SLDC – Gujarat experiences on Existing RE Integration

Shri B. M. Shah
State Load Dispatch Center
Gujarat Energy Transmission Corporation Ltd
Vadodara, India
Sldcdemis.getco@gebmail.com

Shri K. K. Sharma
State Load Dispatch Center
Gujarat Energy Transmission Corporation Ltd
Vadodara, India
sldcregen@gmail.com

Shri V. K. Virparia
State Load Dispatch Center
Gujarat Energy Transmission Corporation Ltd
Vadodara, India
jemisldc.getco@gmail.com

***Abstract*— The Power Installed Capacity of Gujarat State is 28.1 GW. The power installation of renewables sources are 8.0 GW. The wind installation is 5.8 GW and Solar is 2.2 GW. The State has hydro installation of only 0.78 GW and are used as per irrigation and drinking water requirement and not for power balancing. Also, the hydro generation in real time remains available for 0.1 to 0.125 GW only in peaking hours. The reversible pump mode operation in hydro station is yet to be established. There are adequate gas based installation in the State, but due to high variable cost of generation, it is not on disposal for meeting variability and intermittency of wind generation.**

The maximum demand of the State remains in between 15 GW to 18 GW. The 1.5 GW wind variation and 2.5 GW demand variation in a day are quite common. The State is committed to tap generation from all renewables without any curtailment and to supply uninterrupted, reliable & affordable power to its citizens. With strong developed network, SLDC Gujarat has integrated ever highest 4.7 GW wind, 1.4 GW solar, 18.4 GW demand without any interruption and curtailment.

In era of tight DSM regulation, The State grid operation is passing through shortage of balancing resources, absence of ancillary services and many challenges.

The State has always strives for accurate renewable energy forecasting, demand forecasting, maintaining network availability, system parameters (voltages at each buses, system frequency and loading on each elements) for ensuring reliable and economic grid operation by adopting new technologies, software applications.

The system operation scenarios with high RE capacity mainly divides in:

1. **High wind - less solar – less demand scenario**
2. **Less wind – high solar – high demand scenario**
3. **High wind variation – high solar – less demand variation**
4. **High wind variation – high solar – high demand variation**
5. **High wind – high solar – high demand**

In Gujarat, the State demand remains high in month of September - October and peak comes between 12 to 15 hours. At that time, the solar generation remains high during this period. Hence, less Wind – less Solar – High demand scenario prevails occasionally.

There are different kind of challenges in all above scenarios.

Keywords- RE (Renewable Energy), DSM (Deviation settlement), LVRT (Low voltage ride through), FSP (Forecasting service provider), QCA (Qualified communication Agency), CA (Communication Agency), RGMO (Restricted Governing Mode Operation)

I. INTRODUCTION

The Gujarat State has 20% installation from renewables. The RE days are classified as under:

I. High RE days: Total renewable energy contribution is more than 20% in a day

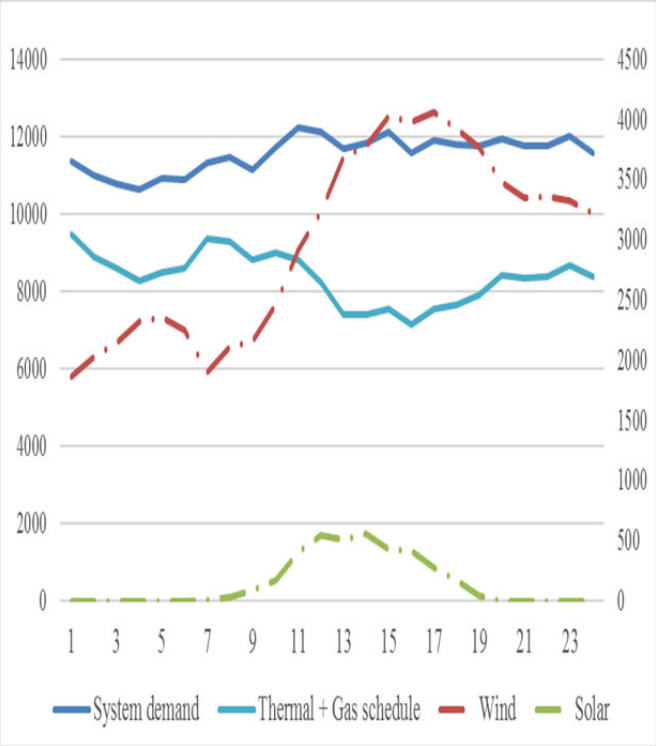
II. Moderate RE days: Total renewable energy contribution in between 10 to 20% in a day

III. Less RE days: Total renewable energy contribution is less than 10 % in a day

The scenario wise operational challenges for integration of renewables are as under:

II. CASE STUDY

1. HIGH WIND - LESS SOLAR – LESS DEMAND SCENARIO

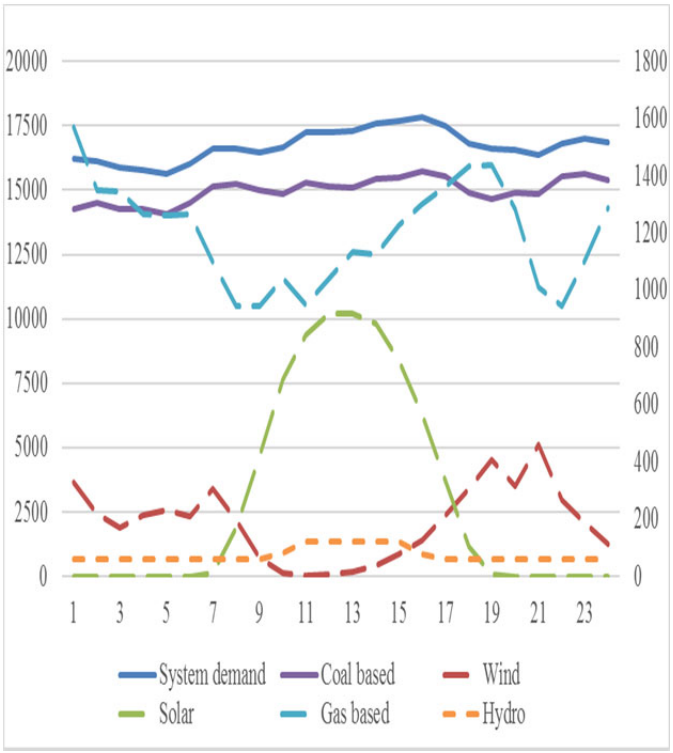


25.07.18			
Total Energy in MUs	277.551	Max wind in MW	4060 @ 17:00 Hr
Wind energy in MUs	71.761	Min Wind in MW	1866 @ 01:00 Hr
Solar energy in MUs	3.663	Max Solar in MW	552 @ 14:00 Hr
% RE	**27.17**	Wind variation	**2194**
Max demand in MW	**12229 @ 11:00 Hr**	Demand variation	1583
Min Demand in MW	10646 @ 04:00 Hr		

The above scenario prevails in the months of mid-June to Aug end. The demand variation in a day remains less. The gas based generators remains off bar. The bigger sized thermal units remains in planned shutdown. The RE variations are being handled mostly by coal based generators which are not flexible and effective resulting into large deviation from schedule. The unutilized pump storage capacity anywhere in PAN India will certainly help the States like Gujarat.

At every node, system voltage remains on higher side. The wind farm pooling stations connected up to 132 kV level faces evacuation constraint.

2. LESS WIND–HIGH SOLAR–HIGH DEMAND SCENARIO

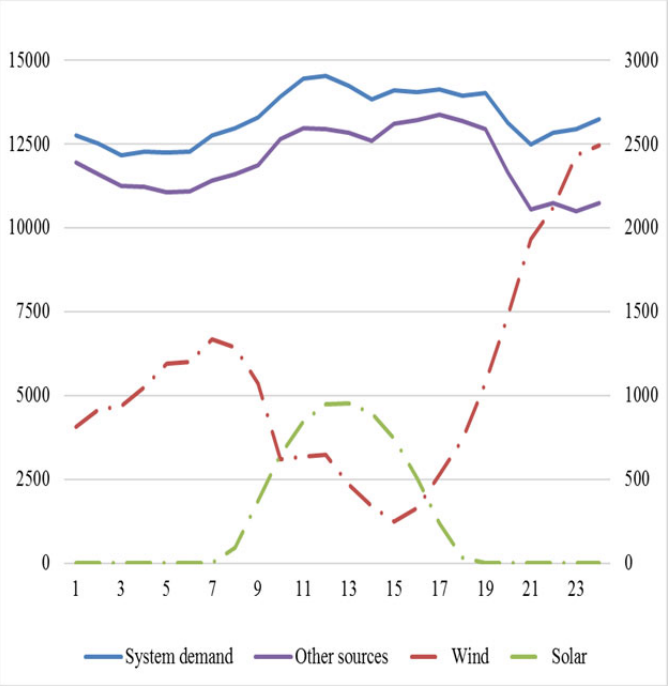


04.10.18			
Total Energy in MUs	401.468	Max wind in MW	461 @ 21:00 Hr
Wind energy in MUs	4.497	Min Wind in MW	04 @ 11:00 Hr
Solar energy in MUs	6.626	Max Solar in MW	920 @ 13:00 Hr
% RE	***2.78***	Wind variation	***457***
Max demand in MW	***17822*** @ 16:00 Hr	Demand variation	2197
Min Demand in MW	15625 @ 05:00 Hr		

The above scenario prevails in the month of September - October. The State demand remains on higher side due to Agriculture crop sowing season. The demand variation in a day remains less. Mostly, all gas and thermal generators remains on bar. The solar generations remains on higher side and easy to have accurate forecast. The RE variations are handled comfortably.

At every node, system voltage remains on quite lower side. The wind farm draws more reactive power. It further detriment the voltage profile. It is very difficult to permit the transmission elements outages.

3. HIGH WIND VARIATION – HIGH SOLAR – LESS DEMAND VARIATION



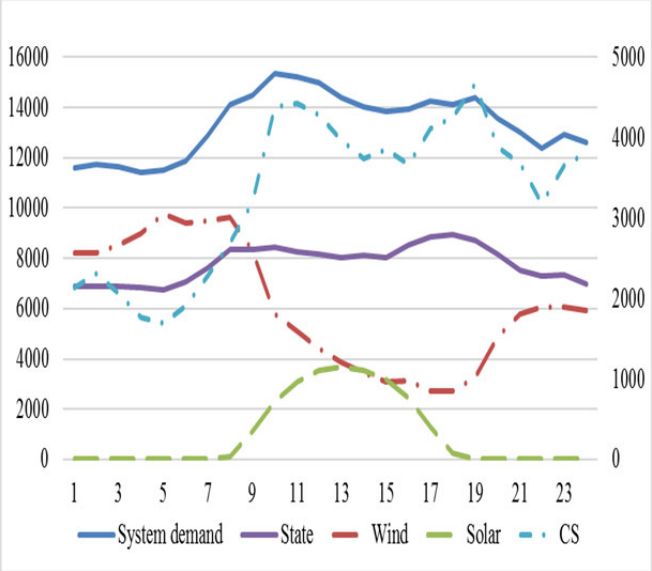
15.11.18			
Total Energy in MUs	319.132	Max wind in MW	2491 @ 24:00 Hr
Wind energy in MUs	25.885	Min Wind in MW	248 @ 15:00 Hr
Solar energy in MUs	6.263	Max Solar in MW	952 @ 13:00 Hr
% RE	10.07	Wind variation	**2243**
Max demand in MW	14527 @ 12:00 Hr	Demand variation	2349
Min Demand in MW	12178 @ 03:00 Hr		

The above scenario prevails in the months of November - December. The State demand remains quite high. The demand variation in a day remains less. The wind generation remains high whereas the State demand remains on lower side during night hours vice versa the wind generation remains quite low whereas the State demand remains on higher side during day hours.

The day ahead accurate wind forecasting helps to optimize operation of gas based units in open cycle (costly) and hydro units and handle RE variation.

At every node, system voltage remains normal in day hours, but in night hours the voltage profiles remains on higher side.

4. HIGH WIND VARIATION – HIGH SOLAR – HIGH DEMAND VARIATION



07.01.19			
Total Energy in MUs	320.315	Max wind in MW	3052 @ 05:00 Hr
Wind energy in MUs	45.884	Min Wind in MW	849 @ 17:00 Hr
Solar energy in MUs	7.683	Max Solar in MW	1144 @ 13:00 Hr
% RE	16.72	Wind variation	2203
Max demand in MW	15368 @ 10:00 Hr	Demand variation	3944
Min Demand in MW	11424 @ 04:00 Hr		

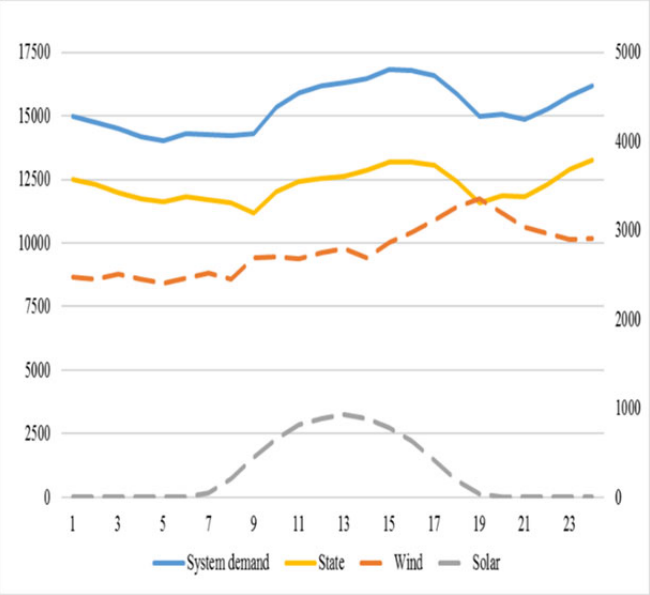
The above scenario prevails in the period of January to March. The State demand remains quite high. The extensive demand variation in a day comprehensively remains high. The wind generation remains high whereas the State demand remains on lower side during night hours vice versa the wind generation remains quite low whereas the State demand remains on higher side during day hours.

Despite of backing down in all thermal units, there are huge under drawls during night hours due to adhering must run RE status. Also, it is not advisable to withdraw thermal units in night hours as it requires in day hours to cater the load with less RE support.

The day ahead accurate wind and load forecast helps to optimize operation of gas based units in open cycle (costly) and hydro units and handle RE variation. The unutilized pump storage capacity anywhere in PAN India will certainly help the States like Gujarat.

At every node, system voltage remains normal in day hours, but in night hours the voltage profiles remains extensively on higher side.

5. HIGH WIND – HIGH SOLAR – HIGH DEMAND:



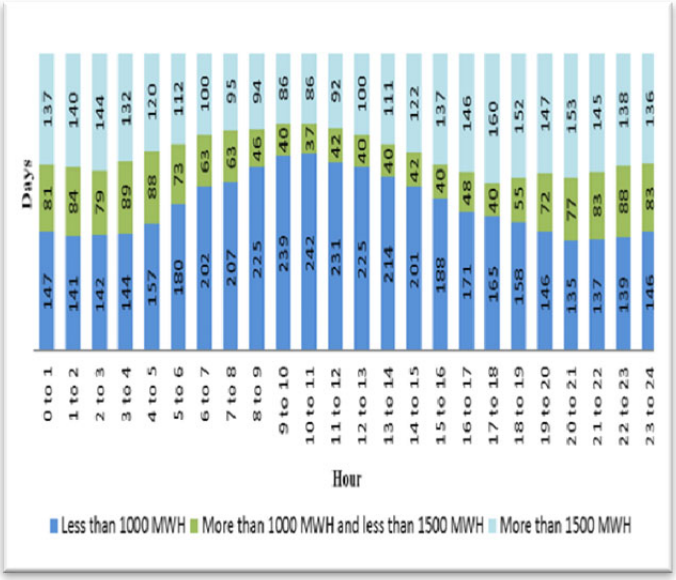
28.05.18			
Total Energy in MUs	368.014	Max wind in MW	3359 @ 19:00 Hr
Wind energy in MUs	66.623	Min Wind in MW	2405 @ 05:00 Hr
Solar energy in MUs	6.931	Max Solar in MW	927 @ 13:00 Hr
% RE	20.00	Wind variation	*954*
Max demand in MW	16811 @ 15:00 Hr	Demand variation	*2776*
Min Demand in MW	14035 @ 05:00 Hr		

The above scenario prevails from March to mid-June. The State demand remains high due to summer season. . The demand variation remains less. The wind generation remains high and wind variation remains moderate. All coal based generators remains on bar. The RE variation can easily handle with the help of day ahead accurate wind and load forecast.

At every node, system voltage remains normal. It is very difficult to permit outages of transmission network associated with evacuation of RE generation. Sometimes, the wind energy generation curtailment is imposed in case of an emergency outage.

III. OBSERVATION ON HOURLY WIND / SOLAR TREND:

The graph of hourly wind and solar trend in Gujarat power system are furnished as under



The hourly wind generation remains less (not more than 500 MW) from 10:00 Hrs. to 13:00 Hrs. for more than 242 days where as the solar generation remains more than 500 MW.

IV EXPERIENCE ON RE FORECASTING:

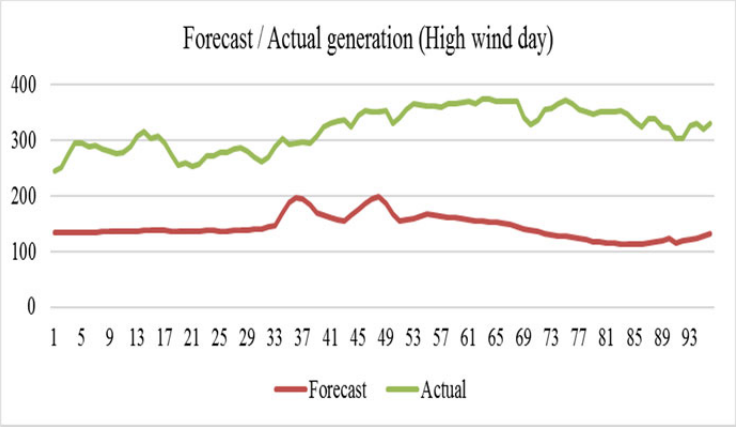
SLDC Gujarat has recognized the need of accurate RE generation forecasting for safe and reliable grid operation. In 2014, the separate section was established. The objective is to accommodate real time weather data and forecast renewable energy from various reliable sources / tools for preparing anticipated variation in RE generation and for same day and next day with corrective update cycle of at least twice a day.

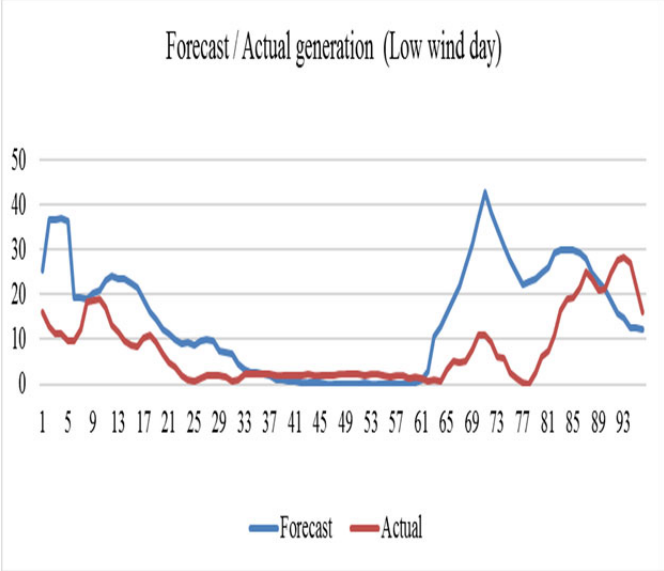
SLDC - Gujarat has also hired service from FSP since 2016. At present, SLDC is getting centralized day ahead, real time and weekly wind generation forecast for State as whole from service provider. SLDC has developed in house wind energy generation forecasting module. SLDC is continuously analyzing trend of wind energy generation forecast provided by FSP and provided by in house module. SLDC is continuously monitoring real time trend with forecasted generation.

It is observed that the accuracy of forecasting depends on so many factors like accurate weather forecasting data, information regarding availability of windmills, real time data of RE generation. The FSP needs some time to tune their model with real time RE generation data. Gujarat SLDC receives real time RE generation data from 73-wind farm pooling stations and 87 solar pooling stations. It is very difficult to maintain 100% availability of infrastructures provides for getting real time data. Therefore, it is not possible to provide 100% real time RE data at pooling station level all the time to FSP. Moreover, the wind farm pooling station owner / QCA / CA never gives information regarding availability of windmills. Hence, it is very difficult to get accurate forecast at centralized level.

SLDC – Gujarat receives decentralized forecast from 43 Nos. wind farm pooling stations covering 60% installation of wind and 86 Nos. solar pooling stations covering 98% solar installation.

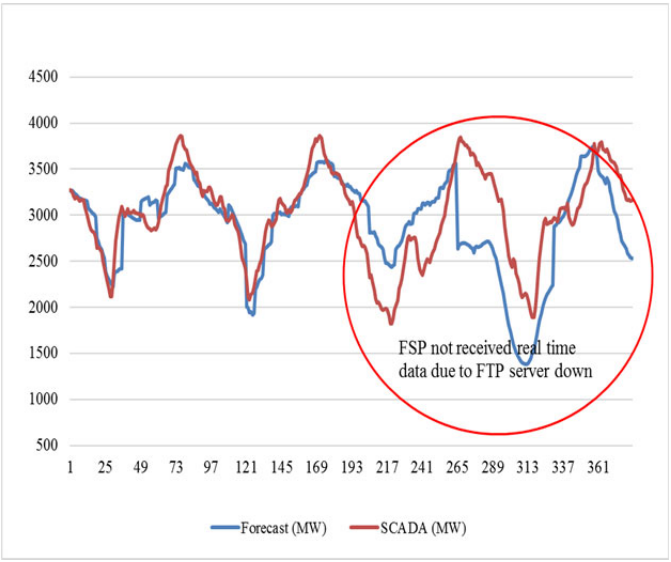
The aggregate forecast vs actual RE generation trend for four-wind farm pooling station in different scenarios presented below:





It is observed that there is vast difference between decentralized forecast and actual provided by CA. In high wind scenario, the actual wind generation remains on higher side whereas it remains less in low wind scenario.

The FSP could not extend accurate RE forecast without real-time data. It is shown below. There was problem in FTP server. The real time data could not extended to FSP resulting vast variation in forecast vs actual.



From the above, it is emerged that SLDC could not rely on decentralized forecast received from various pooling stations as well as centralized forecast received from FSP. Therefore, it is necessary that FSP should develop such robust model that could not depend on loss of real time generation data or weather data. Also, the redundant communication links / equipments / hardware are required be provided to get real time data to SLDC and further extending to FSPs.

The State regulator has introduced following settlement mechanism with the State RE entity selling outside the State (Inter-State transaction):

- If SG (Scheduled Gen.) > AG (actual Gen.)
  - Generator pays to State DSM pool at PPA rate for less generation.
- If SG (Scheduled Gen.) < AG (actual Gen.)

State DSM pool pays to Generator at 0.85% of PPA rate for excess generation.

Recently, the State Regulator has come forward with Forecasting, Scheduling, Deviation Settlement and Related Matters of Solar and Wind Generation Sources Regulations, 2019. This Regulations will apply to all wind and solar generators having combined installed capacity above 1 MW connected to the State grid/substation, including those connected via pooling stations and selling generated power within or outside the State or consuming power generated for self-consumption.

In the event of actual generation of a wind generating station or a pooling station, as the case may be, being less or more than the scheduled generation, the deviation charges for shortfall or excess generation shall be payable by the wind generator or the QCA appointed on its behalf, as the case may be, to the State DSM Pool, as given in Table – I below.

Sr. No.	Absolute Error in the 15-minute time block	Deviation Charges payable to State DSM Pool
1	<= 12%	None
2	>12% but <=20%	At Rs. 0.25 per unit for the shortfall or excess energy for absolute error beyond 12% and up to 20%
3	>20% but <=28%	At Rs. 0.25 per unit for the shortfall or excess energy beyond 12% and up to 20% + Rs. 0.50 per unit for balance energy beyond 20% and up to 28%
4	> 28%	At Rs. 0.25 per unit for the shortfall or excess energy beyond 12% and up to 20% + Rs. 0.50 per unit for balance energy beyond 20% and up to 28% + Rs. 0.75 per unit for balance energy beyond 28%

Absolute Error (%) = 100 X [Actual Injection – Scheduled Generation] / [Available Capacity]
The Deviation Charges specified above shall be effective from 1st August, 2019.

It will certainly help to get accurate decentralized wind forecast.

V PROVISION OF LVRT FEATURES:

The LVRT-term is capturing the ability of a wind turbine to stay connected to the grid throughout a short mains voltage drop. It is essential that a wind park stay online in order to prevent major blackouts whenever there is a sudden dip in voltage.

Hon'ble CERC directed that LVRT should be implemented for all wind turbines connected to voltage level of 66 KV and above except for stall type WEGs and having installed capacity equal to or more than 500 KW. At present, LVRT features are available in 2835 MW WTGs capacity. The absence / sluggish response of LVRT might lead black out in local area.

In Gujarat Power System, no major disturbance occurred to analyze LVRT response. However, there is need to introduce third party agency for accreditation of LVRT installation.

VI POOR / INADEQUATE PRIMARY FREQUENCY RESPONSE OF STATE GENERATORS:

To arrest sharp rise or drop of frequency, quick response from the generators through RGMO/FGMO is an inevitable requirement for safeguarding the grid. There are still several instances of sharp frequency excursions on daily basis. It has to be contained with the help of automatic primary response from the generating units.

As per the 5th amendment of IEGC (effective from 01.05.17), all Coal/lignite based thermal generating units of 200 MW and above, Open Cycle Gas Turbine/Combined Cycle generating stations having gas turbines of capacity more than 50 MW each and all hydro units of 25 MW and above, which are synchronized with the grid, irrespective of their ownership, shall have their governors in operation at all times. Open Cycle Gas Turbine/Combined Cycle generating stations having gas turbines of capacity more than 50 MW each shall have their governors in operation with effect from 01.10.2017. Ideally, governor should respond within 30-40 seconds and the increased generation should sustain for few minutes 3-5 minutes.

The most of State thermal generators are old and not equipped with advance instrumentation and control. The primary response is not effective from these units.

Increasing integration of renewables would lead less dispatch to Synchronous Machines. The primary frequency response will further deplete. Therefore, it is necessary to keep higher synchronous capacity on bar by revising the turn down levels. The clear mandate is require for providing synthetic Inertia / primary response from RE generators.

VII CONCLUSION:

The GoI has given target to the Gujarat State to enhance solar capacity to 8.0 GW and wind capacity to 8.8 GW by 2022. So as a way forward, there is an emerging need to introduce regulatory framework for getting accurate RE forecasting from pooling station owners. The separate grid code / CEA standards for safe renewable energy integration to be framed for commencing HVRT / LVRT features in all type of wind turbines / solar plants.

Also, it shall be necessary that pooling station owners should adopt and vigorously follow the recognized practices for condition monitoring of equipment's, EHV line maintenance.

The grave attentions are to be given for introducing storage devices and to operationalize pump storage devices in the system by way of introducing ancillary services.

For example: The River Bed Power House of Sardar Sarovar Hydro project (multistate beneficiary project) are having 6 units of 200 MW each. All units are capable for reversible pump mode operation. The Construction of Garudeswar weir (Lower reservoir) is under progress and likely to be completed within one year. In this multi-State beneficiary project, the Madhya Pradesh 57 %, Maharashtra 27 % & Gujarat 16% are having allocation of Power. In this, it is very difficult for State like MP to give negative schedule of around 700 MW to plant for pumping operation in off peak hours.

So, it is necessary that such capacity to be open for all for optimum utilization. If we operate 30 machine hour for pump mode operation @ 2.50 Rs and same pumped water utilized for generation for approximately 22 hours @ 4.00 Rs, then there will be benefit of 0.3 crore per day. The annual income would be around 60 Crore.

Therefore, the reversible pump mode operation shall be established in Hydro projects wherever it is feasible. The Central Ministry should establish a separate cell for establishing and optimum utilization of such plants. The Central regulator should come forward for accessing pump storage capacity for other through robust market mechanism.

ACKNOWLEDGMENT

The authors acknowledge the support and inspiration received from the GETCO management in publication of this paper.

The authors are grateful to their colleagues for their liberal contributions for enriching the content in the paper and takes opportunity to convey sincere thanks to Shri B. B. Mehta, Chief Engineer, SLDC for unwavering and continuous support.

REFERENCES

1]. IEGC – 2010 and its amendment

2]. SLDC – Gujarat Annual reports

3]. Paper on Primary frequency response in an RE-rich grid- Operational experience of the Western Regional Grid by Vivek Pandey, Srinivas Chitturi, POSOCO in CBIP conference 2018

4]. Hon'ble CERC order dated 05.01.16 in petition No. 420/MP/2014.

5]. CEA (Technical Standards for connectivity to the grid) – Amendment regulations 2013.

6]. Hon'ble GERC Notification No. 1 of 2019 on Forecasting, Scheduling, Deviation Settlement and Related Matters of Solar and Wind Generation Sources) Regulations, 2019.

BIOGRAPHICAL INFORMATION

Shri B.M.Shah is working as Executive Engineer, at SLDC-Gujarat GETCO. He is graduate Electrical Engineer from LE College of Engineering. He is having more than 25 years of experience in field of Operation and maintenance. At Presently, he plays a key role in Anuual unit outage planning, Transmission element outage planning and coordination, Black start mock drill activities, designing of special protection scheme.