Forecasting and scheduling of renewable energy in Tamil Nadu – Pramod Peter

Background

The renewable energy (especially solar and wind) industry is one of the fastest growing industries in India. The country's solar generation has reached a cumulative capacity of 35.74 GW, while it is 38 GW for wind, as on 31 August 2020. In January 2015, the Indian government expanded its ambition towards renewable energy by targeting to install 175 GW of RE capacity by 2022, which includes 100 GW of solar capacity and 60 GW of wind capacity. Further, the Ministry of New and Renewable Energy has earmarked an estimated Rs 4 lakh crore to achieve the target within the next three years. The recent large scale wind and solar project reverse bidding tenders have brought down their tariffs significantly, while promising to add huge capacity to the grid in the near future.

According to the Ministry of New and Renewable Energy, a total of 6083.48 MW of renewable energy capacity was added during 2019, taking the total RE capacity in India to 84.39 GW. However, market disruptions, an upset supply chain due to the ongoing COVID-19 pandemic and a disturbed trade relationship with China have slowed down capacity addition in 2020, albeit a gradual improvement in RE capacity addition is evident with each passing month and expected to attain previous momentum soon.

India’s power grid has recently pipped Japan and Russia to become the third largest in the world, but it has exposed regulators, generators and other stakeholders to a plethora of new challenges in maintaining grid stability and power quality. In addition, variable generations from wind and solar

energy plants are posing significant technical difficulties of grid management and ever increasing variable RE capacities explicitly justify the requirement of forecasting and scheduling of energy, especially in RE rich states like Tamil Nadu.

The southern state of Tamil Nadu accounts for nearly 17% of renewable energy generation in India and has overtaken Karnataka as the leading renewable power generating state in FY20. With Tamil Nadu's wind generation capacity accounting for 25% (at 9,325 MW) of the total wind generation capacity and total solar generation capacity at 4,180 MW, it is further imperative, if not, mandatory for forecasting and scheduling of RE generation in Tamil Nadu.

Top states in power generation from renewable energy sources (all in Million Units)				
Year	**Tamil Nadu**	**Karnataka**	**Maharashtra**	**Gujarat**
2014-15	11902.39	9694.9	10283.93	7222.27
2015-16	9331.47	10061.03	10756.58	8003.73
2016-17	15153.87	9585.68	11292.7	9497.99
2017-18	16179.86	13463.98	12036.98	11759.63
2018-19	16898.48	21657.53	14974.91	13776.39
2019-20*	14771.69	14730.08	8942.55	10505.54

To achieve effective grid planning, both wind and solar forecasts will need to utilise numerical weather prediction (NWP) models to predict variables such as temperature, humidity, precipitation and wind. However, forecasts for wind and solar PV generation are difficult to produce and are most accurate when near real-time meter/SCADA data and detailed static data (e.g., location, terrain, hardware information, etc.) are available to the forecasting agency.

Regulatory provisions and role of wind/solar generators

Keeping the larger renewable capacity addition plans into consideration, it has been envisaged that nearly all wind and solar generators in the country shall eventually start providing forecasts and schedule the energy with their grid operator. In case there are deviations beyond permissible limits, appropriate deviation settlement charges as applicable through appropriate deviation settlement mechanism (DSM) shall be levied based on the rules set under the applicable DSM regime. Since the Indian grid is functioning under both the central and state rules and regulations, based on the applicable jurisdiction, the respective regulators have started defining laws on wind and solar forecasting and scheduling.

TNERC regulation

In Tamil Nadu, the forecasting and scheduling regulations by TNERC were published in early 2019 along with the draft procedural guidelines. Although the regulation has not been implemented yet and final procedural guidelines have not yet been published, the final regulation provides an insight into the basic requirements and statutory compliances to initiate the forecasting and scheduling of RE generation in Tamil Nadu.

Given below are the salient features of the forecasting and scheduling regulations in Tamil Nadu, followed by a comparative analysis of regulations with other states.

I. Applicable on all wind and solar energy generators (excluding rooftop PV solar power projects)

II. Deviation Accounting based on the Available Capacity (AvC), that is,

Absolute Error in % = 100 X (Actual Generation - Scheduled Generation)/Available Capacity

III. Aggregation not allowed, but allowed at max 25 MW for smaller generators at the nearest PSS, but with the permission of SLDC.

IV. 16 Intra-day revisions allowed, effective from the fourth time block.

V. DSM Ceiling Rate capped at 5 paise per unit, and excess DSM charges shall be remitted back to the generator.

VI. Intra-state and inter-state transactions will be accounted for separately. Separate schedules will be sent for the interstate to SLDC and RLDC.

VII. DSM charges are Rs 0.25/ 0.5/ Rs 1 for each error band >10%. This is significantly lower than DSM charges in other states

VIII. QCA (Qualified Coordinating Agency) shall pay the total amount of deviation charges pertaining to the pooling substation to the SLDC.

IX. The accuracy band is narrower compared to other states; the per unit DSM charge is also lower compared to other regulations

State	Regulation Applicable to	Aggregation Allowed	Error based on	Permissible Deviation	Deviation Charges	Revisions
Karnataka	>=10MW-Wind >=5MW-Solar	Yes	AvC	+/- 15% for all	0.5, 1, 1.5 Rs./Unit	· Maximum of 16 revisions during intra-day, each in one & half hour slot starting from 00.00 hours & the revision will be effective from 4th time block.
Tamil Nadu	All	No	AvC	+/- 10% for all.	0.25, 0.50, 1.0 Rs./Unit	· There can be one revision for each time slot of one & half hours from 00.00 hrs. of a day & maximum 16 revisions are allowed.
Andhra Pradesh	All	Yes	AvC	+/- 15% for all	0.5, 1, 1.5 Rs./Unit	· Wind – One revision for each time slot of one & half hours starting from 00.00 hours of a particular day with a maximum of 16 revisions during a day. · Solar- One revision for each time slot of one & half hours starting from 5:30 hours to 19:00 hours of a particular day with a maximum of 9 revisions in a day.
Maharashtra	>5 MW	No	AvC	+/- 15% for all	0.5, 1, 1.5 Rs./Unit	· There can one revision for each time slot of one and half hours starting from 00.00 hours of a particular day, allowing a maximum of 16 revisions during the day.

The Impact of aggregation in scheduling

Variable Renewable Energy generation becomes more predictable as the number of renewable generators connected to the grid increases owing to the effect of geographic diversity and the Law of Large Numbers. It is a probability theorem, which states that the aggregate result of a large number of uncertain processes becomes more predictable as the total number of processes increases. Applied to renewable energy, the Law of Large Numbers dictates that the combined output of every wind turbine and solar panel connected to the grid is far less volatile than the output of an individual generator.

Due to the aggregation effect, forecasts for geographically diverse aggregates of solar generation facilities have smaller errors than the forecasts for individual facilities in the aggregate. Local effects, which are more random and more difficult to forecast, tend to average away when the aggregated

forecast is looked upon. With aggregation, the impact of forecast errors on individual plants is not as severe because the aggregate forecast of all plants drives the generation scheduling.

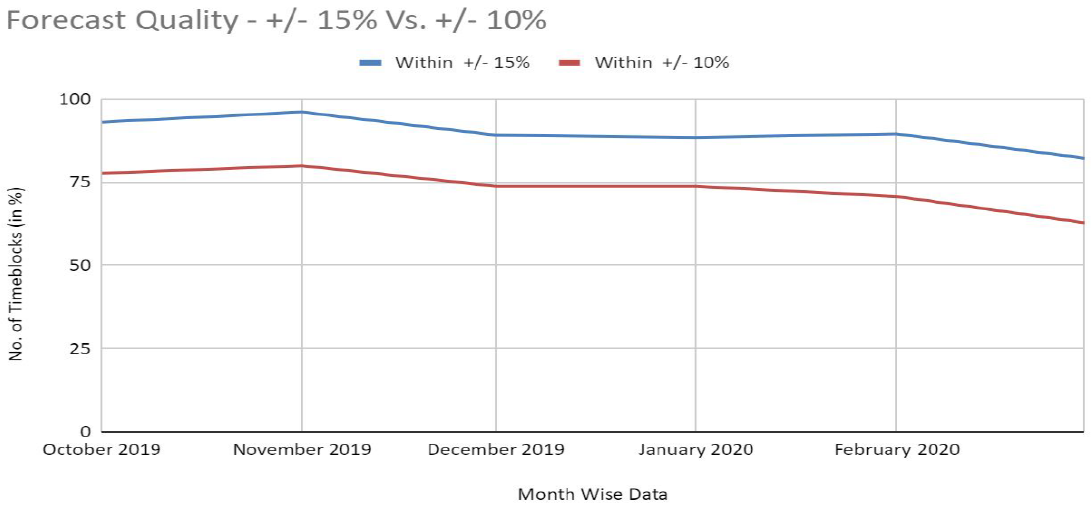
Deviation Settlement Mechanism in Tamil Nadu

The forecasting and scheduling regulations in Tamil Nadu indicate that the error bands and corresponding deviation charges are lower than that in other states. Given below is the deviation band applicable in TN along with the deviation charges for the respective error bands.

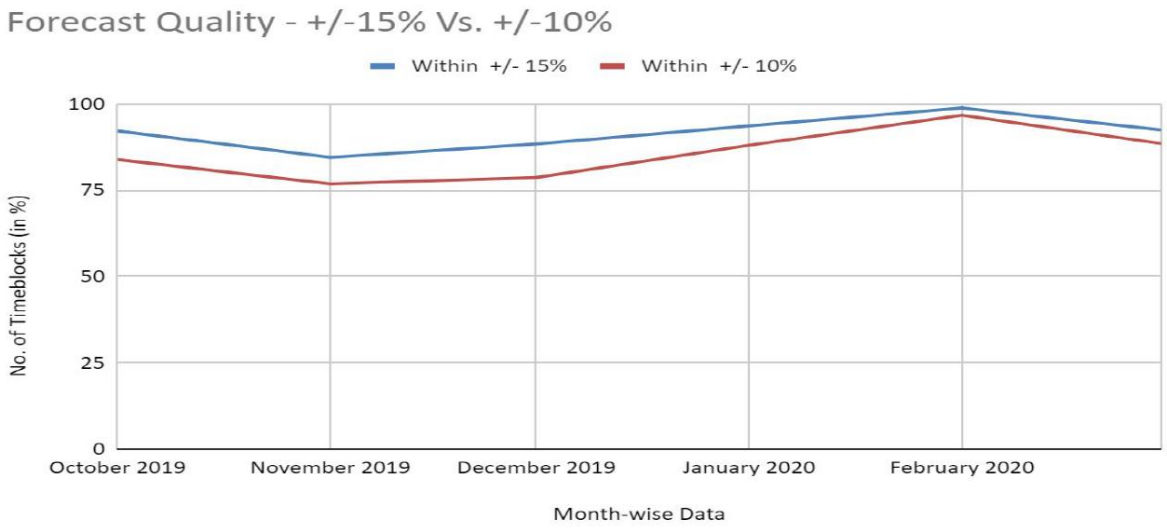
Within +/- 10%	No Charges	No charges payable
+/- 10% to +/- 20%	Charge of **Rs. 0.25**	Per Unit Deviation
+/- 20% to +/- 30%	**Rs. 0.50**	Per Unit Deviation
Above +/- 30%	**Rs. 1**	Per Unit Deviation

The impact of the lower deviation bands on the forecast quality and the impact of corresponding lower deviation charges on the DSM per unit levied on the generators has been shown in the following graphical representations. An analytical observation and comparison with an existing generation forecast based on conventional deviation bands is represented.

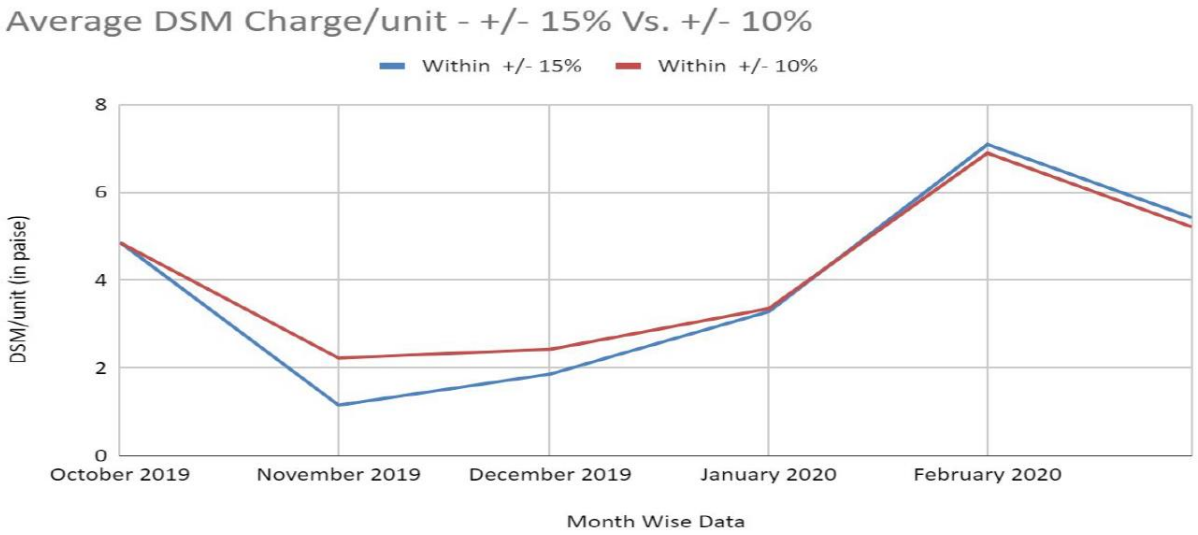
Analysis and comparison on a Wind Substation of 175 MW capacity



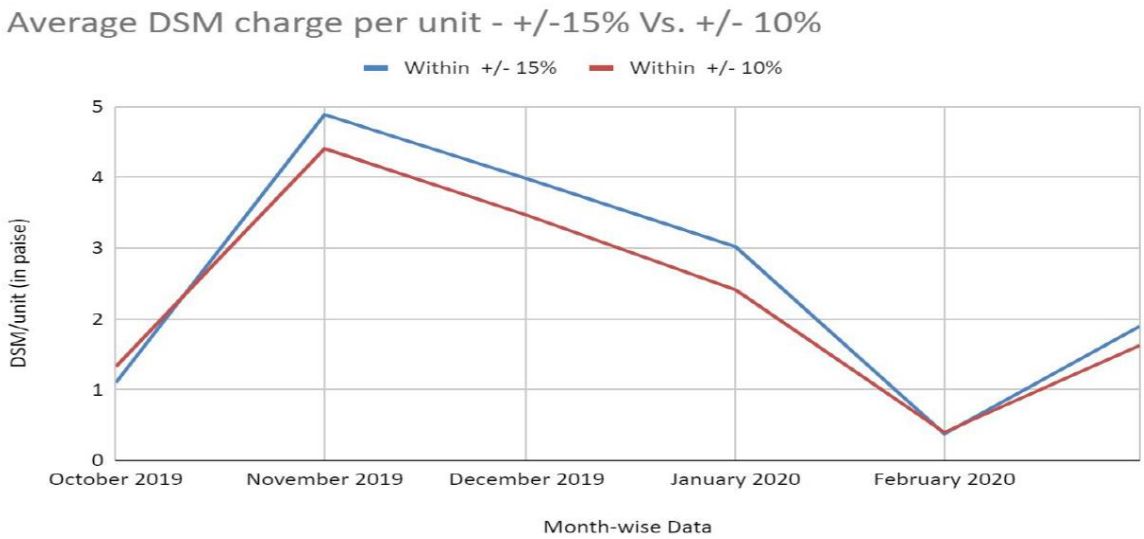
Analysis and comparison on a Solar Substation of 50 MW capacity



Analysis and comparison on a Wind Substation of 175 MW capacity



Analysis and comparison on a Solar Substation of 50 MW capacity



Conclusion

Tamil Nadu has been among the leading states in addition of solar capacity to the grid, and with a large wind capacity, it adds up to a total of 13.5 GW of infirm capacity, whose integration with the state grid has to be very thoughtfully and optimally managed by the grid operator, so that must-run status is maintained. When the forecasting and scheduling regulation is implemented, the grid operator should ensure full evacuation of power from wind and solar plants, with minimal or no curtailments. Adding to this, the 5 paisa/unit limit on DSM charges, which is unique to Tamil Nadu, should imbibe further more

confidence among existing generators, and also among prospective investors to add more RE capacity in the state.

Looking at the current and expected growth profile of solar and wind sector in the country, and the significant number of states like Tamil Nadu announcing forecasting & scheduling regulations (with many in draft regulation stage), it is evident that wind and solar forecasting and scheduling is finding serious interest and ground among grid operators to resolve wind and solar power integration issues. With the Renewable Energy Management Centres (REMCs) and their implementation at the horizon, forecasting and scheduling of wind and solar power will diversify at various levels, right from pooling substation to regional level, with the collective efforts of wind/solar generators, grid operators, regulators, and above all, the Government of India.

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