnebnnet.org	
		Sh. P. Rajagunanidhi	P.RAJAGUNANIDHI,, Executive Engineer, Grid, SLDC, TANTRANSCO,CHENNAI. eegrid@tnebnnet.org , rajaqunanidhi@yahoo.co.in , Chennai-260002	9445857186, 04428586433
		Ms. S. Gomathi	Executive Engineer, Renewable Energy Management Centre, SLDC, Chennai aeceremc@tnebnnet.org ,	9444203708
9.	NHPC	Sh. Manoj Kumar	General Manager (BD&JV), NHPC Ltd., NHPC Office Complex, Sector-33, Faridabad-121003. mkumar@nhpc.nic.in , Ph. : 0129-2278430	7579455850
10.	SECI	Sh. Atulya Kumar Naik	AGM(Power Systems) aknaik@seci.co.in , Fax No.011-71989235 Ph.No. 011-71989214	9717954896
11.	MNRE	Dr P C Maithani, Adviser & Sh. J.K. Jethani, Scientist-D	Ministry of New and Renewable Energy, 14 th Block, CGO Complex, Lodhi Road, New Delhi-110001 pcmaithani@nic.in , jethani.jk@nic.in , Tel./Fax. 011-24368911	9891184867
12.	Power Grid/CTU	Dr. Subir Sen,	COO (CTU-Plg & SG) Power Grid Corporation of India Limited (PGCIL) Saudamini, Plot No.2, Sector 29, Near IFFCO Chowk, Gurgaon (Haryana) - 122001, INDIA Fax 0124-2571990 Tel: 0124-2571700-719 / 011- 26560072 subir@powergridindia.com ,	9650293185
13.	POSOCO	Sh. G Chakraborty	DGM, National Load Despatch Centre (NLDC), B-9, Qutab Institutional Area, Katwaria Sarai, New Delhi-110016 gchakraborty@posoco.in , c.goutam62@gmail.com ,	9433041815
14.	NTPC	Sh. S.S. Mishra	AGM (PE-Solar), NTPC Limited, EOC, Sector-24, Noida ssmishra@ntpc.co.in ,	9650991145
		Sh. A.K. Sinha	AGM (OS-SIIS), NTPC Limited, Core-7, Scope Complex, Lodhi Road, New Delhi anjansinha01@ntpc.co.in ,	9650992971

Chief Engineers of CEA, {IRP, SP&PA – I &II, HETD, TETD, GM, FM, F&CA}

Co- opted Members from Regional Power Committees and CERC

<p>Representative from CERC C/o Secretary, CERC Central Electricity Regulatory Commission (CERC), Chanderlok Bldg., 3rd & 4th Floors, West Wing, 36, Janpath, New Delhi – 110 001 (Phone: 011-23753915) Fax No.011-23753923 secy@cercind.gov.in, cerc.ra@gmail.com,</p>	<p>Sh S R Bhatt Member Secretary Southern Regional Power Committee, No. 29 Race Course Cross Road Bangalore-560 009 Tel: 080-22269012 Mob.: 09620184649 Fax : 080-22259343/ 22352616 mssrpc@yahoo.com,</p>
<p>Sh M A K P Singh Member Secretary Northern Regional Power Committee 18-A, Qutab Institutional Area, Shaheed Jeet Singh Marg, Katwaria Sarai, New Delhi-110 016 Tel: 011-26511211 Mob.: 9968667741 PABX No. 26967842/26868681 Fax : 011-26865206 PABX No. 26967842/26868681 #101 Fax : 011-26865206 msnrpc1@yahoo.com, ms-nrpc@nic.in,</p>	<p>Sh P K Mishra Member Secretary North Eastern Regional Power Committee NERPC complex Dong Parmaw, Lapalang Shilling-793006 Meghalaya Ph: 0364-2534039 Fax:0364-2534040 Mob:9436163419 nerpc@ymail.com, b_lyngkhoi@yahoo.com,</p>
<p>Sh A Balan Member Secretary Western Regional Power Committee, F-3, MIDC Area, Marol, Opp. SEEPZ, Central Road, Andheri (East), Mumbai - 400 093 Mob.: 9483540528 Tel: 022-28221636 Epabx: 022-28200194-95-96#210 Fax:022-2837 0193 ms-wrpc@nic.in, ma_balan@hotmail.com,</p>	<p>Shri A.K. Bandopadhyay Member Secretary EASTERN REGIONAL POWER COMMITTEE 14, Golf Club Road, Kolkata -700 033 Tel: 033-24235016 (direct) Mob.: 9433068533 Fax: 033 24221802, 24171358 mserpc-power@nic.in,</p>

Addresses of SERCs/JERC

<p>Joint Chief (Regulatory Affairs), Forum of Regulators (FOR) C/O Central Electricity Regulatory Commission (CERC) 4th Floor, Chanderlok Building 36, Janpath, New Delhi 110 001 Tel: 91-11-23353503 Fax: 91-11-23753923 , dcra@cercind.gov.in,</p>	<p>Secretary, Gujarat Electricity Regulatory Commission, 6th Floor, GIFT ONE Road 5 C, Zone 5, GIFT City, Gandhinagar – 382355 (Phone: 079 23602000, /9909943568 Fax No.079-23602054/23602055 gerc@gercin.org, chairman@gercin.org,</p>
<p>Secretary, Madhya Pradesh Electricity Regulatory Commission 4th & 5th Floors, Metro Plaza, E-5, Arera Colony, Bittan Market, Bhopal 462 016 Ph: 0755-2464643/9425005834/2430158(fax) Secretary.mperc@gmail.com,</p>	<p>Secretary, Maharashtra Electricity Regulatory Commission 13th Floor, World Trade Centre No. 1 Cuffe Parade Colaba, Mumbai 400 005 Ph.:022-22163975 / 22163976 (Fax) secretary@mercindia.org.in,</p>

Secretary Power etc

secy-power@nic.in, secy-mnre@nic.in, pan-batra@hotmail.com,
i.arora@nic.in, arun.verma@nic.in, chair@nic.in, singhvi.cea@gmail.com,
kkarya_2001@rediffmail.com, kk.arya58@gov.in, balwan72@nic.in,
ravi2658@yahoo.co.in, re_cea@rediffmail.com, psmhaske@yahoo.com,
memberspscea@nic.in, somit.d@nic.in, somit.d@gov.in, aruncea@nic.in, pdsiwal@yahoo.com,
ashok1959@nic.in, ykashyap95@gmail.com, gulshannarang786@yahoo.co.in,
ceaopmwind@gmail.com, cerndcea@gmail.com, rstomer@nic.in, ceitcea@gmail.com,
itcea@nic.in,

Committee Members, MS RPCs

ceepnc@gmail.com , cesldctelangana@gmail.com , celd@gebmail.com , akvbhaskar@gmail.com , slcncmpjbp@gmail.com , parbende@gmail.com , ce.ld@rvpn.co.in , aks40aks@gmail.com , se.remc@rvpn.co.in , cesldc@mahasldc.in , directoropn@tnebn.org ,	seremc@tnebn.org , eegrid@tnebn.org , rajaqunanidhi@yahoo.co.in , aeremc@tnebn.org , mkumar@nhpc.nic.in , aknaik@seci.co.in , pcmaithani@nic.in , jethani.jk@nic.in , subir@powergridindia.com , gchakraborty@posoco.in , c.goutam62@gmail.com , ssmishra@ntpc.co.in ,	mssrpc@yahoo.com , nerpc@ymail.com , b_lyngkhoi@yahoo.com , msnrpc1@yahoo.com , ms-nrpc@nic.in , ms-wrpc@nic.in , ma_balan@hotmail.com , mserpc-power@nic.in , anjansinha01@ntpc.co.in , secy@cercind.gov.in , cerc.ra@gmail.com , ms-wrpc@nic.in , ma_balan@hotmail.com ,
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CEs of CEA

ceirpcea@yahoo.com
skrmohapatra@rediffmail.com
Ravindergupta_cea@rediffmail.com
ravindergupta_cea@nic.in
prabhatkureel@yahoo.co.in
prabhat.kureel@gov.in
ldpapney@gmail.com
cegmcea1@gmail.com
pranika30@yahoo.com
ajay.talegaonkar@gmail.com
ajay.talegaonkar@nic.in
ceaopmwind@gmail.com
nbnareshbhandari@gmail.com

Participants (fourth Meeting 13-06-217)

pan-batra@hotmail.com , rajput.ashok@gmail.com , lsn262003@yahoo.co.uk snehabit@gmail.com hoshiyarsingh393@gmail.com rakeshpanwarzero@gmail.com , alokkimar73@gmail.com , presh26d@gmail.com , manoj_sardana@yahoo.com , neerajthdc@gmail.com tarun.mukhija@seci.co.in , aknaik@seci.co.in , kashish@powergridindia.com , rajeshkumar@powergridindia.com , gchakraborty@posoco.in , ceirpcea@yahoo.com ,
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ceso@bbmb.nic.in,
dirpr@bbmb.nic.in,
jdps@dere.gov.in,
jdtf@dere.gov.in,
directorreg@psercchd.com,
mohanssalm@yahoo.com,
ukn@nhpc.nic.in,
mkumar@nhpc.nic.in,
directore@gmail.com,
skvijay012@gmail.com,
shilpadce@yahoo.com,
vikramsinghfms@gmail.com,
ceirpcea@yahoo.com,
makpsingh@yahoo.com,
id.gaur@gmail.com,
smyash.ayush.verma@gmail.com,
ldparpney@gmail.com,
venkat_talluri@nic.in,
anjansinha01@ntpc.co.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**

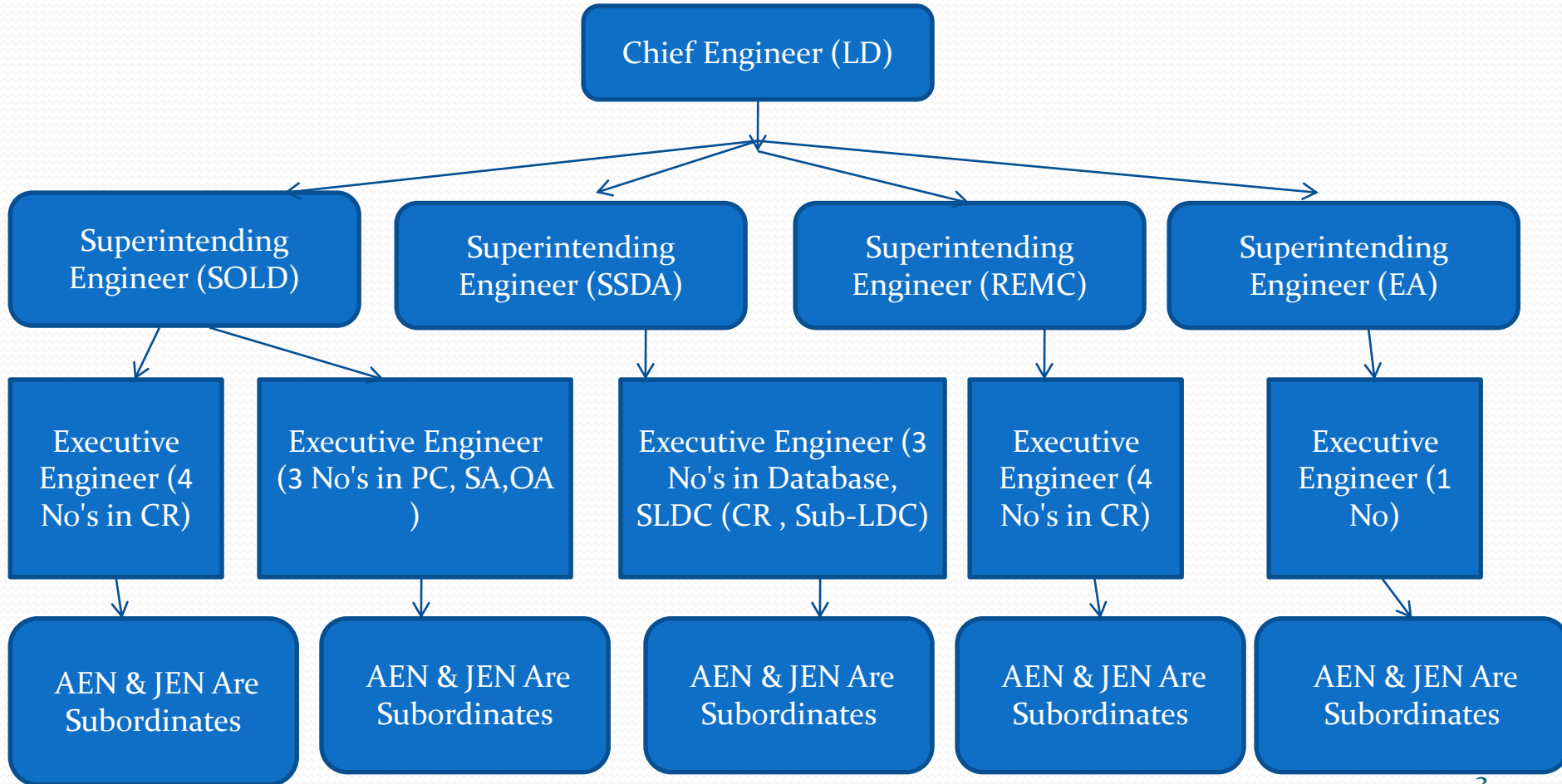


**Presentation By-
State Load Dispatch Centre
RVPNL, Jaipur, Rajasthan**

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.

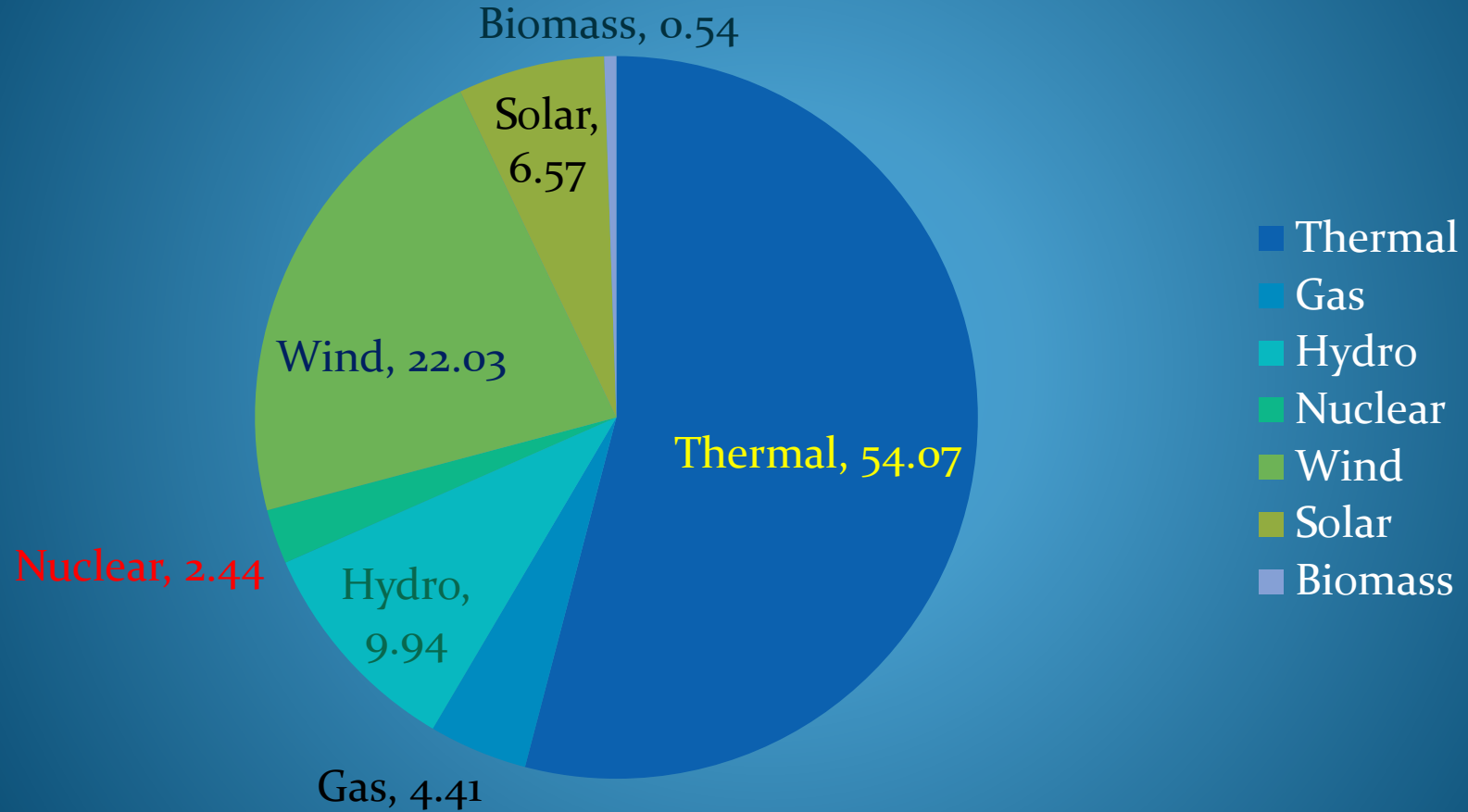
Rajasthan SLDC Setup



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	4

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

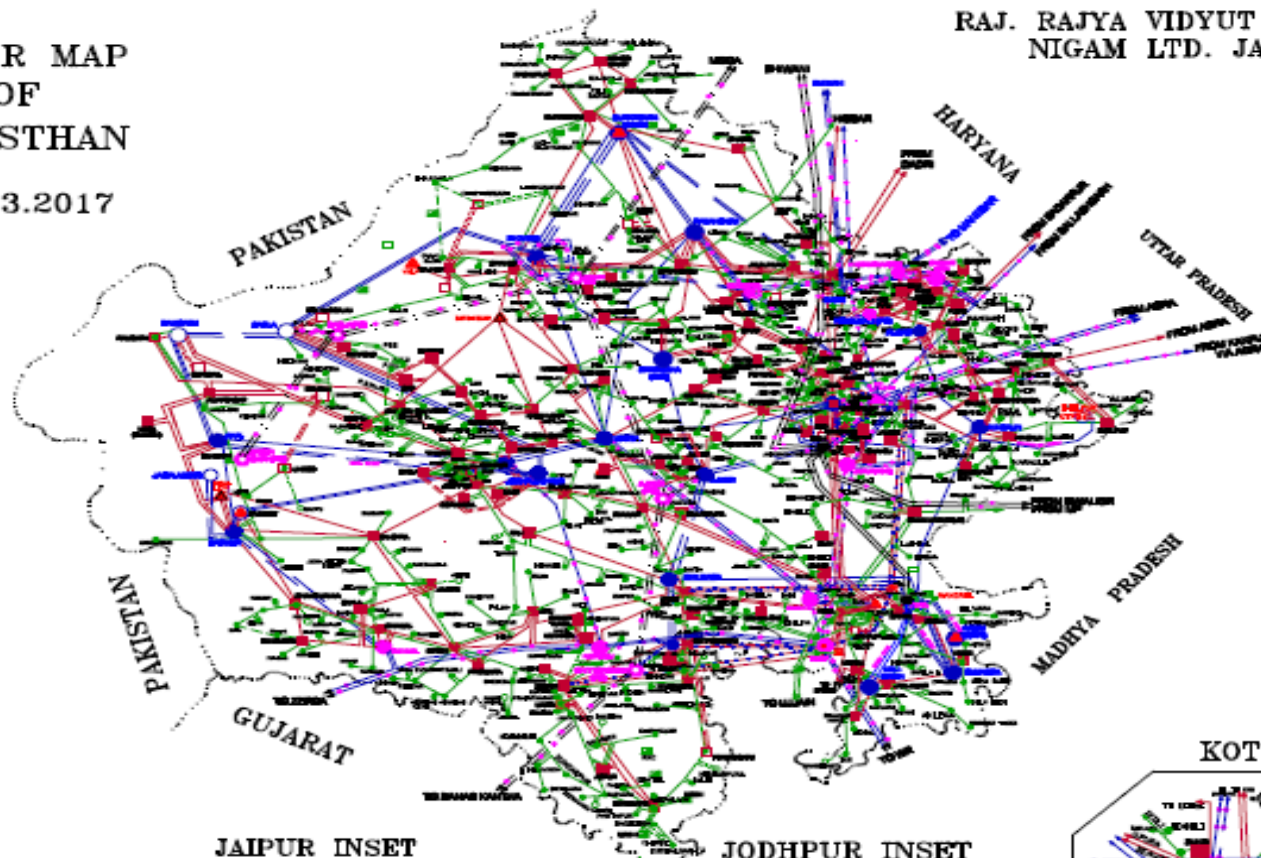
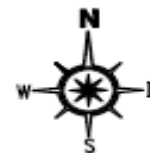
EHV GSS & LINES

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

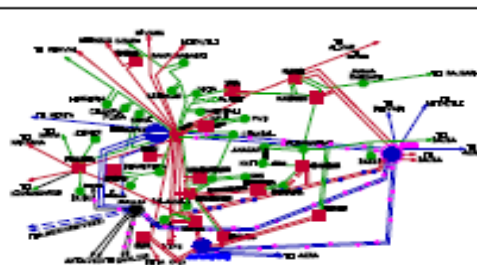
RAJ. RAJYA VIDYUT PRASARAN NIGAM LTD. JAIPUR



LEGEND

S/N	PARTICULARS	EXISTING	PROPOSED
1	132 KV LINE		
2	220 KV LINE		
3	400 KV LINE		
4	765 KV LINE		
5	132 KV G.S.S.		
6	220 KV G.S.S.		
7	400 KV G.S.S.		
8	765 KV G.S.S.		
9	765 KV G.S.S.		
10	HYDROPOWER HOUSE		
11	TH POWER HOUSE		
12	SAES THERMO POWER HOUSE		
13	ATOMIC POWER STN.		

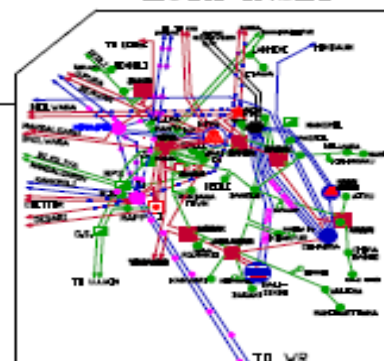
JAIPUR INSET



JODHPUR INSET



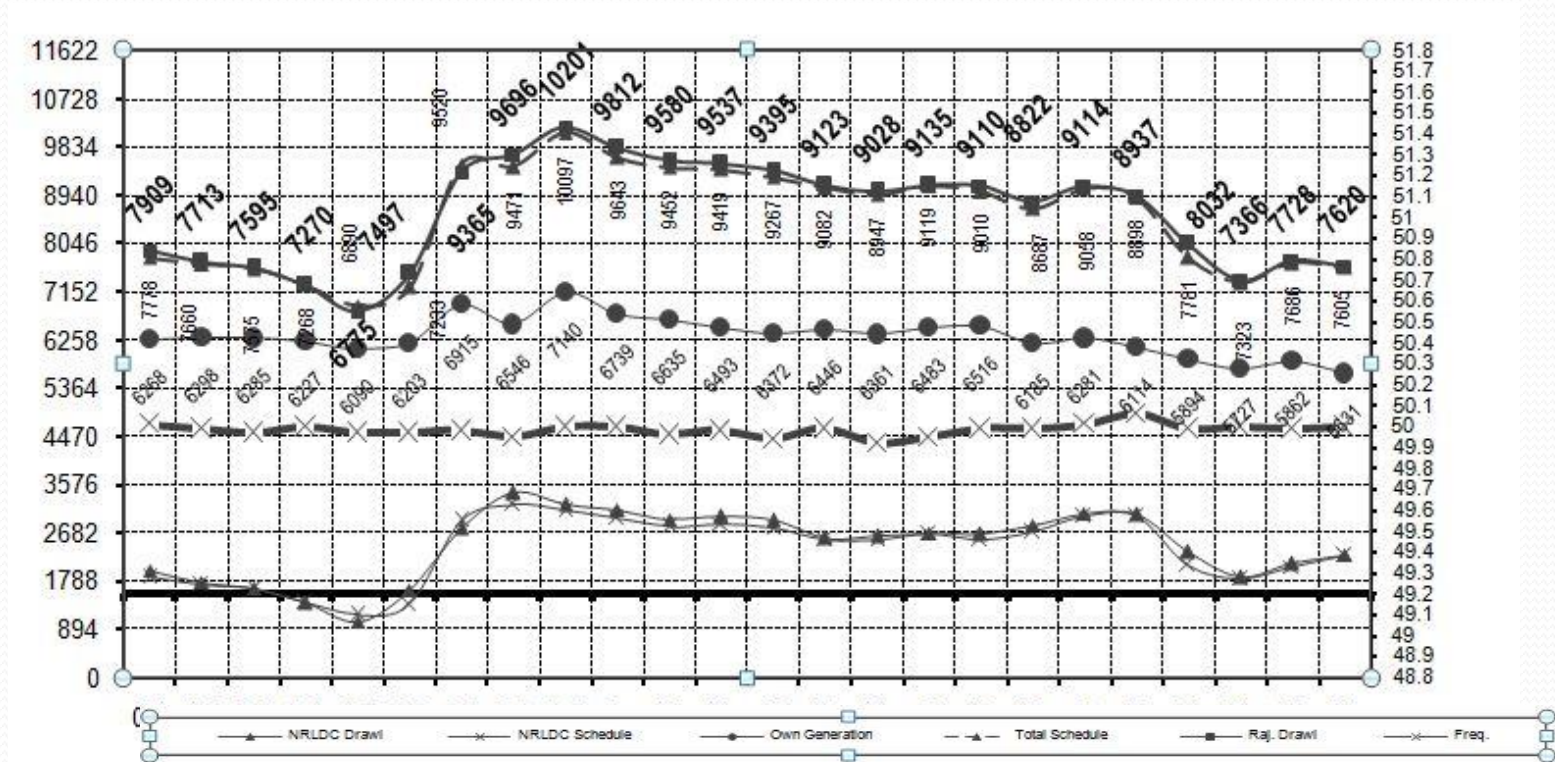
KOTA INSET



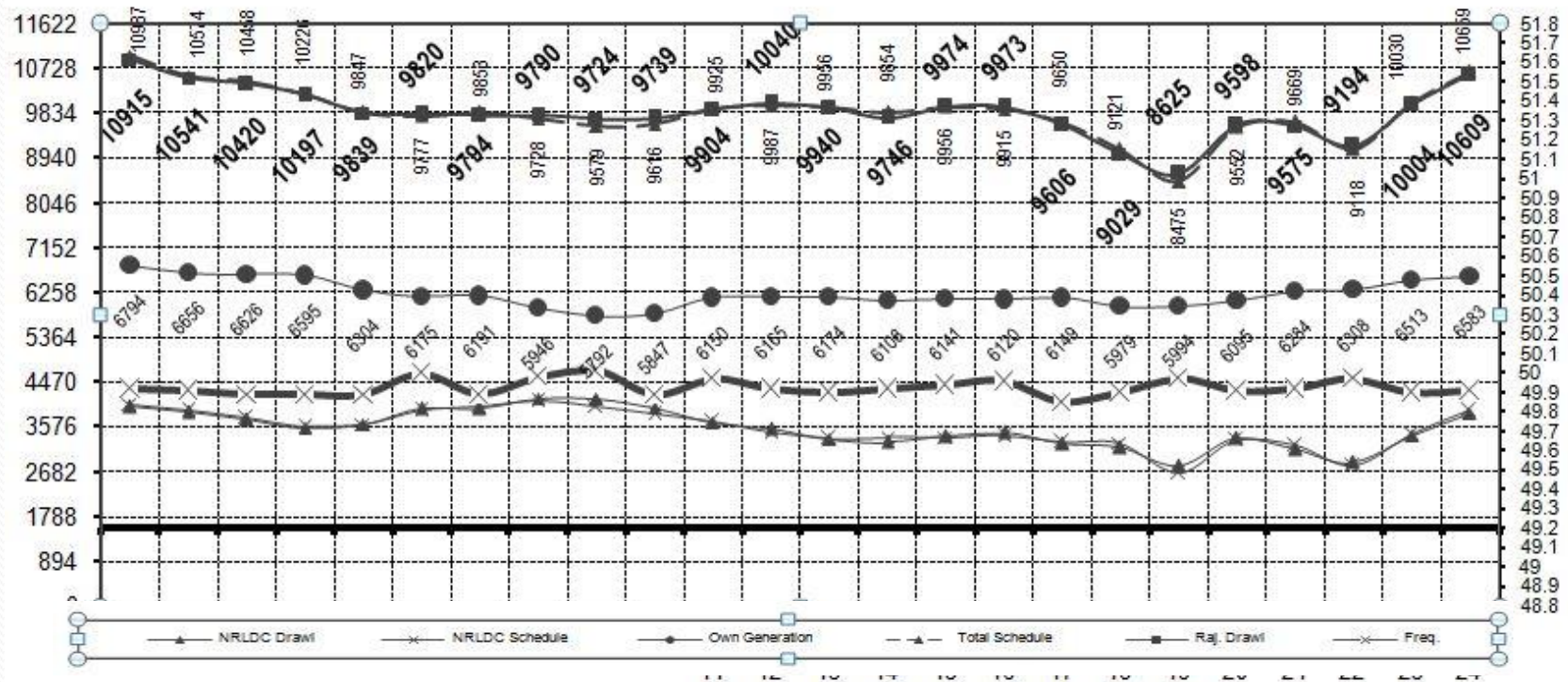
Max Consumption ,Peak Load and Wind for Financial Year 2010-11 To 2016-17

Financial Year	Max. Consumption (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

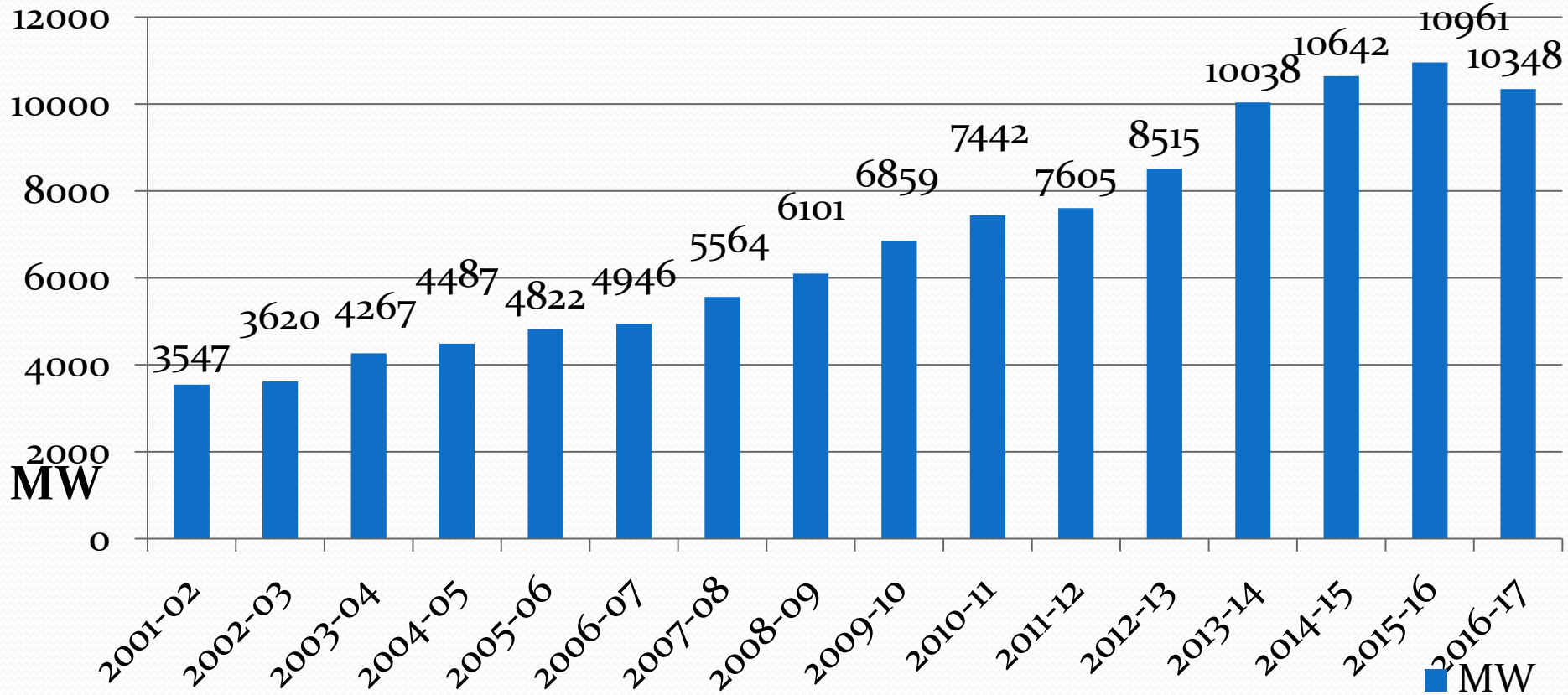
Load Curve of Rajasthan for 25 January, 2017



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

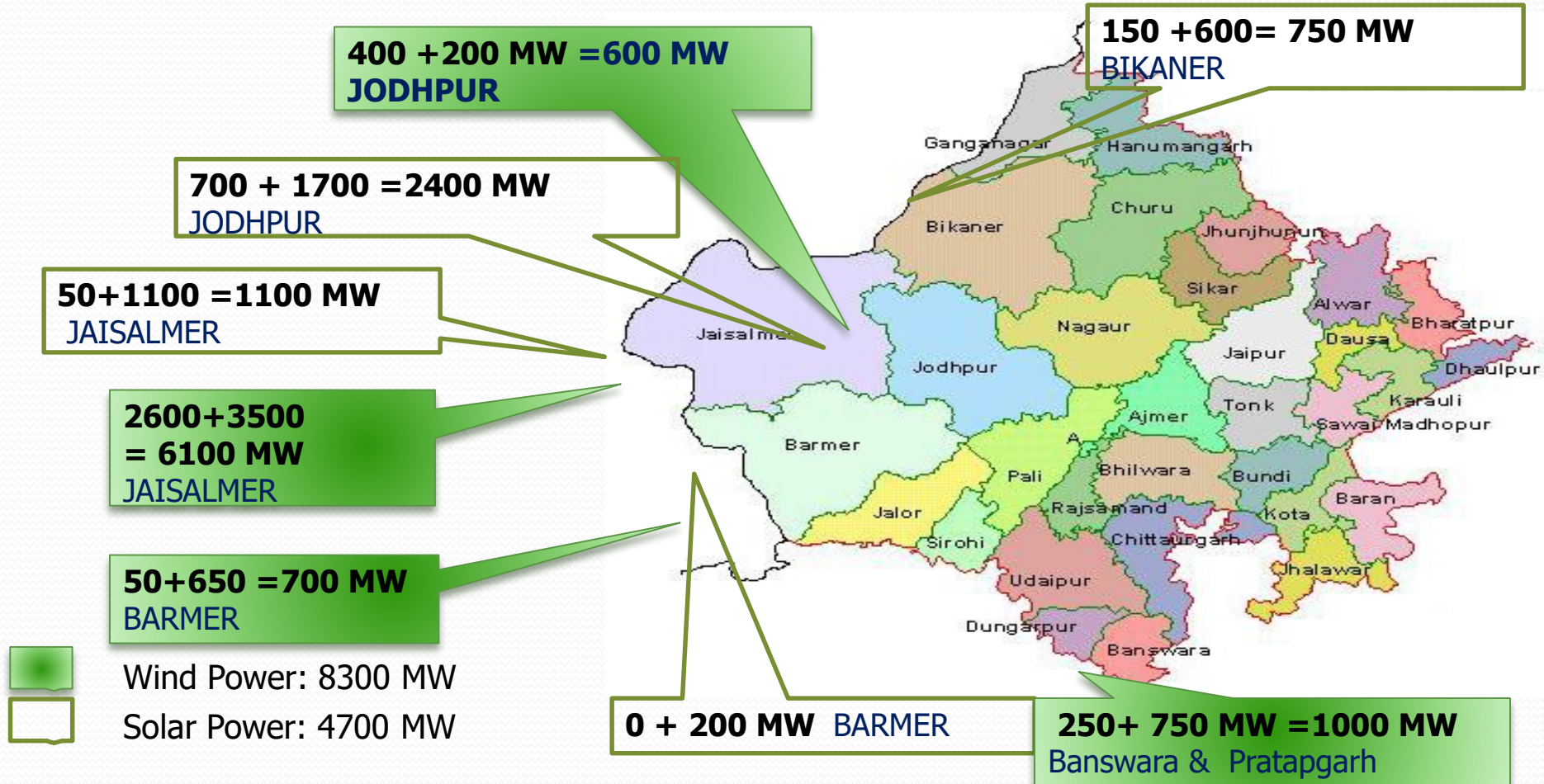
- Rajasthan has very huge potential of Renewable Energy Sources in western part which includes Jaisalmer, Barmer, Jodhpur & Bikaner districts .
- Wind Potential is also in Banswara & Pratapgarh districts of Rajasthan
- RREC has set the targets for solar and wind projects in Rajasthan about 27231 MW upto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

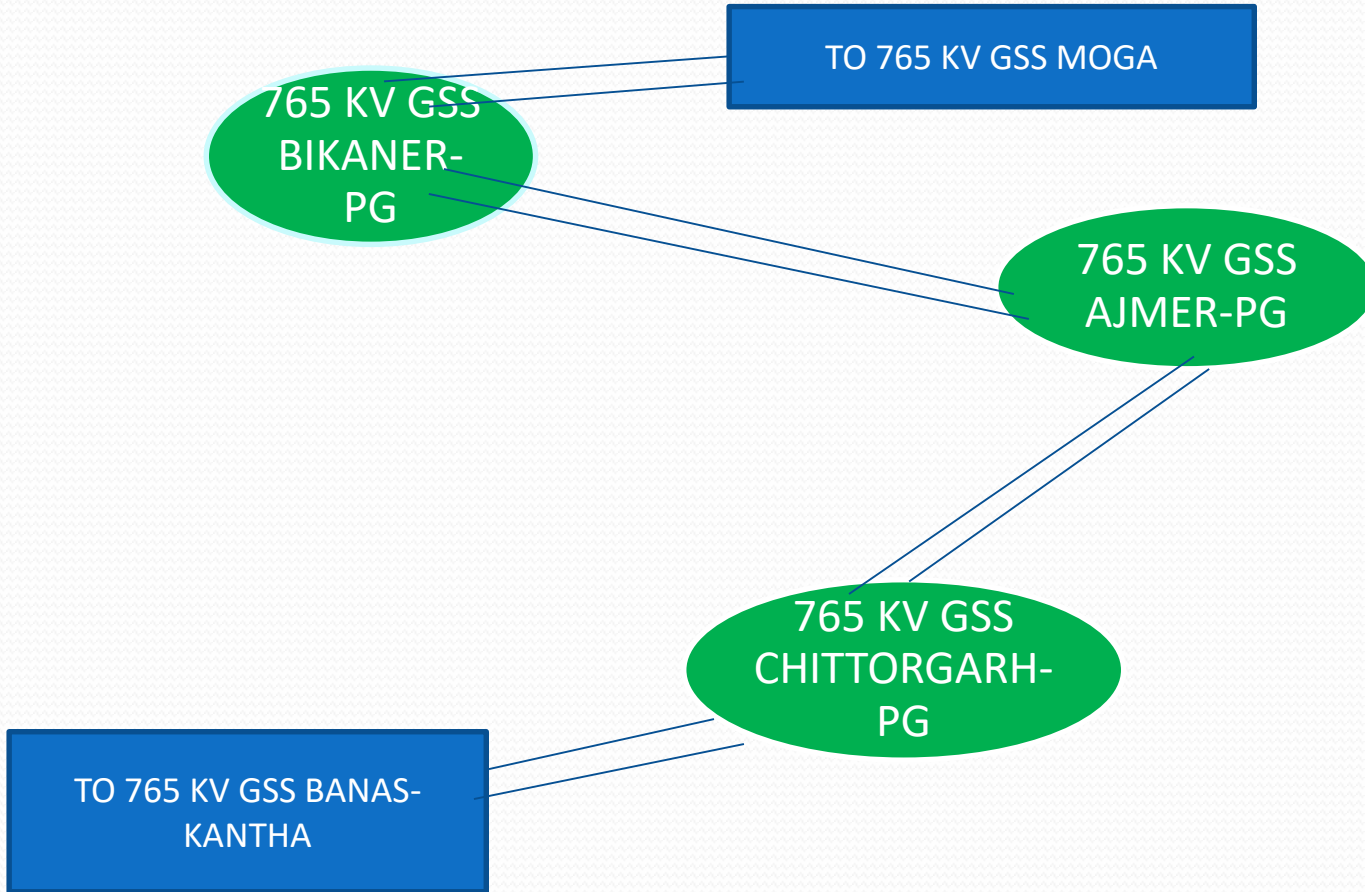
PRESENT FINANCIAL STATUS OF THE SCHEMES

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

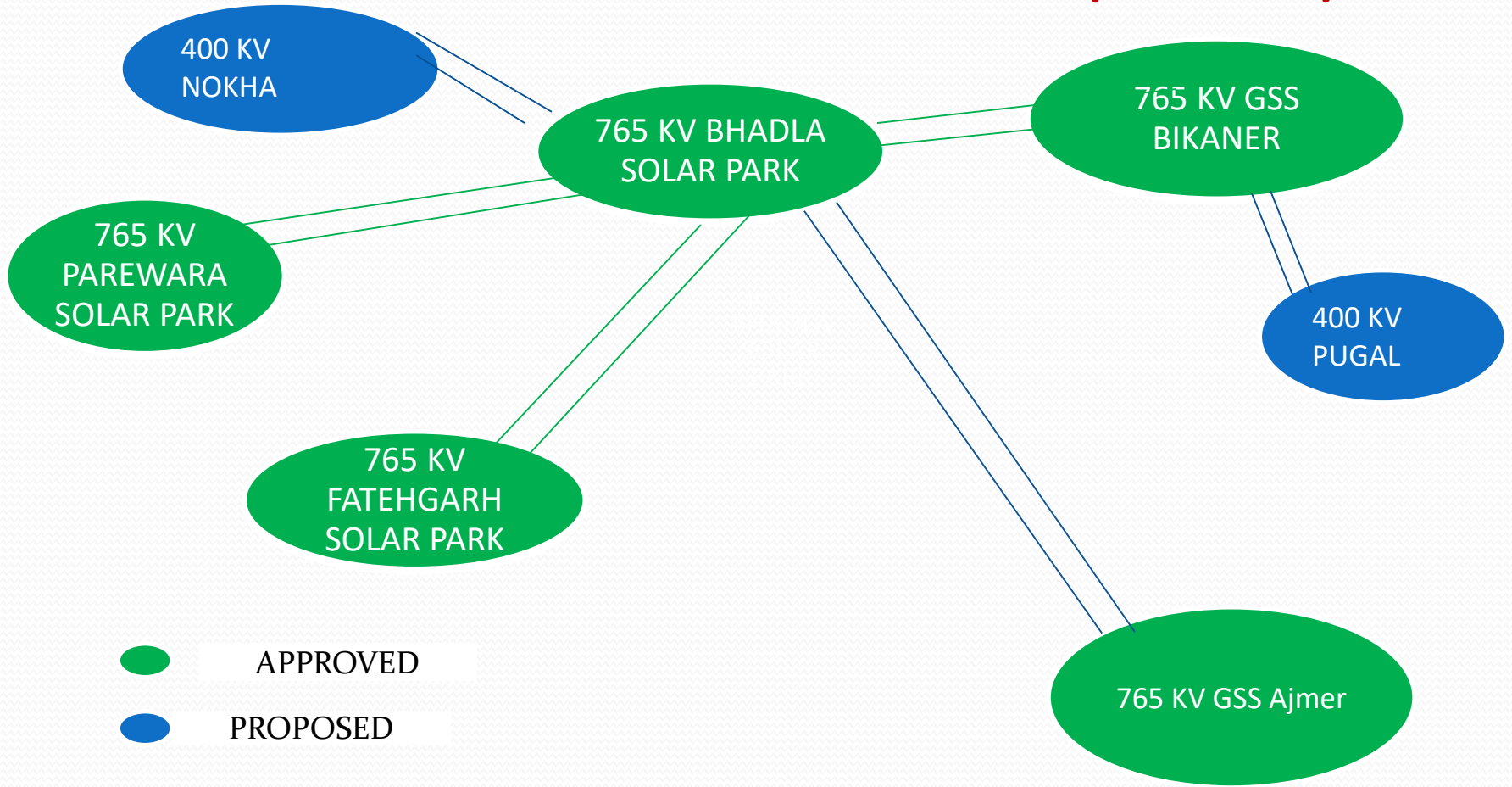
ABSTRACT

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)



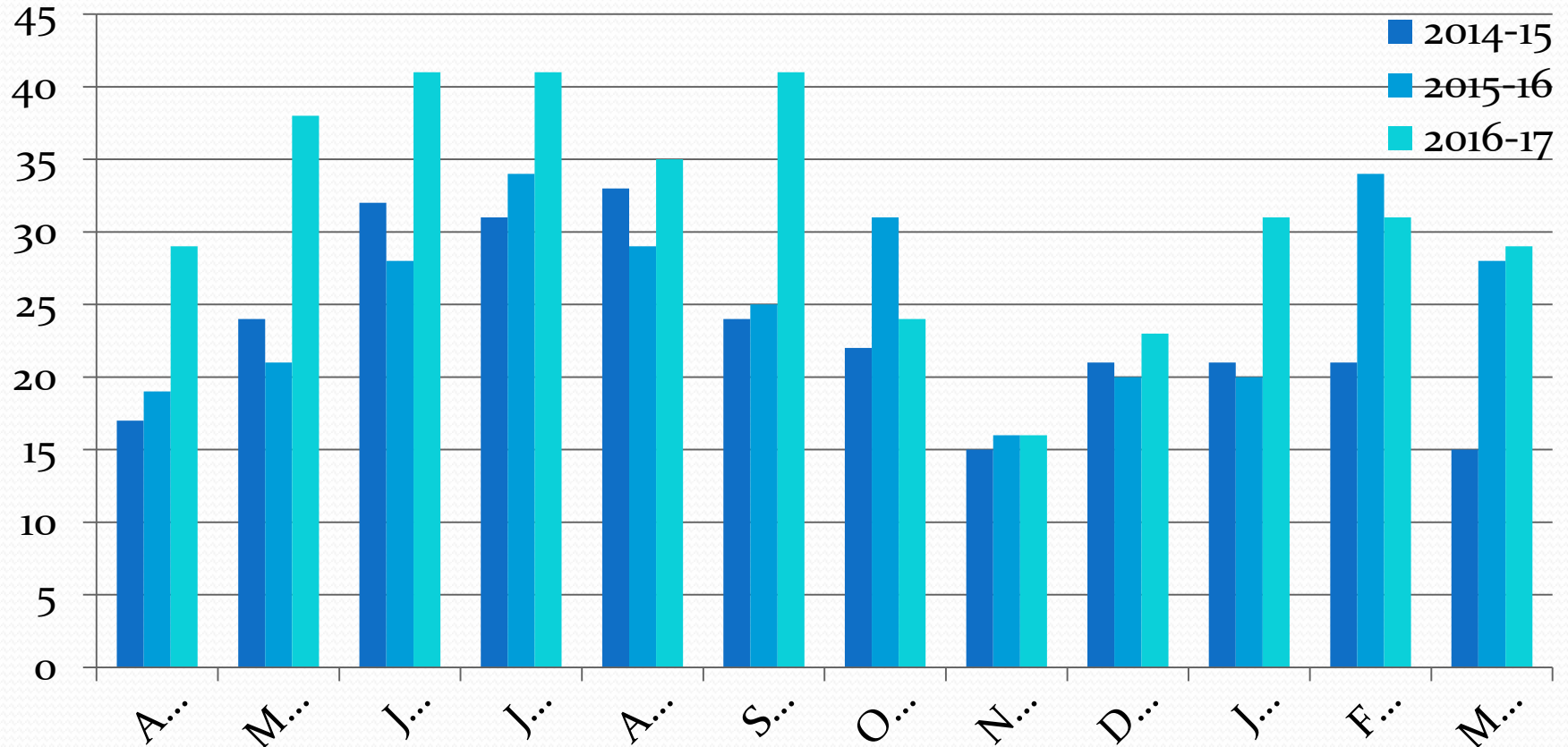
GREEN ENERGY CORRIDOR (PHASE-II)



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

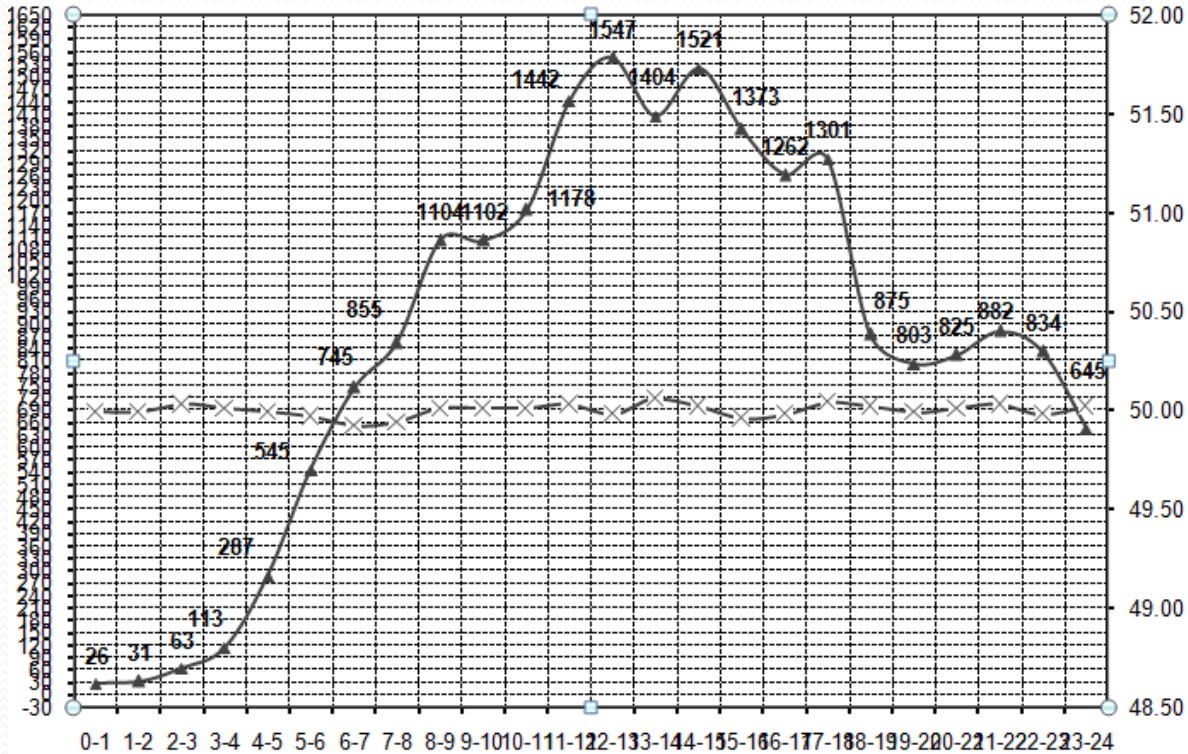
Month wise Max Wind Energy in a day (in MU)



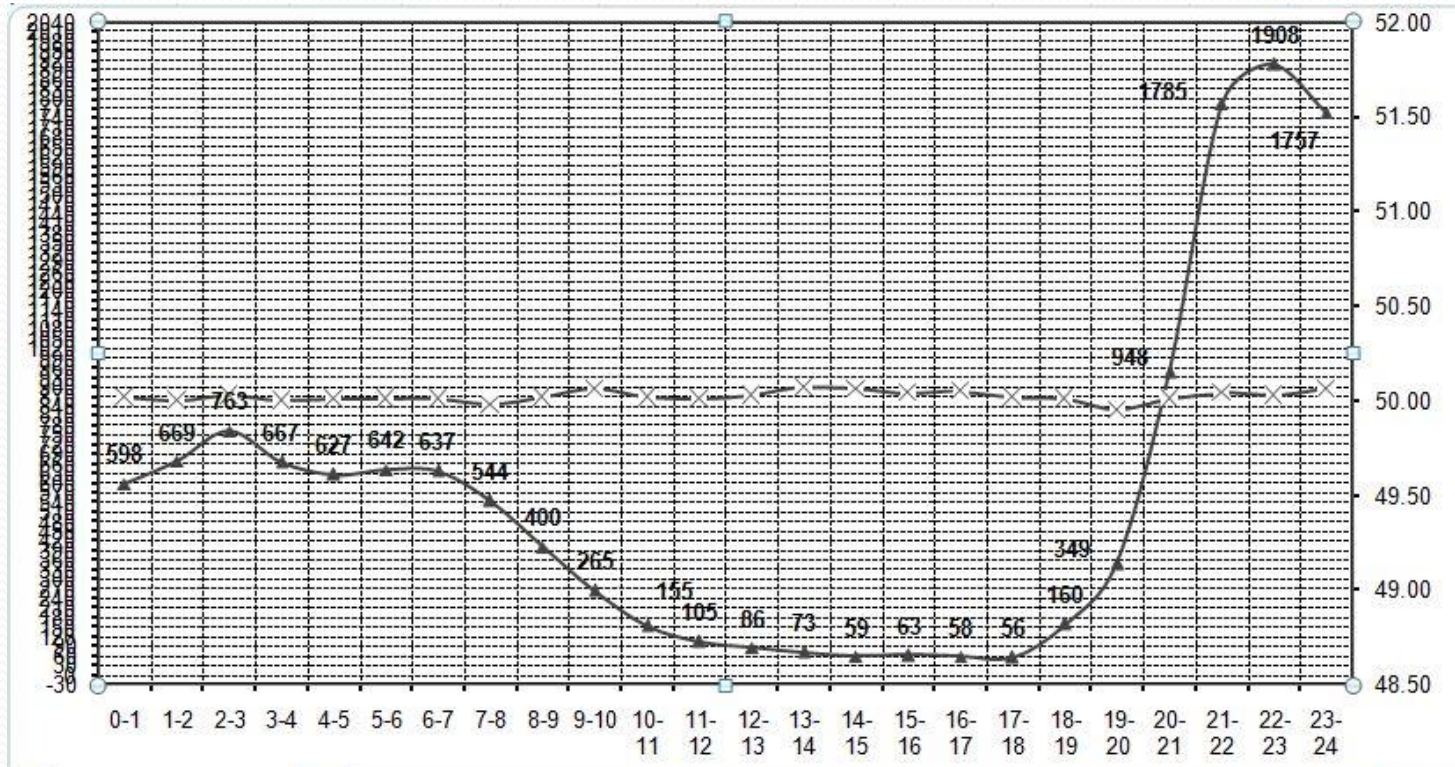
Variation of Winds

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 for 29 January, 2016



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 infrastructure, 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.



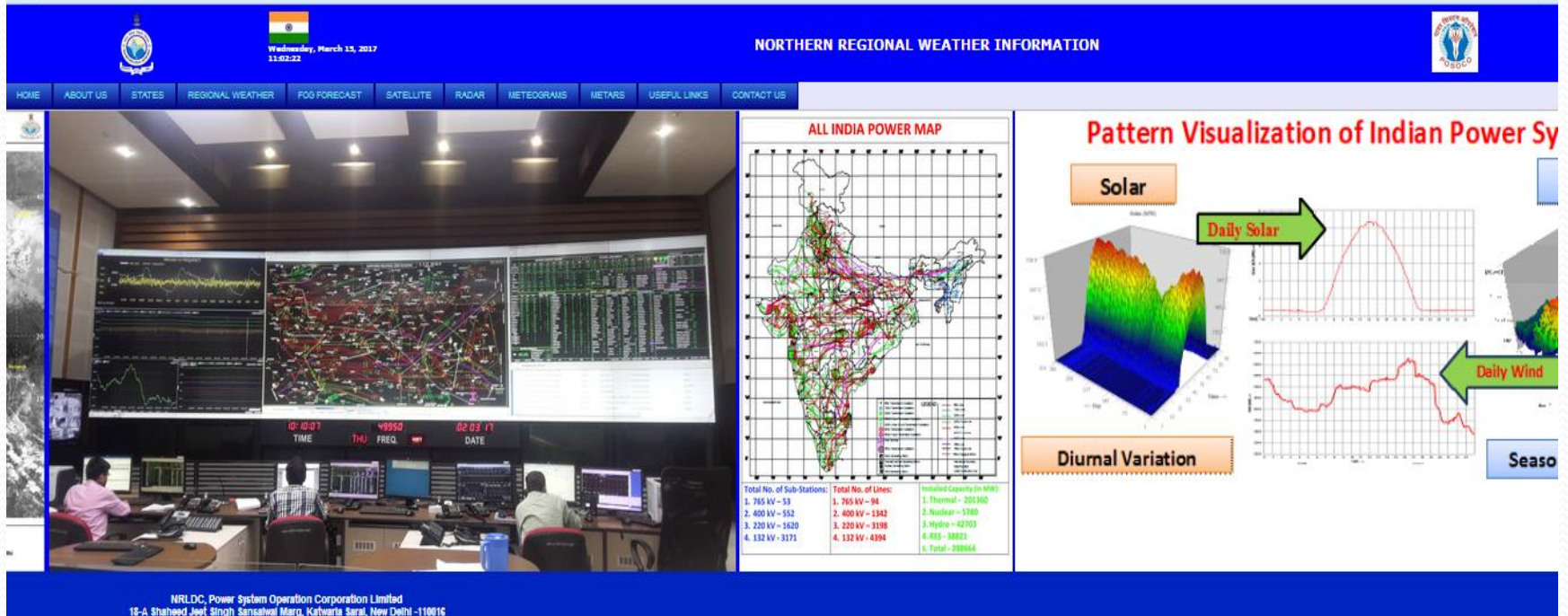
THANK YOU!!

Memorandum 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>



WEATHER PORTAL FOR POWER SECTOR



ERLDC

NERLDC

NRLDC

SRLDC

WRLDC

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*

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

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

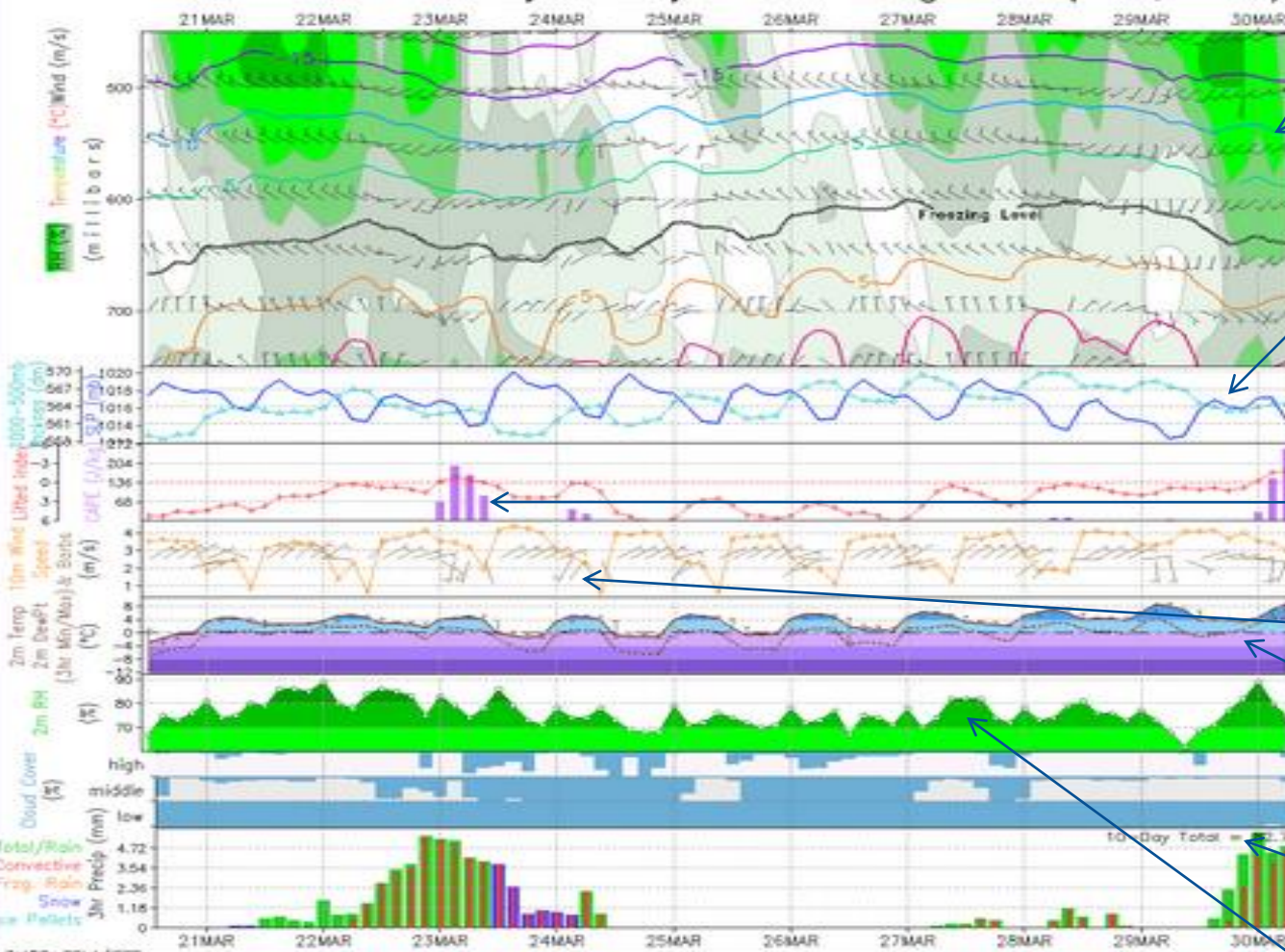
- The world's weather communities use a twenty four hour clock, similar to "military" time based on the 0° longitude meridian, also known as the Greenwich meridian.
- Prior to 1972, this time was **called Greenwich mean time (GMT) but is now referred to as coordinated universal time or universal time 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

DHARMSALA IMD GFS 0~10day 3-hourly Forecast Meteogram for (76.5E, 32.25N)



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 : Thunderstorms 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: Radio Detection and Ranging



- 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

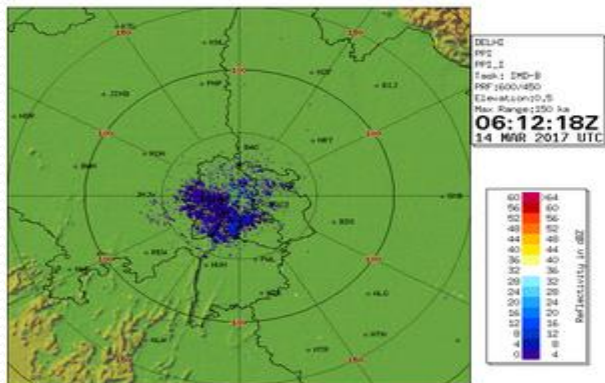
- The Doppler Weather Radar generates different displays and derived products of practical utility based on standard algorithms.
- These displays are updated @ every 10 minutes

Reflectivity (dBZ)

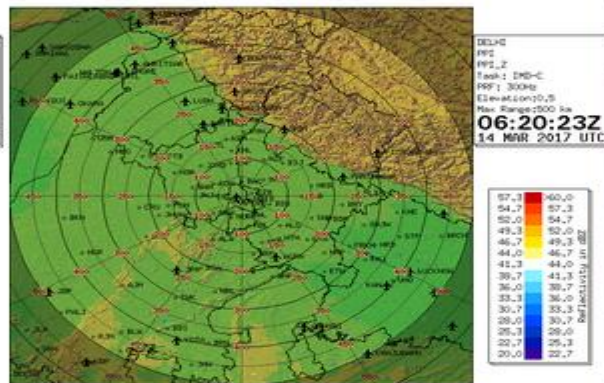
- The colors on the legend are the different echo intensities (reflectivity) measured in dBZ.
- "Reflectivity" is the amount of transmitted power returned to the radar receiver.
- Typically, light rain is occurring when the dBZ value reaches 20, 35-40 Moderate , 40-50 Moderate to Heavy 50-55 Heavy rain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

Products from Doppler Weather Radars

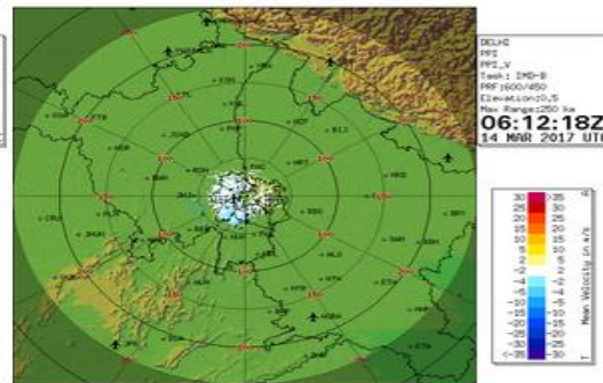
Plan Position Indicator (Z) - Close Range



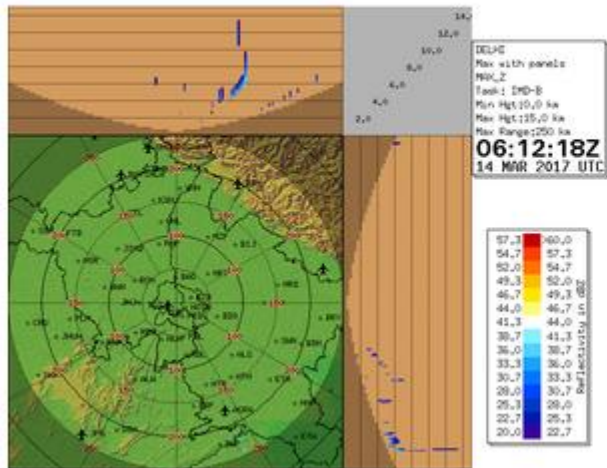
Plan Position Indicator (Z)



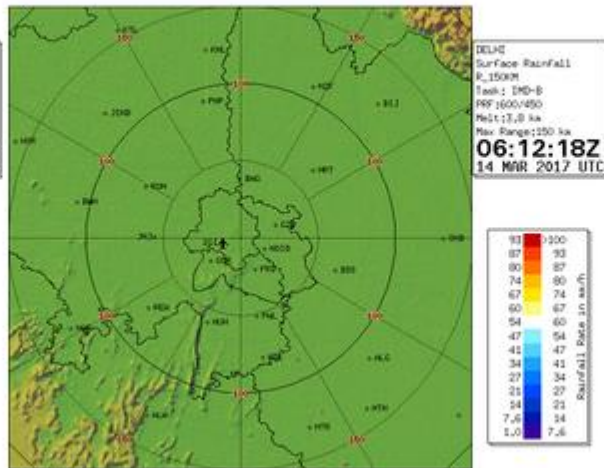
Plan Position Indicator (V)



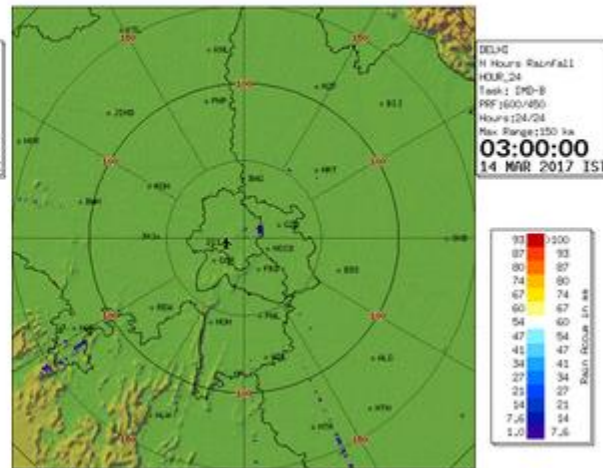
MAX (Z)



Surface Rainfall Intensity



Precipitation Accumulation



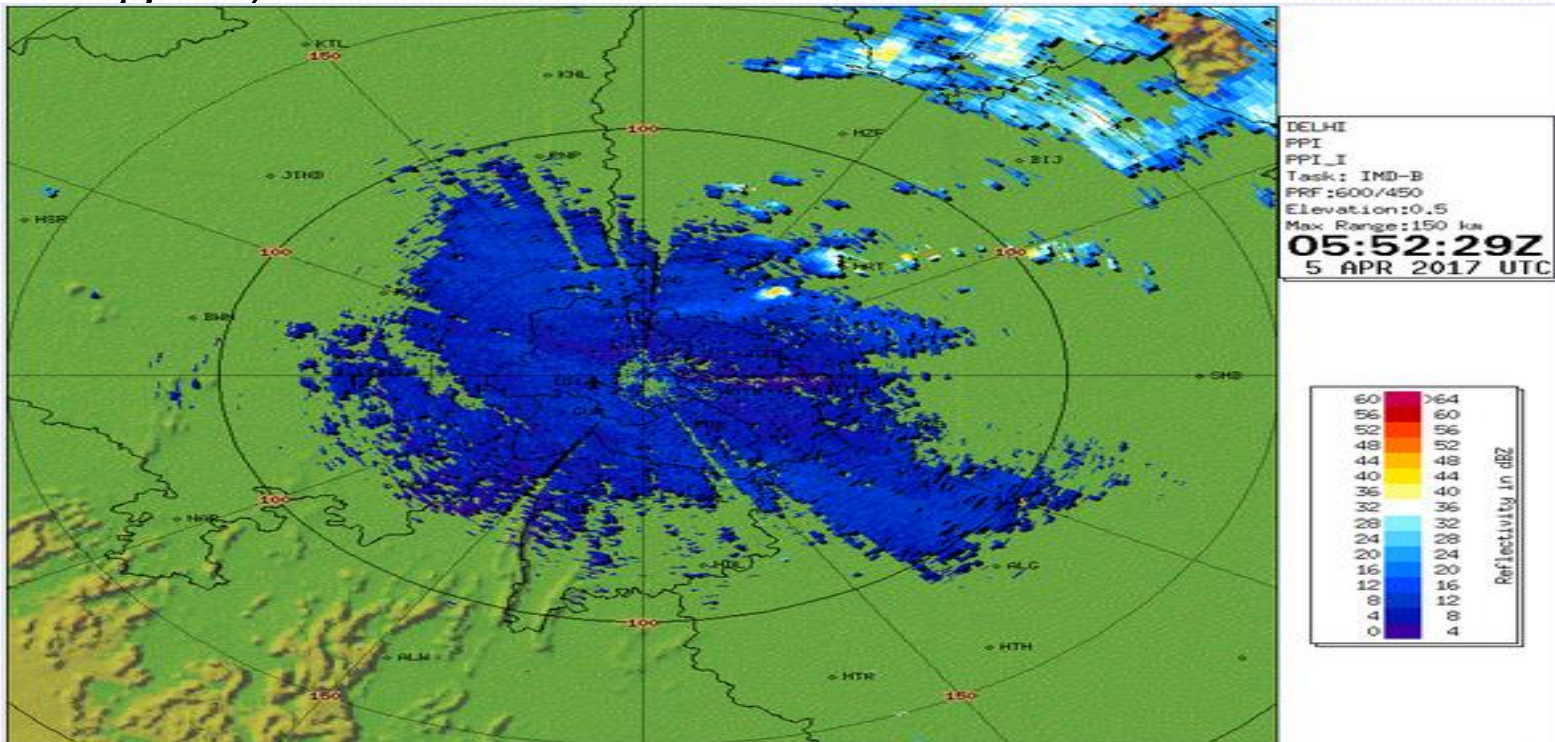
Various Elevation of Radar Images

- 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.

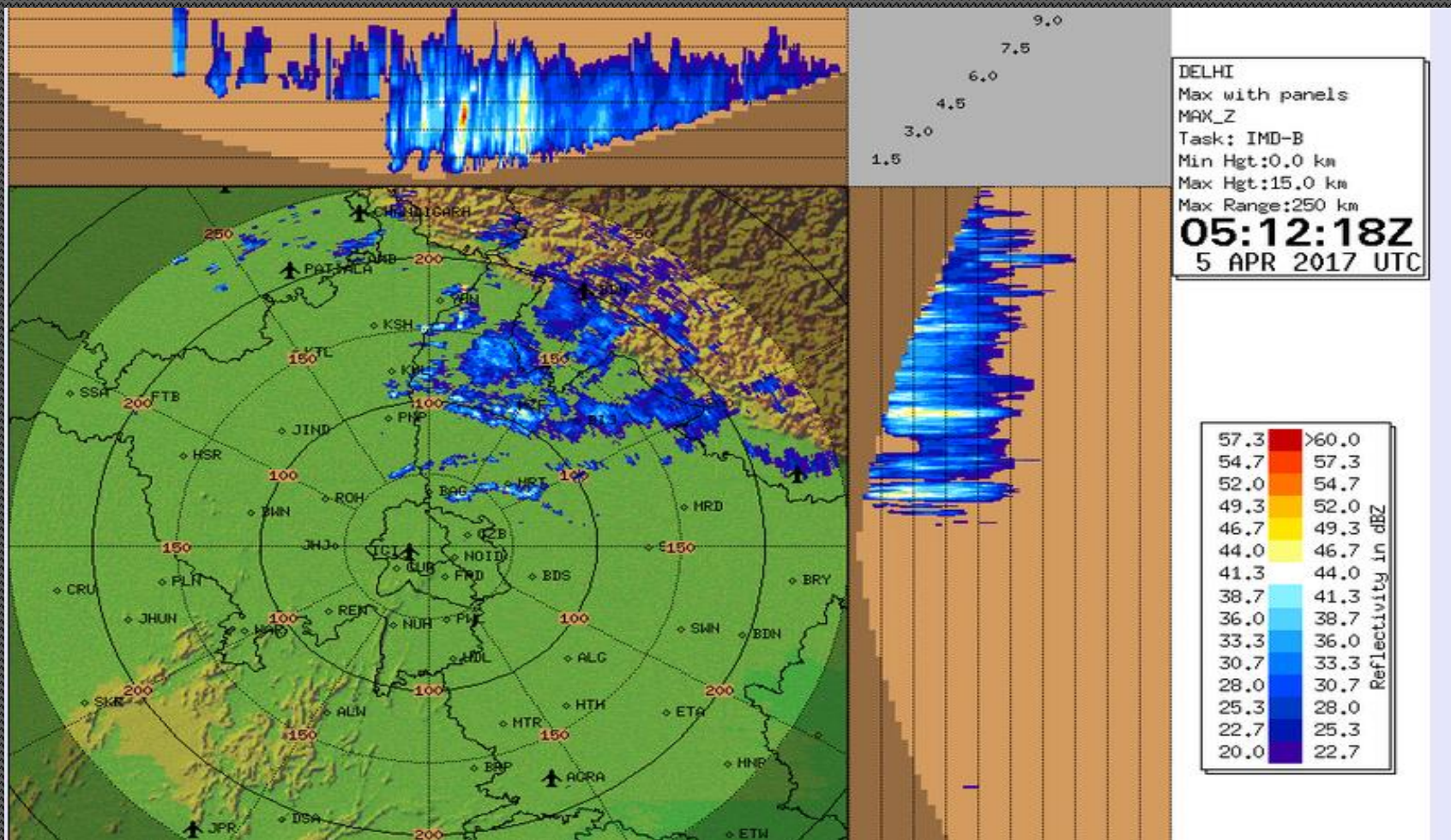
Plan Position Indicator

- 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 angle (generally 0.5 degree)

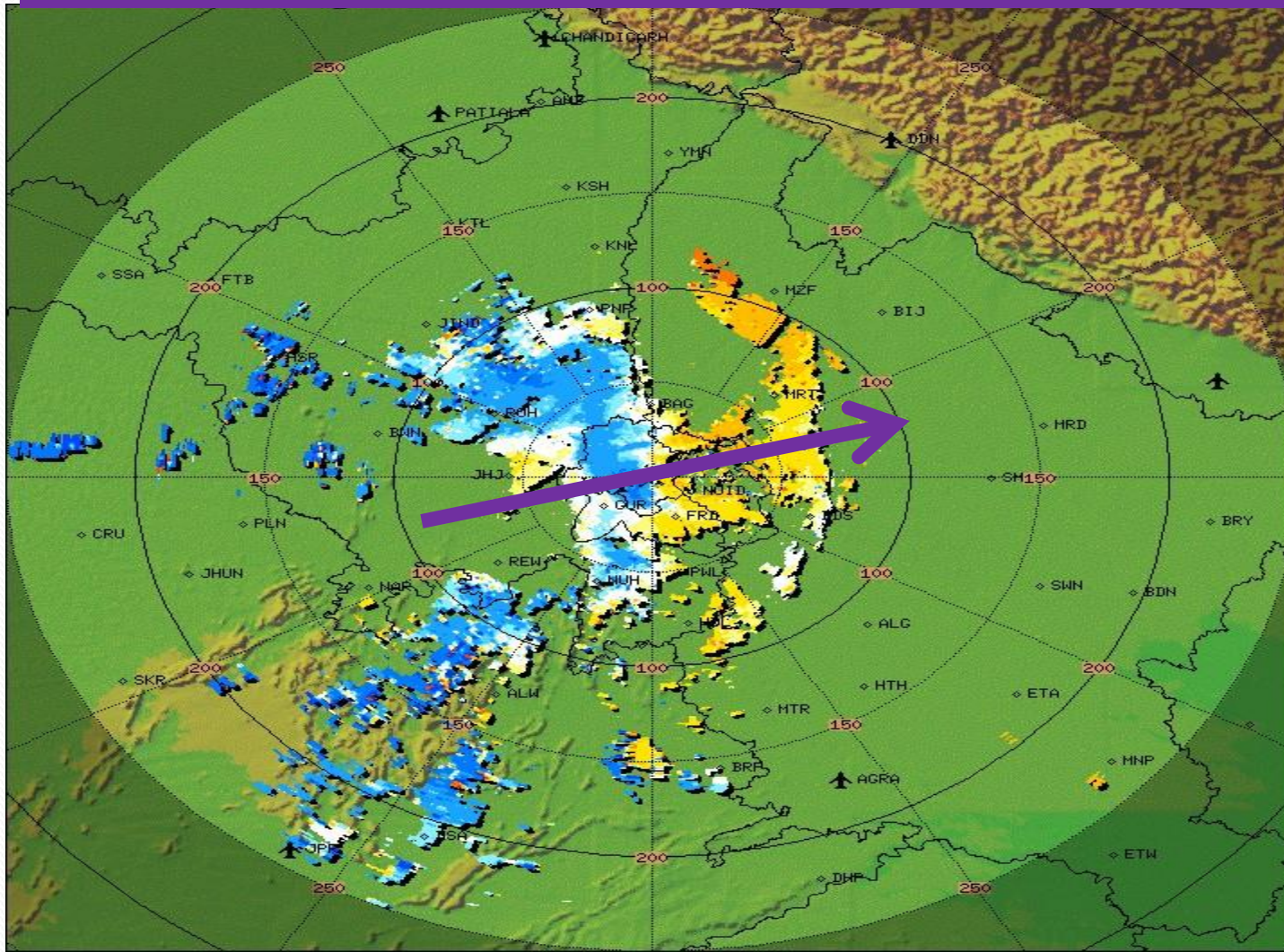


Range Height Indicator

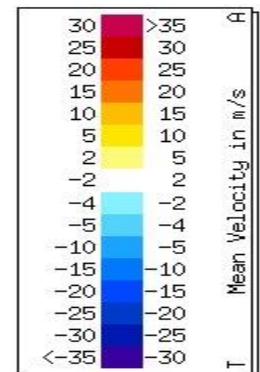
This Product is same as conventional Radars . A Display is generated on the Range on the X-Axis and height of the Cloud Surface on Y-Axis



Plan Position Indicator (Mean Velocity m/s)

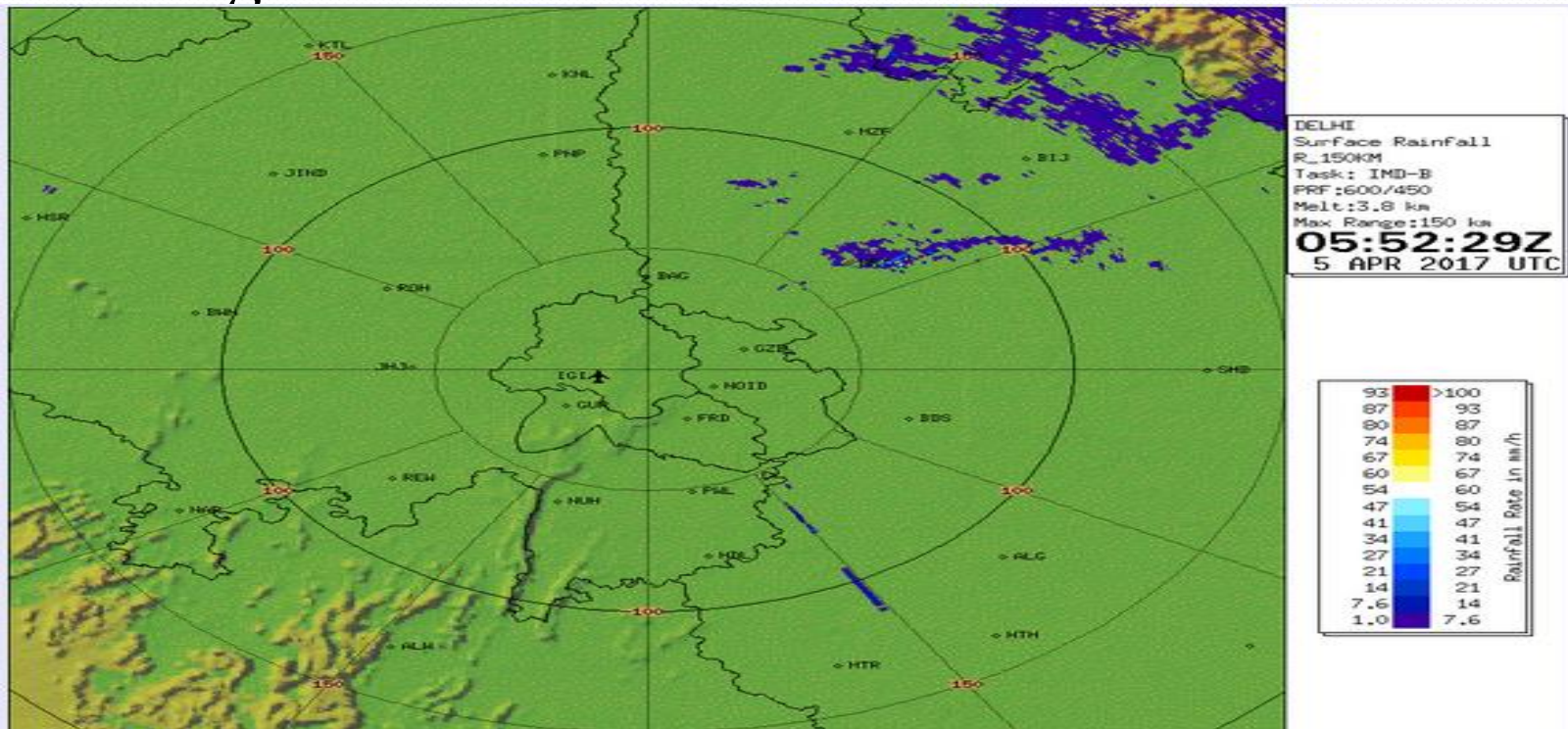


DELHI
PPI
PPI_V
Task: IMD-B
PRF:600/450
Elevation:0.5
Max Range:250 km
15:42:30Z
10 MAY 2017 UTC



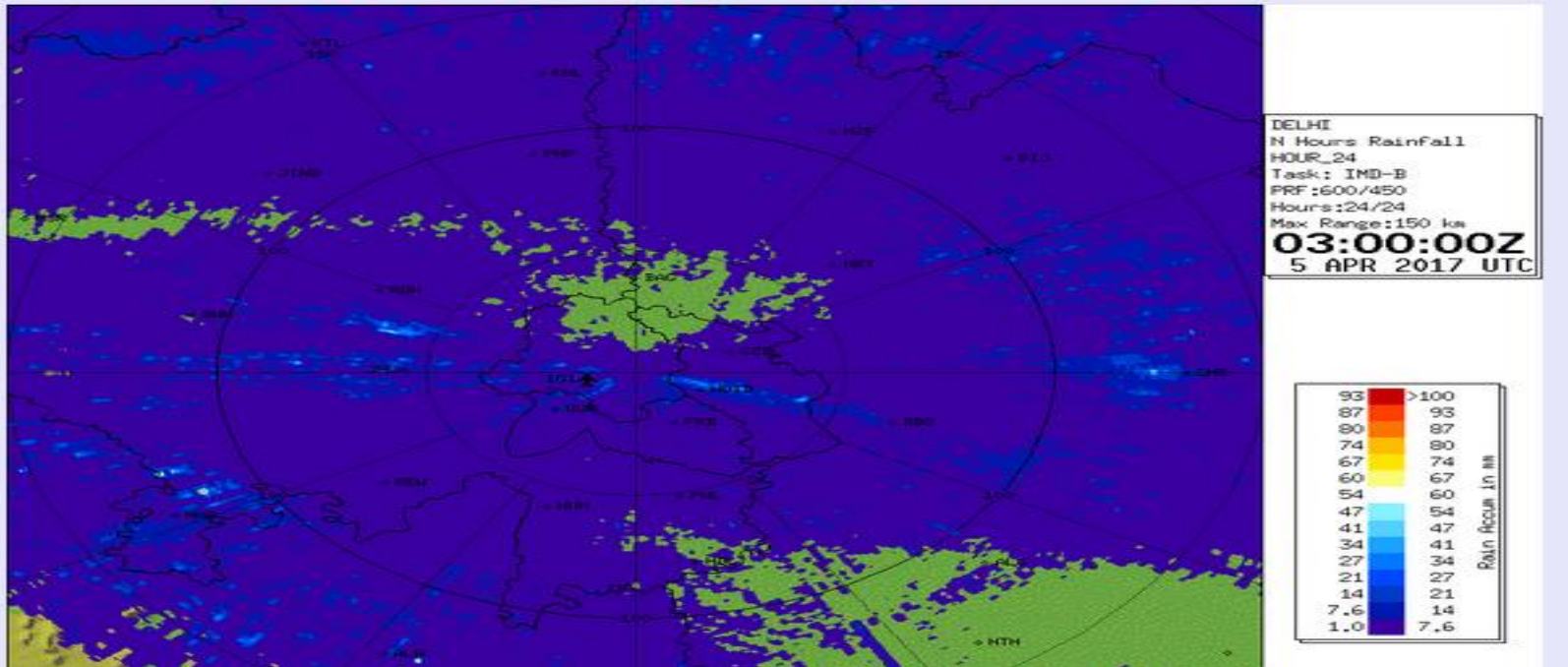
Surface Rainfall Intensity (mm/H)

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



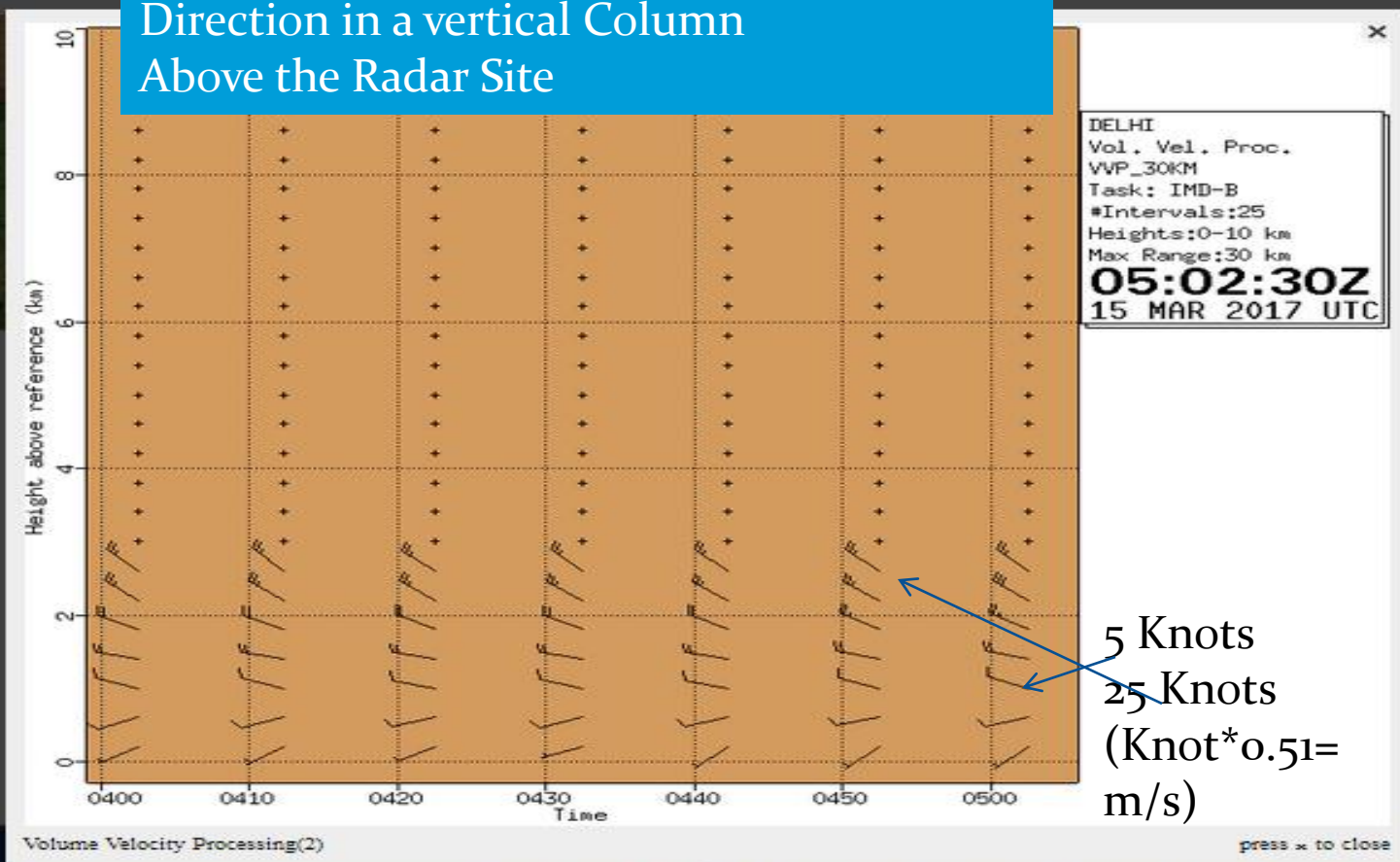
Precipitation Accumulation (mm)

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)

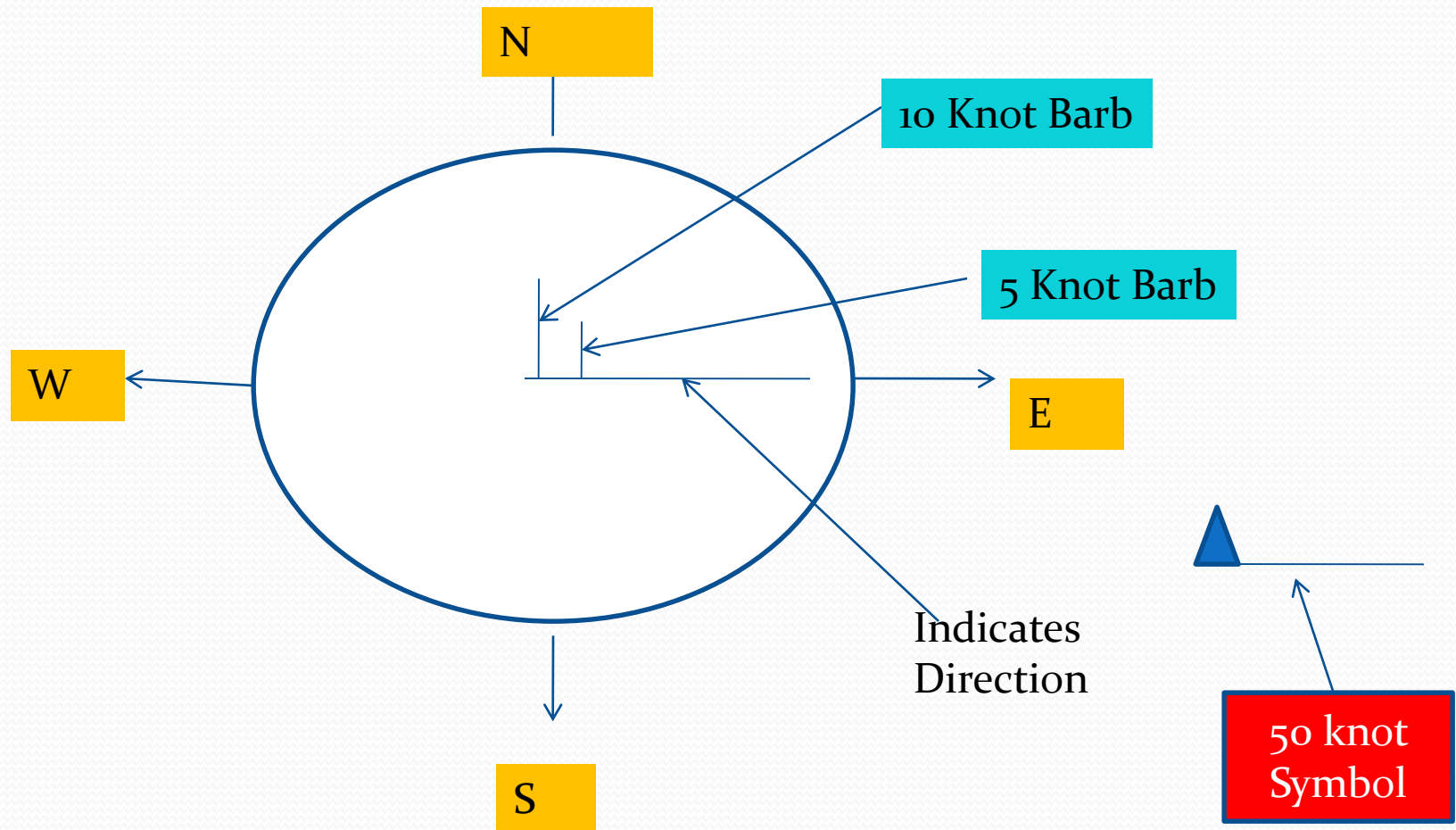


Volume Velocity Processing

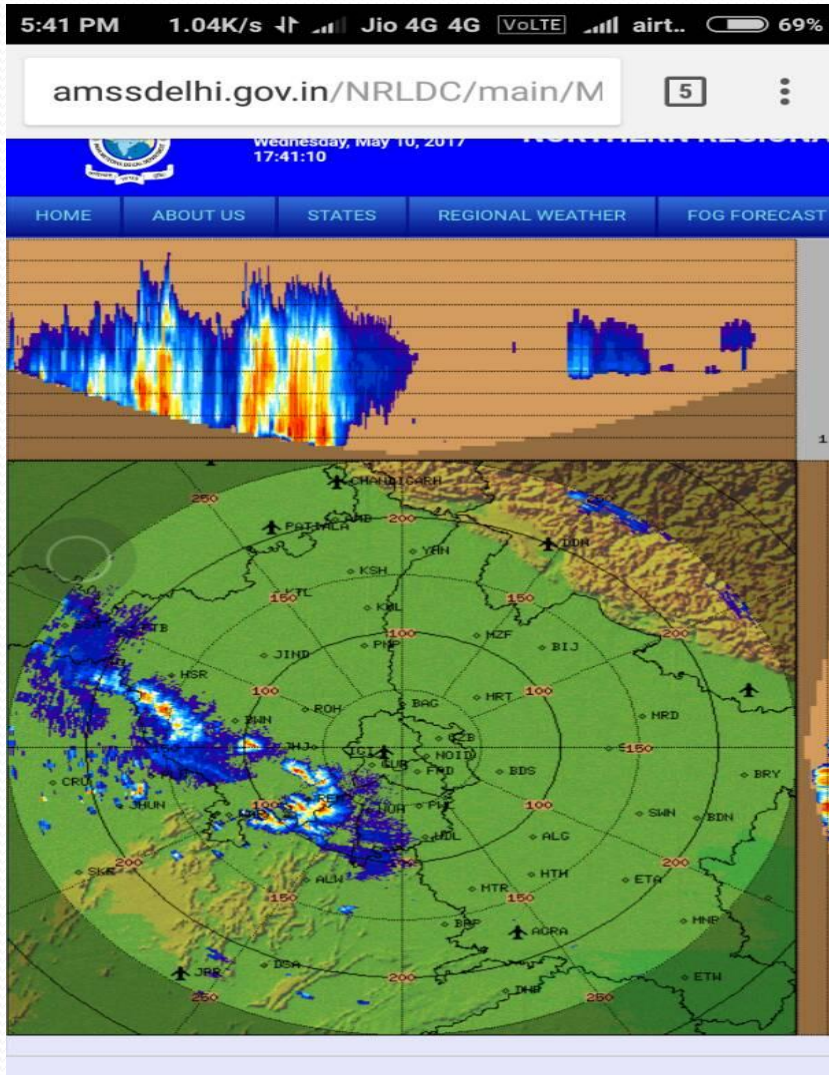
This displays the wind Velocity and Wind Direction in a vertical Column Above the Radar Site



Wind Direction and Speed of the Wind



Radar Image



- It can be used for
 - Identifying 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

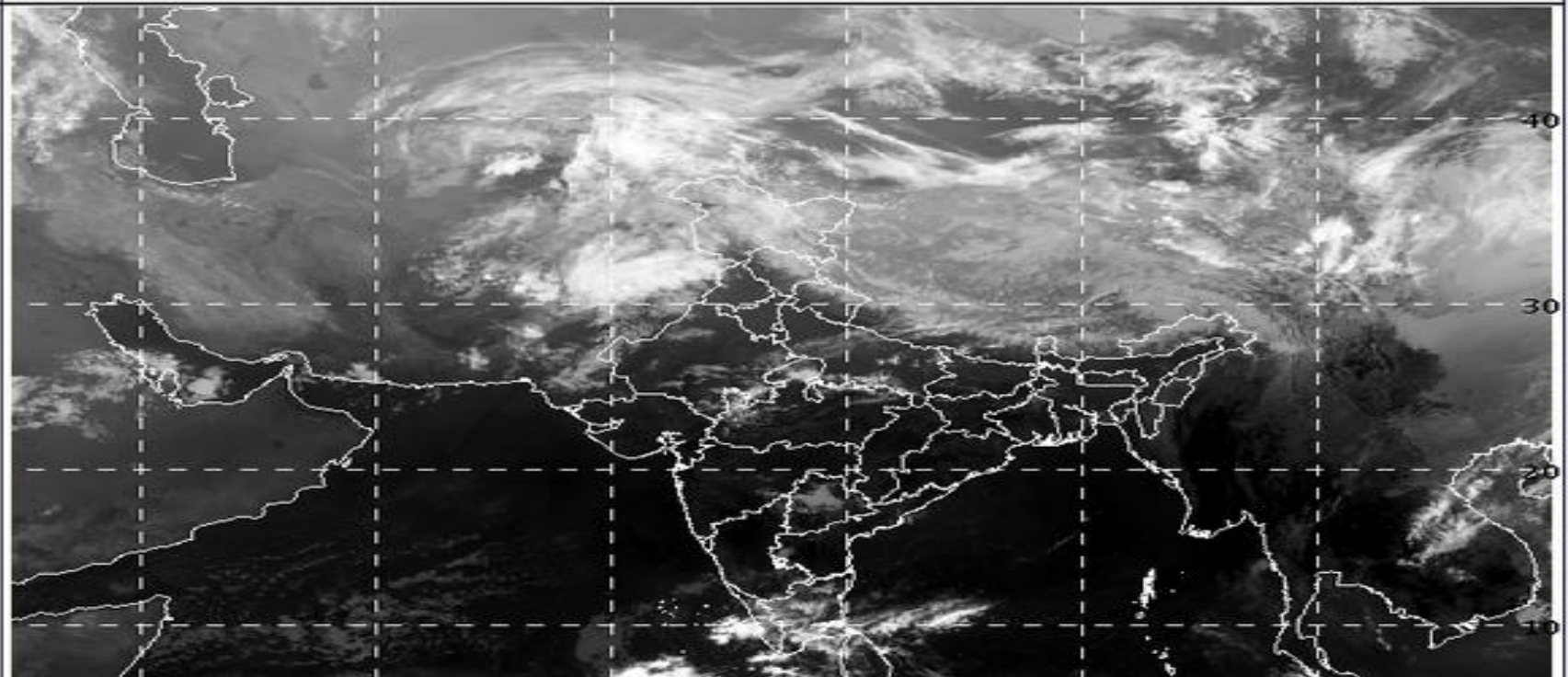
SAT :INSAT-3DR IMG

15-03-2017/02:45 GMT

IMG_TIR1 10.8 um

15-03-2017/08:15 IST

LIC Mercator (LINEAR STRETCH: 1.0%)



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

Station
Code (IGI
Delhi)

Date & Time
in UTC (Z)

Speed of
Wind in
Knots

Visibility
2500 meters
Haze (WE
can use it for
FOG)

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

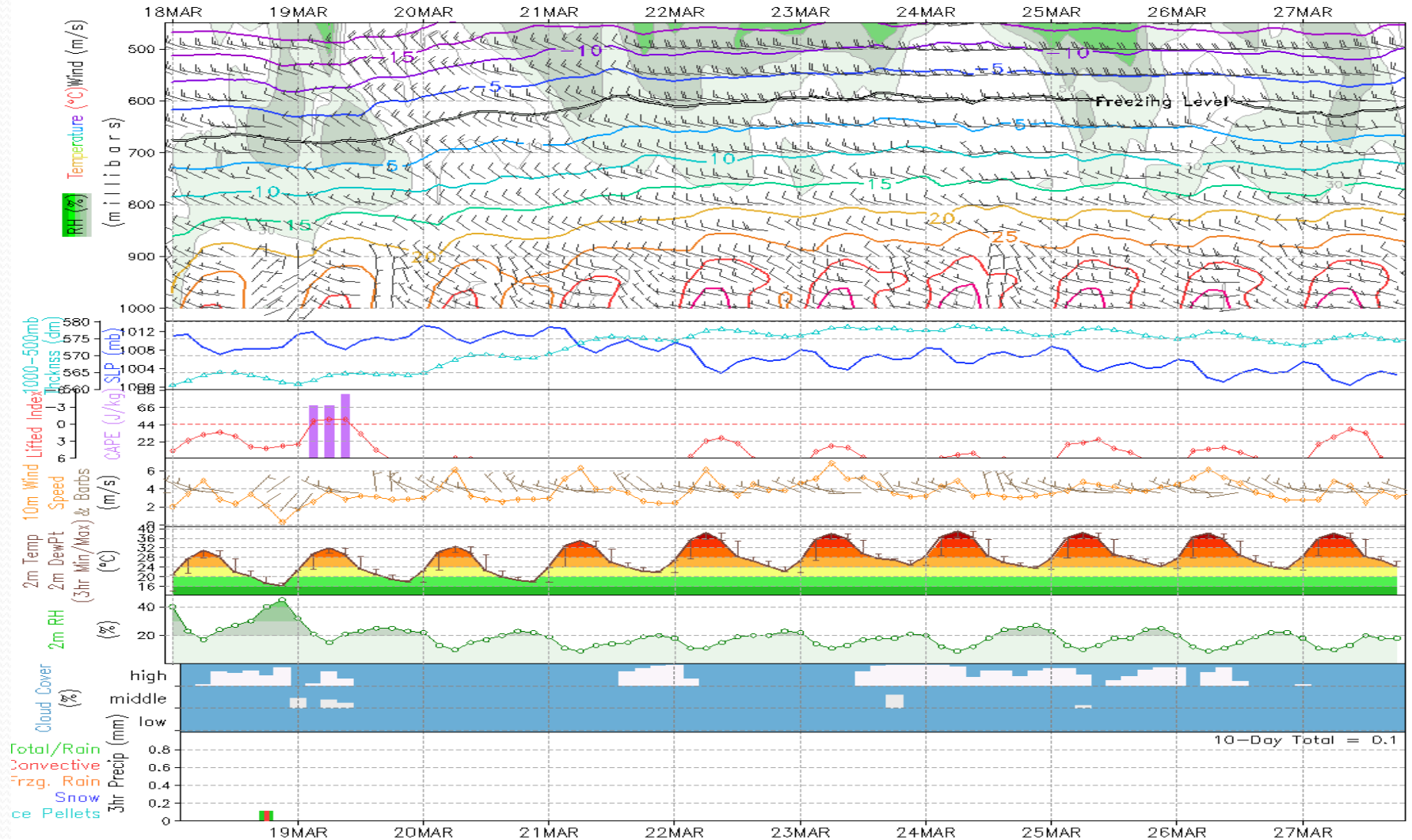
Case-I (BSES)

- 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

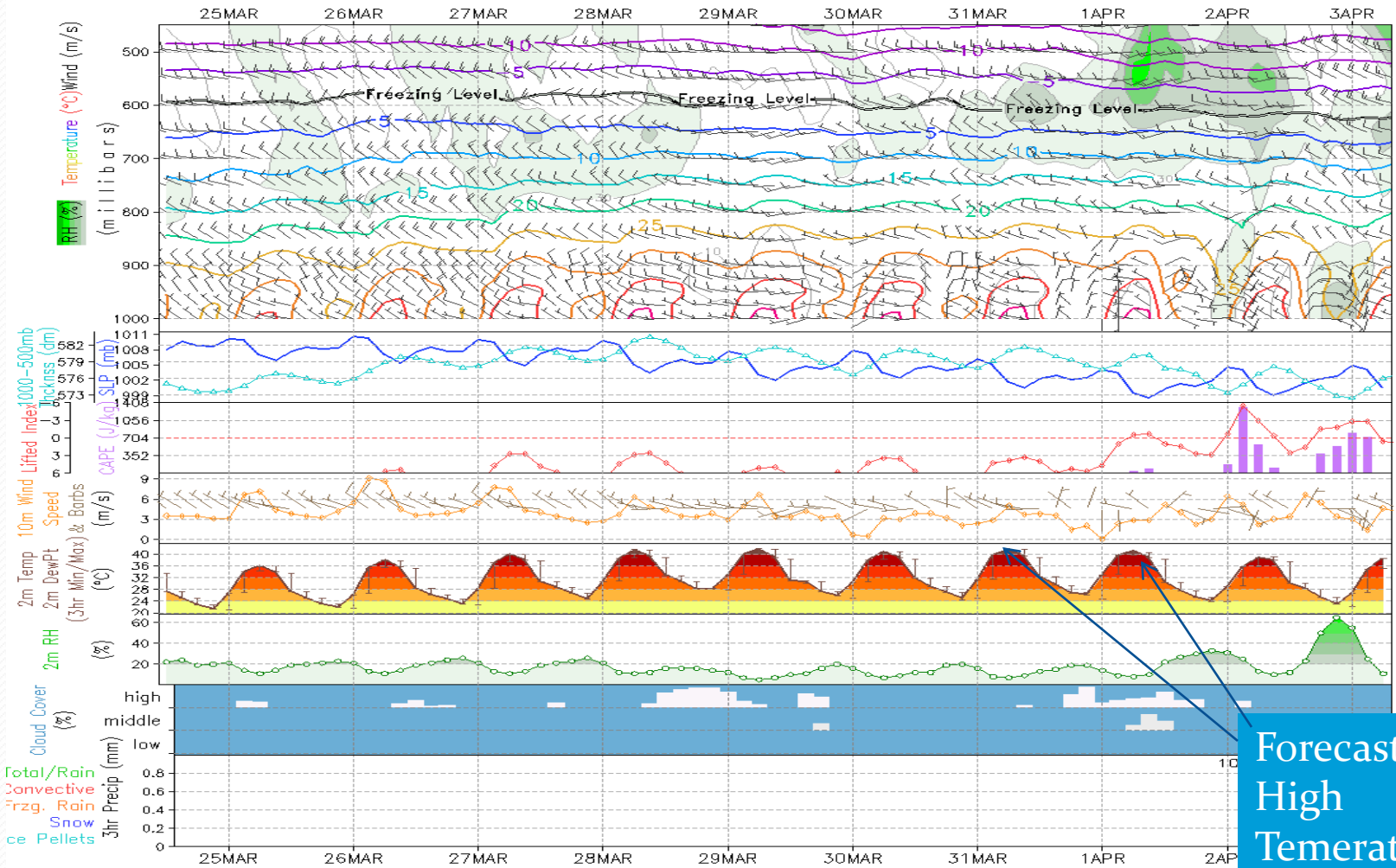
DELHI(SFD)

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



Meteogram of Safadarganj : 25th March 2017

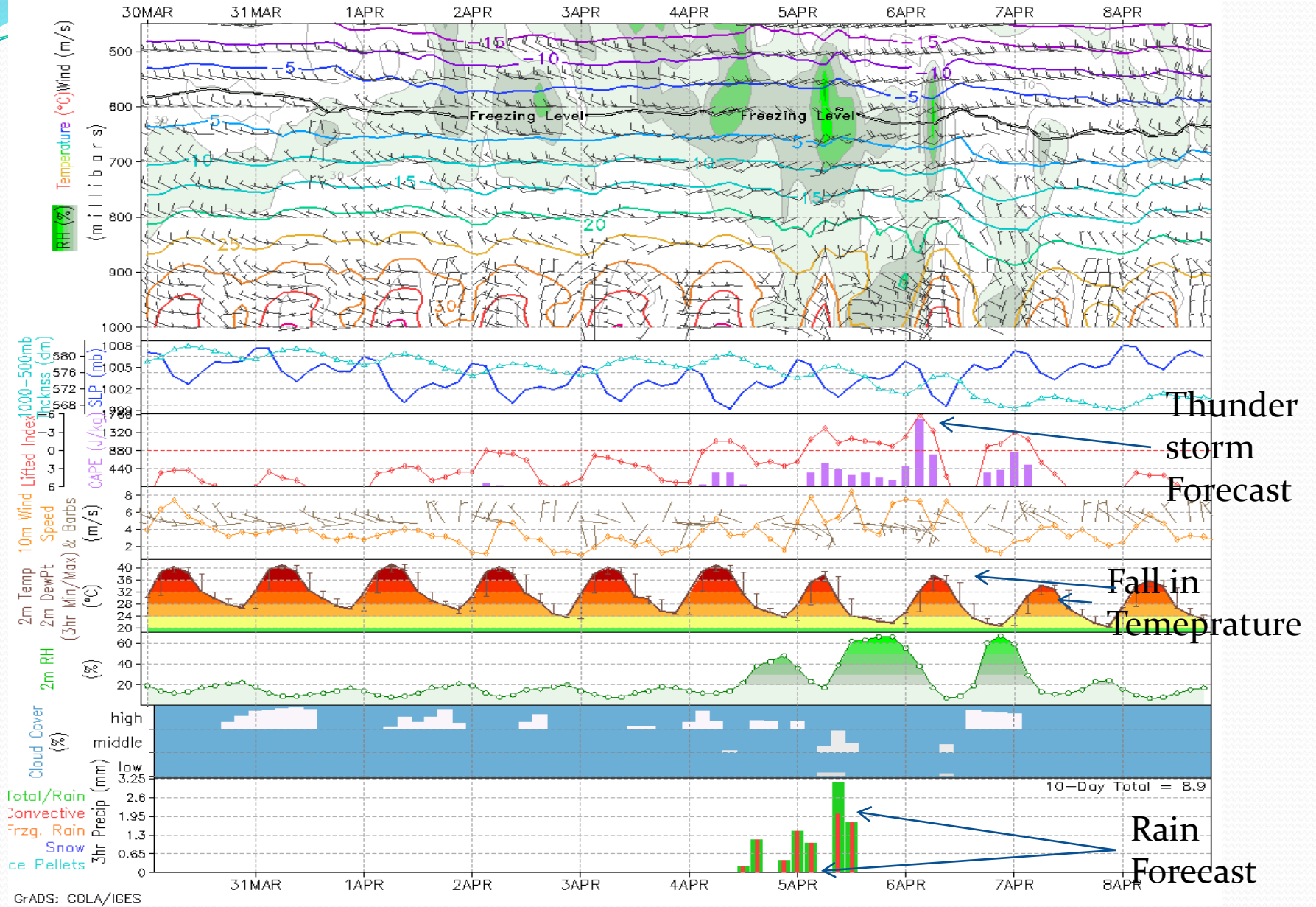
DELHI/SAFDARJUNG IMD GFS 0~10day 3-hourly Forecast Meteogram for (77.25E, 28.5N)



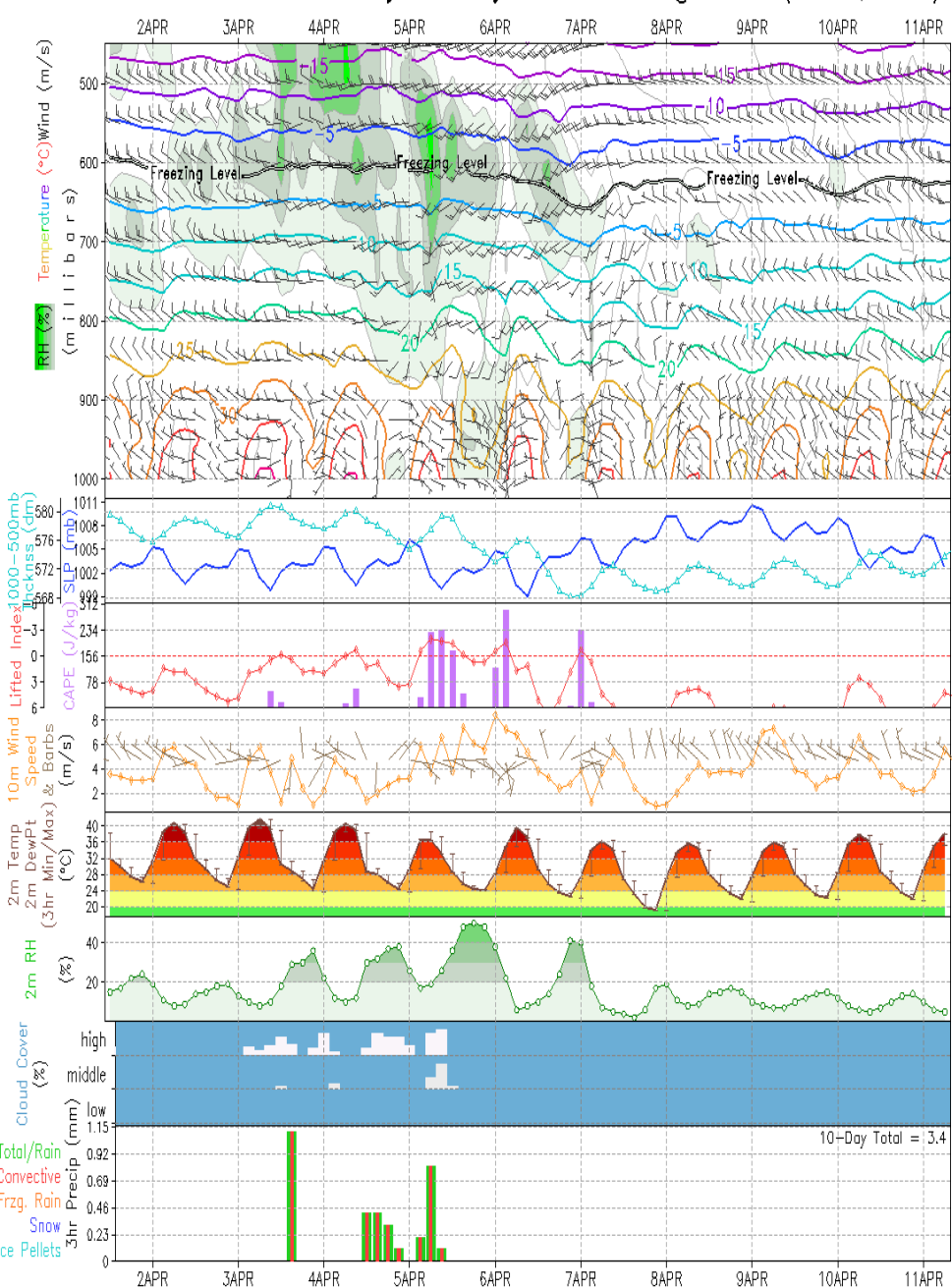
Case-I (BSES)

- The prediction of rainfall as well as fall in temperatures from $\sim 40^{\circ}\text{C}$ 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

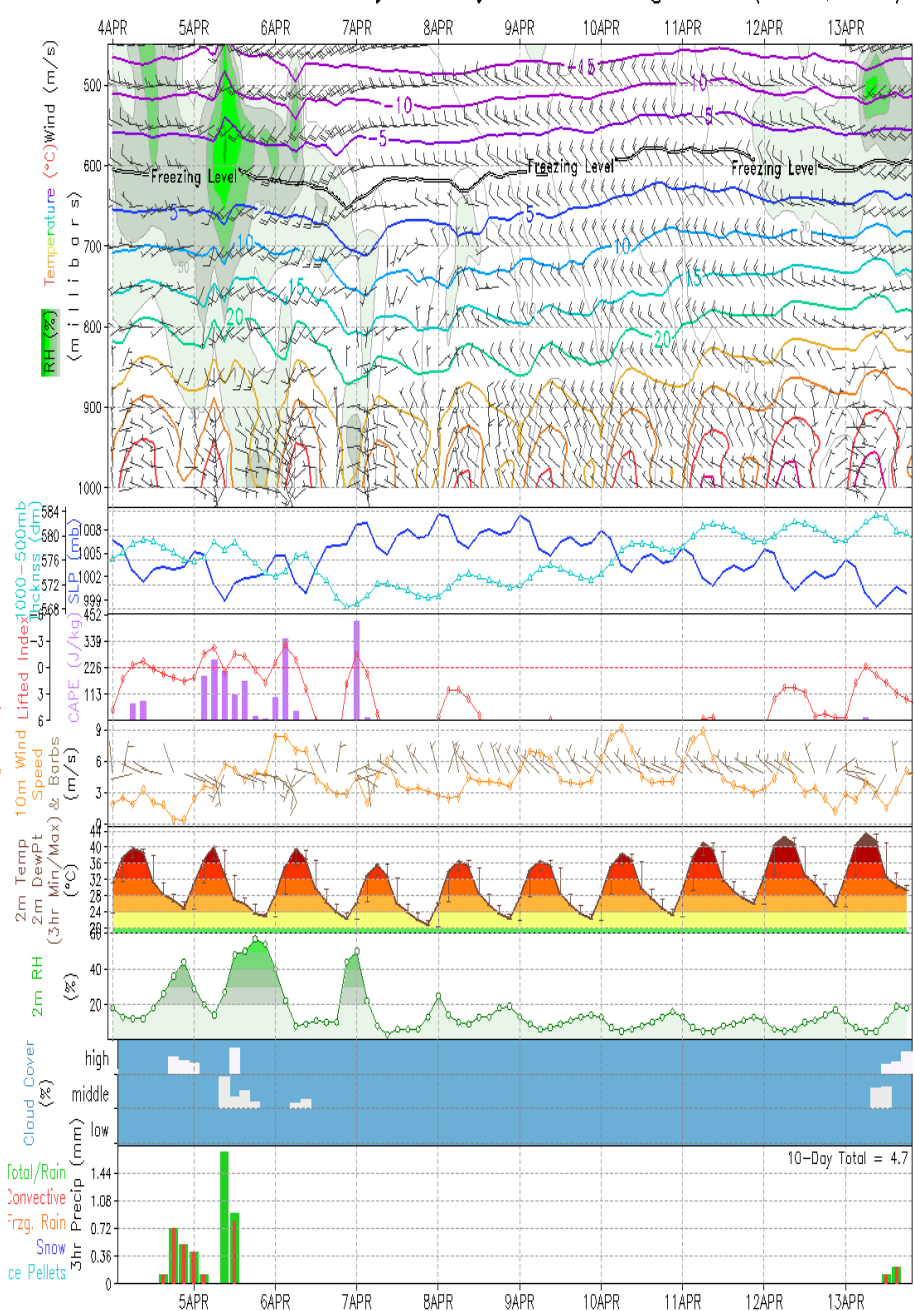
DELHI/SAFDARJUNG IMD GFS 0~10day 3-hourly Forecast Meteogram for (77.25E, 28.5N)



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)

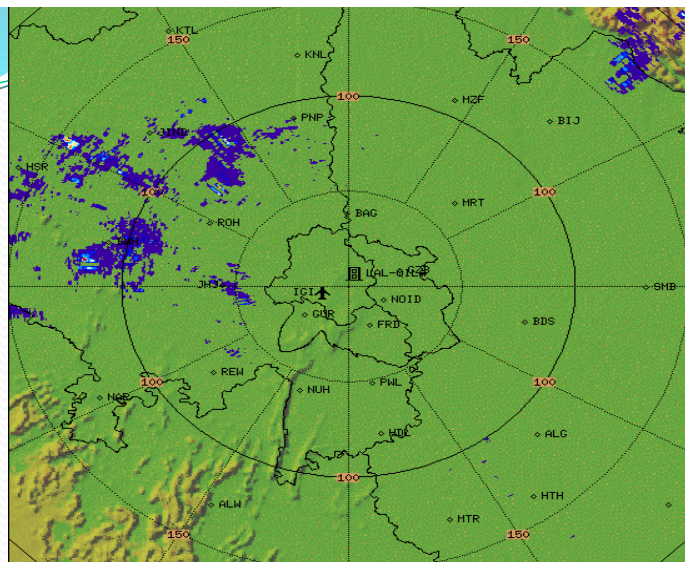


Real Time tracking through radar

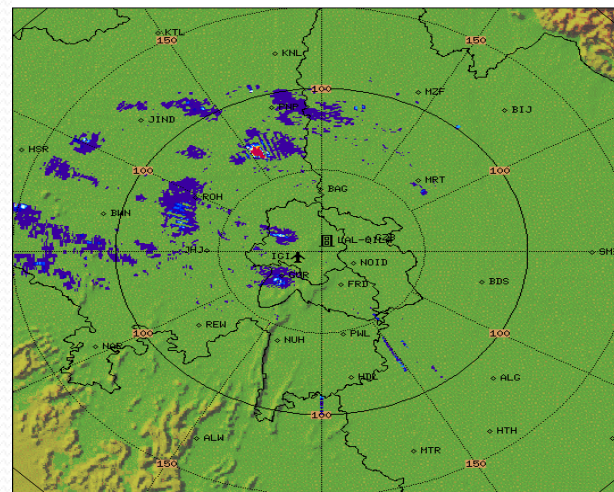
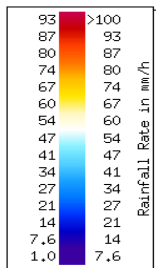
Images

- *Continuous tracking of rainfall movement on 4th and 5th April 2017, helped backing down generation in advance to some 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

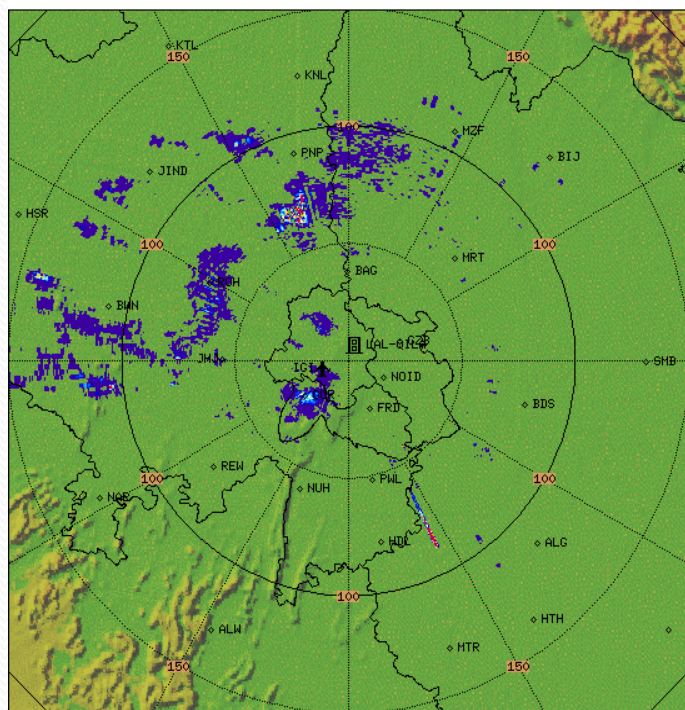
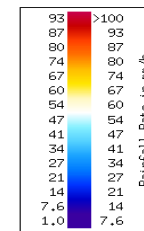
Tracking of Rainfall Movement on 5th April 2017



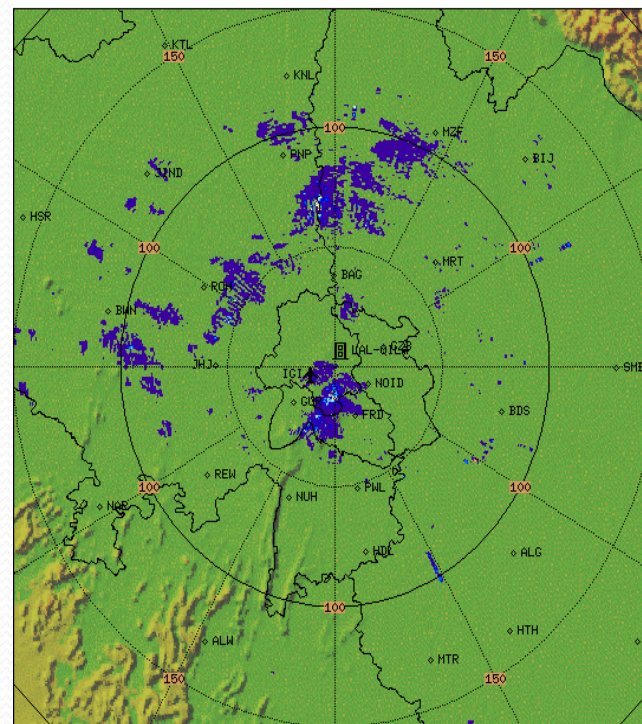
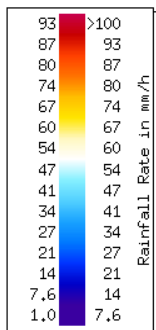
DELHI
Surface Rainfall
R_150KM
Task: IMD-B
PRF:600/450
Melt:3.8 km
Max Range:150 km
11:44:48Z
5 APR 2017 UTC



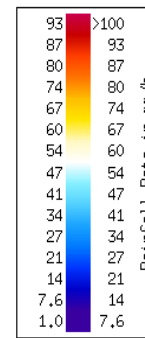
DELHI
Surface Rainfall
R_150KM
Task: IMD-B
PRF:600/450
Melt:3.8 km
Max Range:150 km
12:22:29Z
5 APR 2017 UTC

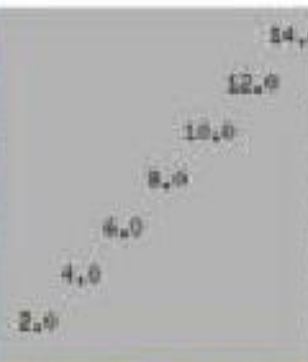
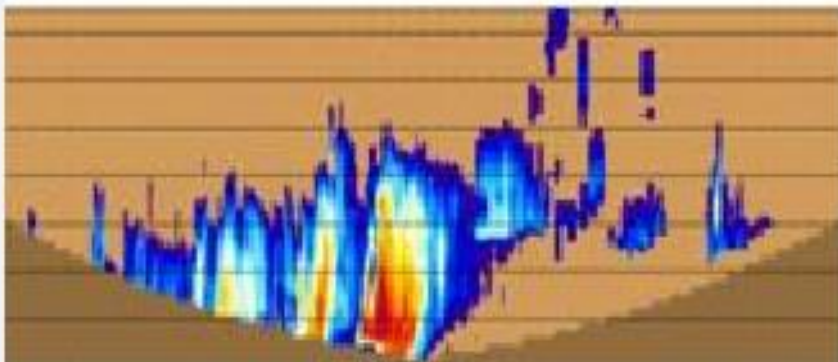


DELHI
Surface Rainfall
R_150KM
Task: IMD-B
PRF:600/450
Melt:3.8 km
Max Range:150 km
12:32:29Z
5 APR 2017 UTC

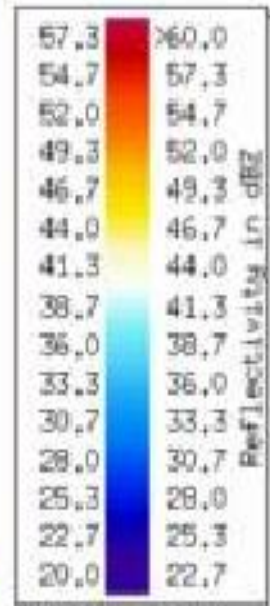


DELHI
Surface Rainfall
R_150KM
Task: IMD-B
PRF:600/450
Melt:3.8 km
Max Range:150 km
12:52:29Z
5 APR 2017 UTC





DELHI
 Max with panels
 MAX_Z
 Task: IMD-B
 Min Hgt:10.0 km
 Max Hgt:15.0 km
 Max Range:250 km
12:32:29Z
5 APR 2017 UTC



Way Forward for Summer/Monsoon 2017

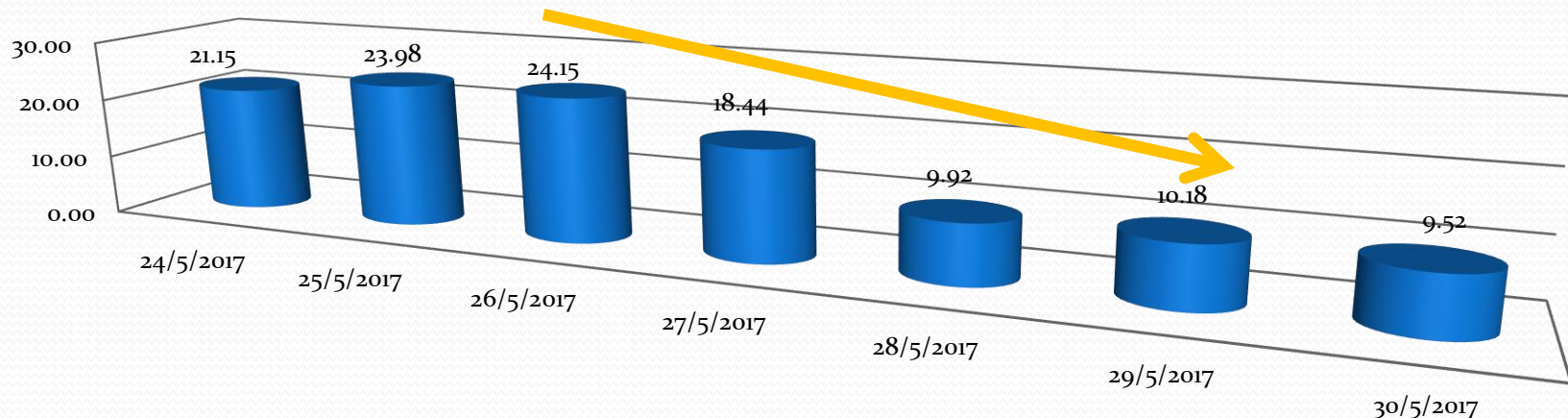
- Tracking of real time Thunderstorm / Rainfall movement shall help plan in advance to back down the generation in at least 1.5 hours in advance, to limit underdrawl.
- *The load fall gradients shall be different for different ambient weather conditions in May, June, July and August and thus, the historical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

Benefit achieved by Uttar Pradesh

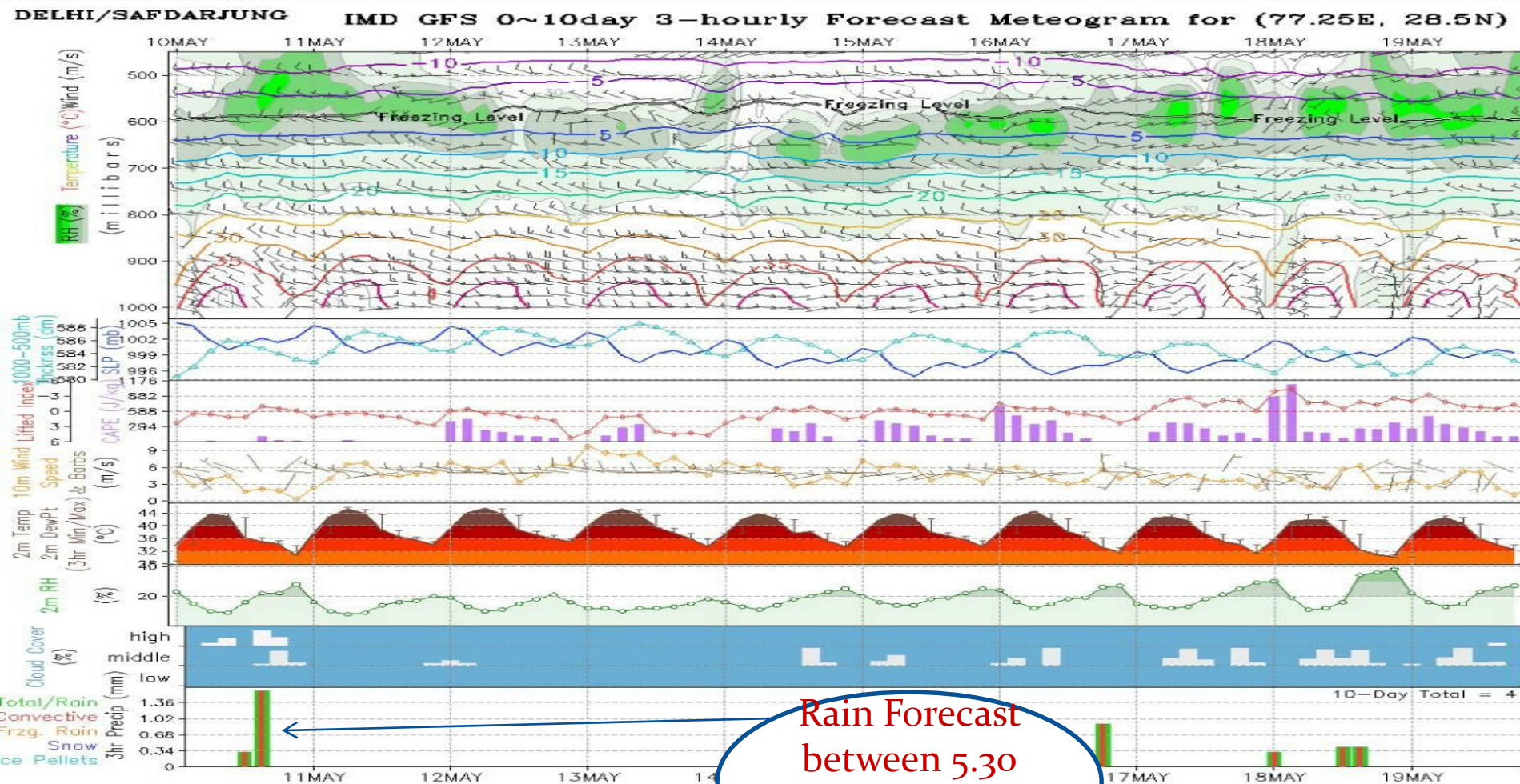
Case-2

- Meteorogram, 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



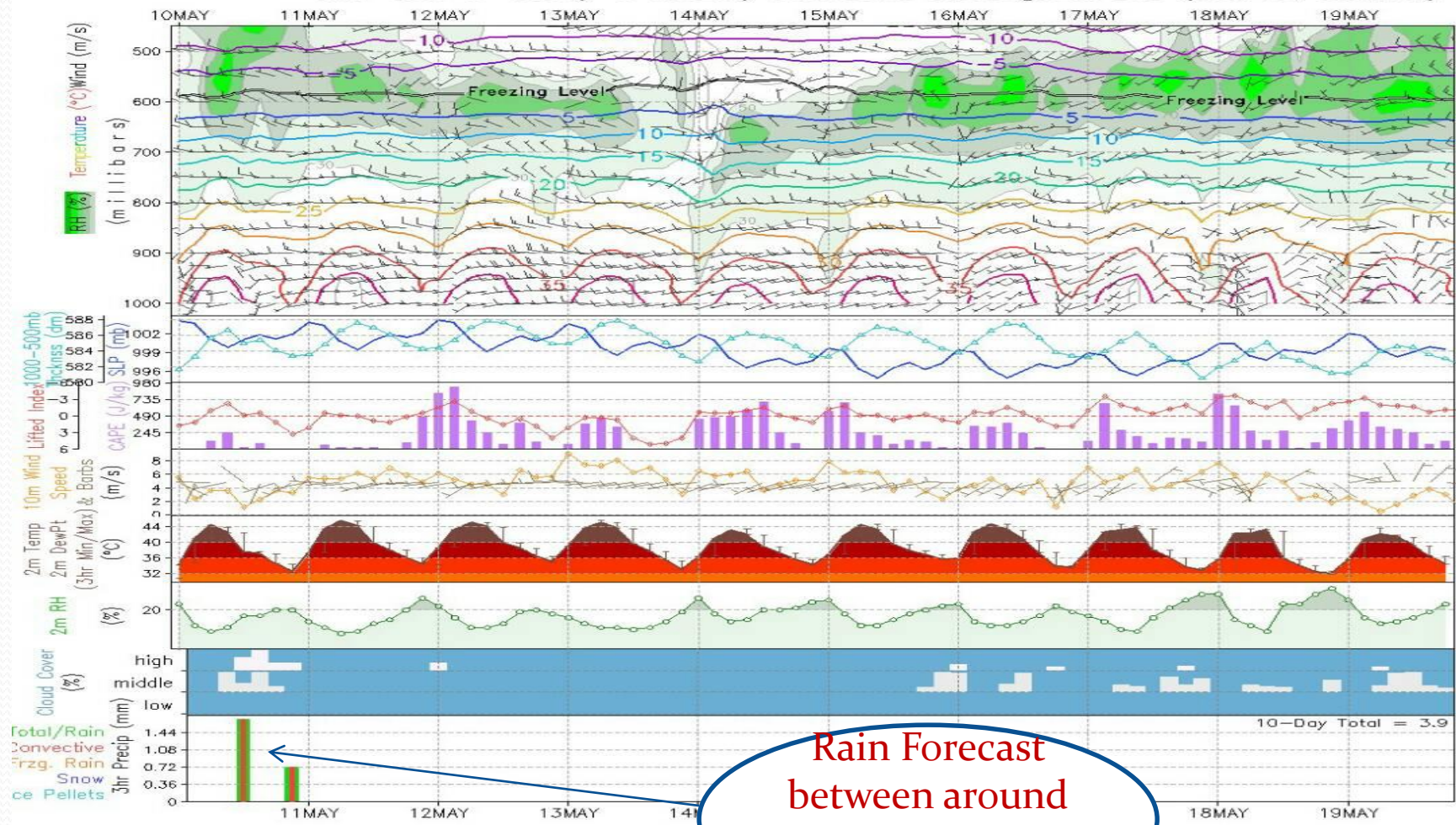
Weather Forecast for Safdarjung -10th May 2017



Rain Forecast
between 5.30
PM to 11.30
PM

Weather Forecast for Hissar -10th May 2017

HISSAR IMD GFS 0~10day 3-hourly Forecast Meteogram for (75.75E, 29.25N)

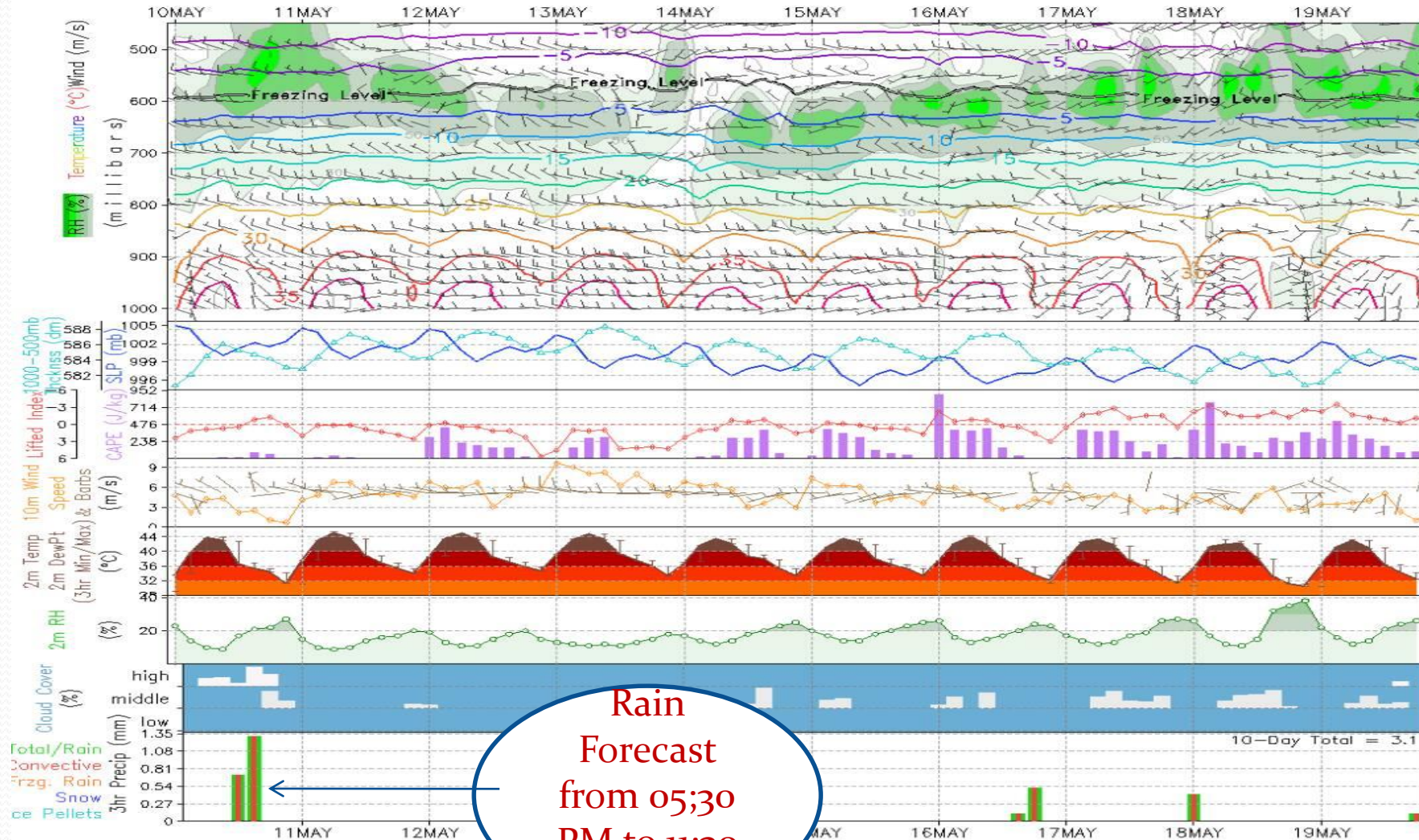


Rain Forecast between around 2.30 PM and 11.30 PM

Weather Forecast for Palam

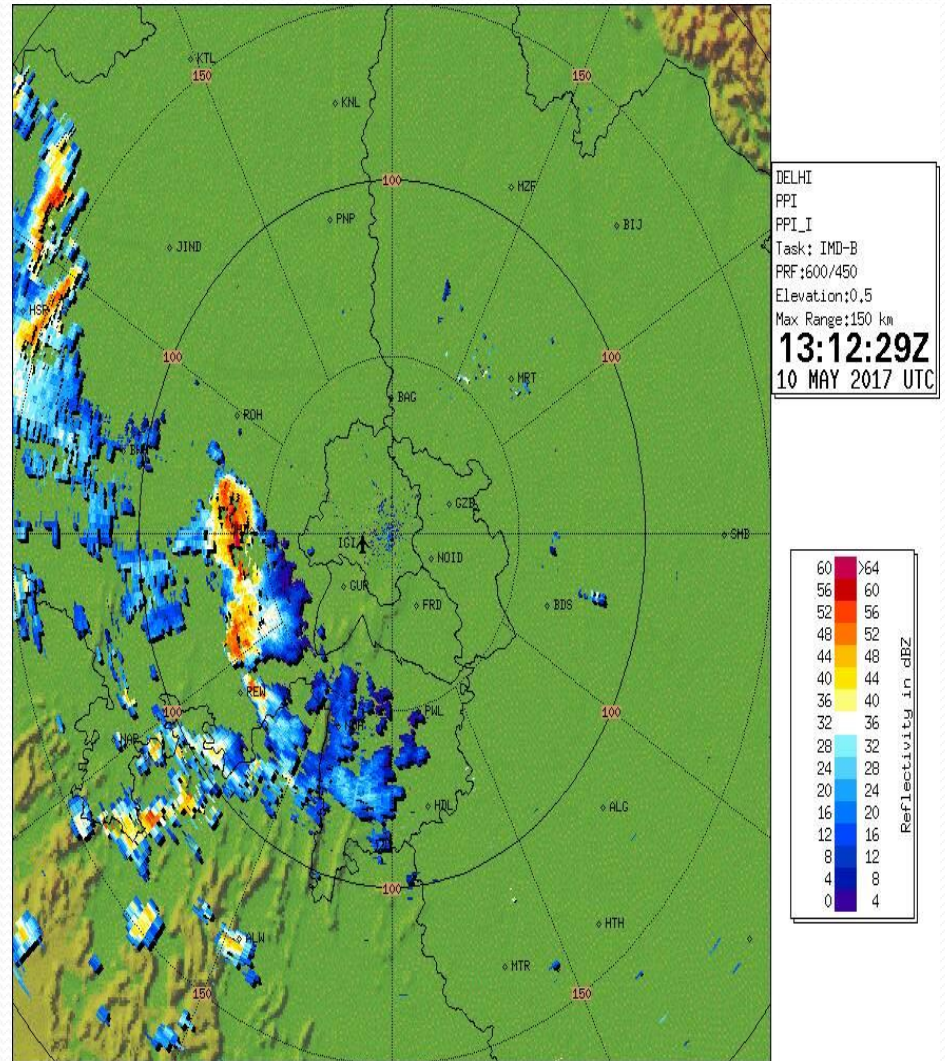
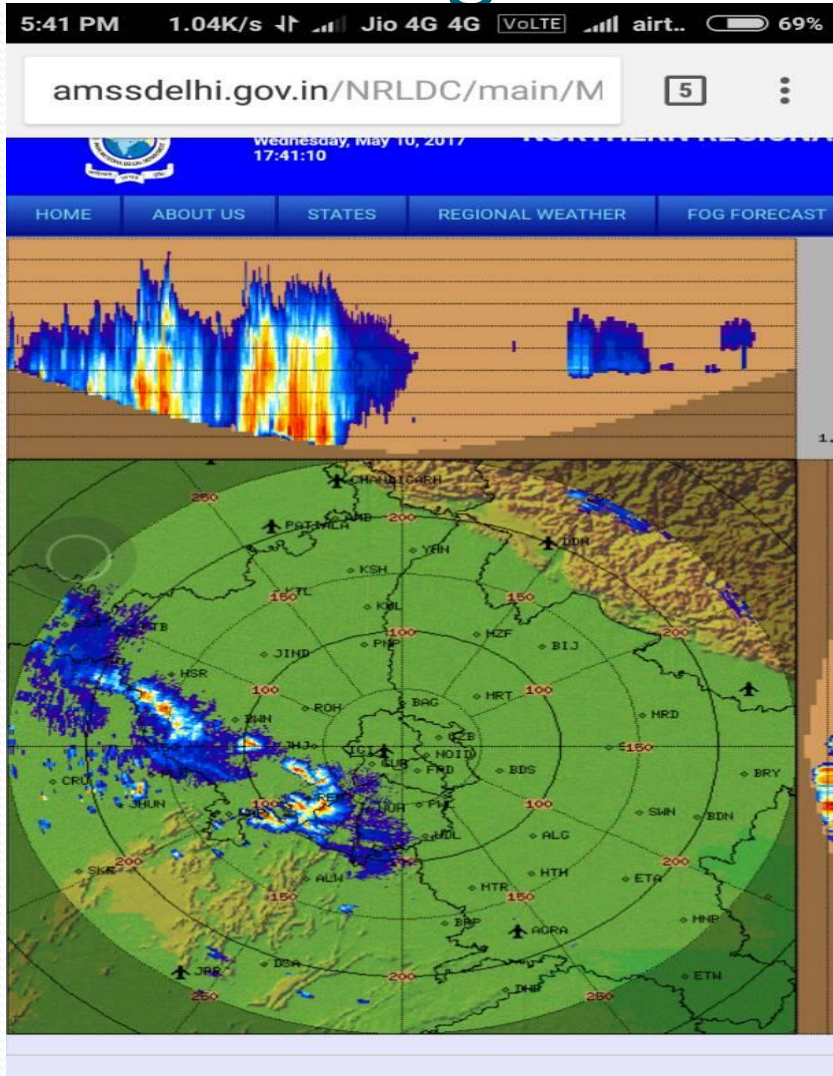
NEW-DELHI/PALAM

IMD GFS 0~10day 3-hourly Forecast Meteogram for (77E, 28.5N)



Rain
Forecast
from 05:30
PM to 11:30
PM

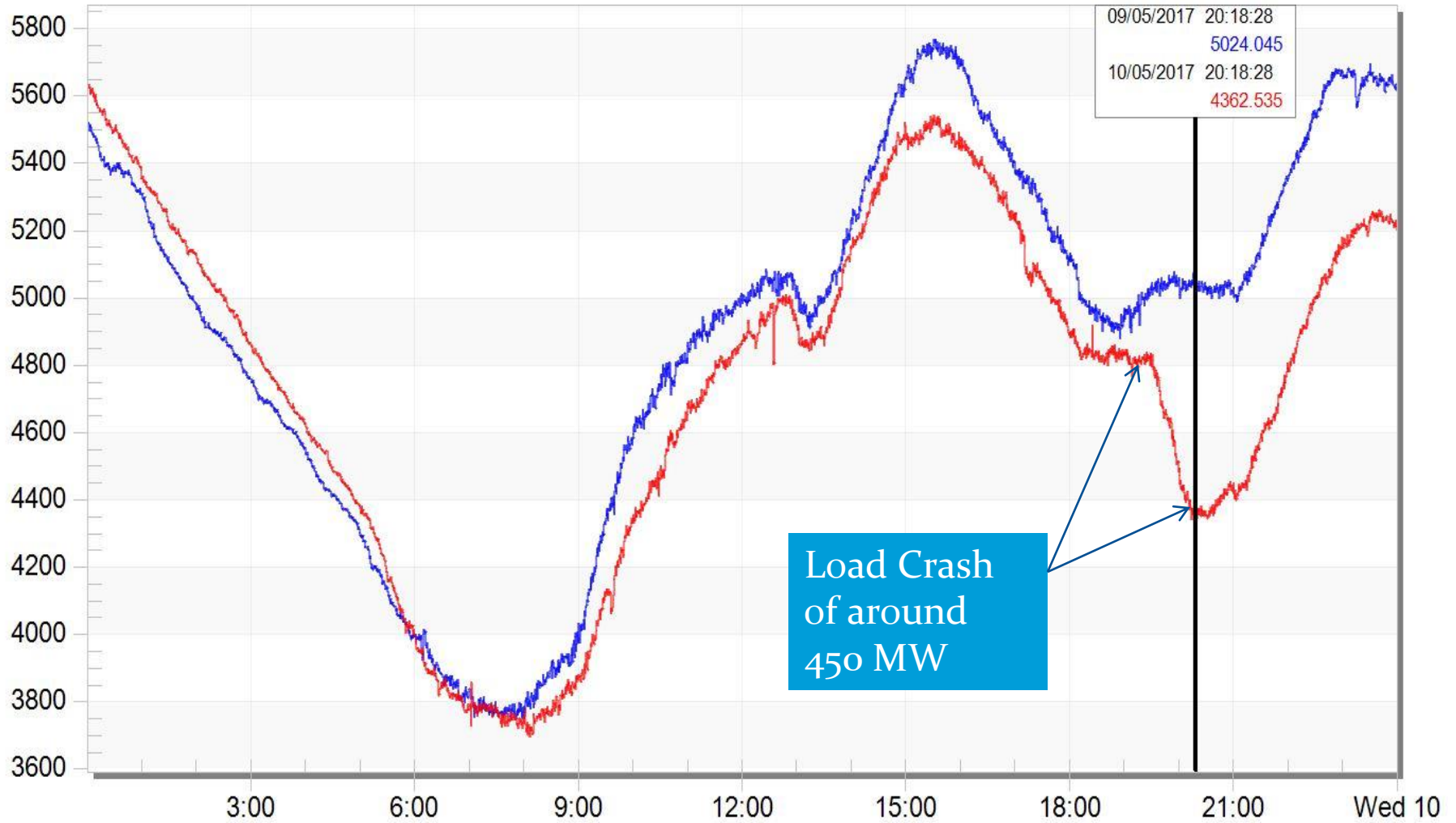
Radar Image



Delhi Demand Met

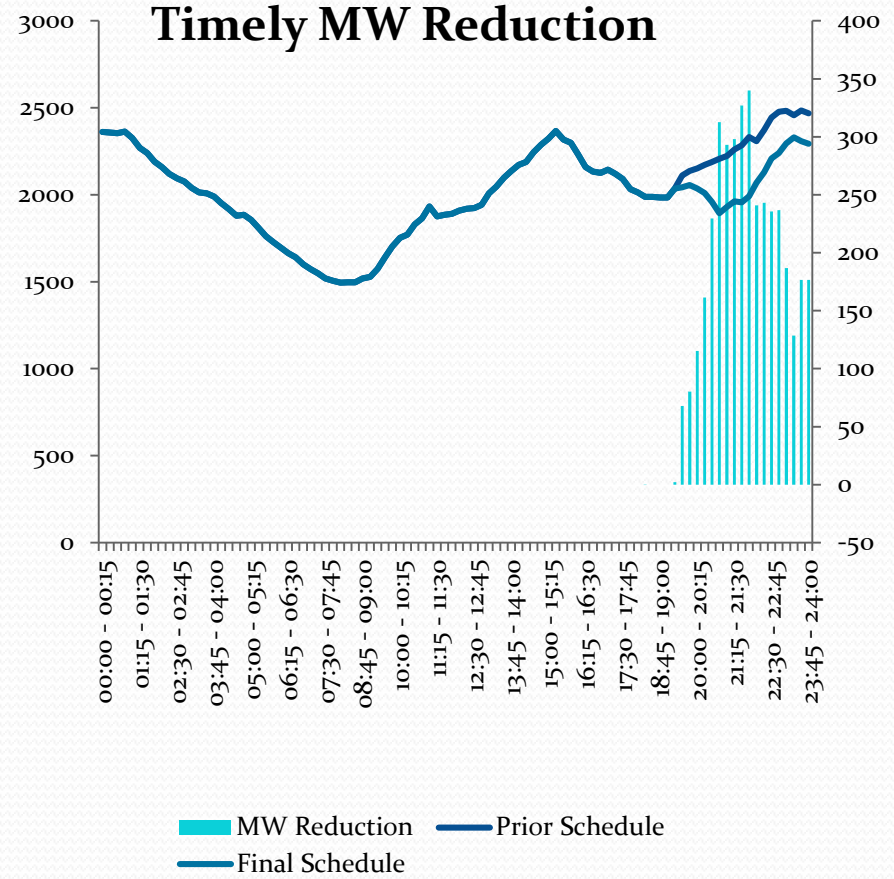
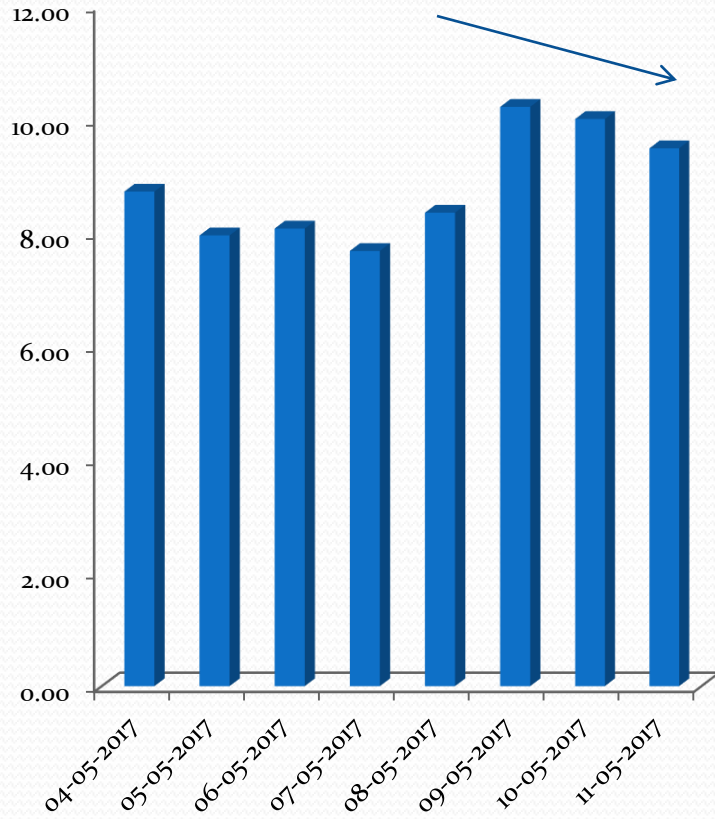
Delhi Demand Met - 09/05/2017 00:00

Delhi Demand Met - 10/05/2017 00:00



Load Crash
of around
450 MW

Total Power Exchange, IDT & Bilateral



Total Mus reduced = 0.24 MUs

Satellite image at 20.15 Hrs

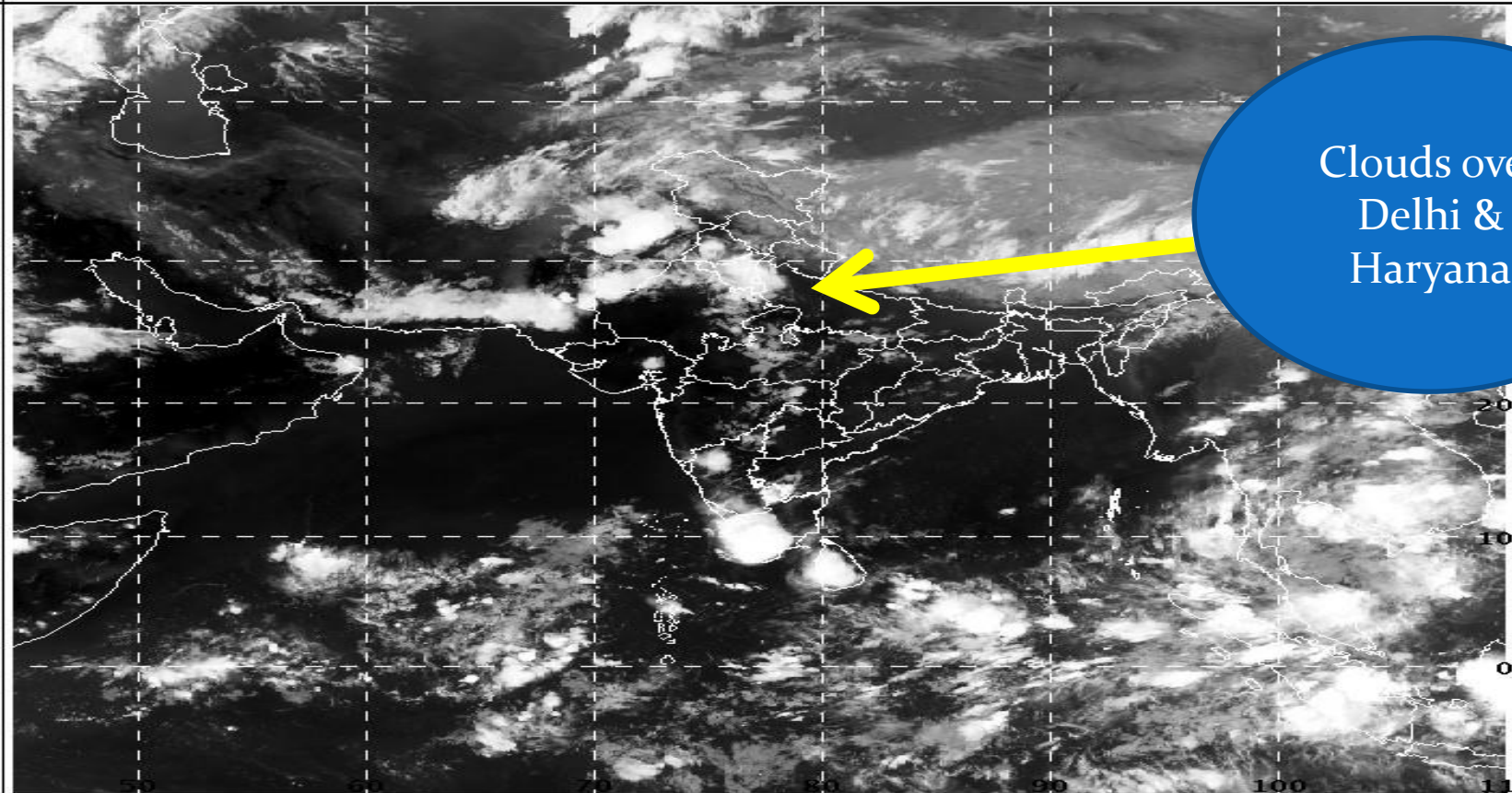
SAT :INSAT-3DR IMG

10-05-2017/14:45 GMT

IMG_TIR1 10.8 um

10-05-2017/20:15 IST

L1C Mercator (LINEAR STRETCH: 1.0%)



Clouds over
Delhi &
Haryana

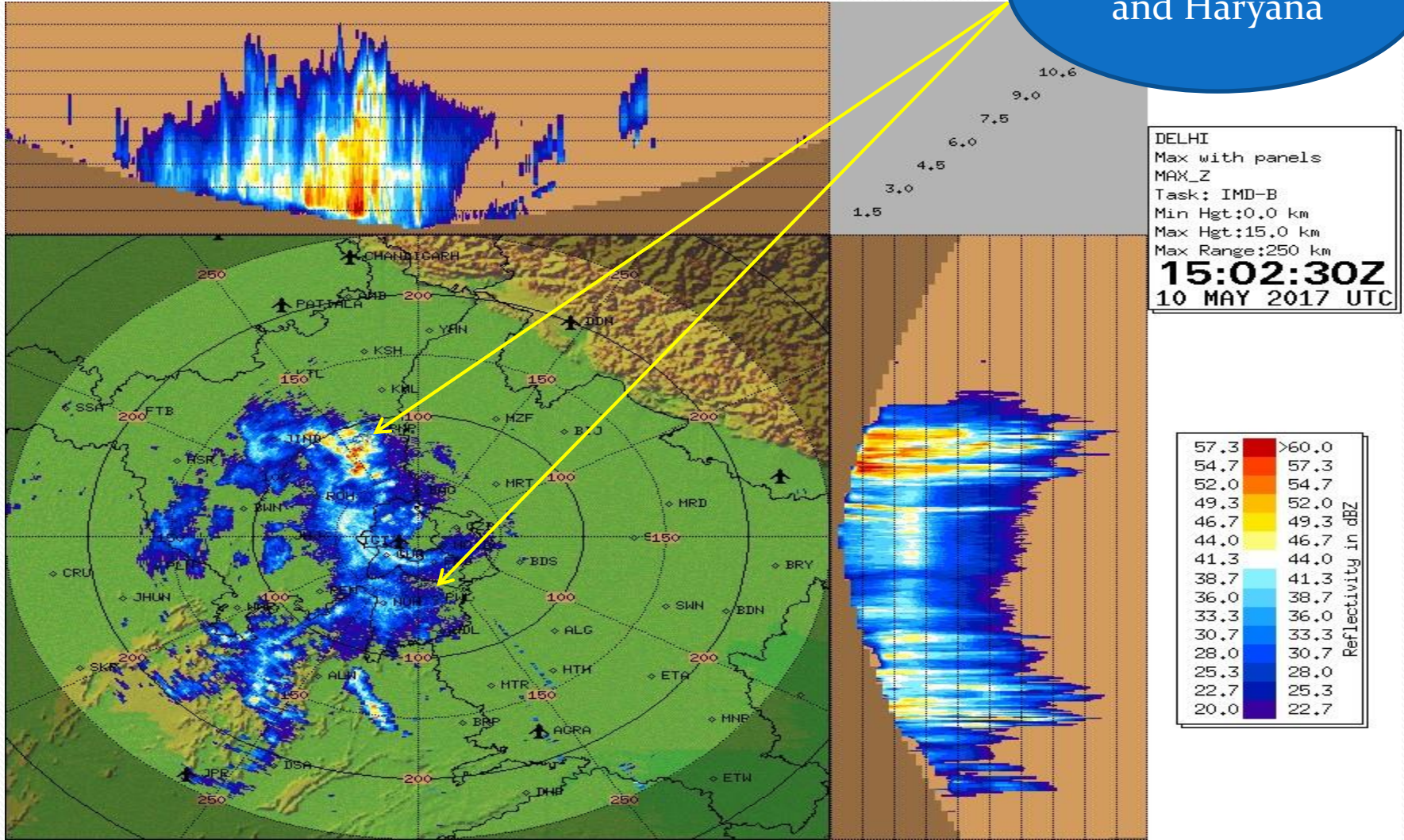
465

908

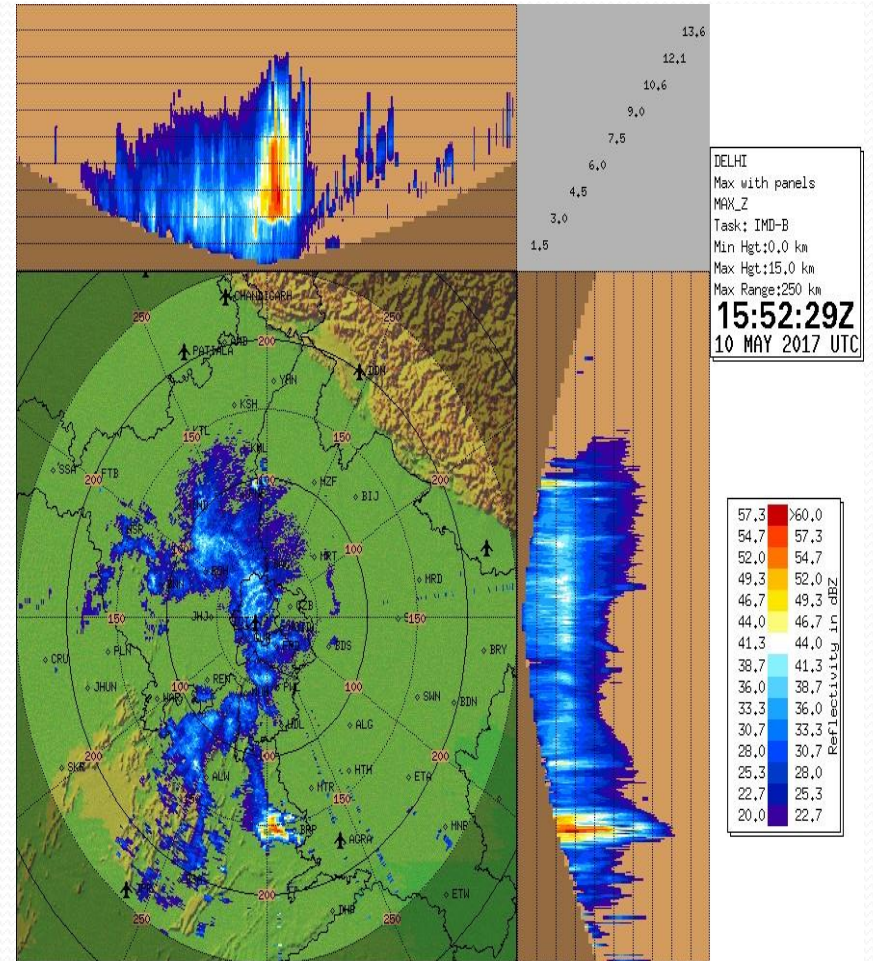
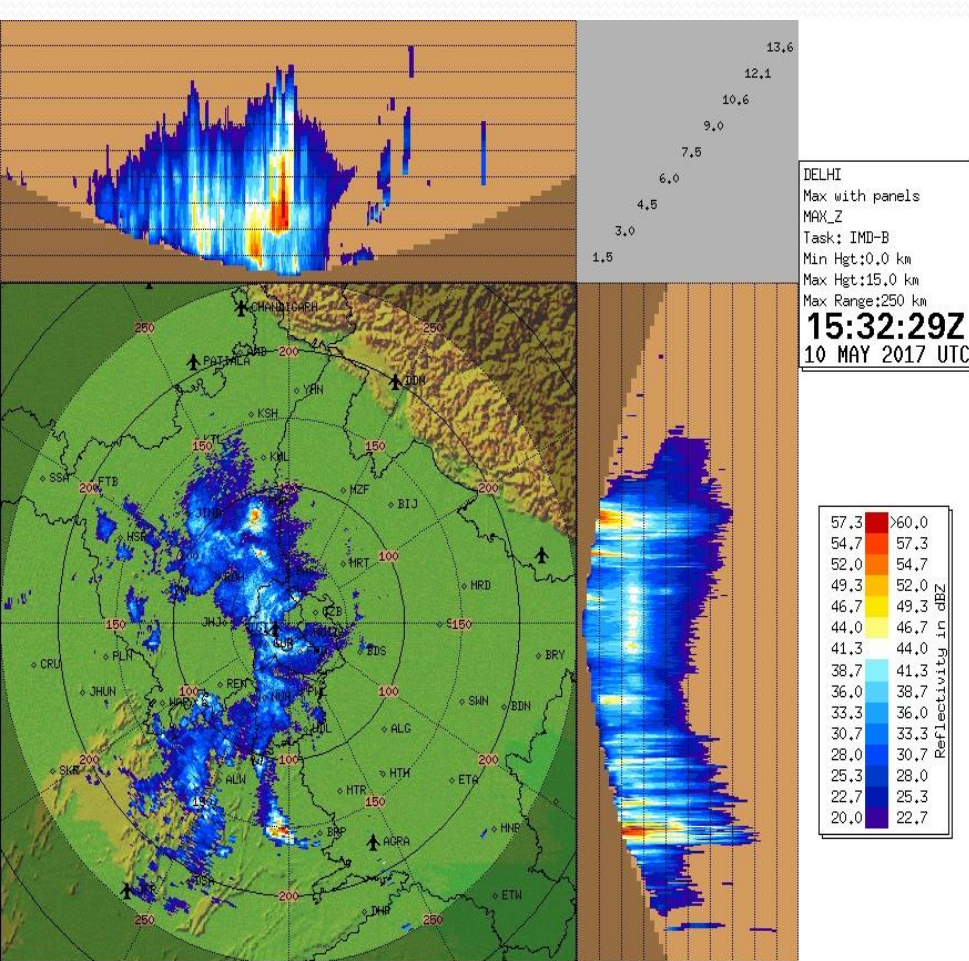
IMD/DELHI

Radar image at 20:32 PM

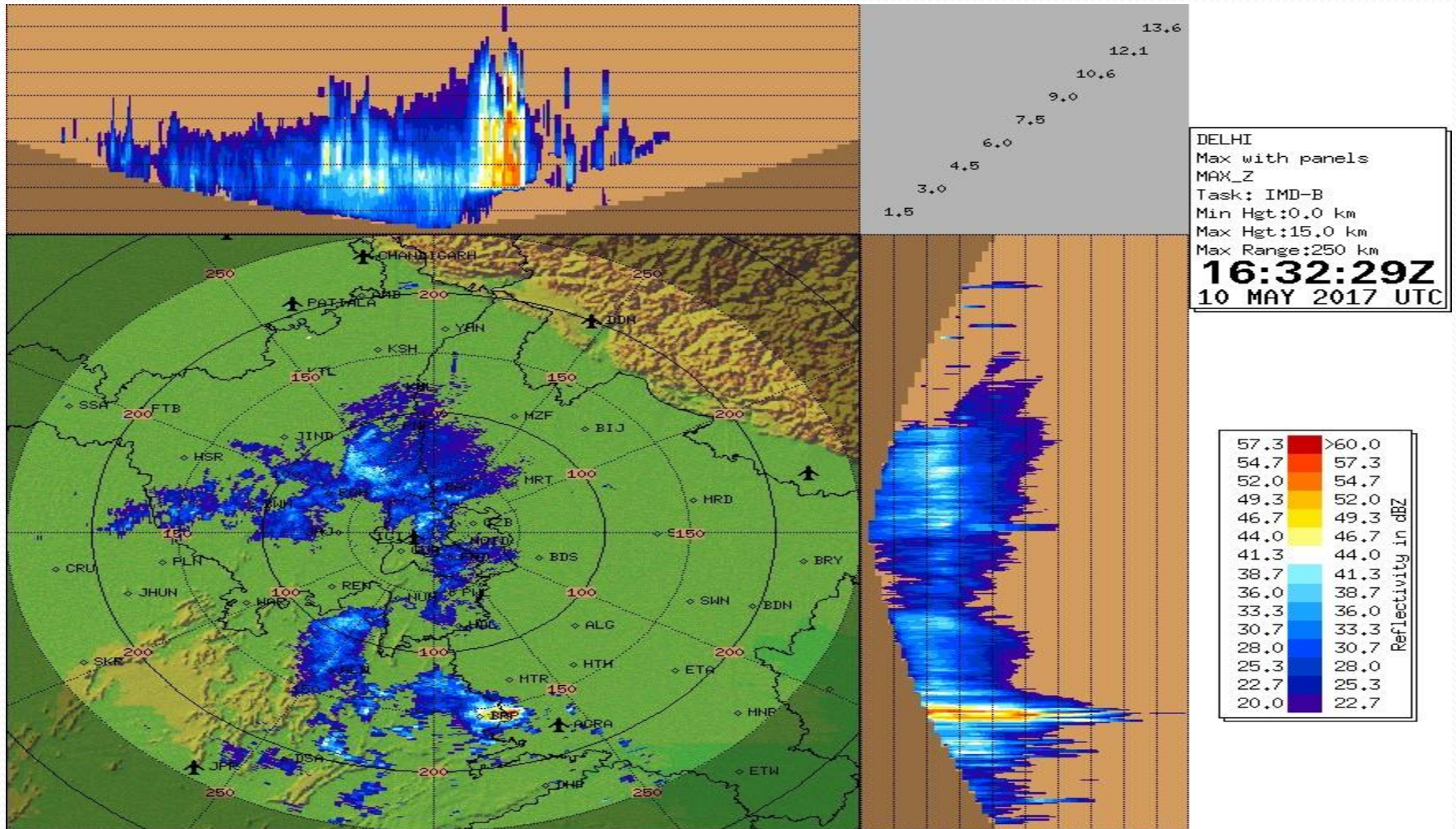
Rains in Delhi
and Haryana



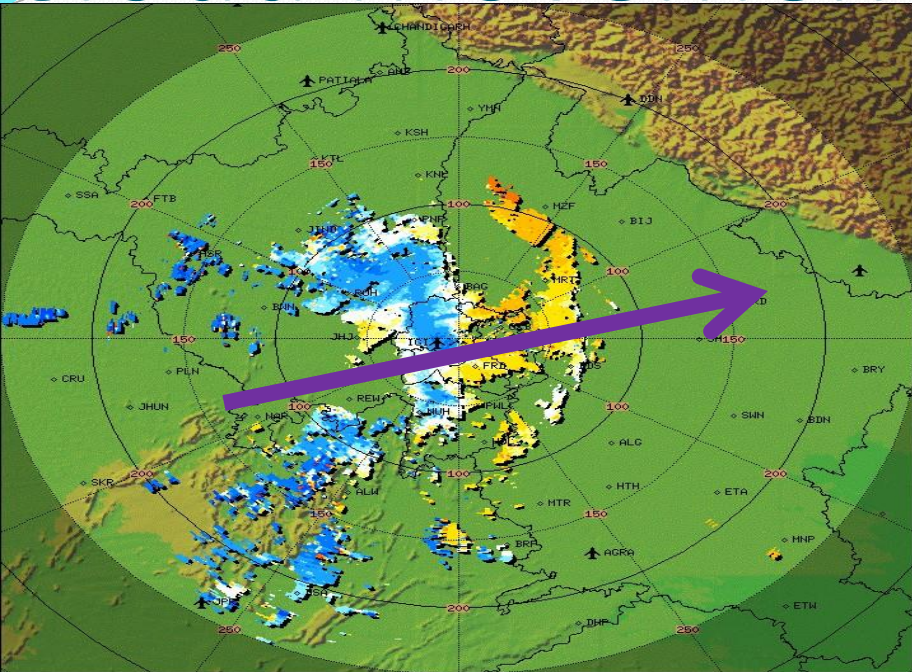
Radar Image at 21.02 PM and 21:22 PM



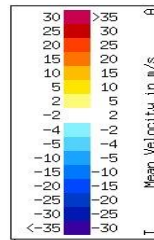
Radar Image at 22:02 Hrs



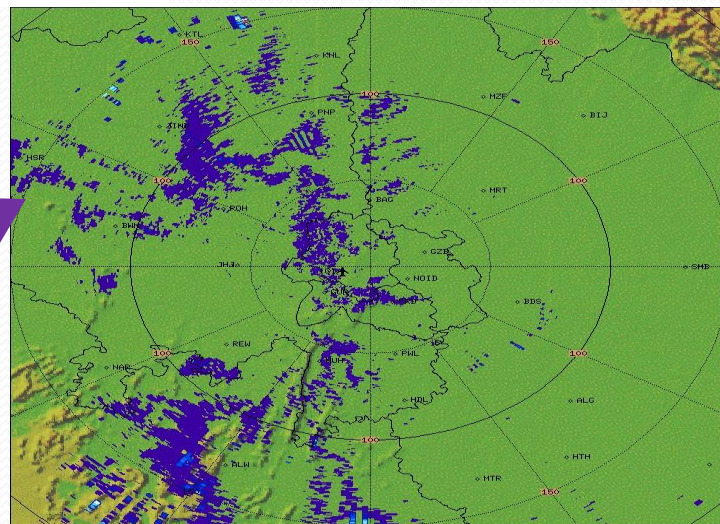
Cloud Movement



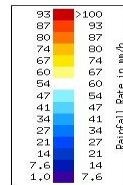
DELHI
 PPI
 PPI_V
 Task: IMD-B
 PRF:600/450
 Elevation:0.5
 Max. Range:250 km
15:42:30Z
 10 MAY 2017 UTC



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



DELHI
 Surface Rainfall
 R_150KM
 Task: IMD-B
 PRF:600/450
 Melt:3.5 km
 Max. Range:150 km
15:42:30Z
 10 MAY 2017 UTC



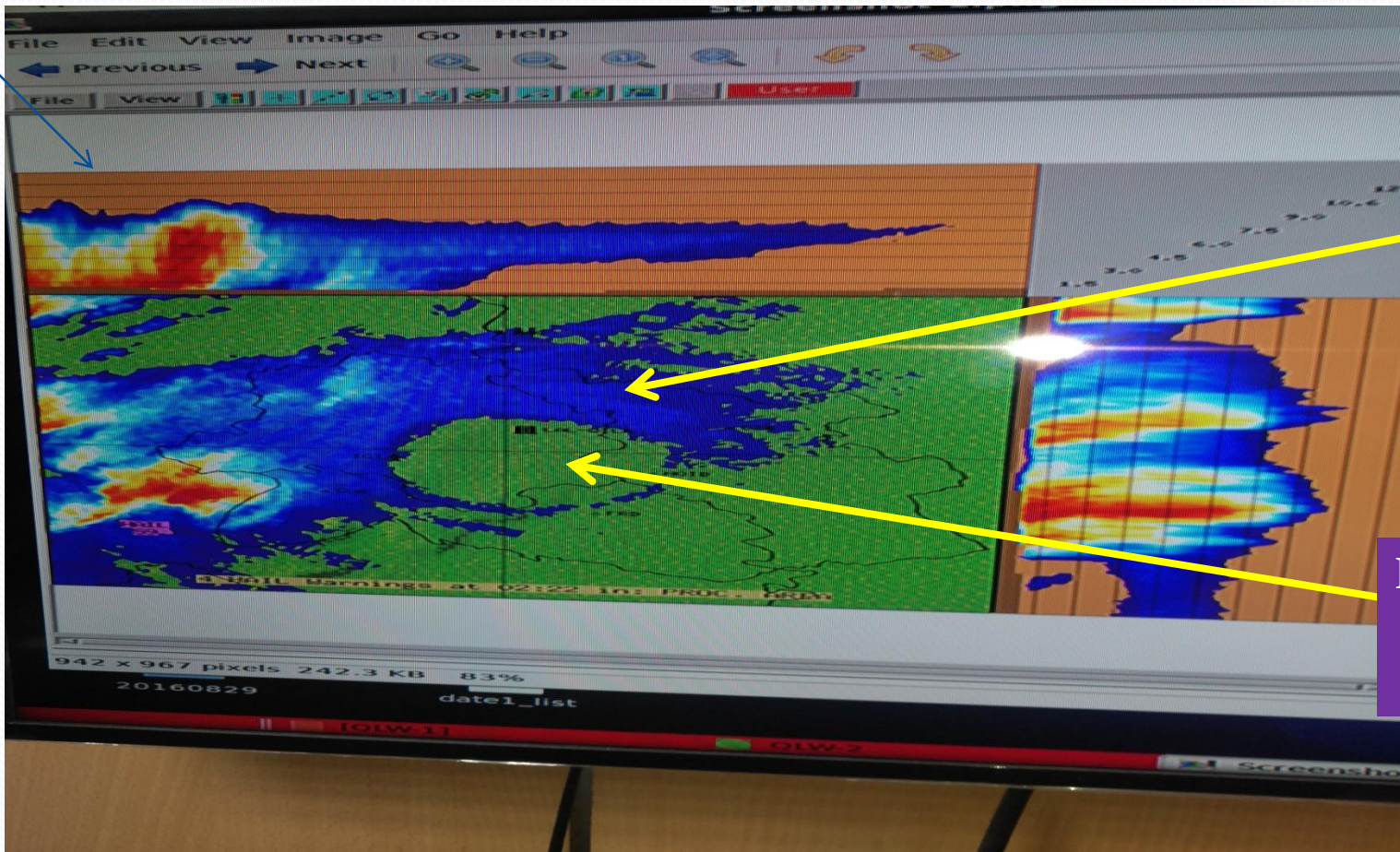
Way Forward

- ***Utilisation of Radar Products in Real time Grid Operation***
- Use of Meteogram/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 & Rajpat



THANKS

Team System Logistics

NRLDC

alok.kumar@posoco.in

09999039321

dkumarp@posoco.in



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 HEP Tehri 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. (°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**

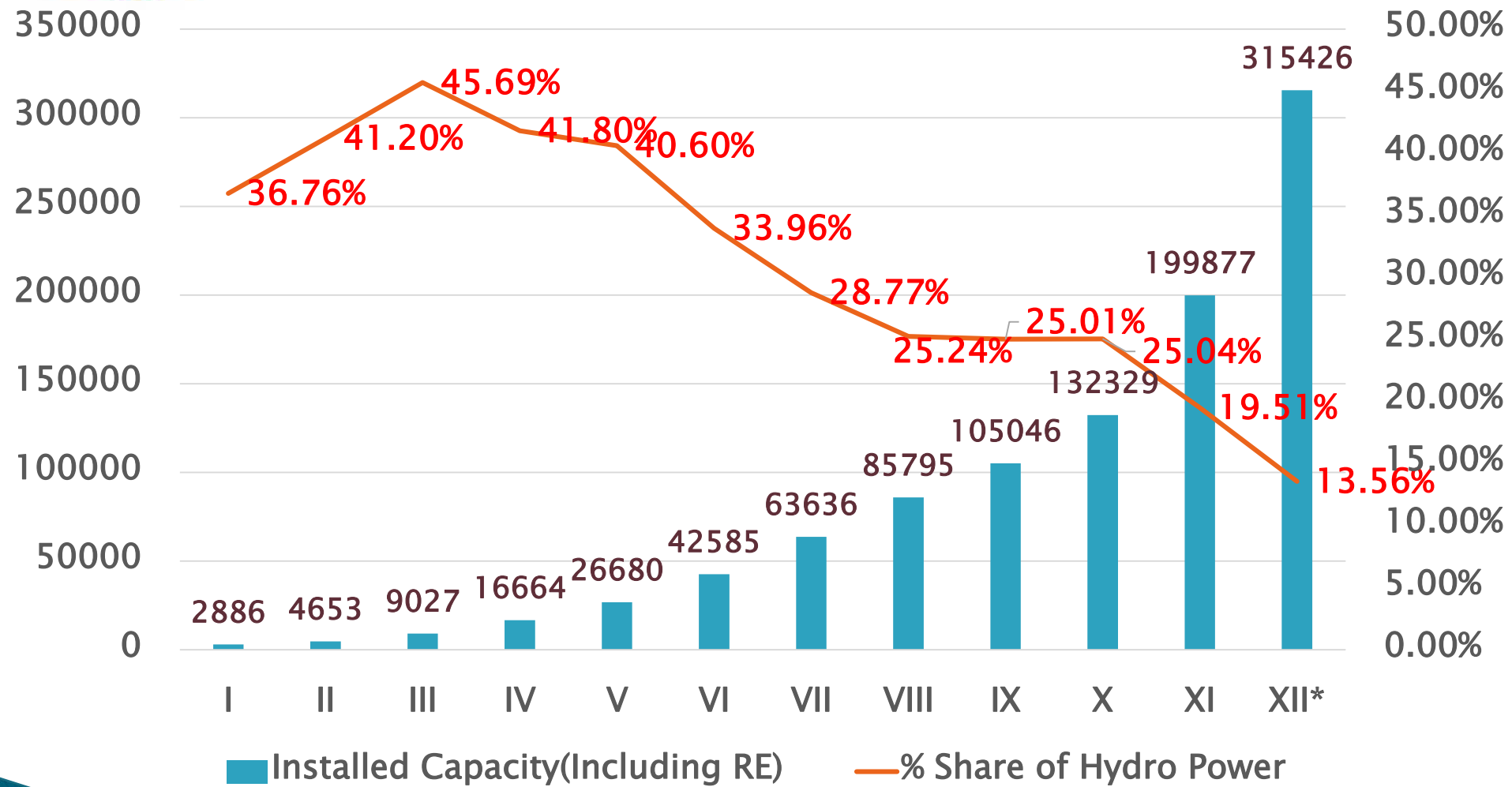
- Thermal:218330MW
- **Hydro:44478MW**
- Nuclear:6780MW
- RES:50018MW

Position in World

- Third Largest Producer
- Forth largest Consumer of Electricity



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



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

Hydraulic Constraints of Operation of BBMB Hydro stations

After re-organization of Punjab, **BBMB** was constituted under Section-79 (1) read with Section -80 (6) of Punjab Re-organization Act, 1966 for the Administration, Operation & Maintenance of Bhakra Nangal and Beas Projects. The nature, constitution and the functions assigned to BBMB under this Act are unique and distinct from other State Power Utilities.

BBMB projects are multipurpose projects. BBMB has been engaged in the activities of regulation of the supply of water for irrigation and power generation from Bhakra – Nangal and Beas Projects.

The BBMB Generating station comprises 6 Power Houses having total installed capacity of 2918.73 MW viz. Bhakra Left Bank Power House (594 MW), Bhakra Right Bank Power House (785 MW), Ganguwal Power House (76.39 MW), Kotla Power House (77.34 MW), Dehar Power House (990 MW) and Pong Power House (396 MW).

Generation from BBMB powerhouses is being done keeping in view primarily the irrigation demand of partner states, stringent hydraulic parameters of BBMB Water Conductor System and also grid requirements.

Irrigation requirement/Water releases from reservoir based projects viz- Bhakra & Pong is decided in the Technical Co-ordination Meeting (TCM) of BBMB on 10 daily basis which is further reviewed on daily basis. Generation from these projects is scheduled accordingly. As regards the Dehar project which has very small pondage, generation is scheduled based on the daily water inflows.

At Bhakra and Dehar there are typical hydraulic constraints and have stringent hydraulic parameters. So power generation from these projects has to be regulated accordingly.

a) **Operating Level Constraints at Nangal Dam**

Down stream of Bhakra there is Nangal Dam having small pondage (Operating level 1144'-1154'). It acts as a balancing reservoir to smoothen the variation of water discharge from Bhakra Power Houses on account of peaking.

For releases less than 22000 cusecs, power generation during peak demand has to be curtailed at less than the installed capacity of Bhakra Power Houses to avoid spilling at Nangal Dam.

b) **Hydraulic constraints at Dehar Power House**

- i) For Power generation at Dehar, water of river Beas is diverted from Pandoh dam to Balancing Reservoir located at Sundernagar through Pandoh Baggi Tunnel and Baggi Sundernagar Open Channel.
- ii) The water diverted from Beas is stored in a balancing reservoir at Sundernagar and used for generation at Dehar Power House through Sundernagar Sallapar Tunnel.
- iii) The storage capacity of balancing reservoir being very less, the inflows and outflows have to regulated in such a way so as to provide maximum generation during peak hours.
- iv) Machines at Dehar power house are operated keeping in view the above mentioned constraints.

AT DIFFERENT POWER HOUSES THERE COULD BE TYPICAL HYDRAULIC CONSTRAINTS. BHAKRA POWER HOUSE AND DEHAR POWER HOUSE OF BBMB HAVE STRINGENT HYDRAULIC PARAMETERS AND THE POWER GENERATION HAS TO BE REGULATED ACCORDINGLY

HYDRAULIC CONSTRAINTS BAGGI SUNDERNAGAR HYDEL CHANNEL

Raising @ 1000 cuses per ½ hrs.

Lowering @ 600 cusec per ½ hr.

MAXIMUM DRAWDOWN LIMIT

Above 2748' - 4 Feet/Hour

- **For Optimising Generation at Mukerian Powerhouse and to avoid spilling at Shahnahar Barrage, minimum number of machines run round the clock at Pong.**
- **For discharge More than 10000 Cs - 2 Machines.**
- **For discharge between 8000 to 10000 Cs – 1 Machine.**

As BBMB is a multi-purpose project, its common asset base is used for both regulation of supply of water and power generation.

Dehar Power House having installed capacity of 990 MW comprises 6 machines of 165 MW each. Due to the hydraulic constraints only 5 machines can be run during peak hours in spite of availability of water for 6 machines.



Adverse Effects of variability of Renewable Power

A K Sinha
AGM, NTPC Ltd



Contents

Renewable Integration Plan and its Impact

Impact on coal and gas based Plants
(Flexible Operation and Damage Mitigation)

Impact of Variable Renewable Integration on Grid

Policy Advocacy

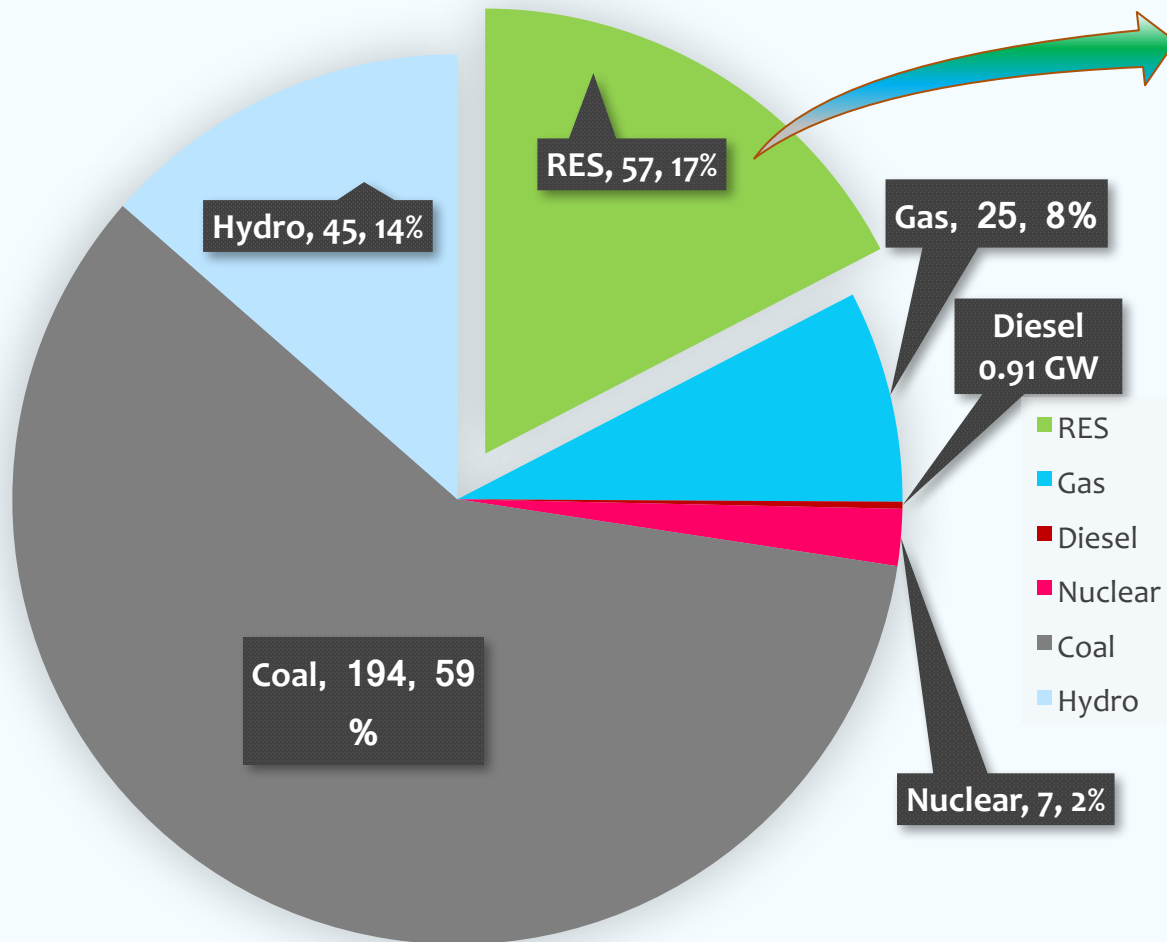
Conclusion

A conceptual illustration of renewable energy. A human hand is shown from the bottom left, cupping a small, green, textured globe of the Earth. On the globe, a blue solar panel is mounted on a black stand, and two white wind turbines are positioned. The background features a bright yellow sun in the top left corner, green trees, and a blue sky with light clouds. A large blue and green diagonal graphic element is on the right side of the image.

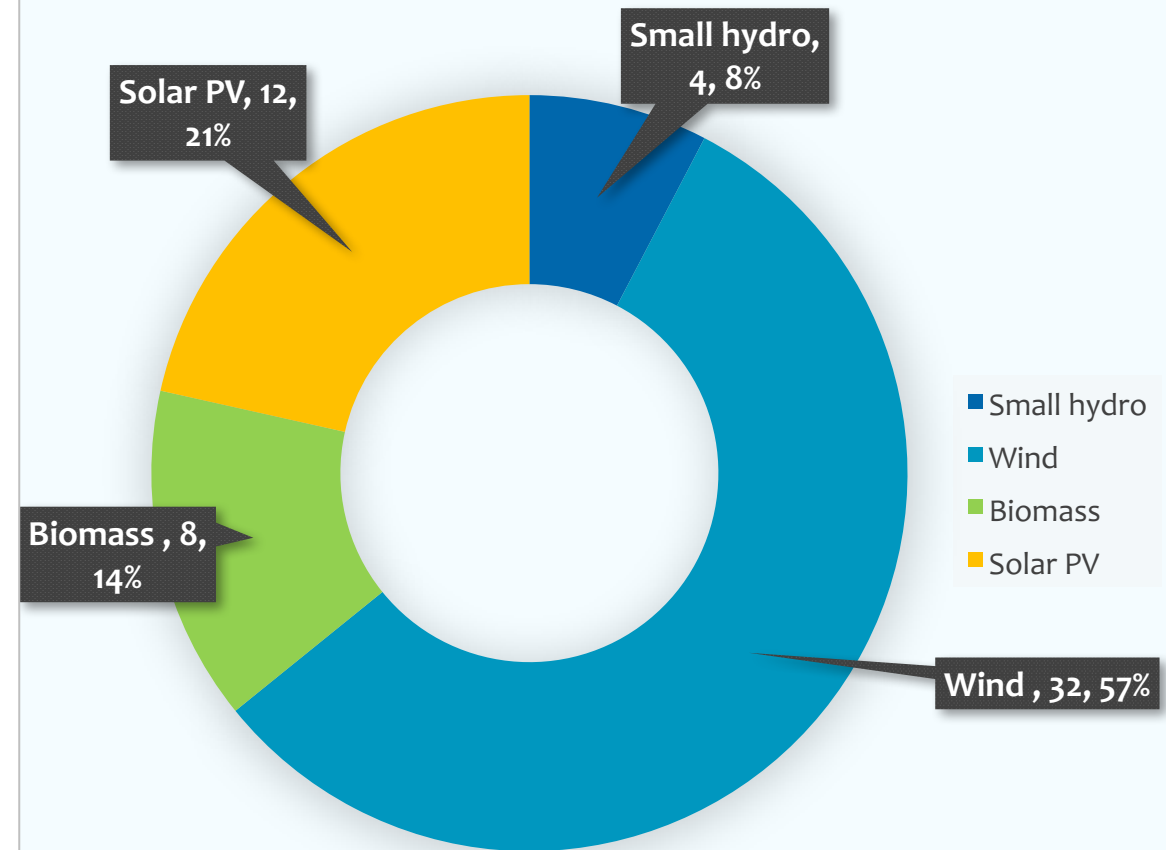
Renewable Integration Plan and its Impact

Present Installed Renewable Capacity

Total Installed Capacity=329 GW
(As on 30.04.2017, source : CEA)



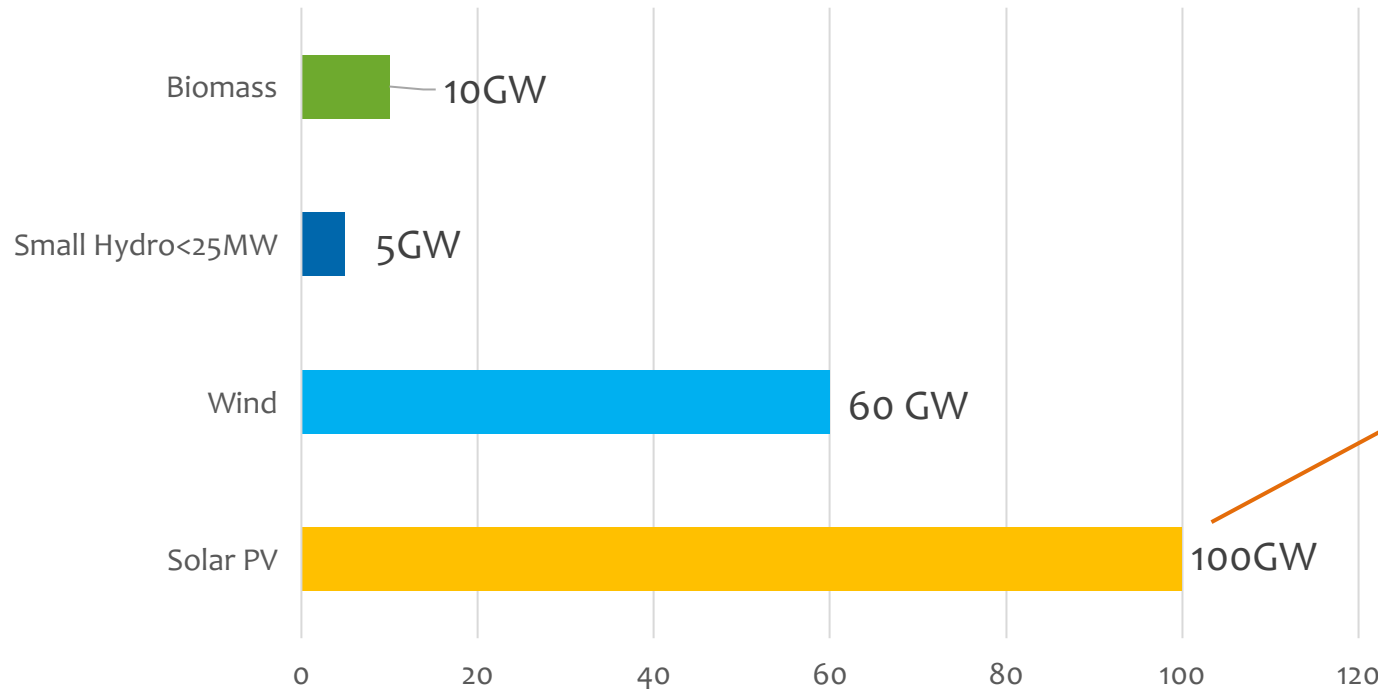
Installed RES=57 MW
(As on 31.03.2017, source : MNRE)



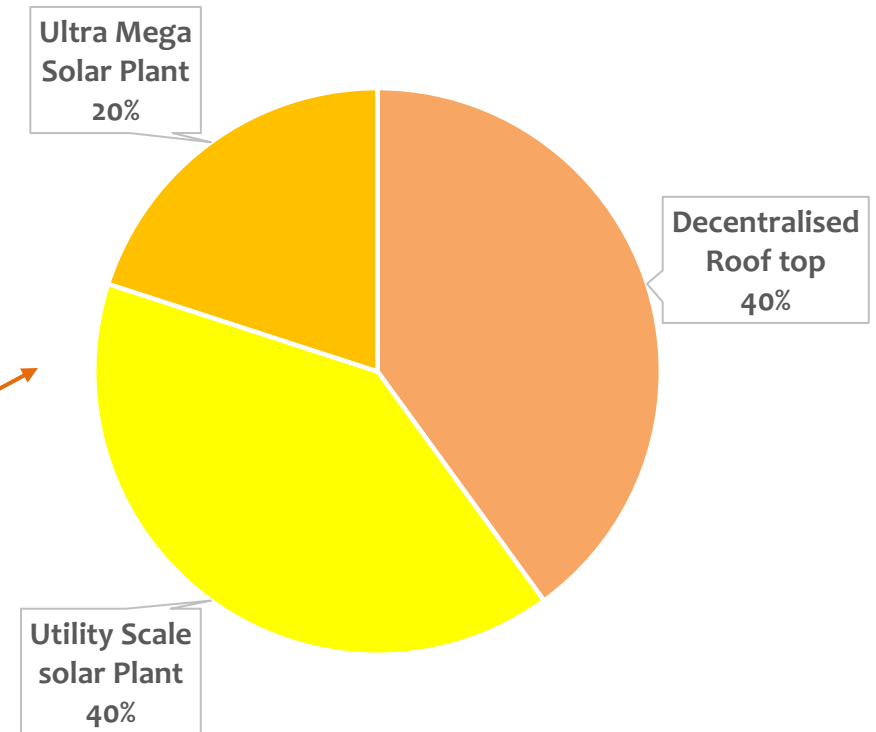
Future Renewable Integration Plan

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.

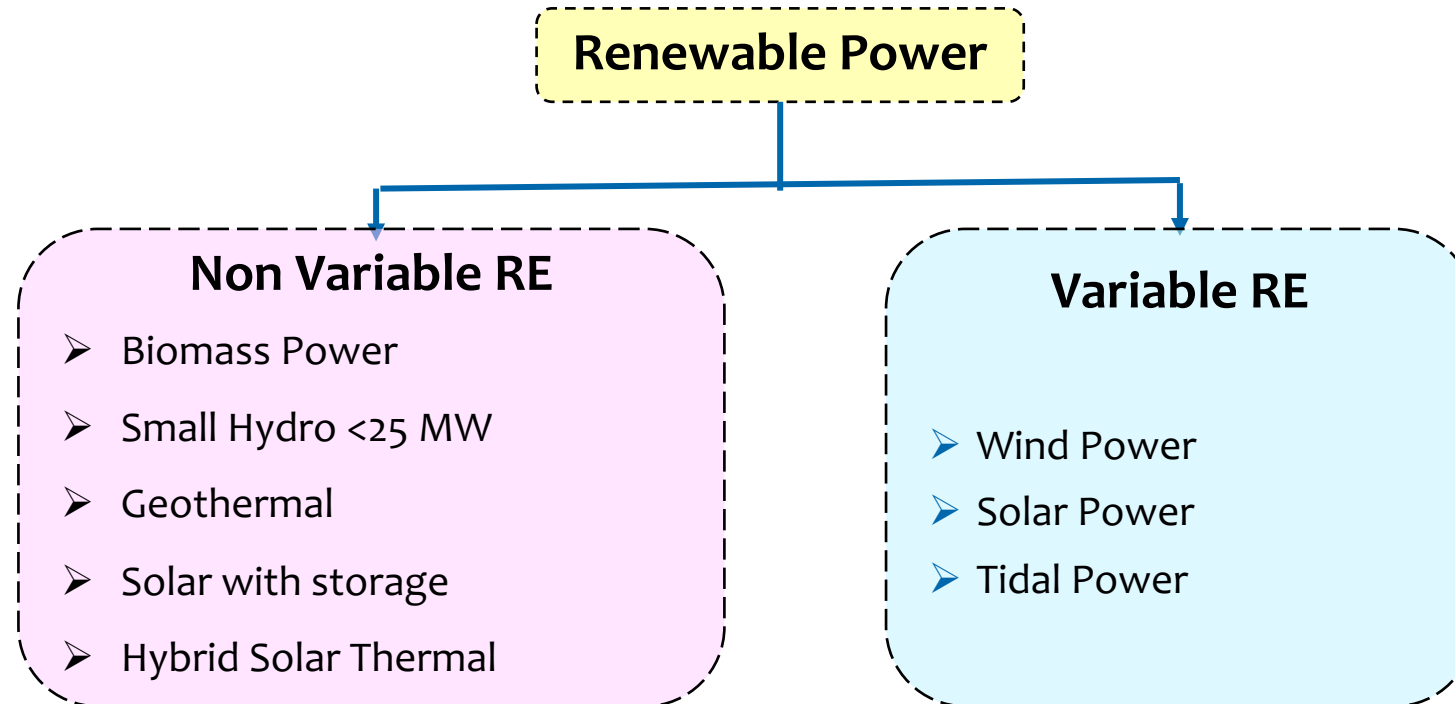
175 GW Renewable Integration Plan by 2022




100 GW solar PV Integration plan



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

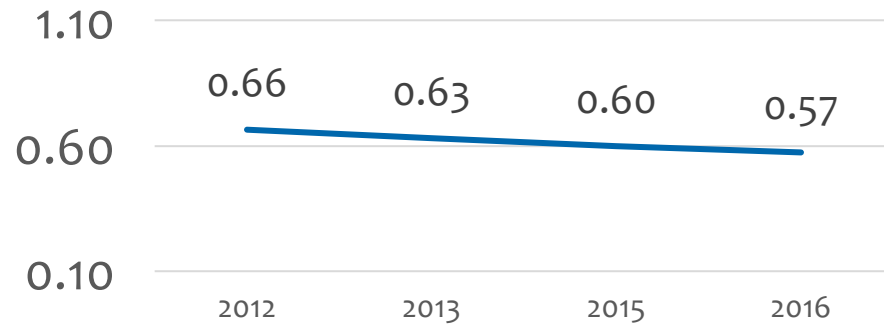
- Difficulty in load frequency control
- Difficulty in scheduling of tertiary reserves
- Requirement of enhanced transmission network and its under utilisation
- Increase in requirement of ancillary services and hence increased system operation cost
- Increase in transmission cost due to all above factors

Impact on existing Plant

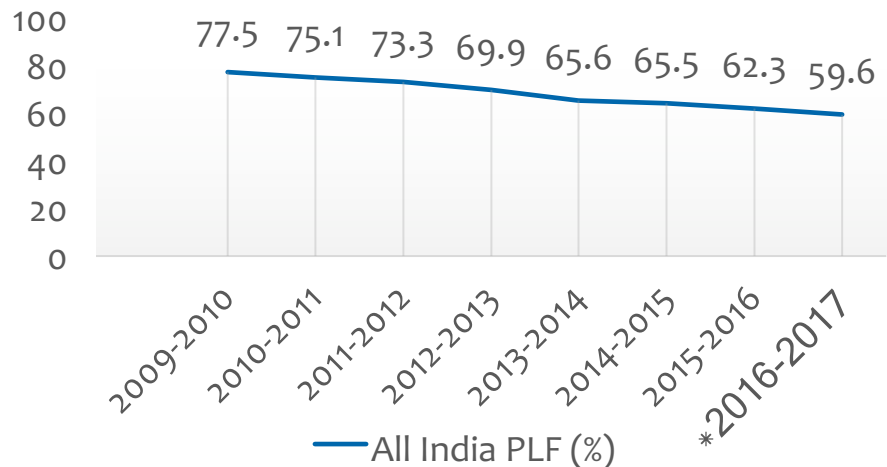
- Lower PLF due to ducking of load curve
- High ramping requirement
- Two shifting and cycling of plants
- Increased forced outage and O&M cost
- Equipments life time reduction
- Poor heat rate and high Aux. Power

Today's Scenario: Cycling without Renewable Integration

Historical Peak demand met to installed capacity ratio



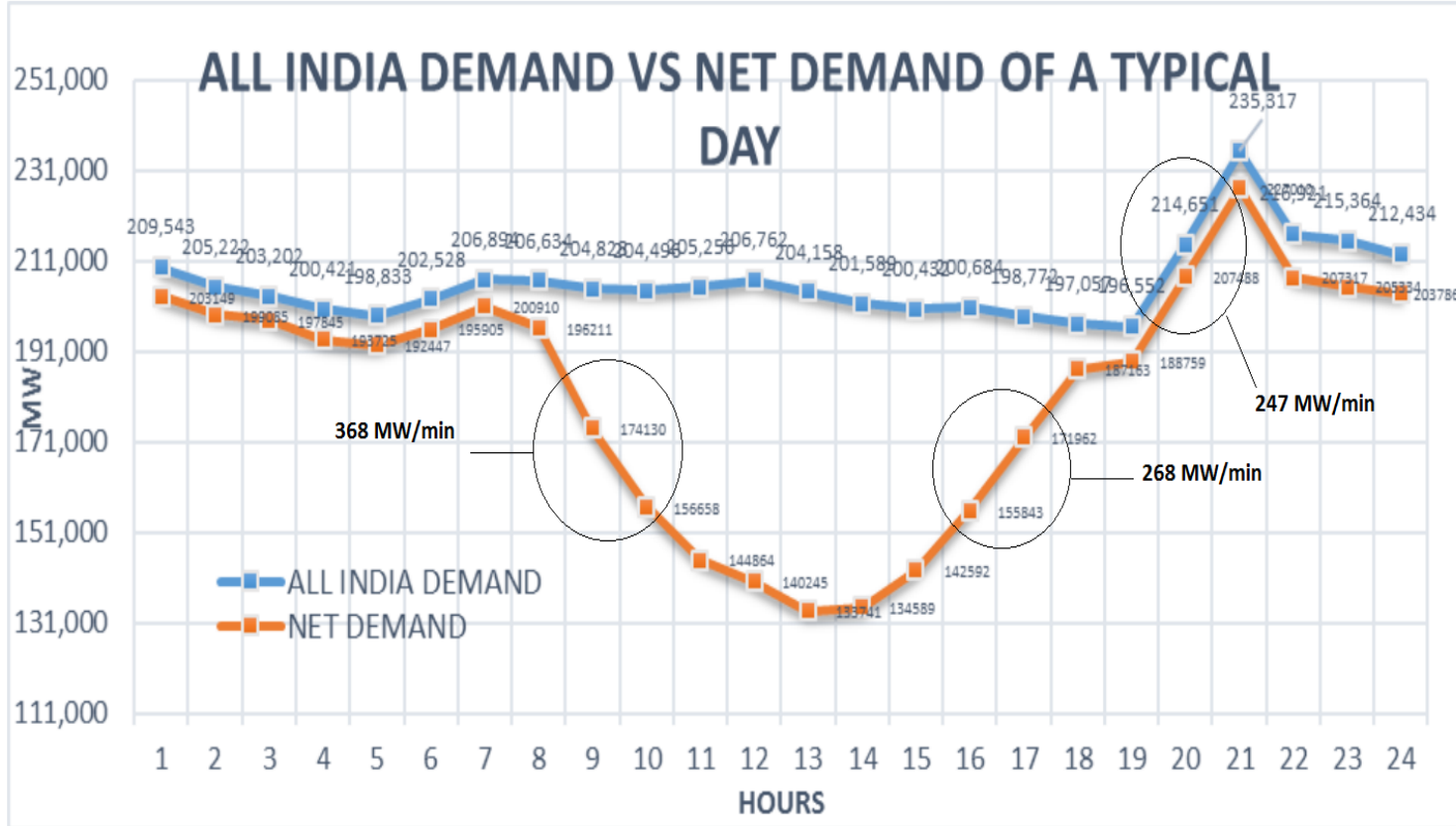
Historical All India PLF



- 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.

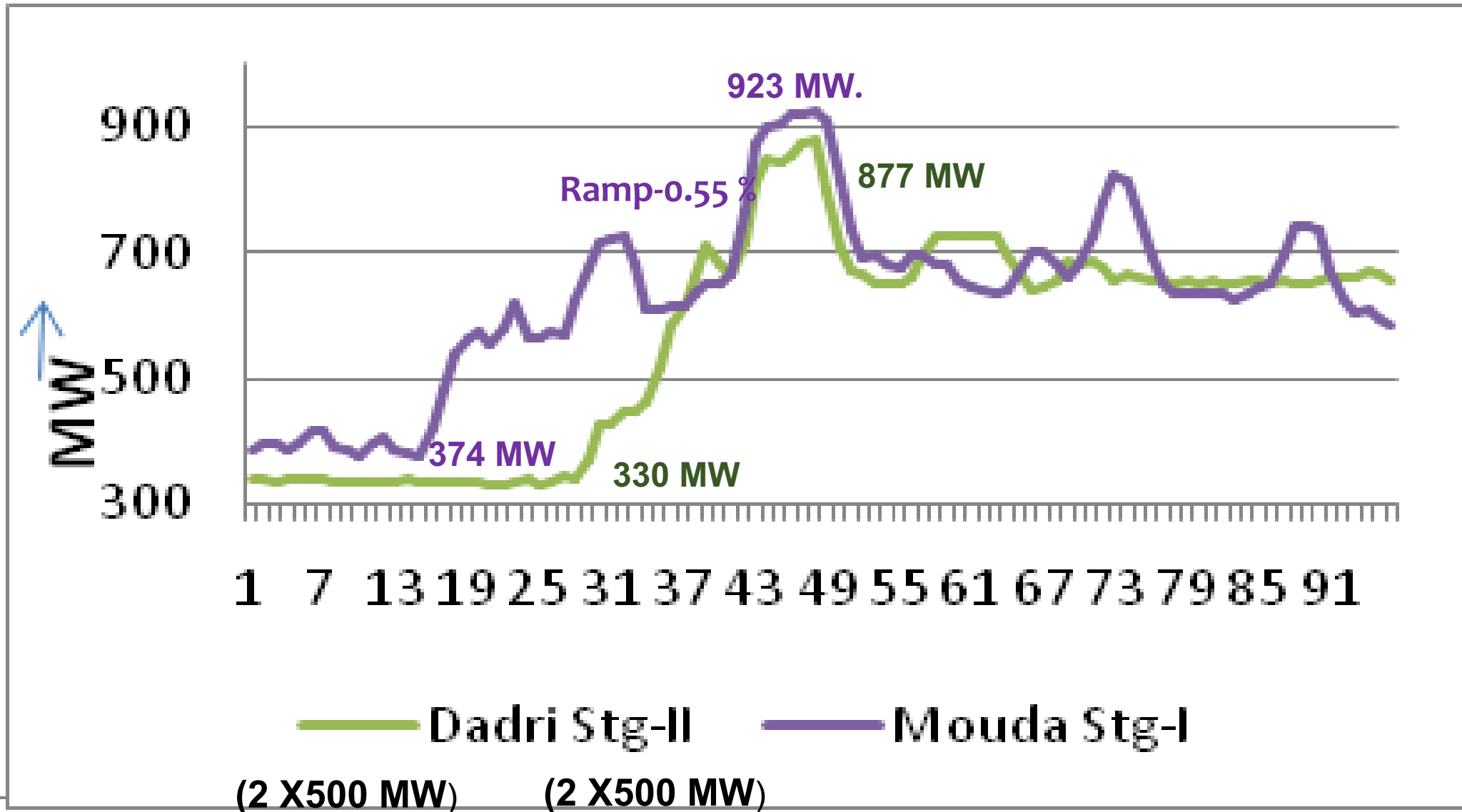
Future Net Demand Curve (2021-2022)

Source: CEA

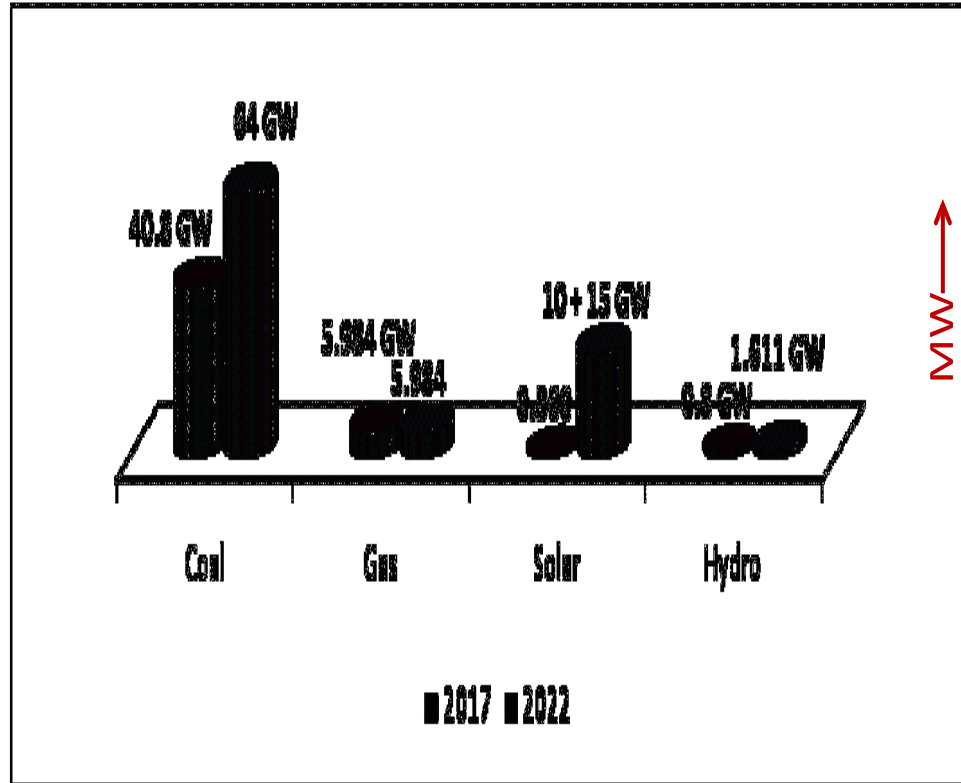


- Installed capacity ~ 523 GW *
- Peak hour ramp rate is 247 MW/min.
- Ramping down rate with sun rise is highest i.e. 368 MW/min.
- Duck belly demand to peak demand ratio is 61% which will lead to partial loading and two shifting i.e. cycling of fossil based power plants and hence low PLF.

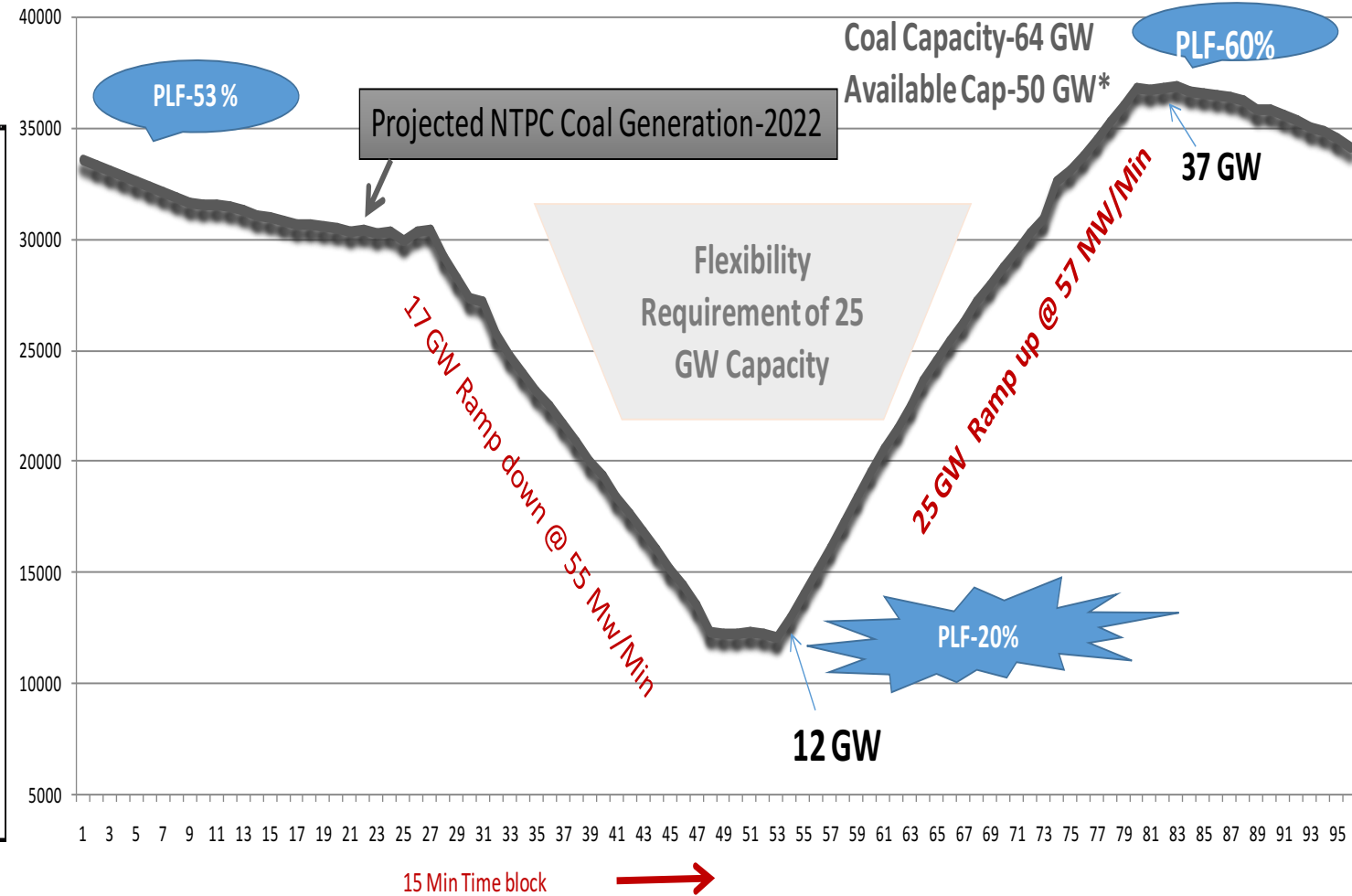
NTPC's present level of Flexible operation



Emerging Scenario for NTPC Group in 2022



Capacity Growth



* Capacity <25 years old

Predicted Generation

Group NTPC's Approach towards Flexibility

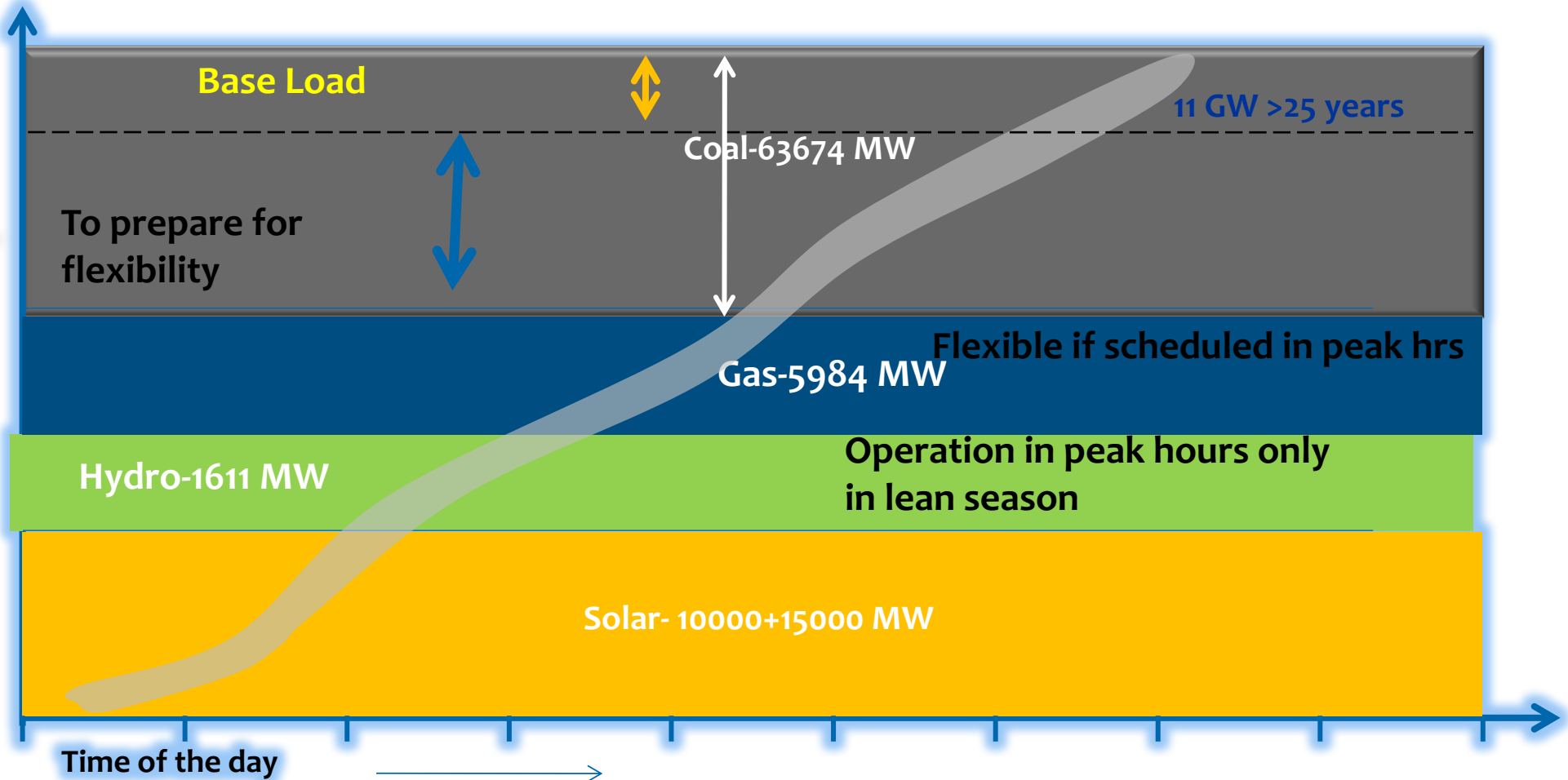
OPTION-1

52.6 GW
Capacity
available for
flexible operation

Flexible

Partly Flexible

Must Run



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

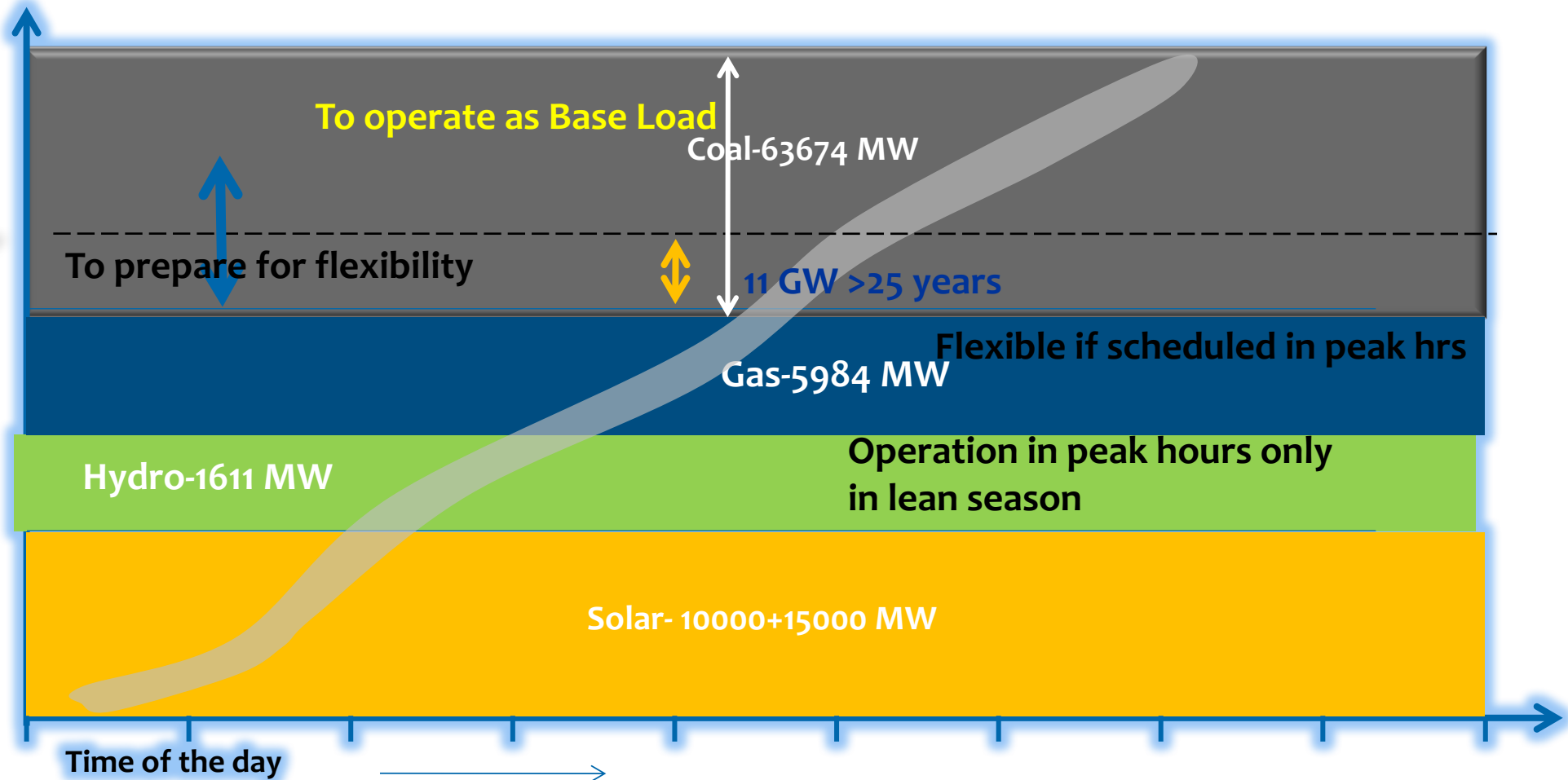
OPTION-2

11+ GW
Capacity
available for
flexible operation

Flexible

Partly Flexible

Must Run



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)

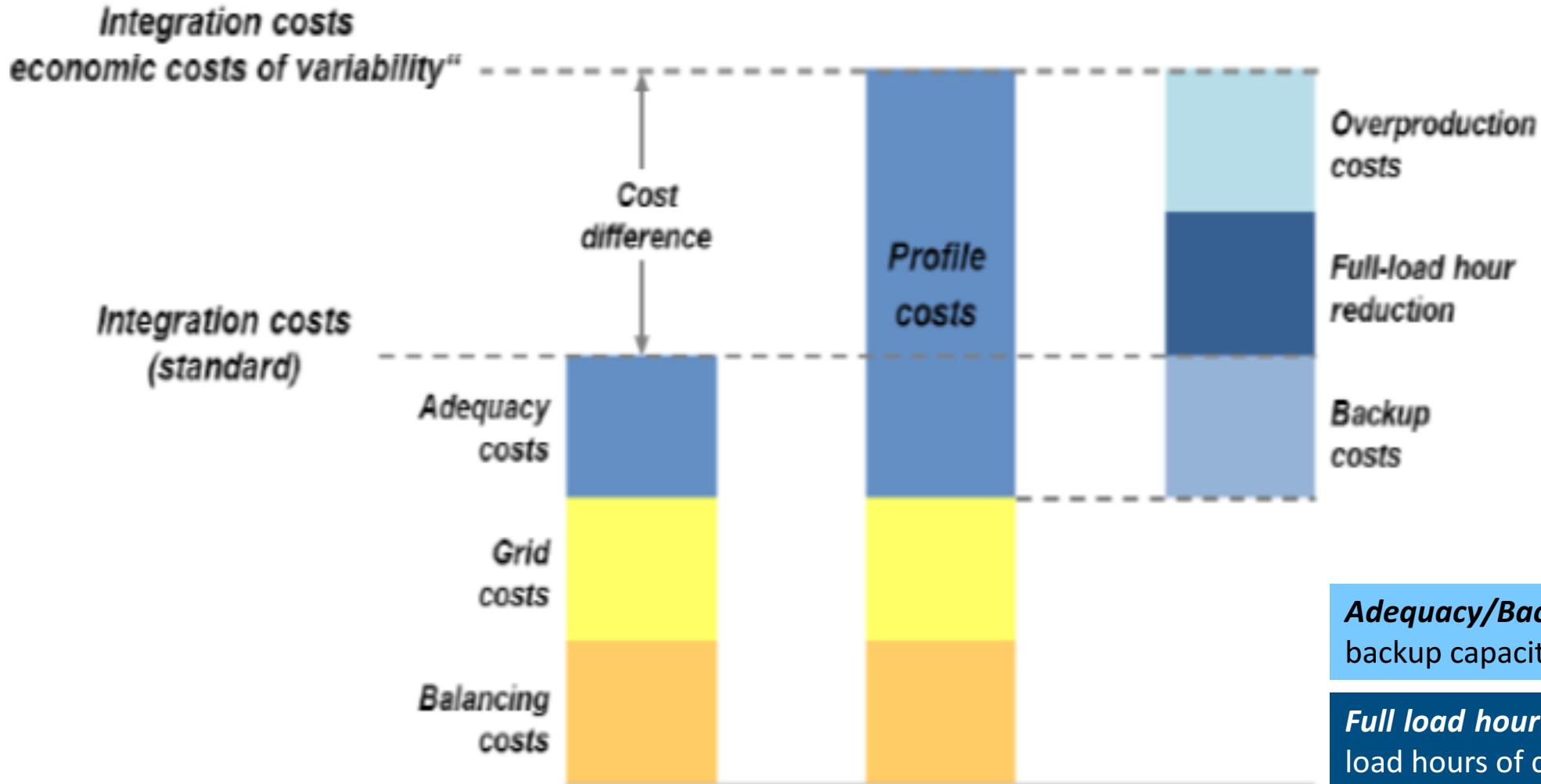
- With participation of all the Units of NTPC the ramp down @ 0.2-0.3 % and peak ramp up @ 0.15 % will be required
- At ramp rate of 1%, 21 % of the units will be required to participate during ramp down and 15 % units will be required during peak ramp up
- But some units will be required to ramp up/down 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 - Reduces the full-load hours of conventional power plants

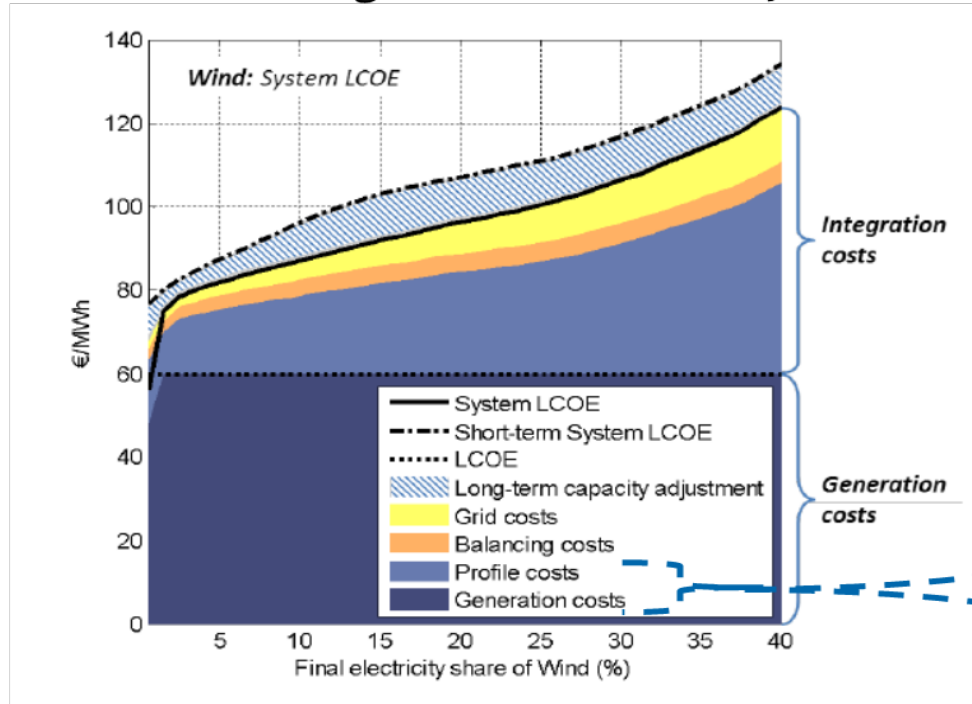
Design and Incentivize cost effective power system based on economic evaluation

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 uncertainty.
 - 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 Levelled Cost of Electricity: German Experience

Effect of increasing share of wind on System LCOE



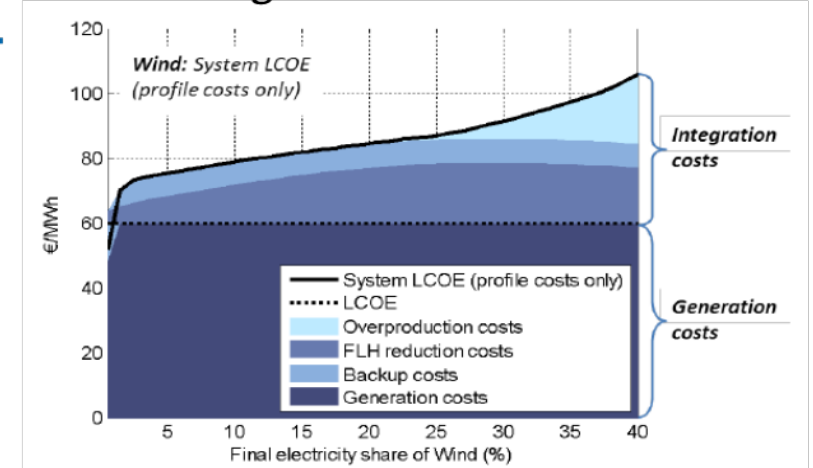
Typical costs (approx.), depending on grid penetration of VRE:

Grid Costs - 3 to 15 Euro /MWh

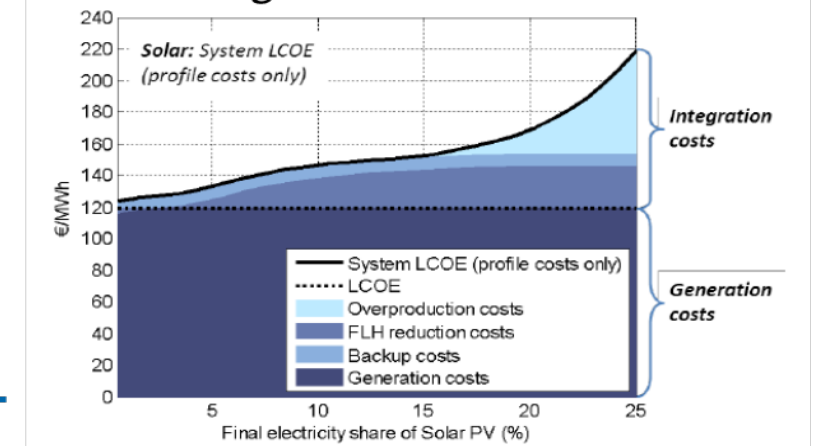
Balancing Costs - 3 to 6 Euro /MWh

	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

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.

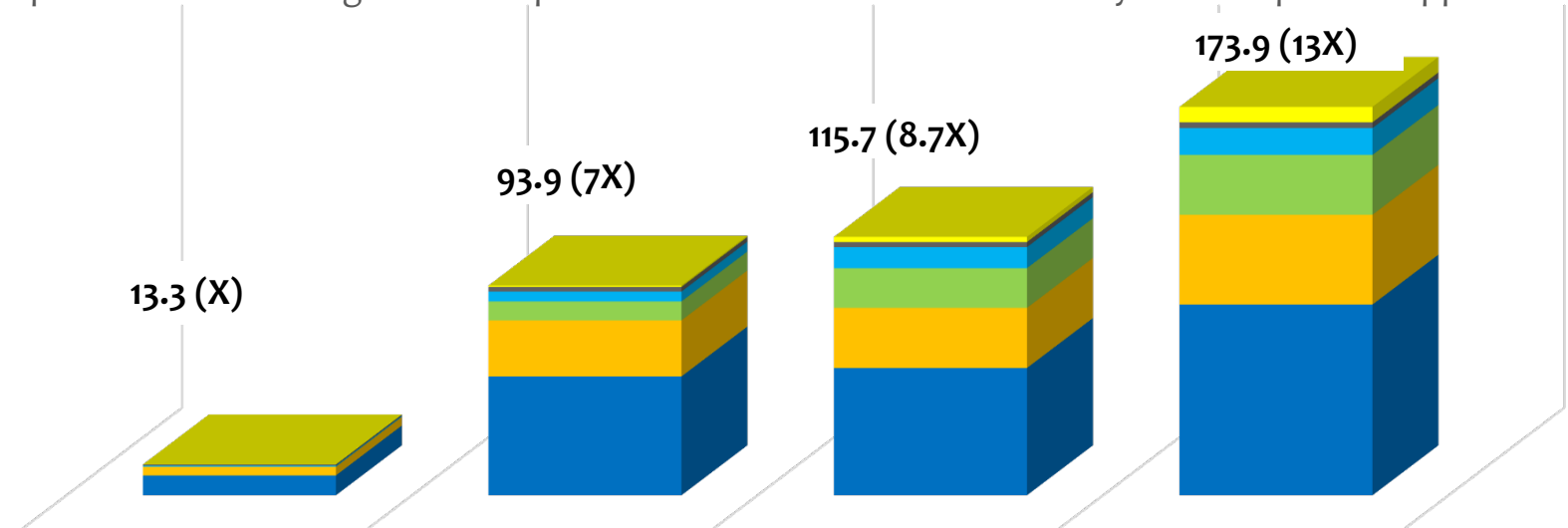
Comparison : Cost to Cycle a Unit, Per Operation

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

■ Maintenance and capital ■ Forced outage ■ Start up fuel ■ APC ■ HR ■ Water chemistry and manpower support

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

EXPECTED CYCLING COST (1000 \$)



	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
■ Maintenance and capital	8.9	53.2	57	85.4

- 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

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

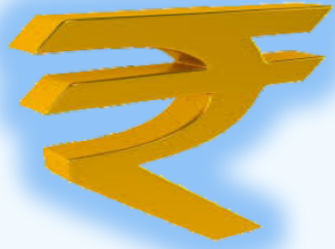
More and more units should be brought under AGC, so that effective ramp rate requirement on individual units can be minimised and better load frequency control can be obtained.

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



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.

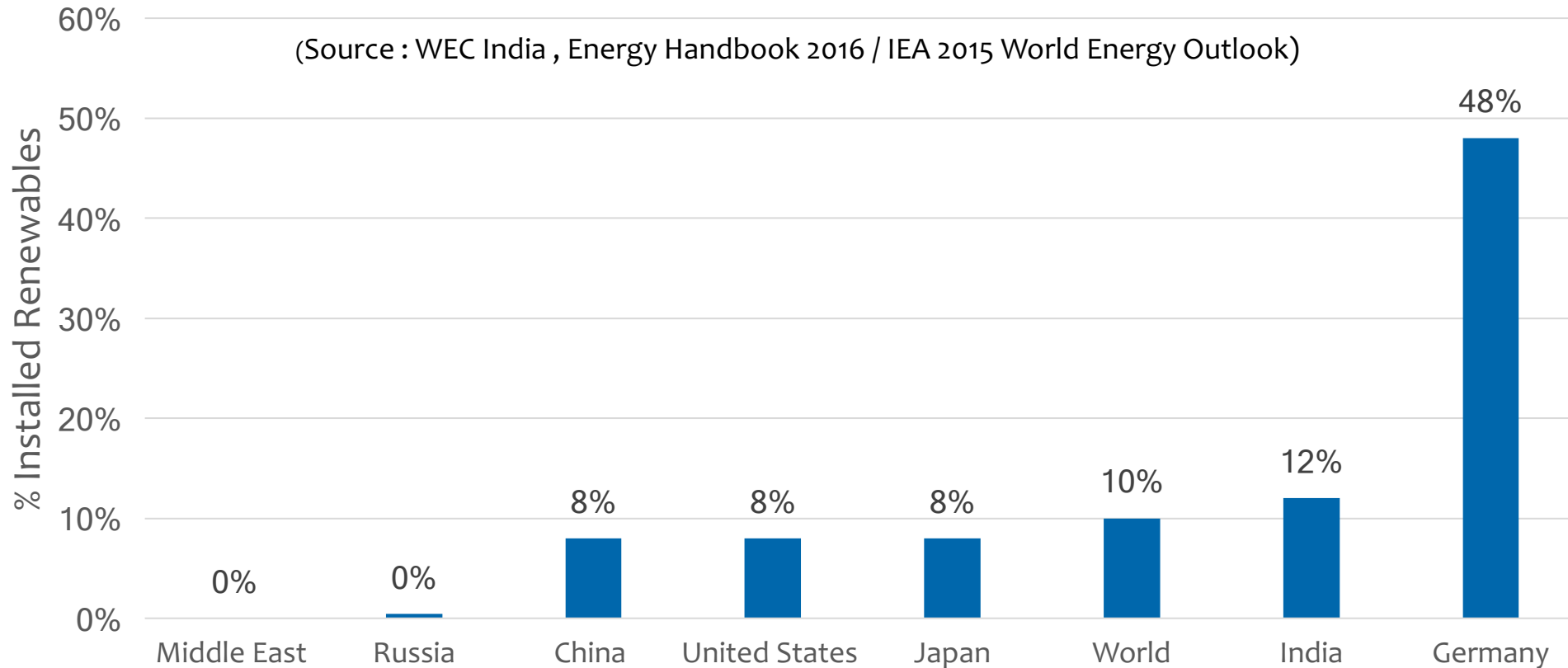
However, these cost can be reduced by adopting suitable operation practices, mitigation technologies, a better policy in picture, though it can not be eliminated totally. After all, we have to pay for better environment.



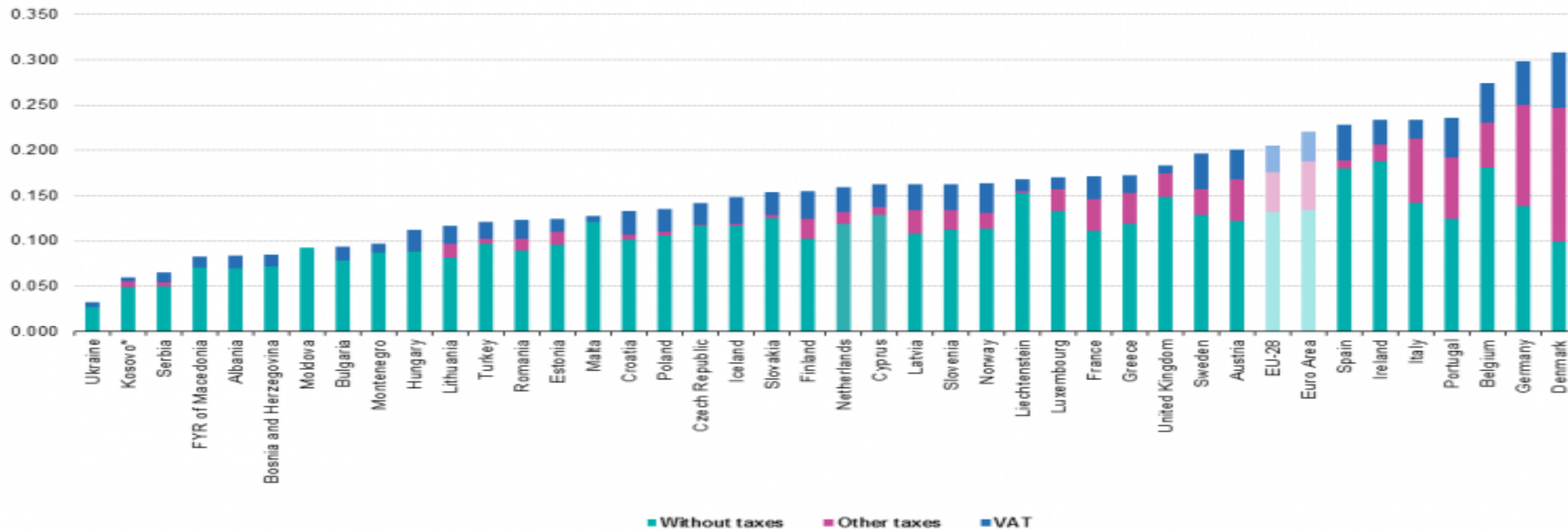
Thank You

World Renewable Scenario

Installed Renewable Capacity Percentage Country wise (2015)



*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)

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

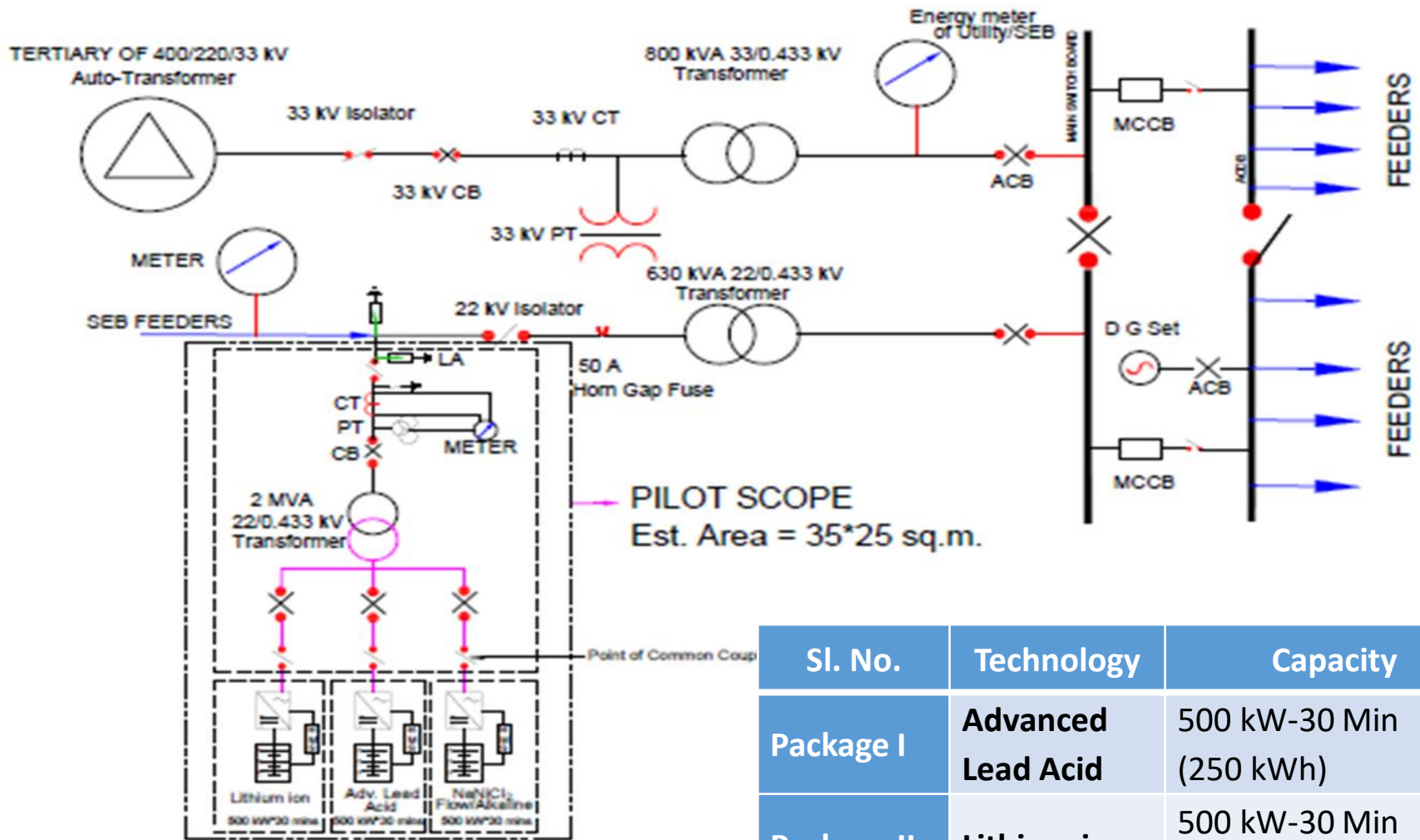
Lower response time

Modularity in size

Flexibility in transportation

Options of many Chemistries

Size of the Pilot Project

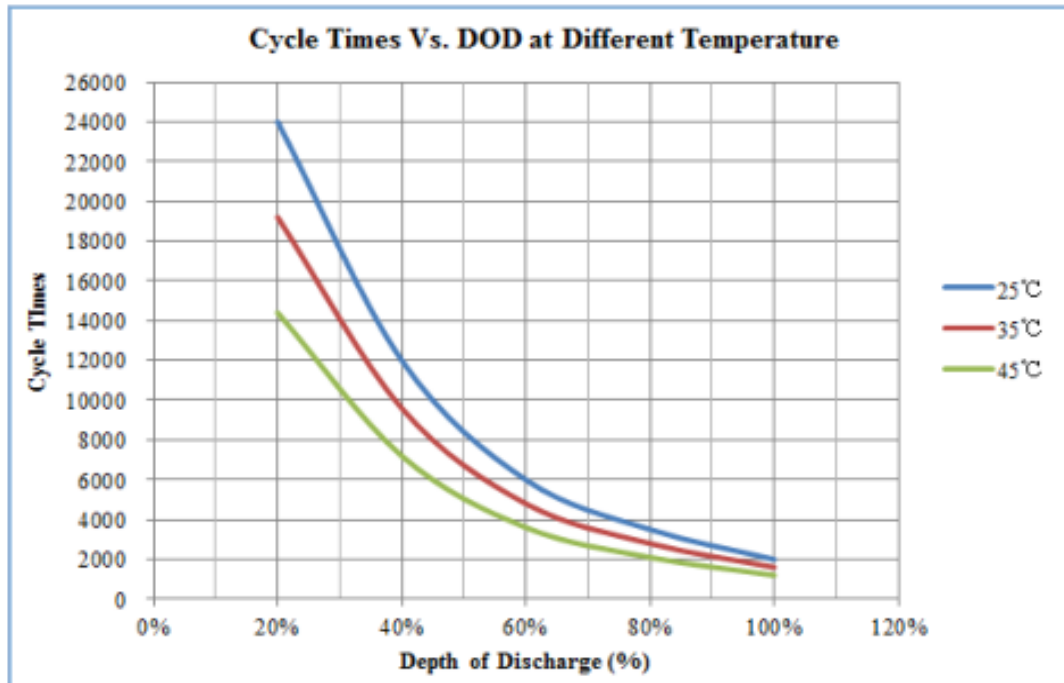


Sl. No.	Technology	Capacity
Package I	Advanced Lead Acid	500 kW-30 Min (250 kWh)
Package II	Lithium ion	500 kW-30 Min (250 kWh)
Package III	Flow	250 kW-4 hours (1000 kWh)

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

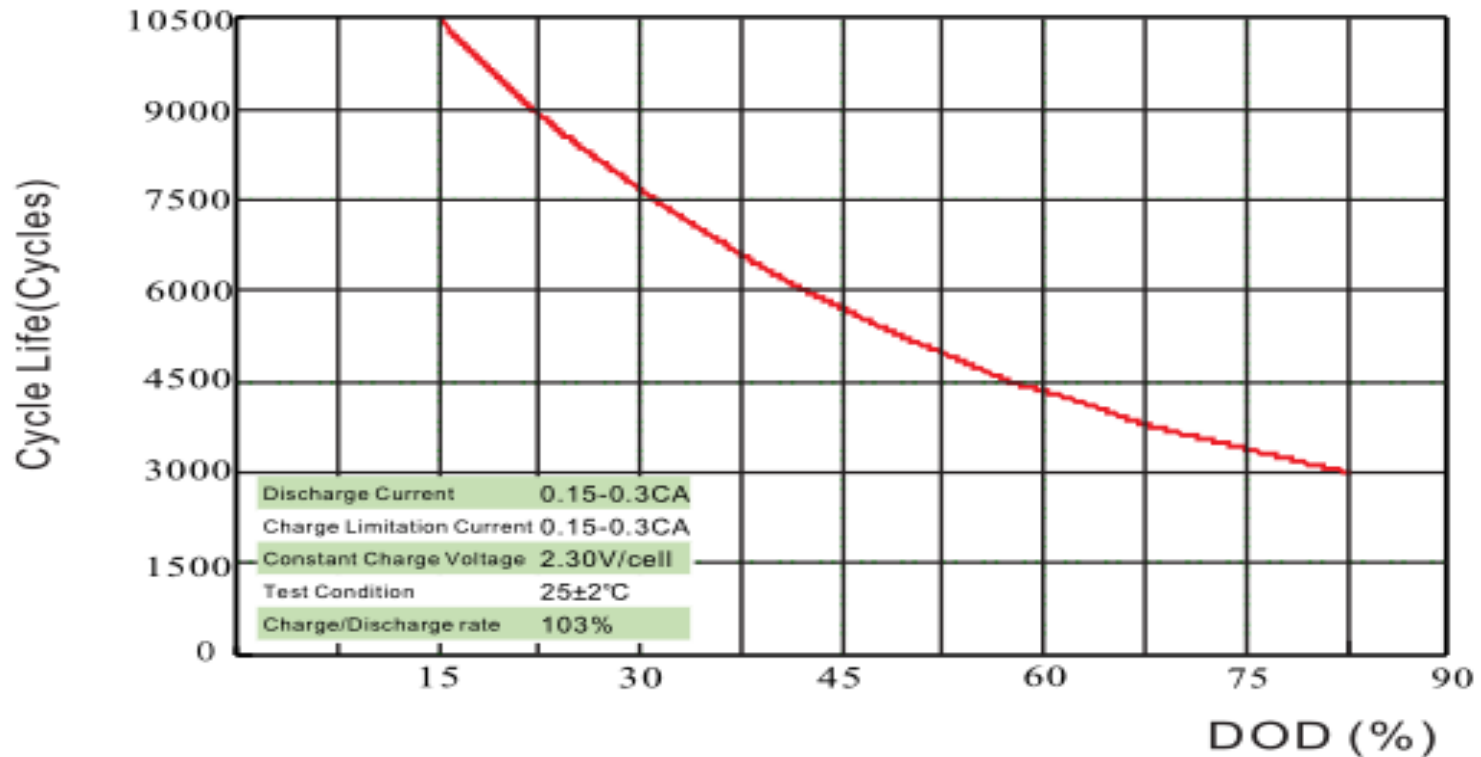
Table 1 Data of Cycle Number

Temp. (°C)	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

DOD VS Cycle life curve



Note: Application on single cell.

System Configuration: Adv. Lead Acid

Internal Chemistry: Cathode-PbO₂, Anode-(Lead+Carbon), Electrolyte-H₂SO₄

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)

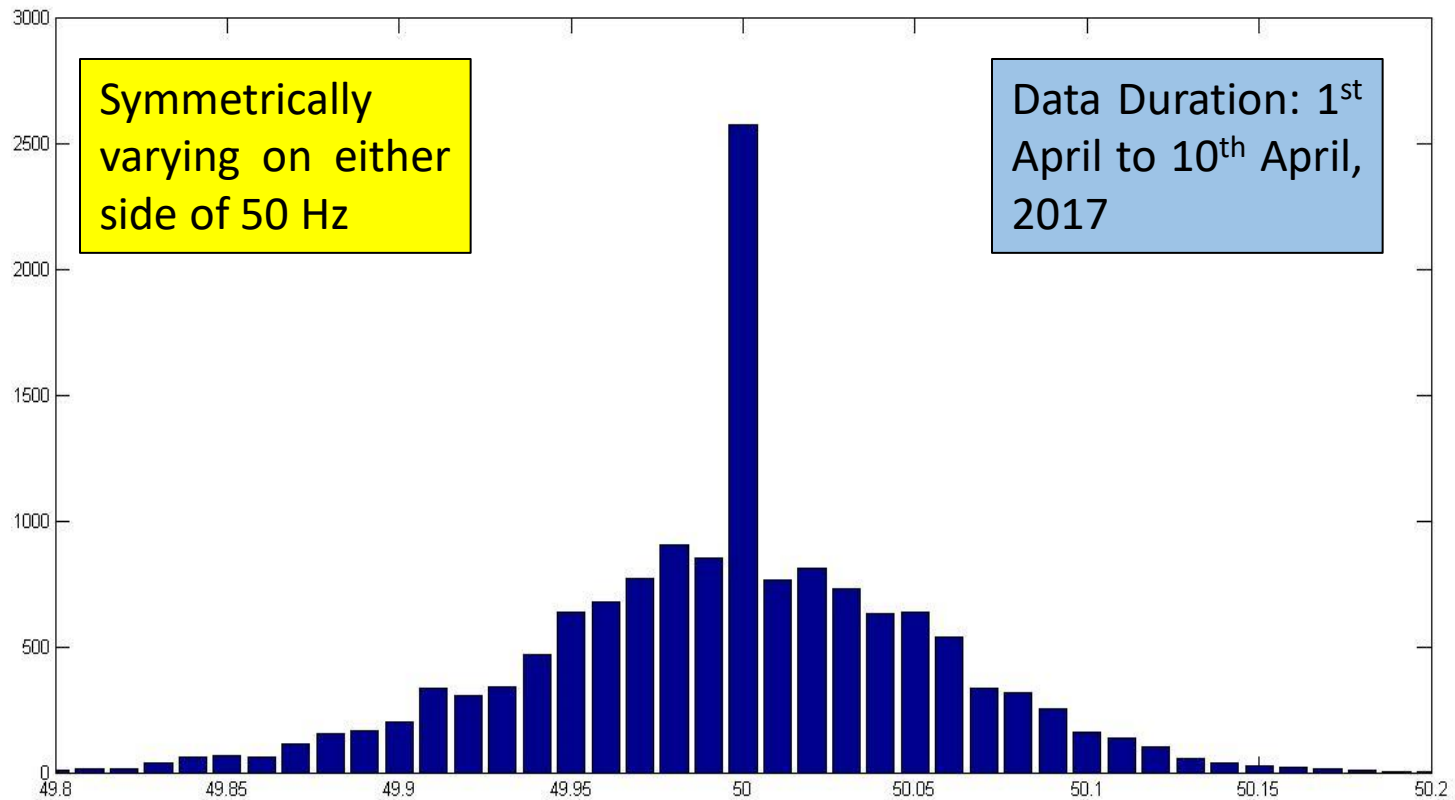
Rated DoD: 70%

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



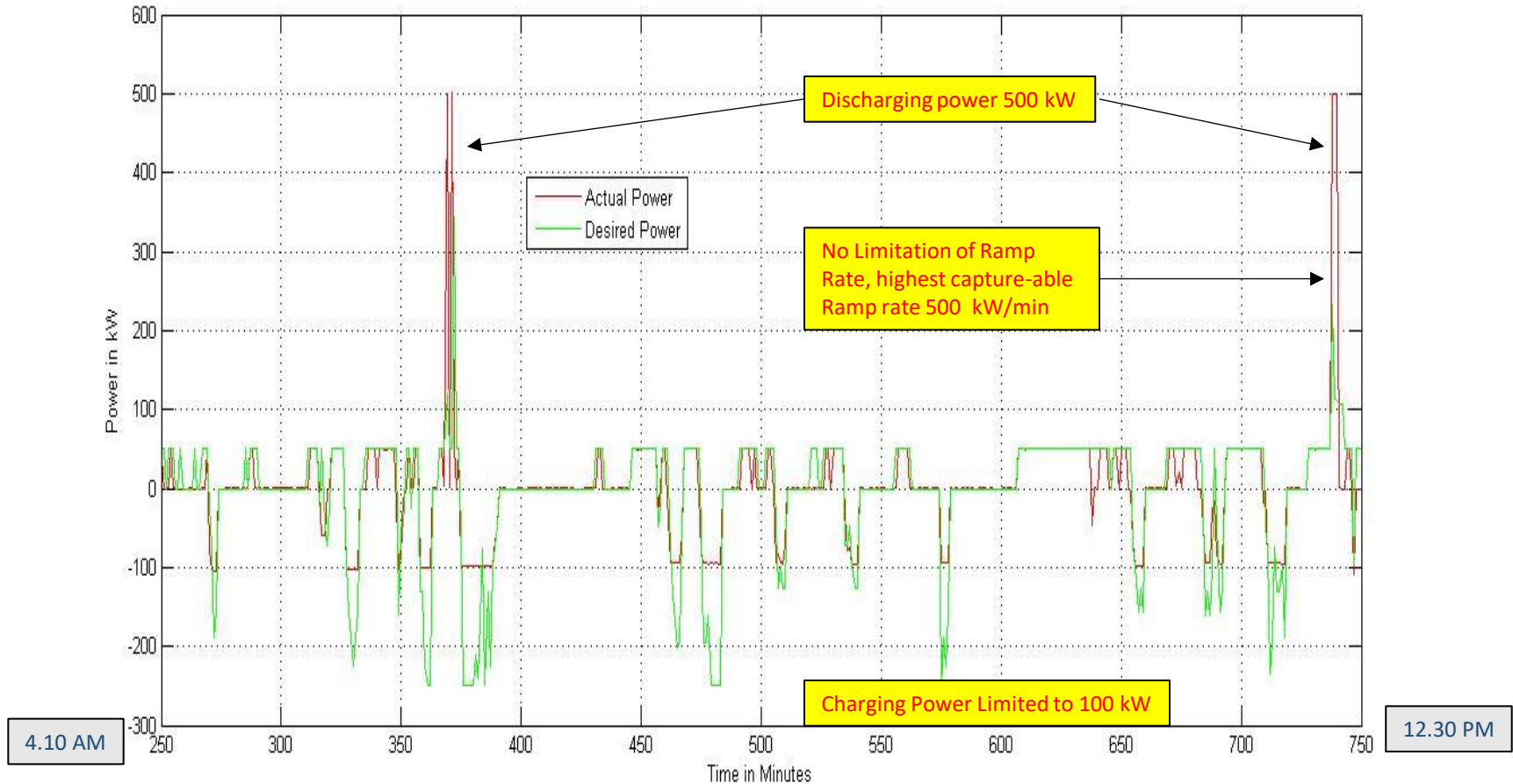
Total Data Points

14400

Number of 50 Hz points

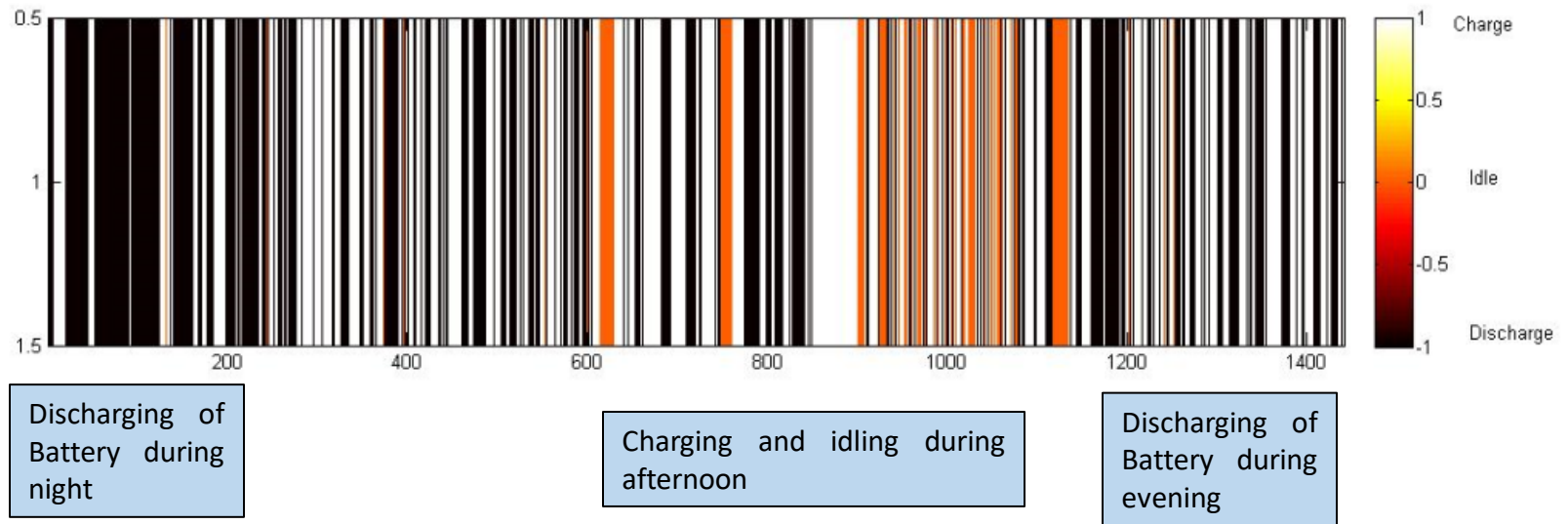
2572 (17.8%)

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



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

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



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

Frequency Regulation Operation

App:scada GraphRelay_MMS Edition:1
 File View History Favorites Tools Window Help
 100% 2017-03-10 12:07:20



POWERGRID Lithium Battery Energy Storage System

2017-03-10 12:07:19

Main Graph | BESS | BMS System | Relay | Energy Meter & AC | Communication | Database | ACK

Name: Relay System | PCS Type: PCS-9726 & PCS-9617 | Running Status: **Static**

Transformer HV Measurement

Ir	0.00	A	Iy	0.00	A	Ib	0.00	A
Vr	232.95	V	Vy	232.73	V	Vb	233.39	V
Vry	402.32	V	Vyb	402.98	V	Vbr	405.40	V
P	0.00	kW	Q	0.00	kVar	PF	0.00	

F50/51 Relay PCS9726 Signals

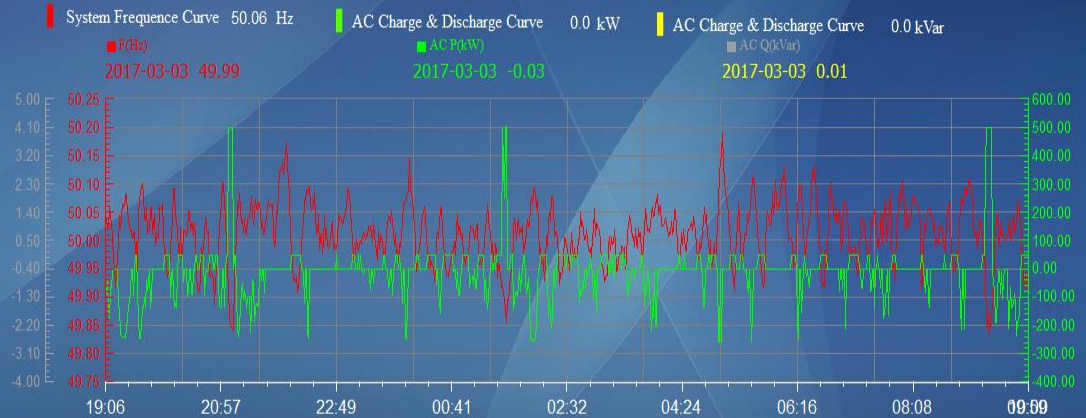
WT HIGH ALARM	<input type="radio"/>	WT HIGH TRIP	<input type="radio"/>	Temperature Controller FAIL	<input type="radio"/>
MR1 WT HIGH ALARM.Op	<input type="radio"/>	MR2 WT HIGH TRIP.Op	<input type="radio"/>		
5051P1.Op	<input type="radio"/>	5051P2.Op	<input type="radio"/>	5051P3.Op	<input type="radio"/>
5051G1.Op	<input type="radio"/>				

PMS Measurement

Vr	232.85	V	Vy	232.11	V	Vb	233.36	V
Vry	402.19	V	Vyb	402.66	V	Vbr	404.31	V
F	50.06	Hz						

PMS PCS9617 Signals

Uncontrollable BESS	<input type="radio"/>	FreqRegulation BESS	<input checked="" type="radio"/>	EnergyTimeShift BESS	<input type="radio"/>
Rmt EnergyTimeSh BESS	<input type="radio"/>	Idle BESS	<input type="radio"/>	SOC Ctrl BESS	<input type="radio"/>
AntIsland.Op	<input type="radio"/>	Op FreqRegulation BESS	<input checked="" type="radio"/>	MG.VTS.Alm	<input type="radio"/>
Grid.VTS.Alm	<input type="radio"/>				



Start | Operator | Host | Safe 15 days | 2017-03-10 12:07:20
 EN | 12:07 | 10-03-2017

Frequency Regulation Operation









पावरग्रिड