Use of Meteogram and Radar Imagery for Grid Operation: An Indian Experience

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***Abstract*—The electricity demand is highly dependent on weather conditions and its wide variation over the day and seasons poses a big challenge to system operators in terms of secure and reliable grid operation. Apart from general variability, variability of load due to weather conditions is also important. Therefore, understanding weather impact on the power system is necessary to plan and manage the secure and reliable system operation. This paper discusses about weather through Meteogram and its usage for generation scheduling, shutdown planning and demand management. Improved real time grid management using Radar imagery along with analysis of overall improvement in system operation using effective visualization of adverse weather conditions has also been highlighted in the paper.**

Keywords— Radar, Meteogram, Forecast, Real time operation, Grid management.

I. INTRODUCTION

The total installed capacity of Indian grid is 357.87 GW as on 30.06.2019[1]. The installed capacity comprises of 226.32 GW of Thermal, 45.39 GW of Hydro, 79.37 GW of RES and 6.78 GW of Nuclear Generation. Extreme Weather conditions invariably affect both power system and its operation to a large extent. The Indian weather is primarily driven by the Asiatic Monsoon system. In addition, the great Himalayan range and the Thar Desert play a vital role to influence it. Diversity of weather conditions ranging from tropical wet to tropical dry and subtropical humid to dry contributes with a huge variation. During summer period, massive convective thunderstorms predominantly affect Northern India's weather. These weather conditions lead to sudden load crash in pockets due to abrupt drop in temperature leading to natural reduction in demand and tripping of distribution feeders results into unwanted changes in system parameters like voltage, frequency, reactive support etc. However, due to short and temporary nature of thunderstorm, demand again regains within few hours.

Cyclones are particularly common in the northern reaches of the Indian Ocean in and around the Bay of Bengal. Cyclones cause heavy rains, large storm surges, and strong winds that often are responsible for major outages in power supply in the affected areas.

Under such extreme weather conditions, accurate anticipation of variations in weather conditions helps in advance operation planning, secure system operation and early restoration of the affected areas. With an aim to increase the resilience of the power grid against such onslaught of the weather phenomenon, Meteogram and Radar imagery are being utilized by the Grid Operator which is proving extremely effective for Indian Power System. Meteogram provides a graphical display of the variations in the weather parameters with a resolution of 3 hours and forecast upto next 10 days for Rainfall, Cloud Cover, Relative Humidity, Wind Speed and index for Thunderstorms (Lifted Index and CAPE) etc. On the other hand, Radar Imagery is being used for knowing the distance and height of clouds, Movement of clouds, Location of Rainfall and its intensity, Total rainfall in past 24 hours and wind speed and direction at the Radar site.

II. WEATHER INFORNATION AVAILABLE AT CONTROL CENTRE

a. Meteogram:

A Meteogram is a visual representation of surface weather conditions in a graphical format. In India, Meteogram for around 435 locations is available which are distributed across the length and breadth of the country as shown in figure-1

Fig.1. Meteogram locations

The various weather parameters available in Meteogram is listed below:

a. Conditions for the lower troposphere (up to 500 mb (millibars)) - Wind, Temperature and Relative humidity.

b. 1000-500 mb Thickness – Indicate the mean temperature in the layer of atmosphere between two levels.

c. Sea Level Pressure.

d. Stability Indices (Lifted Index and Convective Available Potential Energy (CAPE)).

e. Wind speed and direction at 10 Mtr. Height.

f. Air Temperature and Dew Point Temperature at 2-mtr Height.

g. Relative humidity at 2 Mtr Height.

h. Cloud Cover- High Cloud (Cloud at 5-13 km height), Medium Cloud (Cloud at 2-7 km Height), Low Cloud (Cloud at 0-2 Km height).

i. Precipitation.

These parameters are available for 10 days from the date of issue with a resolution time of three hours. Figure-2 shows a sample Meteogram showing all above mentioned parameters in graphical display.

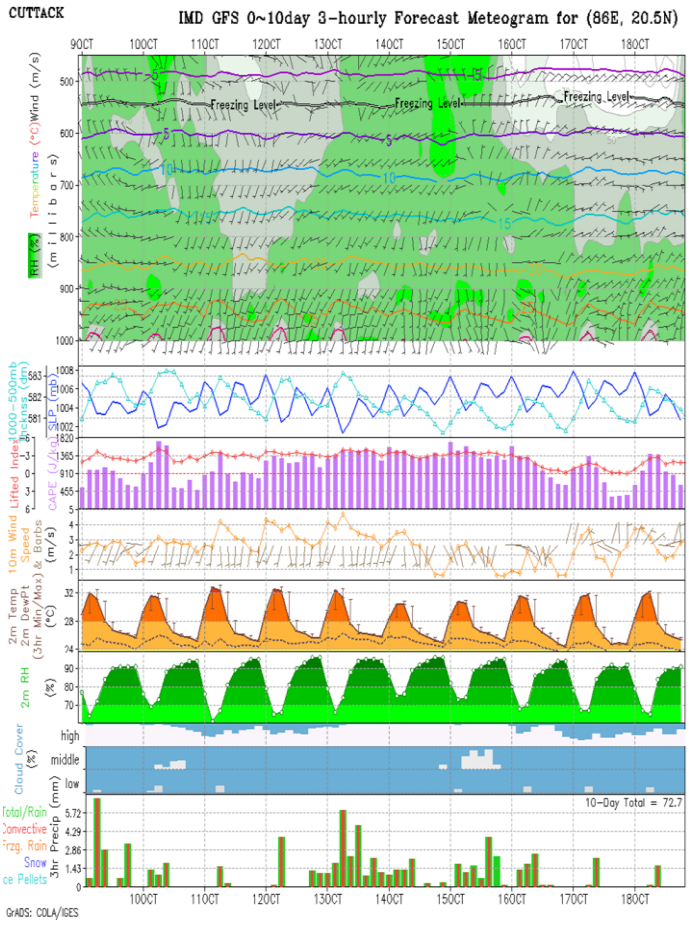

Fig.2. Meteogram Graph

b. RADAR:

Radar is acronym for Radio Detection and Ranging. It uses electro-magnetic waves in microwave region to detect location (range and direction), height (altitude), intensity and movement of moving and non-moving targets. Radar observation are very effective tool for detecting, tracking and monitoring of weather system growth, decay and movement. For monitoring the weather system, six different products in the form of images derived from Doppler Weather Radar (DWR) is available for system operator. These products are listed below:

a. Plan Position Indicator (PPI) – A constant elevation surface data is presented as a cloud image around the radar station. Used to see the intensity of cloud.
b. Max (Z) – This product is used to see both intensity of cloud as well as height of cloud.
c. Plan Position Indicator (Mean Velocity m/s) – Indicate the mean velocity of cloud and its direction.
d. Surface Rainfall Intensity (SRI, in mm/Hrs.) – This gives an image of the rainfall intensity at surface layer with constant height above the ground.
e. Precipitation Accumulation (in mm)- This product shows the rainfall amount (in mm) for the defined time period.
f. Volume Velocity processing – This product displays the wind velocity and wind direction in a vertical column above the radar site.

III. USE OF METEOGRAM FOR GENERATION SCHEDULING AND DEMAND MANAGEMENT

The System Operator studies the available Meteograms in its control area. For short term demand management planning, the forecasted weather scenario available from Meteogram serves as an input for short term load estimation. In case of inclement weather forecast, the Regional system operator issues an advisory to all control centers which are under function control of Regional load dispatch center (RLDC).

The State Load Despatche Centre (SLDC) / DISCOM (Distribution companies) are responsible for portfolio management in their state control area. They exchange the power as per schedule and maintain the deviation within the limit as specified in the regulations to avoid the deviation charges. They take proactive action based on Meteogram to manage its portfolio to meet demand and to avoid the deviation charges. The weather parameters help system operators to take decision on Generation scheduling, Demand management and preparing for transmission outage.

IV. REAL TIME POWER SYSTEM OPERATION USING NEAR REAL TIME RADAR IMAGERY

The system operator monitors the real time weather by using Doppler weather radar image [3]. The different Doppler radar product such as Plan Position Indicator – Close Range, Plan Position Indicator (Z), Plan Position Indicator (V), MAX (Z), Surface Rainfall Intensity, Precipitation Accumulation and Volume Velocity processing are used for real time monitoring of weather system. Radar Imagery is being used for knowing the

precipitation; wind speed and direction at Radar Location; distance, height and movement of clouds; location of Rainfall and its intensity along with Total rainfall in past 24 hours.

V. Case Study-I

A distribution company in India with over 2.4 million customers has managed to take proactive action to manage its drawl from the grid and purchases from power exchange/bilateral contracts. In the summer of 2017, distribution company used Meteogram to predict the increasing temperature (Figure-3) and therefore increase in demand, based on which additional units were brought on bar. This also helped in following merit order despatch, by avoiding costly power exchange purchases during peak summer.

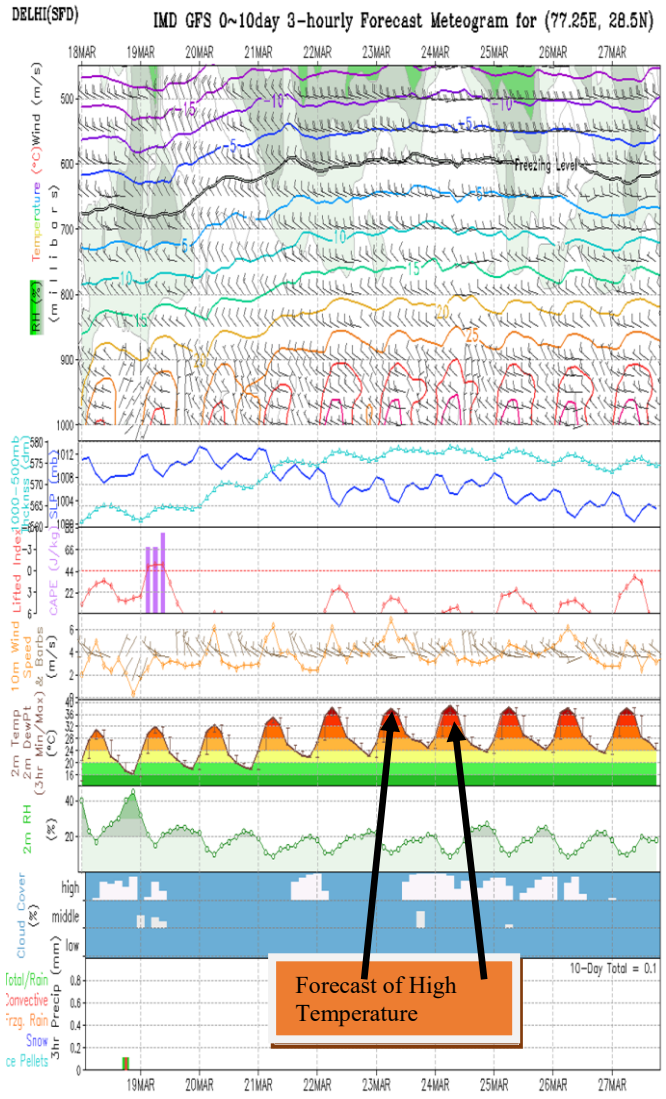

Fig.3. Meteogram Graph (Predicting high temperature)

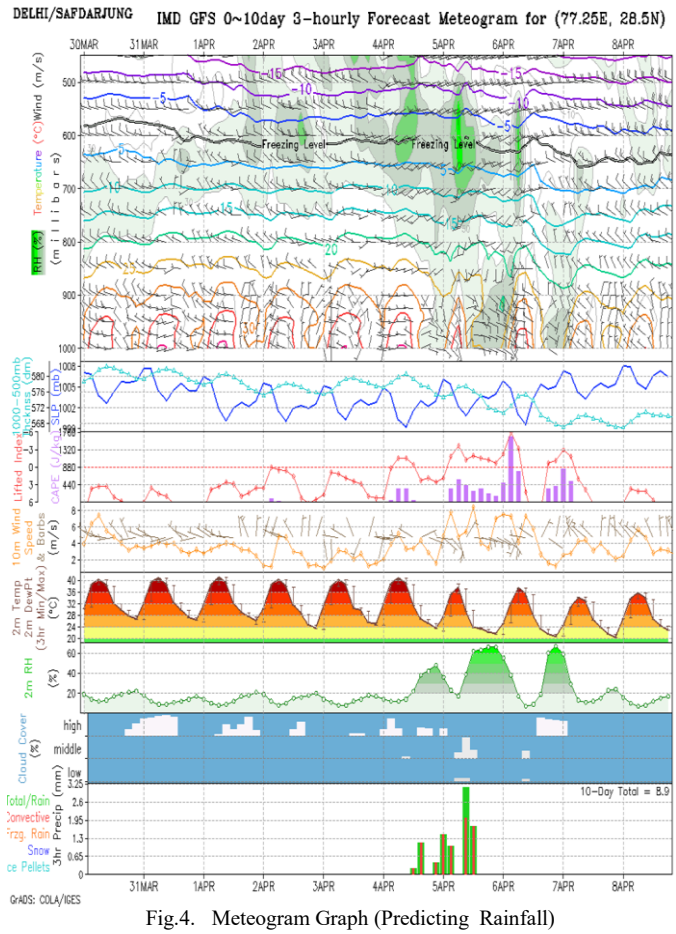

Fig.4. Meteogram Graph (Predicting Rainfall)

Real time Radar imagery helped in sending timely revision for backing down of generating stations in anticipation of thunderstorms/ rain, which saved under drawl of power, thereby also ensuring grid security. Looking at the prediction of rain on 04th and 05th April 2017 in Meteogram (Figure-4), the system operator started continuous tracking of rainfall movement on 04th and 05th April 2017 using Radar imagery and backed down generation in advance to the extent of 60 MW, which led to lowering of under drawl in real time on the evening of 05th April 2017, starting around 18:00 hours.

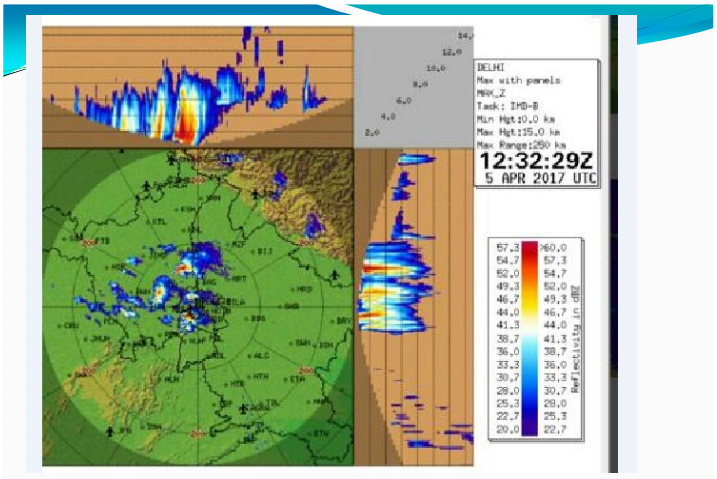

Fig. 5. Radar Image of Delhi at 12:32 UTC (18:02 IST)

The Rainfall accompanied with Thunderstorms hit Delhi

around 23:00 hours on 04th April 2017 and 17:00 hours on 05th April 2017 for which clear prediction was available on Meteogram. As per IEGC (Indian Electricity Grid Code), schedule revision is applicable and would come into effect after four number of 15 min timeslots. Therefore, tracking of Radar image (updated every 10 mins) helped predicting more accurate timing of thunderstorm hitting West and South Delhi on 04th April night and again on 05th April evening. Tracking of real time Thunderstorm, Rainfall movement helped to plan the back down of generation by 1.5 hours in advance to limit under drawl from the grid.

VI. CASE STUDY-II

Meteogram graph for 10th May 2017 predicted 0.4 mm of rain in Delhi control area between 12:00 hours to 17:00 hours 2017 as shown in figure-(6a and 6b). As anticipated, rainfall started around 17:30 hours and the demand of distribution company control area started going down due to switching off the appliances by the consumers. There was a load crash of around 450 MW in the Delhi control area as shown in figure 7.

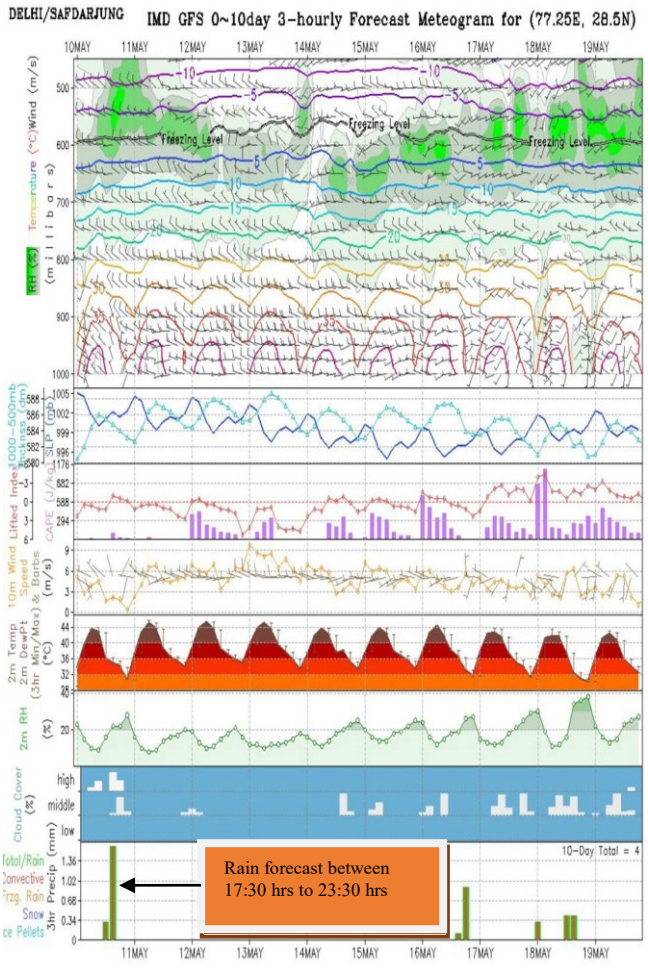

Fig. 6a. Meteogram Graph (Predicting Rainfall)

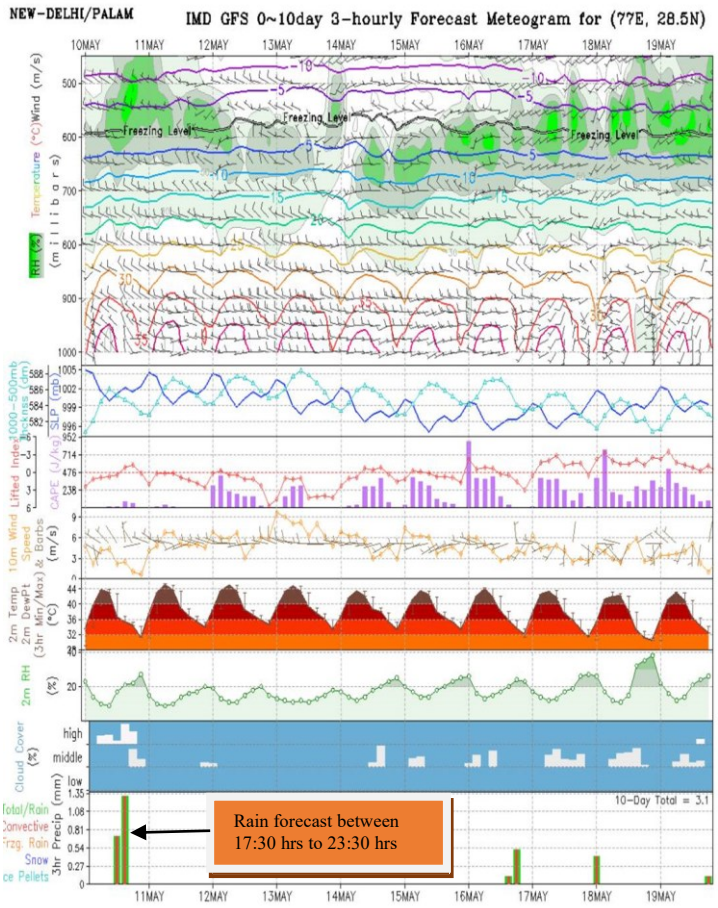

Fig. 6b. Meteogram Graph (Predicting Rainfall)

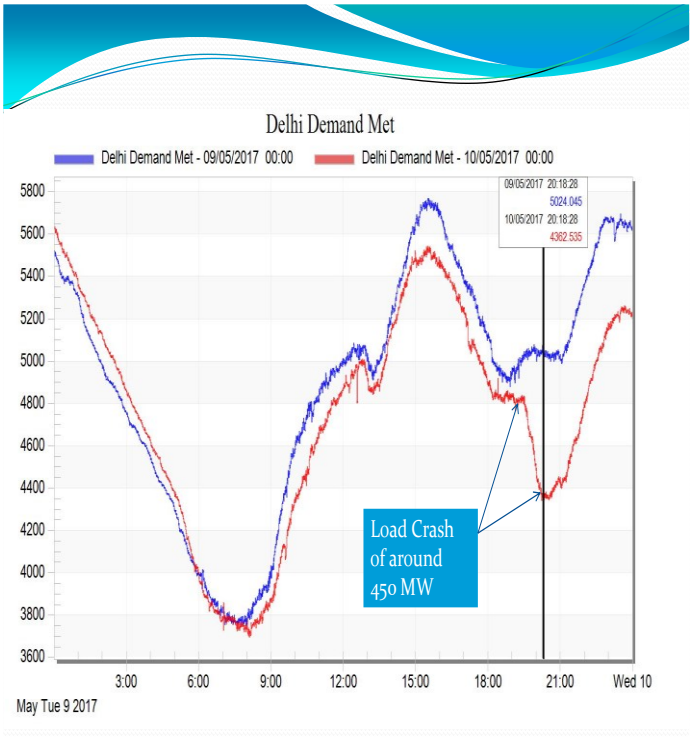

Fig. 7. Delhi demand for 09th and 10th May 2017

The distribution company monitored the Radar imagery in real time and send timely revision to reduce the

generation thus end up saving around 0.24 MUs of costly generation.

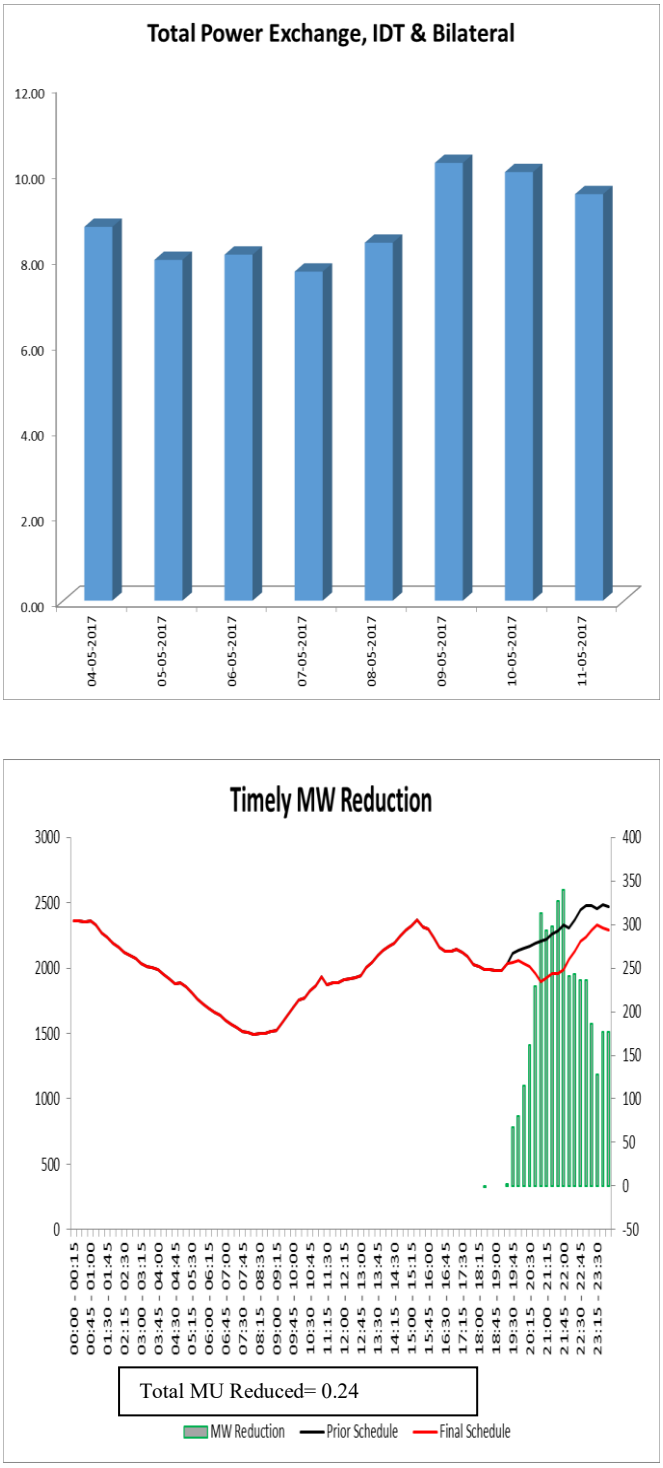

Fig.8. Purchase from Power Exchange and bilateral by distribution company from 4th to 11th May 2017 and Power Surrendered by distribution company from 19 :00 hrs onward on 10th May 2017.

VII. SAVINGS MADE BY NORTHERN REGION POWER UTILITIES WITH THE USE OF METEOGRAM AND RADAR IMAGERY

Uttar Pradesh

Rain forecast available in Regional summary and Meteograms for 27th to 29th May 2017 helped in better load assessment of UP (Uttar Pradesh) control area by UP SLDC. As anticipated, UP demand went down from 19000 MW to 17000 MW due to change in weather conditions. Accordingly, short-term bilateral purchases and purchase from Power Exchange of the order of 2000 MW was done which eventually resulted into saving of 13 MU of costly generation (Figure-9).

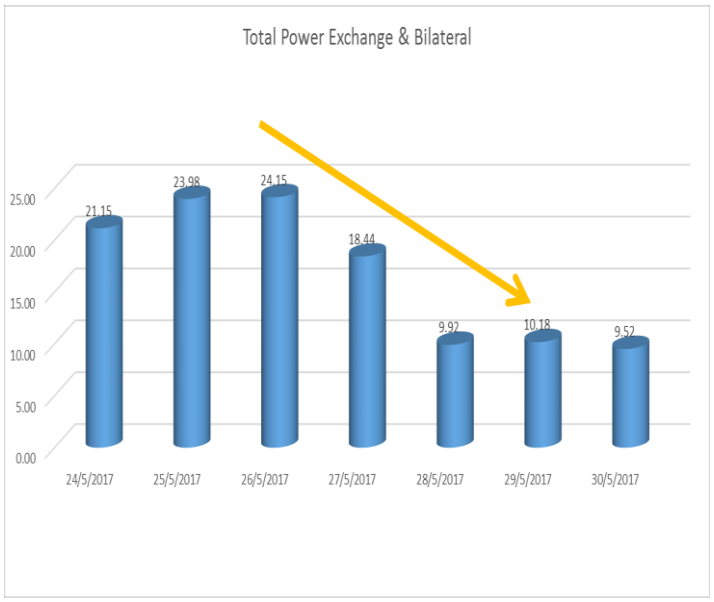

Fig. 9. Total Power Purchase by UP from Power Exchange and Bilateral by UP

Rain forecast available in Meteograms, for 21st to 24th September 2017 helped in load assessment and demand forecast of UP Control Area. Due to inclement weather conditions demand reduced from 18000 to 15000 MW. Accordingly, short term purchases from Power Exchange and bilateral/banking of about 2000 MW was not scheduled. Approximately 17MU direct purchase from Power exchange and thermal backing of costly power station were carried out. In real time operation, Radar imagery helped in managing over drawl/under drawl quickly.

Distribution Company

The Delhi's distribution company has managed to take proactive action to manage its drawl from the grid and purchases from power exchange/Bilateral contracts. The DISCOM has made savings by utilizing Meteogram to study the day ahead weather and thus optimizing purchases from Power exchange and bilateral contracts. In addition to Meteogram, live radar imagery enabled the DISCOM in sending timely revision for backing down of Generating

stations in anticipation of thunderstorm, rain, which saved under drawl of power thereby also ensuring grid security.

Table I. The Summary of savings made by the DISCOM on various occasions.

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

VIII. CONCLUSION

Based on the analysis, we can see that Meteogram are very useful in Generation and Demand Management planning in the short term. Real time Radar imagery improves visualization of the operator by providing real time weather condition in its control area. Based on this, system operator takes decision to schedule power to the end consumer. An overall better load-generation balance helps in maintaining grid parameters within prescribed limits and hence the grid security. Thus, better load-generation balance also helps in optimizing the fossil fuel uses, minimizing the impact on the environment.

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