

Proposed Framework for Forecasting, Scheduling & Imbalance Handling for Renewable Energy (RE) Generating Stations based on wind and solar at Inter-State Level

1. Introduction

The present installed capacity of renewable generation is 34351 MW (MNRE, 28th Feb 2015) which comprises 22645 MW of Wind and 3383 MW of Solar generation as the major components. Presently, almost all of the RE capacity that is grid connected is at the sub-transmission level within the States. By the end of the 12th Plan, the RE installed capacity is expected to increase to about 46,000 MW of Wind and about 10,000 MW of Solar (Green Energy Corridor Report). Further, large Solar generation capacity addition to the tune of 20,000 MW and more is expected by 2019 and this would comprise of large Solar Parks of 500 MW and Ultra Mega Solar Projects of 4000 MW (Recent decisions of the Union Cabinet, Dec 2014).

RE generation by nature is considered intermittent, uncertain and variable. Taking into consideration these aspects and to facilitate integration of RE generation in the grid, special provisions have been made in the Grid Code. However, difficulties have been experienced on implementation of these provisions. There is, therefore, a need for creating a framework for forecasting, scheduling and handling deviations from schedule for the infirm RE generation (like wind and solar) which also factors in the variable and intermittent nature of such generation.

2. Existing Provisions in IEGC for Scheduling and Despatch of RE Generation

Extracts of the relevant provisions regarding wind and solar in the IEGC 2010 are as given below:

Regulation 6.5 (para 23):

Special dispensation for scheduling of wind and solar generation:

(i) With effect from 1.1.2011 Scheduling of wind power generation plants would have to be done for the purpose of UII where the sum of generation capacity of such plants connected at the connection point to the transmission or distribution system is 10 MW

and above and connection point is 33 KV and above, and where PPA has not yet been signed. For capacity and voltage level below this, as well as for old wind farms (A wind farm is collection of wind turbine generators that are connected to a common connection point) it could be mutually decided between the Wind Generator and the transmission or distribution utility, as the case may be, if there is no existing contractual agreement to the contrary . The schedule by wind power generating stations may be revised by giving advance notice to SLDC/RLDC, as the case may be.

Such revisions by wind power generating stations shall be effective from 6th time-block, the first being the time-block in which notice was given. There may be maximum of 8 revisions for each 3 hour time slot starting from 00:00 hours during the day.

(ii). The schedule of solar generation shall be given by the generator based on availability of the generator, weather forecasting, solar insolation, season and normal solar generation curve and shall be vetted by the RLDC in which the generator is located and incorporated in the inter-state schedule. If RLDC is of the opinion that the schedule is not realistic , it may ask the solar generator to modify the schedule.

(iii) Concerned RLDC and SLDC shall maintain the record of schedule from renewable power generating stations based on type of renewable energy sources i.e wind or solar from the point of view of grid security. While scheduling generating stations in a region, system operator shall aim at utilizing available wind and solar energy fully.

Annexure - I: Complementary Commercial Mechanisms

5. The wind generators shall be responsible for forecasting their generation upto an accuracy of 70%. Therefore, if the actual generation is beyond +/- 30% of the schedule, wind generator would have to bear the UI charges. For actual generation within +/- 30% of the schedule, no UI would be payable/receivable by Generator, The host state , shall bear the UI charges for this variation, i.e within +/- 30%. However, the UI charges borne by the host State due to the wind generation, shall be shared among all the States of the country in the ratio of their peak demands in the previous month based on the data

published by CEA, in the form of a regulatory charge known as the Renewable Regulatory Charge operated through the Renewable Regulatory Fund (RRF). This provision shall be applicable with effect from 1.1.2011, for new wind farms with collective capacity of 10 MW and above connected at connection point of 33 KV level and above , and who have not signed any PPA with states or others as on the date of coming into force of this IEGC. Illustrative calculations in respect of above mechanism are given in Appendix.

6. A maximum generation of 150% of the schedule only, would be allowed in a time block, for injection by wind, from the grid security point of view. For any generation above 150% of schedule, if grid security is not affected by the generation above 150%,, the only charge payable to the wind energy generator would be the UI charge applicable corresponding to 50- 50.02 HZ

7. In case of solar generation no UI shall be payable/receivable by Generator. The host state, shall bear the UI charges for any deviation in actual generation from the schedule. However, the net UI charges borne by the host State due to the solar generation, shall be shared among all the States of the country in the ratio of their peak demands in the previous month based on the data published by CEA , in the form of regulatory charge known as the Renewable Regulatory Charge operated through the Renewable Regulatory Fund as referred to in clause 5 above. This provision shall be applicable ,with effect from 1.1.2011, for new solar generating plants with capacity of 5 MW and above connected at connection point of 33 KV level and above and , who have not signed any PPA with states or others as on the date of coming into force of this IEGC. Illustrative calculations in respect of above mechanism are given in Appendix.

Because of various difficulties faced in implementation, the date of implementation of the above Regulatory provisions was extended to 01.01.2012 vide CERC notification dated 14.01.2011. Further, vide CERC Order in Petition no. 356/SM/2013 dated 7th Jan 2014, the Renewable Regulatory Fund (RRF) mechanism has been suspended pending a

review of the entire mechanism. The Commission has since reviewed the mechanism and proposes the following methodology for forecasting, scheduling and deviation settlement of infirm RE sources like wind and solar.

3. Proposed Methodology for Forecasting, Scheduling & Imbalance Handling for infirm RE Generators (wind and solar) at Inter-State Level

The following methodology proposed for forecasting, scheduling and imbalance handling of wind and solar generators would be applicable for the inter-state wind and solar energy generators whose scheduling is done by RLDCs.

3.1 Forecasting:

Wind / Solar energy generation is uncertain and variable but uncertainty and variability can and should be minimized to the extent possible through proper forecasting. In the earlier framework provided in the IEGC, the wind energy generators were mandated to undertake forecasting and scheduling subject to pre-specified tolerance limit. The solar energy generation being at its infancy was not subjected to commercial impact on account of deviation from schedule. Over the period, however, we have gained experience on solar front as well. In fact, solar is considered equally, if not more firm than wind. As such, both wind and solar energy generation are being brought under the requirement of forecasting and scheduling. Accuracy of forecasts can be increased *inter alia* by maximizing geographic diversity in wind / solar energy generation as the errors in forecasts tend to offset each other, the larger the number of generators covered and broader the area included in the forecasts. In order to maximize the accuracy of forecasts, meteorological models must incorporate maximum possible data about as many wind / solar energy generators as possible in as high a resolution (spatial and temporal) as possible, which has to be provided on a mandatory basis by all wind / solar energy generators whose scheduling is done by RLDCs as specified in the grid code.

Forecasting is an essential pre-requisite for scheduling of the wind/solar generation. Forecasting needs to be done by both the wind/solar generator and the concerned RLDC. While the forecast by the concerned RLDC would be more with the objective of

secure grid operation, the forecast by the wind / solar energy generator would be wind-farm/solar facility centric and would form the basis of scheduling. Appropriate use of forecast for scheduling is also expected to reduce commercial impact for the wind and solar energy generators. It is understood that the Renewable Energy Management Centers (REMCs) are being established and these would be equipped with advanced forecasting tools. The wind/solar energy generator may choose to utilize its own forecast or the forecast given by REMC/concerned RLDC. However, any commercial impact on account of scheduling based on the forecast would be borne by the wind/solar energy generator. It would also be prudent to have multiple forecast providers (both for REMC/RLDC & wind/solar energy generators) for better confidence levels/lower forecast errors.

3.2 Scheduling

The wind/solar generators at the inter-state level whose scheduling is done by the RLDCs, would be scheduled like any other generator and would be paid as per scheduled generation and not actual generation. Considering the fact that wind/solar generation is intermittent and variable in nature and also taking into account the fact that accuracy of forecast improves as we move closer in time, the wind/solar energy generator would be allowed more opportunities to revise the schedule. 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 (as against 8 revisions currently allowed as per IEGC 2010).

The wind/solar energy generators may transact power through long-term, medium-term and short-term trades. Some of the wind/solar energy generators may also transact power through short term trades. Revisions are allowed for bilateral transactions but no revision of trades discovered through collective transactions in the Power Exchange(s) is possible.

Transmission charges (POC charges) and losses would be applicable, unless exempted by the Commission through a Regulation or an Order, for the wind/solar energy generator just like any other generator. Further, reactive energy charges would also be applicable.

3.3 Metering

SEMs would have to be placed to facilitate boundary metering, accounting and settlement for the wind/solar energy generator. Weekly meter readings would be forwarded to the RLDC for energy accounting as per the existing practice.

3.4 Imbalance Handling

One of major concerns raised by the wind/solar energy generators is the variability of charges payable for deviation as these are variable and linked to the system frequency. Hence, a mechanism also needs to be evolved to provide more certainty of the payment liability on account of deviation from the schedule.

Deviations from schedule are bound to occur for the wind/solar energy generator. Presently, the deviations at the inter-state level (for Regional Entities) are settled based on the provisions of the CERC DSM Regulations. Considering the fact that wind/solar energy generation is variable and intermittent, more opportunities to revise the generation schedules have been proposed above. However, the deviations from schedule are still bound to occur and a methodology to account for and settle the deviations by wind/solar energy generators is required.

It is essential that desired limits be stipulated for deviation so as to provide enough signals/incentive to the wind/solar energy generator to forecast as accurately as possible. Accordingly, keeping in view the first level of volume limits as per the DSM Regulations, the desired operating band of $\pm 12\%$ is being proposed for the wind and solar energy generators.

If the tariffs for wind and solar generation are assumed to be in the range of Rs. 5/kWh and Rs. 7/kWh respectively, it would imply that wind/solar energy generator would receive payment at these rates approximately for the energy scheduled. Further, the buyer would be paying these rates for the energy scheduled to the wind/solar energy generators and demonstrating RPO compliance based on schedule.

When the wind/solar energy generator under-injects, he still receives payment for the energy injected as per schedule @ wind/solar Tariff. However, because of deviation he would be liable to pay a pre-defined charge to the DSM Pool and also buy REC for the energy equivalent to deviation. The total payout for the wind/solar energy generator should be such that it modulates its behaviour to remain within the desired operating band as far as possible. The same philosophy should apply for over-injection as well.

If the actual generation is in the range 88% to 100% of schedule, the wind/solar generator would pay for the shortfall energy @ Rs. 3/kWh (may be reviewed periodically by the Commission through an Order) to the DSM Pool. In addition, the wind/solar energy generator would buy RECs (equivalent to the shortfall energy) and transfer them to the buyer to enable it to fulfill its RPO obligation. Assuming the current market rate of REC at Rs. 1.50/- per unit for non-solar and Rs 3.50 per unit, the outgo for a wind/solar energy generator [Rs 3 plus Rs 1.50 per unit (assumed REC price) for wind energy generator and Rs 3 plus Rs 3.50 per unit assumed REC price for solar energy generator] would be less than what it earns based on scheduled generation [Rs 5 per unit for wind energy generator and Rs 7 per unit for solar energy generator (assumed wind and solar tariffs respectively)], if it operates within 12% deviation. This is being consciously allowed to motivate the Wind/Solar energy generator to remain within the desirable band of 12% deviation. This can be treated as an incentive for better forecasting.

If the actual generation is below 88%, the wind/solar energy generator would pay @ Rs. 4/kWh for the shortfall energy to the DSM Pool (may be reviewed periodically by the Commission through an Order). In addition, the wind/solar energy generator would buy RECs (equivalent to the shortfall energy) and transfer them to the buyer to enable it to fulfill its renewable purchase obligation. In this case (that is, in the event of deviation beyond 12%), there is a clear disincentive as the outgo for the wind/solar energy generator would be more than what it earns based on scheduled generation.

If the wind/solar energy generator over-injects, ideally it should not be paid for as the variable cost is zero. However, in order to encourage wind/solar energy generation, when the actual generation is in the range of 100% to 112% of schedule, the wind/solar energy generator would be paid @ Rs. 4/kWh for the excess generation (may be reviewed periodically by the Commission through an Order). In addition, the wind/solar energy generator would also be issued RECs for such excess generation. Here again, there is an incentive for the wind/solar energy generator for remaining within the band of positive 12%.

Beyond 12% on the positive side, the wind/solar generator would be issued only RECs for the excess generation. No payment would be made to such generators from the DSM Pool for generation above 112% of the schedule.

In the above process, the charges for deviation from schedule for wind/solar energy generator would be delinked from the frequency based charges as applicable under the DSM mechanism. It is also possible to argue that RE generation is to be treated as must run and hence, charges for deviation should not be linked to frequency. The mechanism also provides a payment cap for the charges payable by the wind/solar energy generator in different scenarios reducing the uncertainty. The 12% volume limits would provide an incentive to the wind/solar energy generator to make efforts to improve the forecast accuracy, minimize deviations from schedule and maximize his payoff. Another advantage achieved is that it provides enough signals so that the wind/solar energy generator does not game the system.

Some of the wind/solar generators, especially the embedded small wind/solar energy generators, may argue that it is difficult for them to adhere to the schedule within the specified limits of 12% on account of variability of the wind/solar energy generation. It has been noted, however, that the special provisions/dispensations given for these wind/solar energy generators in the IEGC are not being utilized by the wind/solar energy generators to revise the schedules periodically. The scheme proposed in this

paper is for the wind/solar energy generators whose scheduling is done by the RLDCs, and such wind/solar energy generators should make all efforts & investment for proper forecasting and scheduling of the generation. Further, as such generating stations are yet to come up, the necessary tools/techniques for forecasting may be made part of the capital investment. This is also essential from the perspective of secure & reliable grid operation.

4. Fulfillment of RPO

The distribution licensee purchasing wind/solar energy would be using the wind/solar energy procurement to demonstrate compliance with the RPO in the respective State. There could be a difference in the quantity of RE contracted/scheduled and the energy actually delivered by the RE generator. Hence, a methodology must be available to handle the difference.

For the purpose of fulfilment of RPO by the buying utility, the '*scheduled energy*' would be considered as the quantum of renewable energy procured by the concerned utility. On the supply side, if the wind/solar energy generator injects more than the scheduled quantum then REC may be issued to the generator equivalent to the excess energy generated for the green component. If the wind/solar energy generator injects less than the scheduled quantum, then it would have to procure RECs from the Power Exchanges equivalent to the shortfall quantum. It is also important to mention that solar RE generators would procure or get (as the case may be) Solar RECs and wind generators would procure or get (as the case may be) Non-solar RECs. The difference settled in terms of REC ensures indirectly that energy equivalent to the difference of schedule and actual has been physically injected into the system.

In order to ensure that RPO compliance is fulfilled, the quantum of RECs to be given to the wind/solar energy generator or the quantum of RECs to be procured by such generator to balance the energy difference be clearly specified in the DSM account published by the RPC of the Region where the wind/solar energy generator is physically located. This would also provide a monitoring mechanism for each wind/solar energy generator.

The above proposed methodology obviates the need for a physical settlement either in terms of revision of schedules to account for actual energy or in terms of operating a pool account as was being done under the erstwhile RRF mechanism.

5. Data Telemetry and Communication Facilities

The wind/solar energy generator whose scheduling is done by the RLDCs, shall provide full data telemetry and communication facilities to the concerned RLDC.

6. Compliance to Technical Standards

The wind/solar energy generator whose scheduling is done by the RLDCs, shall comply with the technical standards such as for fault ride through, etc. as per the CEA Technical Standards for Connectivity of the Distributed Generation Resources Regulations 2013.

7. Other Issues

- a. It is mentioned above that the quantum of RECs to be given or procured would be as per the DSM account issued by the RPC. However, effective monitoring and compliance mechanisms also need to be put into place to ensure the effective implementation of the proposed scheme. The Central Agency would be assigned the task of tracking and monitoring compliance by the wind/solar generators.
- b. The SERCs would need to be informed about the proposed mechanism in detail so that the scheduled energy quantum is accepted as energy procured towards RPO compliance of the buying utility in the concerned State. The entire scheme could be taken up in the meeting of the Forum of Regulators (FOR) to sensitize the SERCs.
- c. The wind/solar energy generators whose scheduling is done by the RLDCs and functioning as ISGS would be a new type of entity under the REC mechanism. As per the present scheme of things under the REC mechanism, the SNA provides accreditation and CA registers the RE generator and issues the RECs. At the Regional level, the RLDCs may be designated for verification of metering etc. for the ISGS wind/solar energy generator whose scheduling is done by the RLDCs. Based on the certification by concerned RLDC, the Central Agency may Register the wind/solar generator.

- d. The wind and energy generator who would be part of this scheme would need to act as both a “seller” and a “buyer” of RECs. Hence, under the present REC mechanism, such generator would be registered both as a buyer and a seller in the Power Exchange.

In view of the aforesaid methodology, amendments have been proposed to the following regulations, via:-

- i. IEGC Regulations, 2010;
- ii. DSM Regulations, 2014 and
- iii. REC Regulations, 2010

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