



Submission to CERC on the proposed framework on “Forecasting, Scheduling and Imbalance handling for Renewable Energy (RE) Generating Stations based on Wind & solar at Inter State level”.

Central Electricity Regulatory Commission

Public notice no. 1/14/2015-Reg. Aff (FSDS)/CERC Dated 31<sup>st</sup> March 2015



30<sup>th</sup> April 2015

To,  
Central Electricity Regulatory Commission  
Chanderlok Building,  
36, Janpath, New Delhi- 110001

Kind Attention – Ms. Shubha Sarma (Secretary)

**Submission to the CERC on the proposed framework on “Forecasting, Scheduling & Imbalance Handling for Renewable Energy (RE) Generating Stations based on wind and solar at Inter-State Level” (CERC Public notice No. 1/14/2015-Reg. Aff. (FSDS)/CERC, 31<sup>st</sup> March 2015)**

Honourable CERC,

This document is a submission by Manikaran Analytics Ltd. (formerly known as Manikaran Wind Power Ltd.) and Ernst and Young (“we” or “our”) to provide feedback on the proposed framework as per the heading above and the invitation contained within the document referenced above.

We have reviewed the proposed framework as detailed in the document published for consultation at [http://www.cercind.gov.in/2015/draft\\_reg/frame.pdf](http://www.cercind.gov.in/2015/draft_reg/frame.pdf) (the “proposed framework”). This document refers to aspects of the existing provisions in IEGC 2010 for scheduling and dispatch of RE generation, and proposes amendments. While the amendments achieve some of CERC’s aims to remove particular issues with the original IEGC 2010 framework, we don’t believe all of the issues claimed to be solved are in fact solved. The following list describes the summary of our feedback on each issue as outlined in the proposed framework, and the subsequent document describes each issue in more detail.

- ▶ We agree with the general aims of the proposed framework: to incentivise accurate forecasts of wind/solar generators, and provide a fair playing field.
- ▶ We don’t believe the proposed framework will achieve these aims, mainly because the penalties are not equal for the same volume of over-injection and under-injection (negative and positive forecast errors). As such the proposed framework will encourage gaming in that wind/solar energy generators will be incentivised to forecast their maximum likely generation in any period to maximise their net revenue.

Manikaran Analytics Ltd. and Ernst and Young (then ROAM Consulting) presented recommendations to CERC and the CEA in November 2013 and would be happy to provide an update of these recommendations to CERC. If you have any feedback or questions on our submission, please don’t hesitate to contact Amresh Khosla on +91 99712 88477 or Nick Cutler on +61 422 701050.

Yours sincerely,  
For MANIKARAN ANALYTICS LTD  
  
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## 1. Detailed feedback

The following sections provide our response on the aims and general statements described in the proposed framework.

### 1.1 Minimising uncertainty and variability through forecasting

Page 4 in the proposed framework states: “...*uncertainty and variability can and should be minimized to the extent possible through proper forecasting.*”.

We agree with this statement. State-of-the-art forecasts are an excellent tool to reduce the uncertainty in wind and solar generation. However, while accurate forecasting could reduce the variability in the market outcomes (such as reducing ramping required from scheduled generators to compensate for wind/solar forecast errors), forecasts cannot actually reduce the variability in the wind and solar resource.

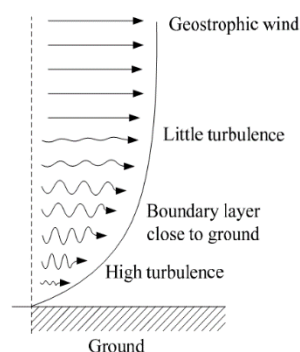
### 1.2 Maximizing Geographic diversity in Wind and Solar

Page 4 in the proposed framework states: “...*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.*”.

We partially agree with this statement. By “the larger the number of generators” we assume you mean the number of wind farms and solar farms rather than wind turbines and solar panels. In this case, we agree that the average forecast error relative to the installed capacity being forecast reduces with the larger the geographic area being covered. However, the absolute size of the forecast error in megawatts will increase the higher the capacity that is included no matter how geographically diverse they are. The largest forecast errors experienced will also increase.

If this statement is referring to wind turbines or solar panels, we partially agree as the same argument as made for wind/solar farms applies.

Additionally, we have observed that the variation in wind speeds across multiple wind turbines in a single wind farm is low during the high wind season when the geostrophic wind stays steady (as shown in the figure to the right). During the low wind season, the turbines across the wind farm can have a very high variability in wind speed (this difference in wind speed between the two opposite/farthest turbines could be 2-3 m/s). In these cases the predictability of the wind farm production weakens.



### 1.3 Solar requires forecasting as well as wind

Page 4 in the proposed framework states: “...*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.*”.

We agree with this decision. Solar should be required to provide forecasting and scheduling as well as wind.

### 1.4 Increasing the number of opportunities for forecast resubmission

Page 5 in the proposed framework states: “*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.*”.

We do not have an issue with the number of opportunities to resubmit forecasts be increased from 8 times per day to 16 times per day. The shorter the lead time, the more accurate the forecasts being submitted will be. Ultimately, we believe the



lead time required for the forecasts should be based on what the electricity market requires to adequately manage dispatch and power system security.

## 1.5 Delinking deviation charges to the system frequency

Page 6 in the proposed framework states: *“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.”*

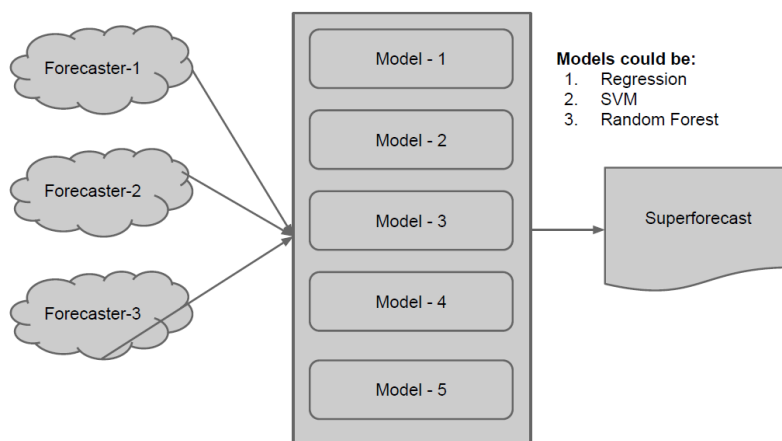
We completely agree that the linking of deviation charges to the system frequency was a major issue with the IEGC 2010 framework. This IEGC 2010 rules provided different charges for under-injection and over-injection and this encourages generators to game the system rather than provide the most accurate forecast possible.

## 1.6 Incentives should encourage the most accurate forecasting

Page 6 in the proposed framework states: *“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”*.

We greatly welcome the incentive mechanism for precise forecasting. This will encourage and motivate the schedulers to employ the best analytical hardware/software tools to derive at an ensemble forecast with lowest deviation results. Figure 1 below shows a diagram of how multiple forecasts combined together can create a very accurate forecast.

**Figure 1: Diagram of how multiple forecasts, even from different forecasters can be combined together to achieve a more accurate forecast**



## 1.7 The desired operating band of $\pm 12\%$ of the schedule

Page 6 in the proposed framework states: *“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.”*

We appreciate the intentions behind the integration of the DSM pooling & REC mechanism for wind & solar forecasting. We also support the idea of a desired operating band, where the forecast penalty is less for small forecast errors within this operating band. This would provide extra incentive for a wind/solar farm to provide a forecast within this band.

However, we don't believe that defining the desired operating band as a percentage of the schedule achieves all the desired outcomes of the desired operating band. We believe the objectives of a desired operating band are:



- ▶ To provide extra incentive for a wind/solar farm to achieve a forecast error within that band as often as they can.
- ▶ To provide wind/solar farms with reduced penalties for near-accurate forecasts so that they can transition to providing good quality forecasts (if such a transition is required). The penalty rate can then be increased at a later date.
- ▶ To represent the operating band that is desired from the perspective of power system operating and managing power system security.

To expand on the last point above, a desired operating band for managing the power system would be a threshold in megawatts of forecast error, regardless of how much intermittent generation is being injected into the grid. However, by defining the desired operating band as a percentage of the schedule, this band in megawatts changes depending on the schedule. Furthermore, when the schedule is very low, as can often happen for wind/solar farms, the percentage error is also very low. For example, when the schedule is 1 MW, the desired operating band is a very small +/-0.12 MW. Moreover, the deviation becomes undefined when the schedule is 0 MW. For very large schedules for large power stations, such as a 450 MW wind farm, when the schedule is 400 MW, the desired operating band is +/-48 MW.

To meet all the objectives of a desired operating band, we recommend that it be defined as 10% of installed capacity, or 10MW (or equivalent), whichever is smaller. This way, the operating band is never larger than 10 MW (or equivalent) for large power stations, and it is always the same amount in MW for each power station, no matter what their schedule is. The desired operating band then remains consistent for managing the power system.

## 1.8 The ideal market payment for over-injection

Page 8 in the proposed framework states: *“If the wind/solar energy generator over-injects, ideally it should not be paid for as the variable cost is zero.”*

We disagree with this statement. Ultimately, a wind/solar energy generator will over-inject in a particular period when its forecast is too low. The most accurate forecasts will have an equal occurrence of over-injecting and under-injecting (negative and positive forecast errors).

Additionally, generators are not paid as per their variable cost in the market, they are paid based on the cost of the marginal generator. The variable cost of a generator that over-injects should have nothing to do with how much it should be paid for that.

## 1.9 Arguing that RE generation is to be treated as must run

Page 8 in the proposed framework states: *“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 statement that RE generation should be must run is inconsistent with other statements in the proposed framework, including that in Section 1.8 above: *“If the wind/solar energy generator over-injects, ideally it should not be paid for as the variable cost is zero.”*

We don't believe that RE generation should be considered as must-run – we believe that RE generation should get priority over other generators with a higher variable cost, but may need to be constrained sometimes due to network issues, or if it is the marginal generator.

## 1.10 Possible objections from wind/solar generators

Page 8 in the proposed framework states: *“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.”*

We don't believe the wind/solar energy generators can adhere to any specified limit for their forecast accuracy at all times due to the inherent uncertainty in their renewable resources. Hence, we believe that having a volume limit is a misleading aim to wind/solar generators we agree it is something they may argue against. We recommend that the penalties simply be



lower within a desired operating band, as has been suggested in the proposed framework. But adhering to a specified limit should be the goal for wind/solar generators to achieve all the time – rather it should be something they aim to achieve as often as possible.

As stated elsewhere, we also recommend that the penalties are equal for the same volume of over- and under-injection, and dependent on the volume so that the total penalty increases the larger the forecast error.

### 1.11 Proposed framework does not provide incentives for the most accurate forecasting or prevent gaming

Page 8 in the proposed framework states: *“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.”*

We disagree with all these statements. We don’t believe the 12% volume limits have any influence on wind/solar energy generators to improve their forecast accuracy. This is because the penalties for inaccurate forecasts increase the larger the forecast error, regardless of the 12% volume limits.

Additionally, the signals from the proposed framework will NOT be enough to ensure the wind/solar energy generators do not game the system. This is because the penalties for positive and negative forecast errors are not equal.

The problem can be demonstrated with a simple example as follows.

Firstly, Table 1 summarises the payments and deviation penalties for a wind generator as is understood by us from the proposed framework. We note that exactly how the penalties are applied is not entirely clear from the rules as they are described. Indeed, both Manikaran Analytics and Ernst and Young initially derived a different meaning from the rules. We recommend including some worked examples to show exactly how each penalty and revenue is applied in each foreseeable case.

**Table 1: Payments and deviation penalties for a wind generator in the proposed framework**

Payments	Description	Amount (Rs./kWh)
<b>Tariff</b>	Payment for the scheduled (forecast) generation	5
<b>REC price</b>	Payment for all scheduled (forecast) generation	1.5
Deviation penalties	Description	Amount (Rs./kWh)
<b>Shortfall energy 88-100%</b>	Penalty for generation in shortfall up to 88% of the schedule	3
<b>Shortfall energy &lt; 88%</b>	Penalty for all additional generation in shortfall <88% of the schedule	4
<b>Over-injection 100-112%</b>	Payment for generation in excess up to 112% of the schedule	4
<b>Over-injection &gt;112%</b>	No payment for generation >112% of the schedule	0
<b>REC oversupply</b>	Payment for RECs for the additional generation above the schedule	1.5
<b>REC shortfall</b>	Penalty for shortfall in actual generation, purchased from market.	1.5

Based on our assumptions on how the penalties are applied, we note assuming that the price received for RECs and paid for RECs in the market are the same, the net result of the REC payment is that the wind/solar generator will receive the REC payment for their actual generation in all cases.

Table 1 shows that the penalties imposed on a wind generator (or solar generator) are much higher for over-injection than for under-injection. For example, consider that a 100 MW wind farm is unsure as whether their generation will be as high as 75 MW or as low as 25 MW for the next period, and the most likely generation will be 50 MW. Assuming that their actual generation is 50 MW, consider the two cases when the wind farm submits a forecast for 25 MW or 75 MW. In both cases the forecast error is 25 MW, but the financial outcomes are very different as follows.

- ▶ Forecast generation: 75 MW, actual generation: 50 MW, under-injection, deviation is 33%. The wind farm has the following revenues and penalties:
  - ▶ Tariff revenue for 75 MW at 5 Rs/kWh.
  - ▶ REC revenue for 75 MW at 1.5 Rs./KWh.
  - ▶ 88% of schedule is 66 MW. Wind farm pays 3 Rs./kWh for 9 MW.



- ▶ Wind farm pays 4 Rs./kWh for 66-50=16 MW.
- ▶ Wind farm purchases 25 MW of RECs from the market at 1.5 Rs./kWh.
  
- ▶ Forecast generation: 25 MW, actual generation: 50 MW, over-injection, deviation is 200%. The wind farm has the following revenues and penalties:
  - ▶ Tariff revenue for 25 MW at 5 Rs./kWh.
  - ▶ REC revenue for 25 MW at 1.5 Rs./kWh.
  - ▶ 112% of schedule is 28 MW. Wind farm receives 4 Rs./kWh for 3 MW.
  - ▶ Wind farm receives 1.5 Rs./kWh for the extra 25 MW produced.

Assuming that this example lasts for one hour, the total payments (in Rs. Lacs) for these two cases is as follows in Table 2.

**Table 2: Net payments including deviation penalties for a wind generator for two examples**

Cases	Under-injection	Over-injection
<b>Actual wind generation</b>	50 MWh	50 MWh
<b>Forecast wind generation (schedule)</b>	75 MWh	25 MWh
Revenues/Penalties	Amount (Rs. Lacs)	Amount (Rs. Lacs)
<b>Tariff revenue for schedule</b>	3.75	1.25
<b>REC revenue for schedule</b>	1.125	0.375
<b>Shortfall energy 88-100% penalty</b>	-0.27	N/A
<b>Shortfall energy &lt; 88% penalty</b>	-0.64	N/A
<b>Over-injection 100-112% revenue</b>	N/A	0.12
<b>REC oversupply revenue</b>	N/A	0.375
<b>REC shortfall purchase (penalty)</b>	-0.375	N/A
<b>TOTAL</b>	<b>3.59</b>	<b>2.12</b>

In the under-injection case the wind farm pays penalties, and in the over-injection case the wind farm receives additional income. However, this extra income is not enough to compensate for the loss in revenue from the schedule being much lower. This is not an equal penalty for two forecast error outcomes that are equivalent in terms of their impact on the power system (i.e., with a 25 MW error).

The full picture of how a wind farm (or solar farm) would forecast their generation to minimise their penalties is shown by the following example. With every forecast, there is some inherent uncertainty. This forecast uncertainty may be different with every forecast as some periods are more certain than others. Suppose the situation where the most likely generation for a 100 MW wind farm is 50 MW, but there are many other possible outcomes as described by the probability distribution in Figure 2.

**Figure 2: Simplified example probability distribution of outcomes for actual wind production during an uncertain period**

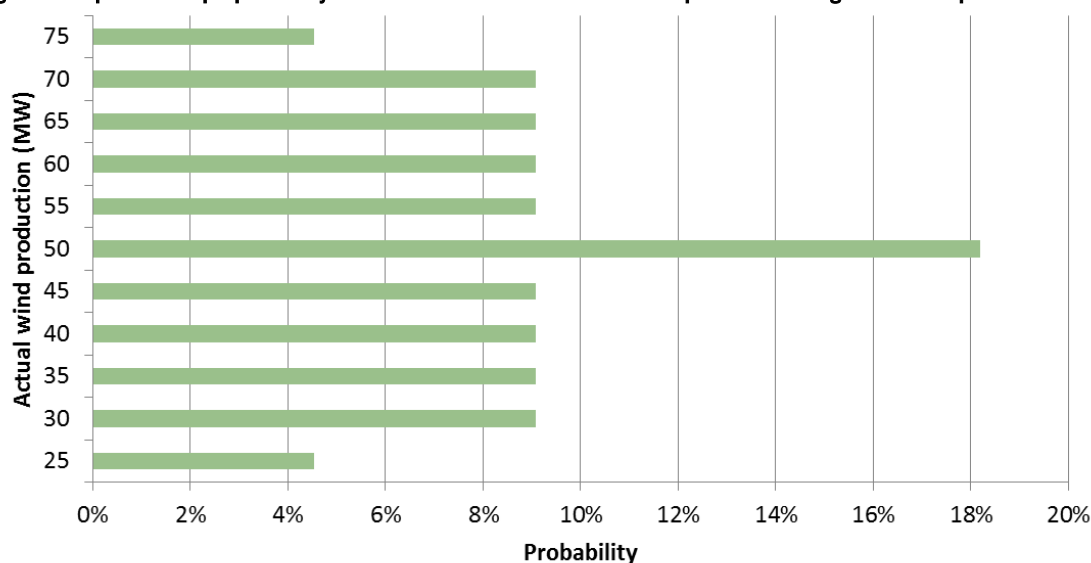






Figure 2 shows that in this example, 50 MW has a probability of around 18% and is by far the most likely outcome. However, the set of possible outcomes ranges from 25 to 75 MW. If this wind farm was presented with this situation 22 times, it can expect the actual wind generation to be:

- ▶ 50 MW on 4 occasions
- ▶ 25 or 75 MW on 1 occasion each
- ▶ 55, 60, 65, 70, 30, 35, 40 or 45 MW on 2 occasions each

Subject to this uncertainty, it can be shown that the forecast the wind farm should submit to optimise their net revenue (minimise their penalties) is 75 MW, even though this level of wind generation only has a 4% chance of occurring.

Other examples have shown that the wind farm (or solar farm) is likely to be incentivised to provide a schedule of the maximum generation they can expect, rather than the most likely generation. The calculations for the example above and other examples are provided in an attached Excel workbook,

## 1.12 Deviations are bound to occur

Referring to page 6 -point 3.4 of 'Imbalance handling' –Para 2 of proposed draft *“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”*

We agree with this statement provided certain exemption is allowed as is suggested above in pt. no. 1.7 ie. Either 10% of installed capacity or 10MW whichever is lower (or equivalent).

## 1.13 'Imbalance handling' –about the commercial settlement in the proposed draft – Manikaran Analytics' initial understanding

Referring to Page no. 6, 7 & 8 para 4 para 4 of *“Imbalance handling”* – about the commercial settlement in the proposed draft

**Table 3: Description of Manikaran's initial understanding of the penalties**

Ranges	Below 88% of Schedule	In between 88% -100% of Schedule	In Between 100% - 112% of the Schedule	Beyond 112% of the Schedule
<b>Settlement for the Energy under DSM Pool Account</b>	All of energy shortfall will be payable by generator at Rs. <b>4/kWh</b> to DSM pool Account	All of energy shortfall will be payable by generator at Rs. <b>3/kWh</b> to DSM pool Account	Generator will receive for excess energy generated up to 112% of schedule at Rs. <b>4/kWh</b> from DSM pool Account	<b>Generator will not receive any amount</b> for excess generation beyond 112% of Schedule from DSM pool Account.
<b>Settlement for the deviation under REC integration</b>	Generators have to buy the REC for the energy deficit to meet the schedule; will be bought at Rs. 1.50/kWh (Non Solar) & Rs 3.50/KWh (Solar) approx. and will transfer to the buyer.		Generator would be entitled for issuance of REC for the quantum of energy which would be over generated from the schedule and may cost Rs. 1.50 /kWh (Non Solar) & Rs.3.50/kWh (Solar) approx. (as specified in the proposed regulation).	

Manikaran Analytics Ltd. has analysed the above understanding of the commercial mechanism on a 75 MW wind farm and found that the generator could have a revenue loss of around 2% and 25% in high and low wind months, respectively.

**Table 4: Analysis by Manikaran Analytics using actual forecasts for a wind farm in India**

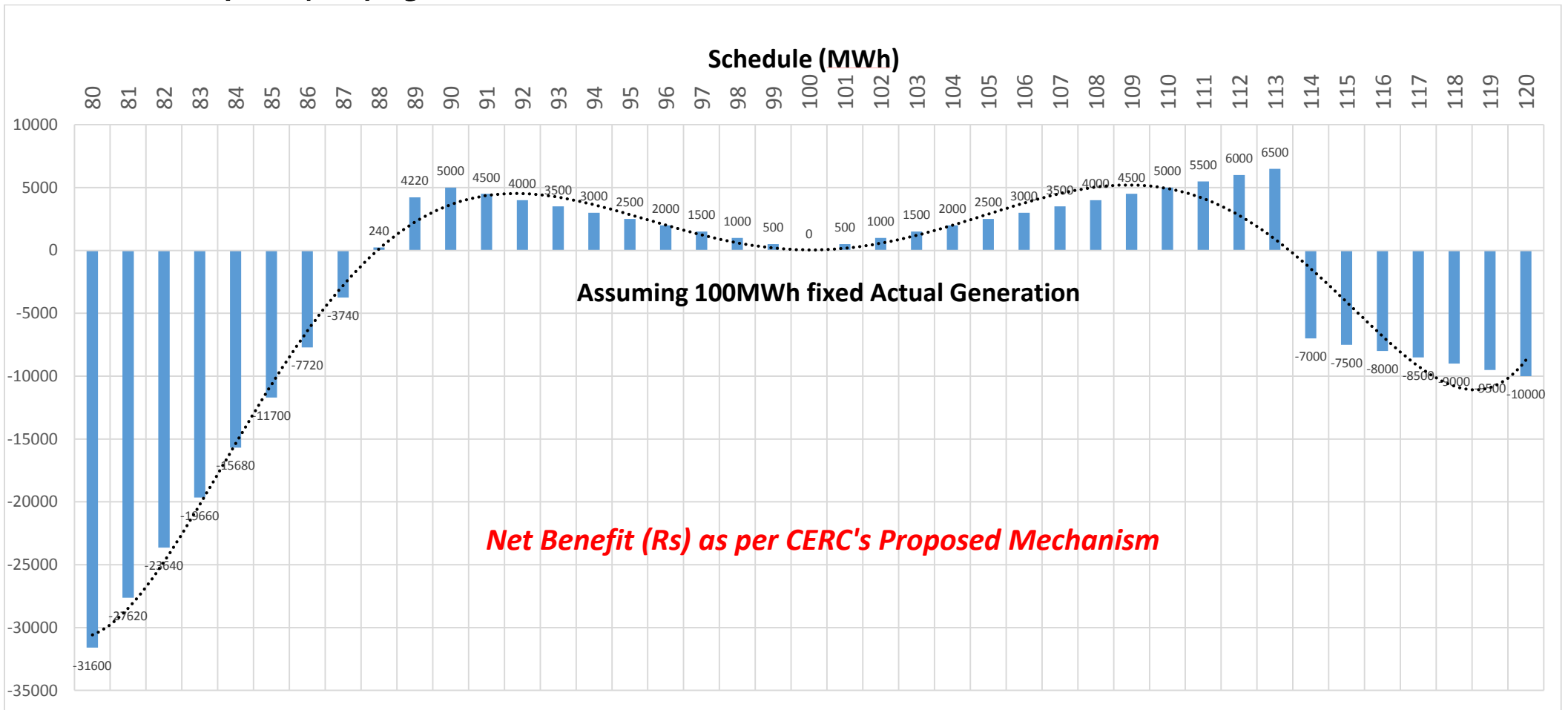


75 MW Wind Farm	Net Amount Receivable/ Payable after DSM Pool settlement (in Lacs)	Net Amount Receivable/ Payable for REC (in Lacs)	Amount receivable for AG if receivable @Tariff Rate (@Rs5pu) (in Lacs)	NET PROFIT (+) / LOSS (-) (in Lacs)	Commercial Impact from the AG if receivable @Tariff Rate
Notation	A	B	C	$D = (A+B) - C$	$E = D / C$
<b>High Wind Month (July– 2014)</b> RRF Acc. (Exemption 30%) : 95% Accuracy without exemption 79%	1,981.80	-70.65	1,946.23	-35.07	-1.8%
<b>High Wind Month (August – 2014)</b> RRF Acc. (Exemption 30%) 88% Accuracy without exemption 70%	1,243.83	-11.22	1,327.92	-95.31	-7.2%
<b>Low Wind Month (Nov – 2014)</b> RRF Acc. (Exemption 30%) 54% Accuracy without exemption 29%	162.73	-0.39	214.13	-51.79	-24.2%

Proposed Mechanism			Deviated Energy Bifurcation				Net Amount on DSM Pool Accounting (in ₹ Lacs)	Net Amount for REC settlement (in ₹ Lacs)	Amount receivable for AG @Tariff Rate (in ₹ Lacs)	NET PROFIT / LOSS (in ₹ Lacs)
Parameters	SCH (MWh)	ACT (MWh)	Below 88%	Btw 88% to 100%	Btw 100% to 112%	Beyond 112%				
<b>CASE1</b>	80	100	0	0	9.6	10.4	4.4	0.3	5	-0.3
% bifurcation	100%	-	0%	0%	12%	13%	Loss with Proposed mechanism			-6.30%
<b>CASE 2</b>	120	100	20	0	0	0	5.2	-0.3	5	-0.1
% bifurcation	100%	-	17%	0%	0%	0%	Loss with Proposed mechanism			-2.00%



## CERC Proposed (draft) regulation: Unbalanced Penalization & Non-linear Bonus



It has been observed that equal penalization on both sides of bias is not linear and even the bonus between the +/-12% is not consistent, as the scheduler should receive the highest bonus for perfect forecasting and linearly decrease with increase in deviation. Moreover, the penalization on either side of deviation should be balanced which is not evident in the above graph.

**\*\* End of Suggestions \*\***

