Wind Energy Forecasting and Scheduling in India

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Introduction

India has the fourth highest wind installed capacity in the world. As on 30.06.2015, the total installed capacity for wind energy in India was 23,763 MW. With such large scale wind power deployment, and with even more aggressive target for harnessing the wind energy in the near future, wind industry is going to play a significant role in the operation of electricity markets and power systems. In the past, on several occasions, System Operators in India have been forced to curtail wind energy generation though wind enjoys ‘Must Run’ status owing to its intermittent nature. This has resulted in loss of generation and revenue for wind projects impacting the project viability. The practice of forecasting wind power generation and scheduling the same is envisaged as a potential solution to tackle the issues posed by the intermittency. This is also expected to increase the acceptability of intermittent generating source like wind among the system operators and allow better management of the Grid.

Basics of Forecasting and Scheduling

Need for forecasting and scheduling: Given the ambitious target set by Government of India, of adding 60 GW wind power by 2022, there is an urgent need for streamlining the mechanism of forecasting and scheduling wind energy for proper grid integration.

Forecasting: The prediction of wind energy available for generation in the future is called forecasting. Forecasting is done with the help of forecasting tools which combines meteorological data (wind speed, temperature, etc.) and turbine level data (type of turbine, installed capacity, swept area, hub height, etc.) into an algorithm and a forecast is generated.

Scheduling: The process of generating schedules (in MW or MWh) based on the forecast created on day ahead or intra-day basis for a certain time block (fifteen minutes) for the proper dispatch of energy. Apart from wind energy forecasts, schedules also take into consideration issues such as grid availability, machine maintenance etc.

Different approaches to forecasting: Wind forecasting is generally based on the required forecasting horizon; which is broadly categorised based on duration-long term (day ahead/ seasonal) and short term (hour ahead) forecast. The basic approaches for forecasting are enlisted below:

- **Physical Method (Numerical Based):** A Numerical Weather Prediction (NWP) model is the commonly used method for forecasting of weather elements represented by equations of physics through the use of numerical methods.
- **Statistical Method:** In this method, relationship between wind speed prediction and measured power output from the wind farm is derived to predict the wind power.
- **Hybrid Method:** It is a combination of above mentioned forecasting methods with the proper tools.

Different approaches to scheduling: The key approaches to scheduling adopted globally are mentioned below:

- **Decentralized Scheduling:** In this method each wind farm needs to forecast and schedule its generation. This type of mechanism is preferred for wind generators who wish to participate in open access or day ahead or intra-day markets.
- **Centralized Scheduling:** In case of centralized scheduling, the forecasting is done by a single entity (the grid operator in most cases) for all wind projects in the control area. Generally, the wind energy generation forecasts prepared for larger control area are consistent and have higher accuracy levels.
- **Integrated Scheduling:** It is a combination of the above mentioned scheduling techniques wherein centralized schedules are created for all wind farms in a cluster and decentralized schedule are created for captive and open access wind farms.
Regulatory Framework for Scheduling in India

The concept of forecasting and scheduling of wind generators and commercial settlement thereof was first introduced in Indian context by CERC through Indian Electricity Grid Code (IEGC), 2010. The RRF or the ‘Renewable Regulatory Fund’ mechanism was envisaged to be implemented from January 1, 2011. However, owing to several implementation issues, the mechanism was never made operational. In order to formulate an implementable framework, CERC on 31.03.2015, issued draft Amendments to (i) the Central Electricity Regulatory Commission (IEGC) Regulations, (ii) the Central Electricity Regulatory Commission (Deviation Settlement Mechanism and Related Matters) Regulations and (iii) the Central Electricity Regulatory Commission (Terms and Conditions for recognition and issuance of Renewable Energy Certificate for RE Generation) Regulations. Based on the comments and suggestions received from various stakeholders, CERC has published the 3rd amendment to IEGC. It is called Central Electricity Regulatory Commission (IEGC) (Third Amendment) Regulations, 2015 issued on 07.08.2015. On the same date, CERC also issued 2nd amendment to regulation for Deviation settlement mechanism and related matters.

Brief Snapshot of the Recent Amended Regulations

The CERC has amended the IEGC to accommodate mechanism for Forecasting, Scheduling and Imbalance Handling for Renewable Energy (RE) generating stations based on wind and solar energy. The salient features of the framework are mentioned below:

- **Applicability:** Wind and Solar generators which are regional entities.
- **Forecasting responsibility:** Forecasting shall be done by wind and solar generators which are regional entities as well as by RLDC. The forecast by the concerned RLDC shall be responsible for ensuring secure grid operation while the forecast by wind/solar generators shall be generator centric.
- **Scheduling Responsibility:** The responsibility of providing generation schedule lies with wind and solar generators. They have the option of accepting the concerned RLDC’s forecast for preparing its schedule or they can prepare schedule based on their own forecast.
- **Revision of schedules:** There may be a maximum of 16 revisions for each fixed one and half hour time slot starting from 00:00 hours during the day.

- **Error Calculation:** The formula for error calculation is:
  \[
  \text{Error (\%) = 100} \times \frac{\text{Actual Generation - Scheduled Generation}}{\text{Available Capacity}}
  \]
  Where, **Available Capacity (AvC)** is the cumulative capacity rating of the wind turbines and solar inverters that are capable of generating power in a given time-block. AvC will be equal to the installed capacity unless one or more turbines are under maintenance or shutdown.

- **Imbalance Handling:** The tolerance band being proposed is +/-15% for wind and solar generators.

  The settlement in case of over or under injection would be as follows:

<table>
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<th>S No.</th>
<th>Absolute Error in the 15 minute time block</th>
<th>Deviation charges payable to Regional DSM pool</th>
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<tr>
<td>1.</td>
<td>Within +/- 15%</td>
<td>No commercial implication</td>
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<tr>
<td>2.</td>
<td>&gt;15% but &lt;= 25%</td>
<td>10% of PPA rate</td>
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<tr>
<td>3.</td>
<td>&gt;25% but &lt;=35%</td>
<td>20% of PPA rate</td>
</tr>
<tr>
<td>4.</td>
<td>&gt;35%</td>
<td>30% of PPA rate</td>
</tr>
</tbody>
</table>

In case of multiple PPAs, the weighted average of the PPA rates shall be taken as the PPA Rate.

International Experience

In German power sector, currently more than 75 GW of RE capacities are subject to forecasting. The German power transmission system is subdivided into four areas, each run by an independent TSO. Forecasting is done for wind generators located in the control area by the respective TSO. The forecast horizon is typically up to three days and temporal resolution of the forecast is of fifteen minutes to one hour. The Wind Power Management System (WPMS) which is developed by ISET is used by the four TSOs for forecasting of wind power. The accuracy of the predictions has significantly improved over the last year and is roughly above 95%. In order to improve wind power forecasts intense research and development efforts are already on track.

In Spain, Red Eléctrica de España, S.A. (REE), the Spanish TSO, is dedicated to the transmission of electricity and the operation of electricity systems of Spain. REE, started a Control Centre of Renewable Energies (CECRE) in 2006, to monitor and control renewable energy generation in Spain and to cope up with the issue of intermittency of these sources. REE was one of the first TSOs in the world to have a power forecasting system integrated with other tools in real-time operations. Hourly forecasts for
the next 48 hours are computed by region or the node at the transmission system. REE uses forecasts which are computed using single or combination of forecast models provided by multiple forecast providers. REE constantly performs comparison of forecasting errors to track the forecasts with the least error and better performance. It is observed that combined forecast is better since the mean absolute error is the lowest for all time horizons. TSO in Spain was able to reduce the errors with the help of forecasts from multiple forecast providers.

Developments in India: Gujarat

Owing to high wind energy potential, significant wind power projects have been commissioned in the state of Gujarat. Hence, in order to contain wind generation variability, several initiatives have been undertaken in the state to improve wind energy forecasts and thereby assist System Operators in maintaining the stability of the grid. Analysis of the existing conditions reveals that significant variations exist not only in physical infrastructure but also in institutional mechanisms within the state.

A few wind farm developers in Gujarat have initiated forecasting wind generation and providing day-ahead schedules to SLDC. The state has also installed RTUs at all 220 kV and above substations for remote data transfer to SLDCs. Real time renewable energy (Solar & wind) generation data is integrated with existing system and posted on the website of Gujarat SLDC. It is important that the detailed assessment of Gujarat experience of wind forecasting & scheduling is undertaken and gaps in processes, systems and institutional structure are identified for successful implementation of the forecasting and scheduling framework in across India.

Key Issues

The key issues which need to be addressed for successful implementation of a forecasting and scheduling mechanism would include:

- The roles of implementing institutions such as SLDC, RLDC, NLDC and RPC should be clearly defined.
- It is important to analyse the preparedness of all wind rich states viz. Gujarat, Rajasthan, Karnataka, Tamil Nadu, Maharashtra, etc., for implementation of such mechanisms at the State level.
- Improvement of infrastructure facilities and formulation of suitable procedures, protocols and capacity building/ training of staff at the implementing institutions (SLDC, RLDC, NLDC, RPC, SNA) should be undertaken.

Conclusion

The level of RE penetration (in terms of energy generated) in India is presently around 5 to 6 percent. While the capability of generators to forecast generation and to provide timely schedules are key requirements, it is equally important that other institutions involved, whether central level or state level are adequately prepared. Apart from wind/solar generators, the implementing institutions such as SLDC, RLDC, NLDC and RPC need to be geared up with adequate infrastructure and trained manpower.

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