

## Power System Operation & Control C2

Operation planning strategies, methodologies and supporting PS2

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# Evolution of Renewable Energy Monitoring Centre in Southern Regional Grid: Experience through Data, Forecasting and Challenges

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### Motivation

- Section I : Experience in planning and integration of large volumes of real time data telemetry from distributed renewable energy sources in southern regional grid of India.
- Section II : Experience in setting up of dedicated Renewable Energy Management Centre (REMC) and use of the SCADA data (both real time & historical) to provide improved forecasting of the integrated renewables.

### Method/Approach

- Section I : Data sets report to the control centre at SRLDC over SCADA communication protocols i.e. IEC 60870-5-101/104. The data corresponding to other control areas or neighbouring regions report over ICCP (Inter Control Center Communication Protocol) to SRLDC
- Section II: The flow of renewable energy into the National grid network and provide visibility of available renewable energy to the system operator for optimal utilization of conventional and renewable sources by using REMC modules (i) Real time SCADA systems, (ii) Scheduling & (iii) Forecasting of Renewable Energy(RE) at State and Regional level.

### Objects of investigation

- Section I : Study tours were conducted to Ostro Kutch Wind Farm (250MW) in Gujarat and Param Pujya Solar Park (100MW) in Karnataka in 2018 to identify the data that can be telemetered from the respective plants including communication approach based on available Infrastructure.
- Section II :The performance of the forecasting engine over several time blocks and seasons have been analysed and with better SCADA data availability

### System under Study

- Section I : Southern Regional Grid of India consist of 5 States and 1 Union Territory - Andhra Pradesh, Telangana, Karnataka, Kerala, Tamilnadu and Puducherry. The Southern Region (SR) of the country alone shares 40% of renewable energy of total all India installed capacity with close to 50 GW capacity.
- Section II : REMCs are established in renewable energy rich States and at Regional centre along with conventional control centre. Four REMC centres are located in SR at Andhra Pradesh, Karnataka, Tamilnadu & Southern Regional Load despatch centre (SRLDC). Telangana REMC is new addition to the project. due to increase in renewable energy in the State.

### Discussion

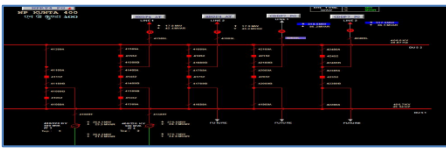
- Section I: Preliminary data Integration for grid connected RE stations as regulations for telemetry requirements of RE were still evolving.
- Connectivity of Solar park and Data Integration.
- Formulation of Telemetry requirements for RE stations.
- Integration of Real time Inverter/Wind turbine level data from RE stations.
- Section II: Development and commissioning of REMC at SRLDC with state of art SCADA systems, forecasting & scheduling modules in common platform on February 2020.
- Accuracy evaluation of forecast by different forecast service providers is determined by root mean square error normalized to available capacity.
- Impact of Real time data availability on Forecast performance.
- Challenges & Way forward

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#### Preliminary data Integration results



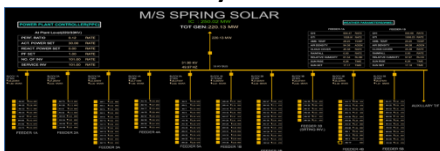
- The standard set of data that reports to the control centres at the regional level are classified under three categories
- Analog: Voltage (kV), Frequency (Hz), Active Power (MW), Reactive Power (MVAR) and Transformer Tap Position (OLTC).
- Status: Circuit Breaker, Isolator and Switch Positions
- Sequence of Events (SoE): from Trip Signal of feeders

#### Formulation of Telemetry Requirements for RE stations

Telemetry from WTG-Inverter	Plant level Telemetry	Telemetry from Developer Pooling Station
WTG Inverter Active Power (kW)	No. of WTG Inverter online	Global Inverteral Involvement (GIEI) (W/m <sup>2</sup> )
WTG Inverter Reactive Power (MVAR)	Voltage Control Mode/Setting	Ambient temperature (°C)
Wind Speed (m/s)	Power Factor control mode/Setting	Direct Irradiance (DIm <sup>2</sup> )
WTG Inverter CB Status	Reactive Power Control Mode/Setting	Sea state and wave height
LVRT Trigger (Status/SoE)	Active Power Control mode/Setting	Cloud cover (Clear)
BEVET Trigger (Status/SoE)	Frequency control mode	Humidity (%)
	Frequency control drop (%)	Relative humidity (%)
	Constant Reactive Power set point	Air Density (Kg/m <sup>3</sup> )
	Active power ramp rate UP and down setting	Wind Direction (Degrees from North)
	Performance Ratio	Barometric Pressure (Pascal)
	Minor/Signal level setting of Voltage Control mode	

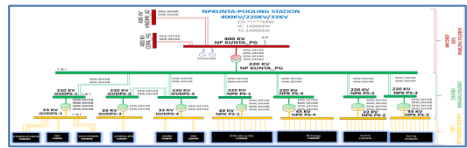
- Based on the CERC Framework and the inputs received from study tour conducted in 2018, list of real time telemetry parameters were formulated by Power System Operation Corporation Ltd (POSOCO).
- Additional Telemetry list were broadly classified into turbine/inverter level, plant level and developer pooling station level including weather parameters, power plant controller for Inter State Transmission System (ISTS) connected RE generators.

#### SCADA data visibility at Inverter level



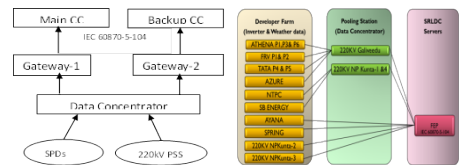
- Inverter level data from solar farms and wind turbine level data from wind farms along with weather data and plant level settings have been integrated at SRLDC.
- A snapshot of single line diagram in SRLDC REMC SCADA for an SPD providing real time data telemetry upto individual inverters is depicted.

#### Connectivity of NPKunta Solar Park



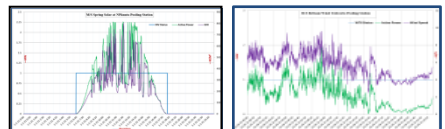
- These data sets are the bare minimum telemetry required to be made available to the corresponding load despatch centre before connecting to the grid. These data sets report to the control centre at SRLDC over SCADA communication protocols i.e. IEC 60870-5-101/104. The data corresponding to other control areas or neighbouring regions report over ICCP (Inter Control Center Communication Protocol) to SRLDC.

#### Integration of Real time Inverter/Turbine level data from RE stations



- Custom architecture was designed for communication with Data Concentrators (DCs) to collect the real time SCADA data from associated downstream RE generators and further reporting as single remote terminal unit (RTU) to SRLDC in dual channels to Main and Backup Control Centres.

#### Inverter/WTG Status vs generation data



- A typical day plot of single inverter and WTG generation data (in MW) received from an SPD, along with weather parameter and digital status (ON/OFF) of inverter/WTG is shown.

#### Conclusion

- Huge RE penetration in the region over a small period of time, it became challenging for the grid operator to manage load generation balance in real time and to honour the real time despatch/drawl schedules. Under these conditions, real time monitoring of RE generation along with forecast at generator voltage level became need of the hour.

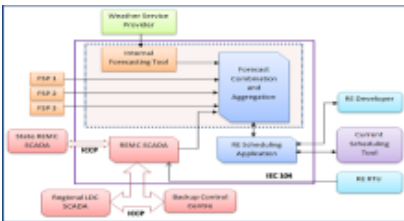
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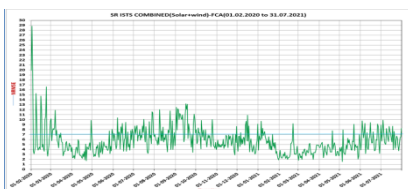
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#### Development and commissioning of REMC at SRLDC



- The data acquired by REMC SCADA from RE stations over standard IEC 104 protocol serves as input to the internal forecasting tool (IFT). The REMC SCADA will also provide/obtain required information with National as well as State SCADA systems on ICCP protocol.
- The forecasting module predicts wind and solar generation at Regional, State and generator level. The module uses forecast from different Forecast Service providers (FSP) and forecast from internal forecasting tool to form a final forecast (Forecast Combination & Aggregator, FCA module output) for both operators and SRLDC users.
- The scheduling tool provides web interface platform to the scheduling entity or qualified coordinating agency (QCA) to upload their schedules and view the forecast provided by FCA. They can enter day ahead and intra-day schedule as well as available capacity through the scheduling tool as applicable in IECG regulations. Available capacity entered is further taken as input to forecasting tool for getting an accurate forecast of generation.

#### Accuracy Performance of Forecasting Tool



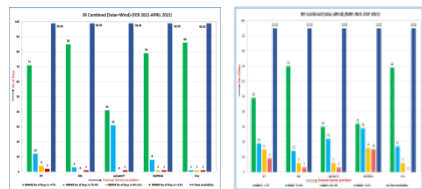
- Normalized Root mean square error is calculated for total number of 15 minutes blocks (N) during a year with following formula:
- $$NRMSE(k) = \left( \frac{1}{N} \sum_{t=1}^N e^2(t+k) \right)^{1/2}$$
 Where e is the error in % =  $\frac{(Actual - Forecast) \times 100}{Available\ capacity}$
- The performance of forecast tool period from Feb 2020 to July 2021.

#### Geo tagging of RE at plant level



- All regional RE generators are geo tagged in map board and real time forecast vs actual, various weather information such as ambient temperature, irradiance, wind speed and along with other weather information can be visualized up to macro level as shown in the figure 8. Power forecast with temporal resolution 15 minutes (1Time Block) starting from 00:00 hrs of next day is provided for day-ahead forecast whereas, week ahead forecast is provided with temporal resolution of 1 hour for next week. Forecast with temporal resolution of 15 minutes for next 24 hours is provided for intra-day forecast and forecasts can be revised every 90 minutes (i.e., upto 16 revisions in a day).

#### Impact of Real time data availability



- It can be noticed that during the period of March - April 2021, NRMSE value is maintained below 6% and value is in the range of 8-10% during the period June - July 2021.
- The real time data availability is less during the period June-July 2021 thus impacting the forecasting performance NRMSE error when compared to Feb-April 2021.

#### Conclusion

- Availability of information on renewable generation and forecast has aided system operator in grid management, however there is further scope for improvement in functioning of REMC with some challenges & way forward.
- Integration of upcoming REMCs with regional REMC and handling of large volumes of RE data being received in real time from state REMCs.
- Utilisation of real time weather telemetry from RE generators for improving the performance of REMC forecasting tool.