IEGC PROVOSIONS FOR RENEWABLE GENERATION SCHEDULING & UI SETTLEMENT

Background

- CERC in September, 2009 constituted a Task Force with representation of Engineering Wing of the Commission Staff, CEA, System Operator, C-WET, WISE and State Commissions/ Utilities/ SLDCs of Tamil Nadu, Rajasthan, Gujarat and Karnataka for integration of renewable sources energy into the Grid
- Three meetings of Task Force held on 13.11.2009,15.12.2009 & 18.1.2010 and its decisions were incorporated in Grid Code issued on 3.5.2010.

Scheduling Procedure for Wind Generators

As per sub-regulation 23 of Regulation 6.6 of IEGC,2010

- Scheduling of wind power generation plants shall be done with effect from 1.1.2011 (now w.e.f 01.01.2012) for the purpose of UI where

  i) 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

  ii) connection point is 33 KV and above

  and

  iii) where PPA has not yet (by 03.05.2010) been signed.

Scheduling Procedure for Wind Generators- Cont.

- For capacity and voltage level below this, as well as for old wind farms 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.

Scheduling Procedure for Solar Generators

- 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.

Scheduling Procedure for Renewable Generators

- 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.

Forecasting for Wind Generation

As per Para 3 of Annexure-I (Complementary Commercial Mechanism) of IEGC

- Wind energy being of variable nature, needs to be predicted with reasonable accuracy for proper scheduling and dispatching.
- Wind generation forecasting can be done on an individual developer basis or joint basis for an aggregated generation capacity of 10 MW and above connected at a connection point of 33 kV and above.
- If done jointly, the wind forecasting facility shall be built and operated by wind developers in the area and sharing of the cost shall be mutually discussed and agreed.

Forecasting for Wind Generation

As per Para 4 of Annexure-I (Complementary Commercial Mechanism) of IEGC

- The wind energy forecasting system shall forecast power based on wind flow data on day ahead basis.
- Wind/ power forecast with an interval of 15 minutes for the next 24 hours for the aggregate Generation capacity of 10 MW and above.

UI Mechanism for wind Generators

As per Para 5 of Annexure-I (Complementary Commercial Mechanism) of IEGC

- 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%.

UI Mechanism for wind Generators- Cont.

- 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 (now w.e.f 01.01.2012) ,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 (i.e. 03.05.2011).

UI Mechanism for wind Generators- Cont.

As per Para 6 of Annexure-I (Complementary Commercial Mechanism) of IEGC

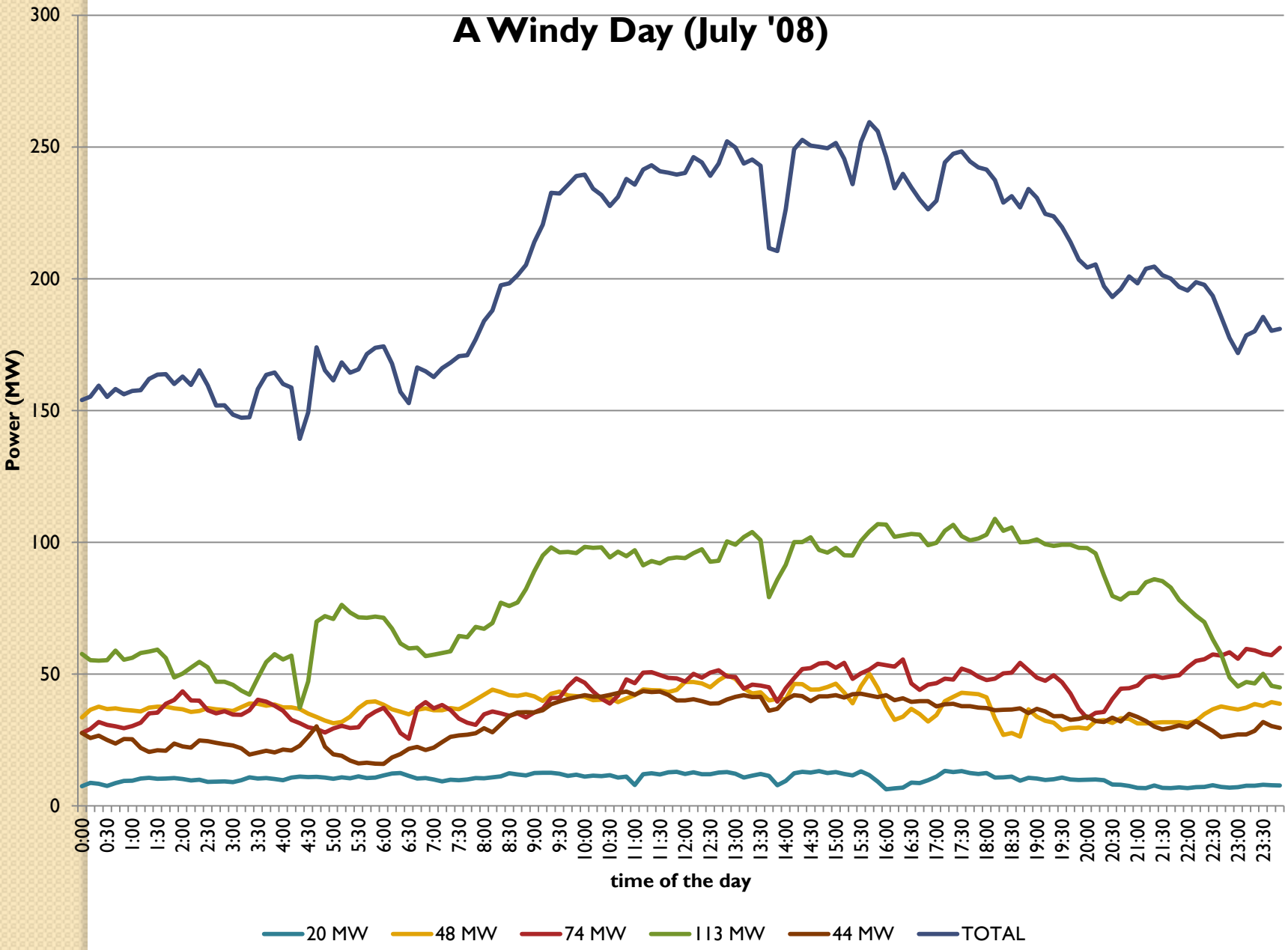
- A maximum generation of 150% of the schedule only, would be allowed in a time block, for injection by wind, from the grid security point of view.

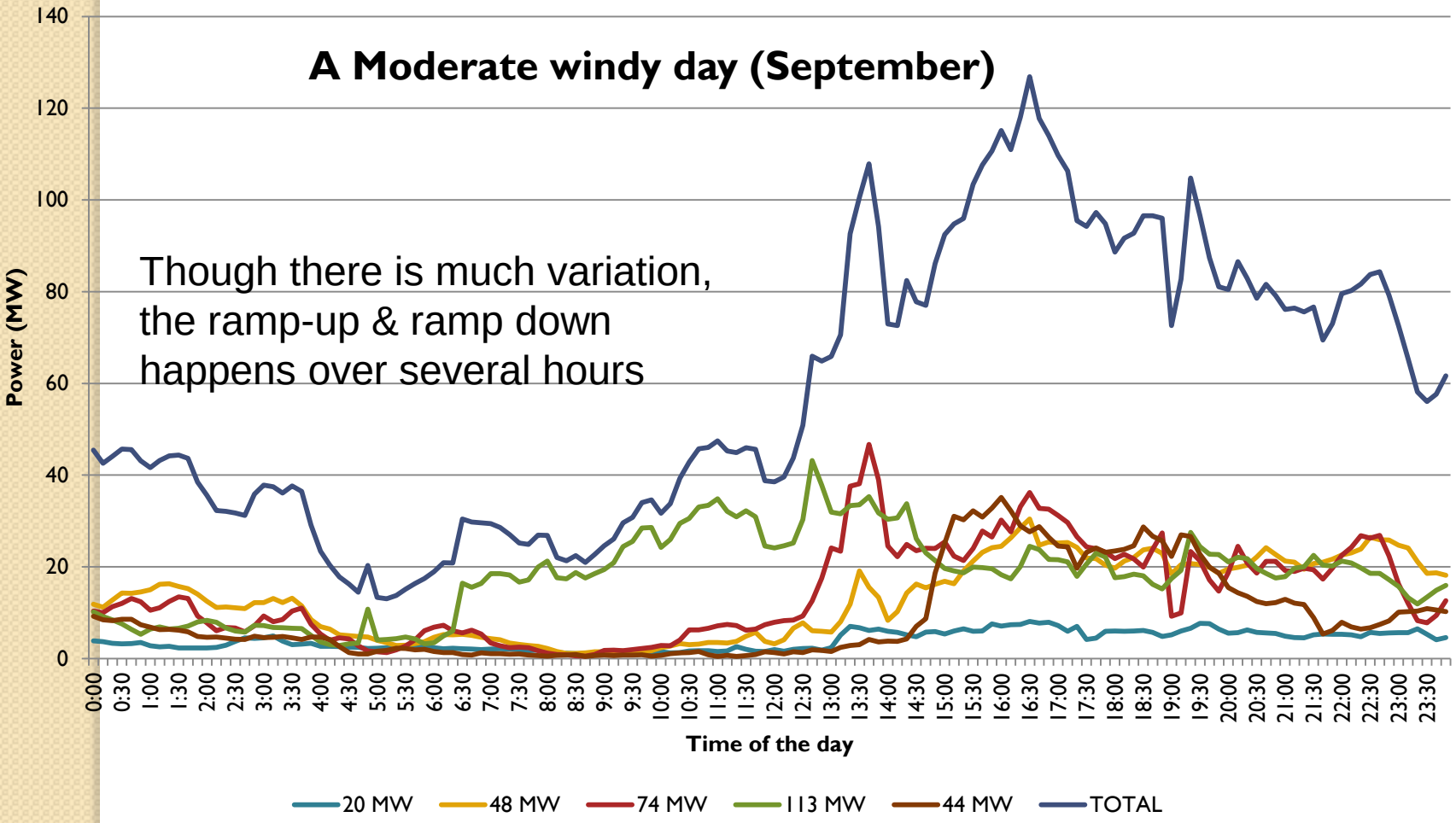
- For any generation above 150% of schedule, if grid security is not affected by the generation above 150%, the only charge payable to the wind energy generator would be the UI charge applicable corresponding to 50-50.02 HZ .(At present Rs 1.55/kWh)

Type of forecast required-Time Horizon

- Energy Forecast Over day month and year – Cash Flow of Wind Generator
- MW Forecast- Day ahead useful for System operation
- Ramp Forecast- Hours ahead -to reduce forecast gap

Variability of Wind Generation




A Moderate windy day (September)
Though there is much variation, the ramp-up & ramp down happens over several hours
Power (MW)
140
120
100
80
60
40
20
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
6:30
7:00
7:30
8:00
8:30
9:00
9:30
10:00
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11:00
11:30
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14:00
14:30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
Time of the day
20 MW
48 MW
74 MW
113 MW
44 MW
TOTAL

Errors

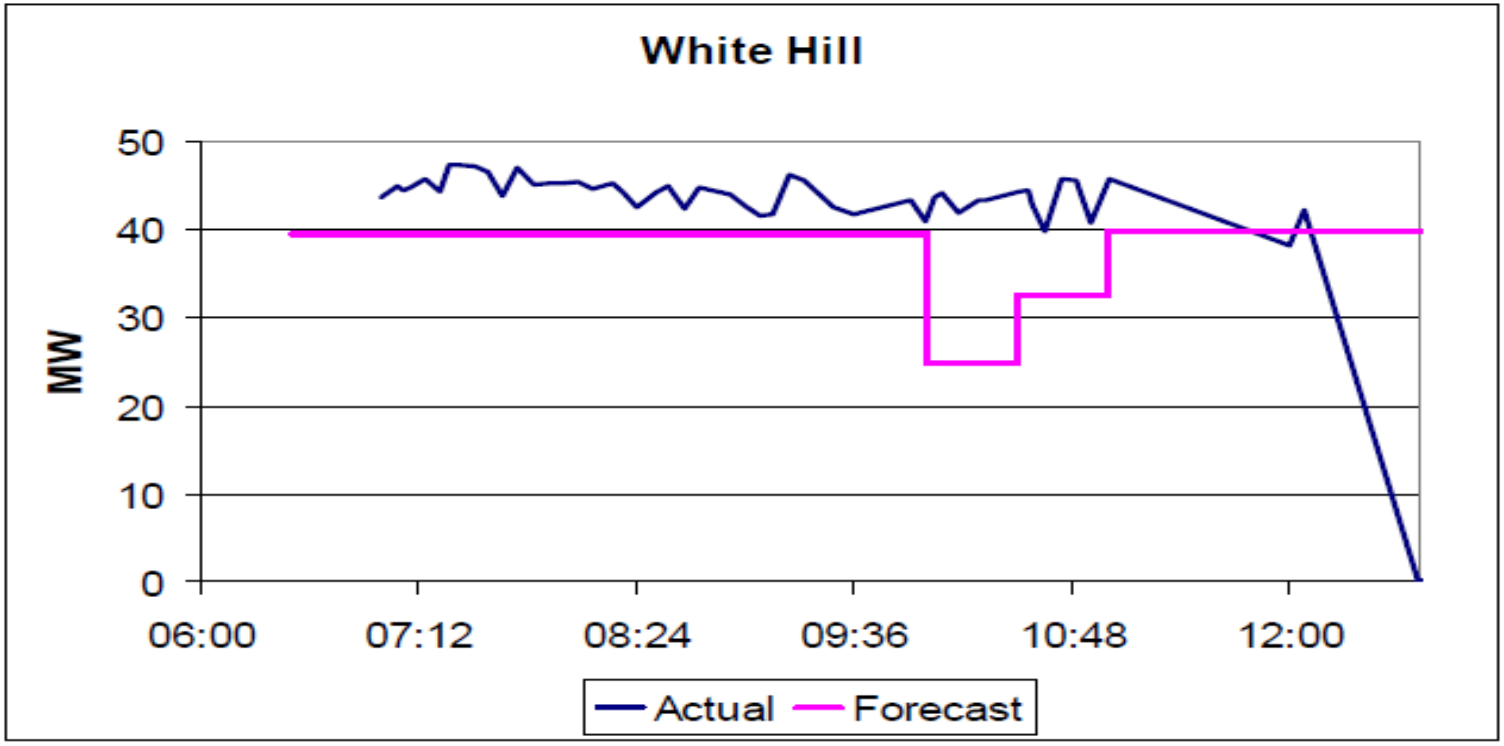
$$MAE = \frac{\sum_{i=1}^{N} |e_i|}{N} \qquad RMSE = \sqrt{\frac{\sum_{i=1}^{N} e_i^2}{N}} \qquad SDE = \sqrt{\frac{\sum_{i=1}^{N} (e_i - \bar{e})^2}{N}}$$

Mean Average Error(MAE) , Root Mean square Error (RMSE) are in MW or kwW when expressed in % are normalised with respect to Installed Capacity. If the average error e is zero than RMSE and SDE are equal .

New Zealand

- White hill 58 MW Wind

Schedule and dispatch



Reduction in Forecast error

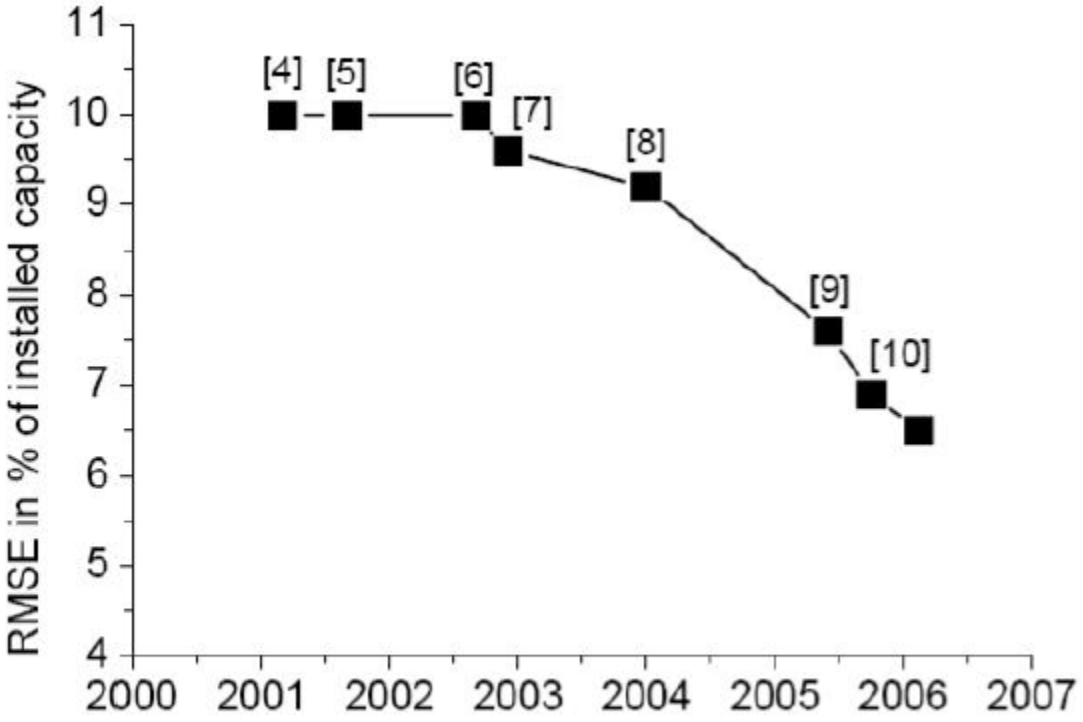


Figure 11: The development of the forecast error during the last years in the E.On Netz area. The numbers in square brackets are references from Lange et.al.

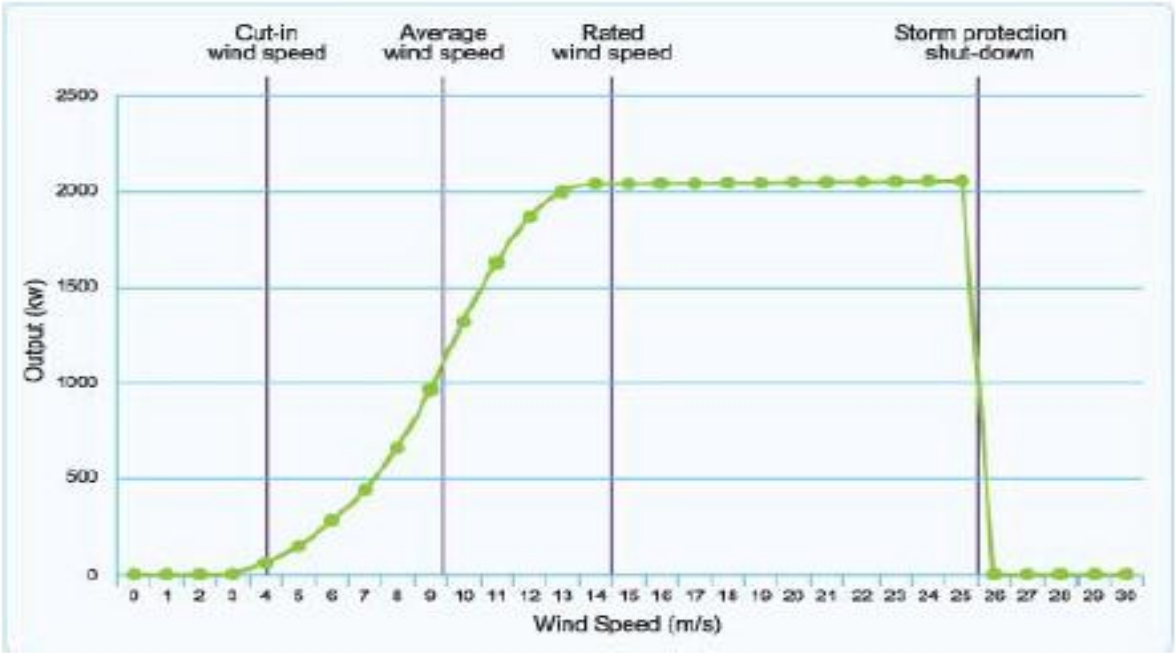
Error decreases near Real Time

Table 3. Level of accuracy of wind power predictions in Germany (NRMSE = normalized root mean square error, % of installed wind capacity). Source: Rohrig [12].

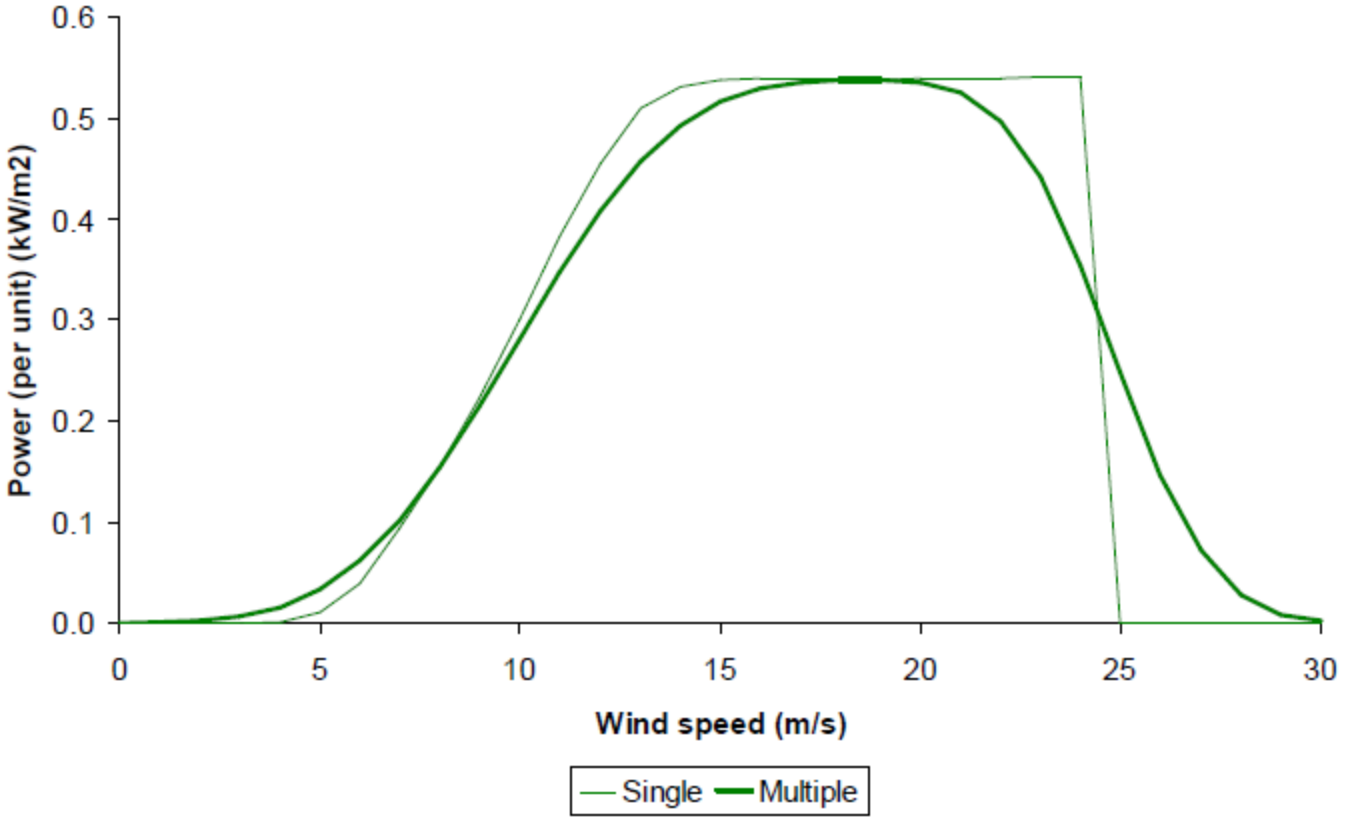
NRMSE [%]	Germany (all 4 control zones) ~1000 km	1 control zone ~ 350 km
day-ahead	5.7	6.8
4h ahead	3.6	4.7
2h ahead	2.6	3.5

Wind Turbine Power Curve

Generic Power Curve



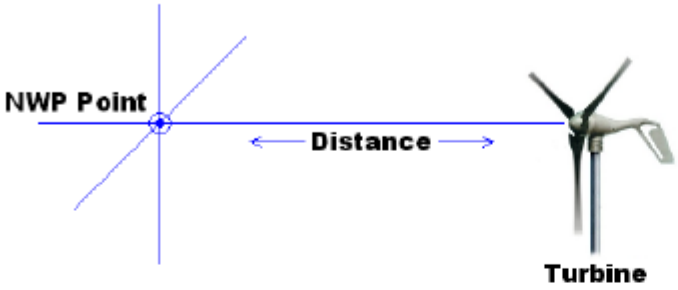
Wind Power Model



Impact of Forecasting error

- Over forecast of wind can put upward pressure on the real-time price because in the transition from pre-dispatch to real-time, the amounts of MWs (priced at –say Rs 5 per kWh) from wind decreases in the real-time supply
  - **More expensive resource in the UI gets dispatched in real time**
- Conversely, under forecast of wind can put downward pressure on the real-time price because in the transition from pre-dispatch to real-time, the amounts of MWs (priced at –Rs 5 per Kwh) from wind increases in the real-time supply.
- More expensive resource in the st*ack* can get backed down or if already dispatched in Collective, results in inefficiency.

Wind Forecast Errors

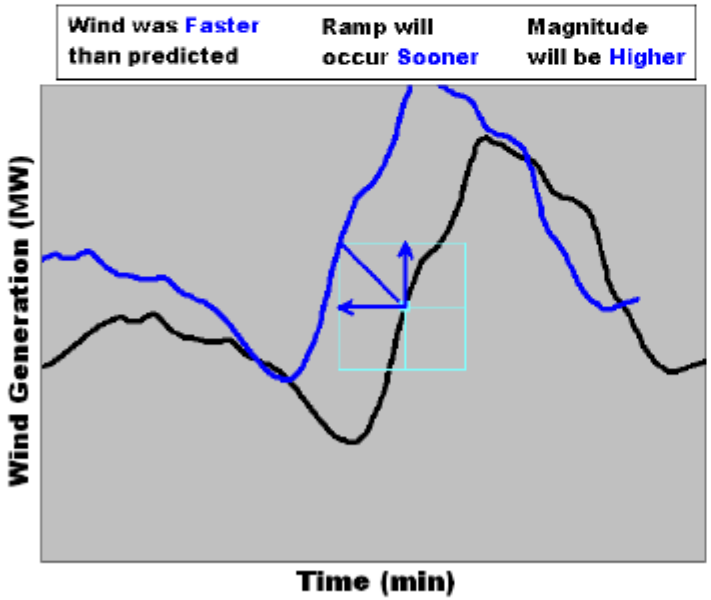


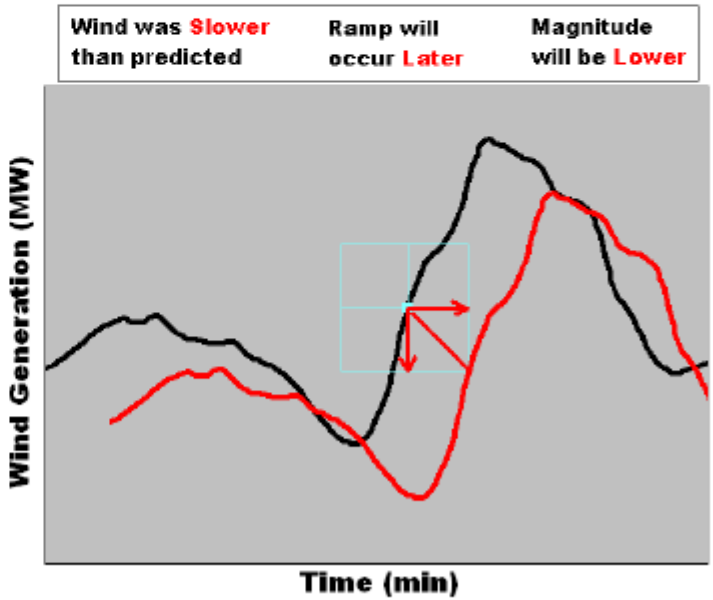
Rate, Distance, Time

$$v = \frac{d}{t}$$

Power Conversion

$$P = \alpha \rho A v^3$$





(Black line shows original forecast, red and blue lines show actual)

Forecast Error Example

Forecast Hour	*Goal (%)*	*Current (%)*	*Persistence (%)*
1 hour ahead	3	6	5.5
2 hours ahead	5	8	7.5
3 hours ahead	7	9	9.5
4 hours ahead	9	10	11
5 hours ahead	10	11	12.5
6 hours ahead	10	12	13.5

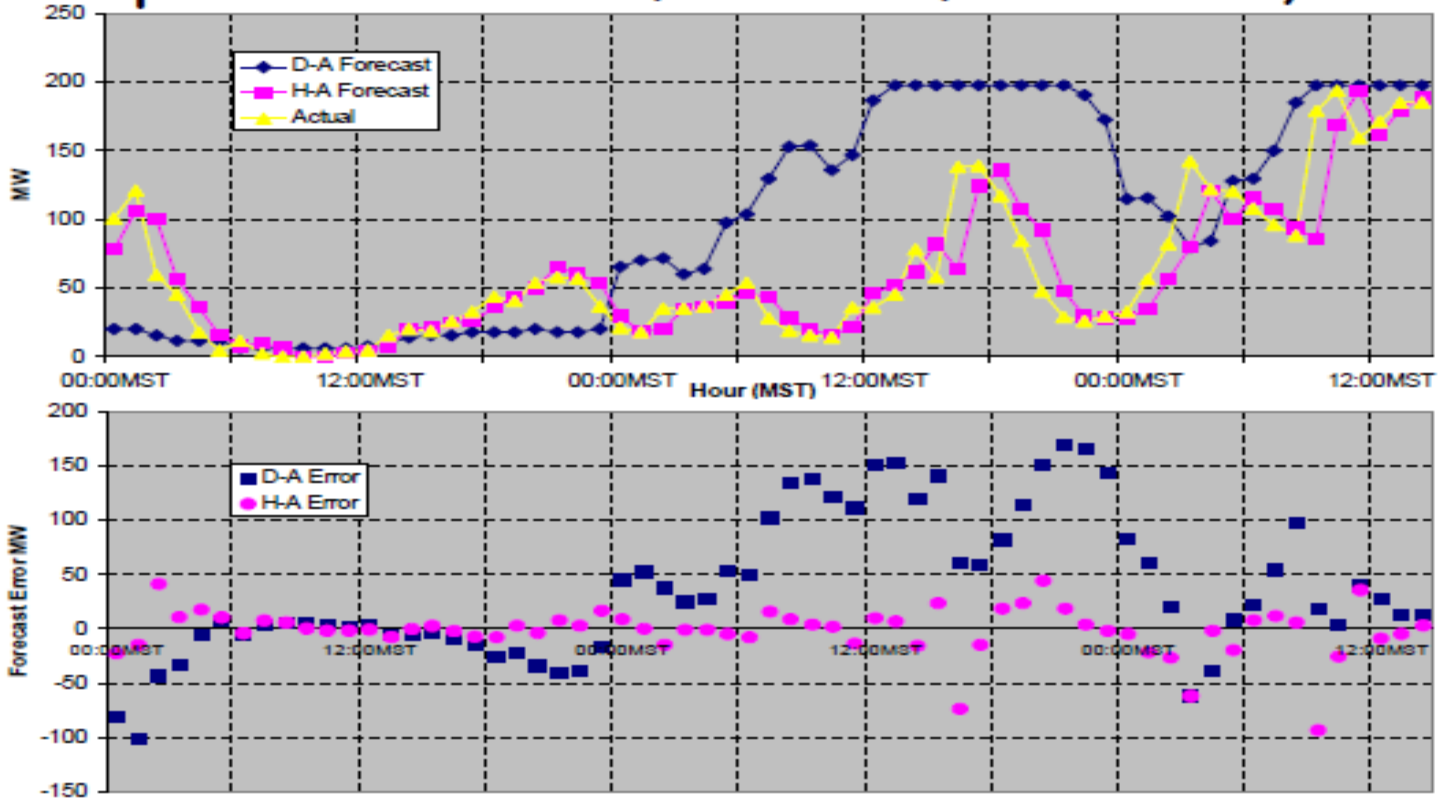
$$\text{Normalized MAE in \%} = \frac{1}{n}\sum_{i=1}^{n}\left|p_i - o_i\right| \times \frac{100}{P_{\text{nameplate}}}$$

The above table shows the NMAE "Goal %" for a vendor for a specific wind plant, "Current %" for the vendors' ability to forecast historically and "Persistence %" using the same historical data

Example New Maxico 204 MW

How Good is the Forecast?

- Sample D-A and H-A forecasts for Nov 1-3, 2005



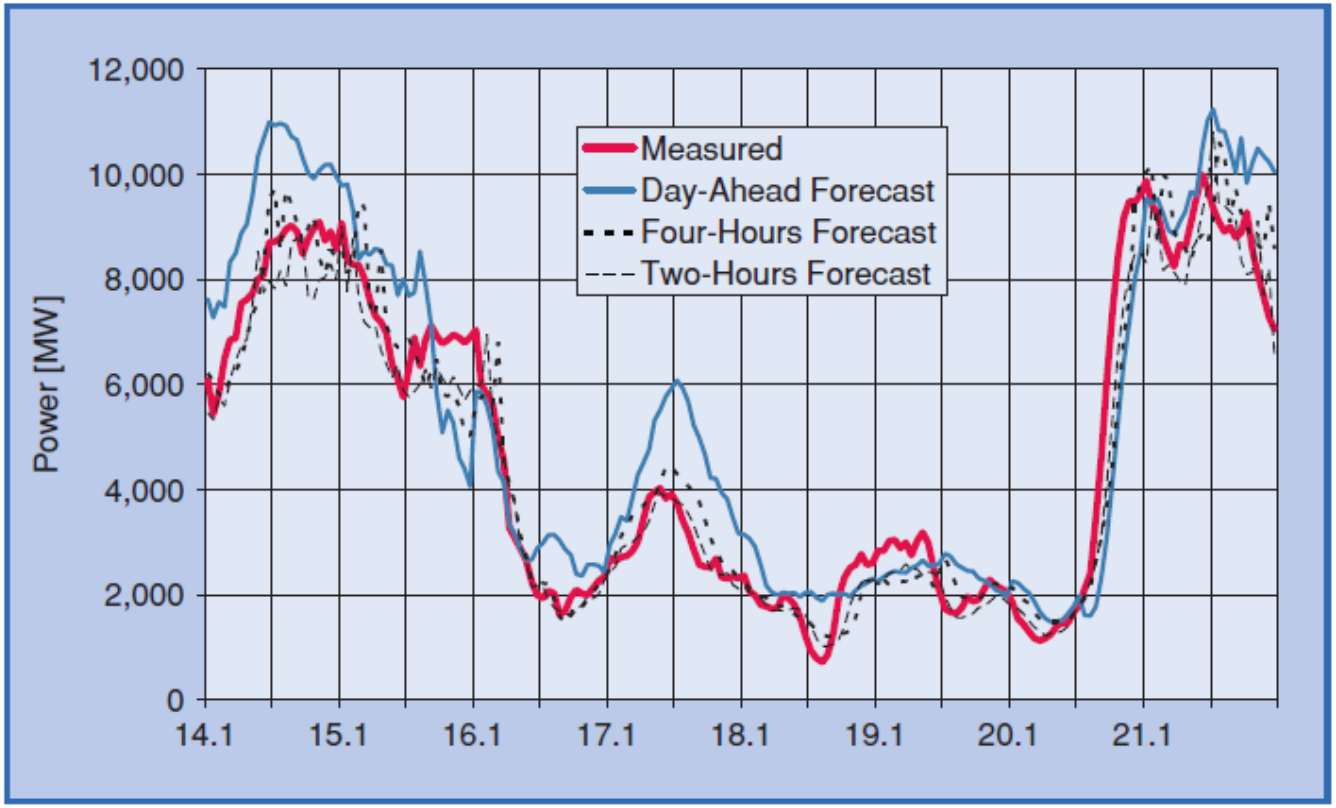


figure 5. Example time series of online measurement and forecasts of wind power generation in Germany; forecasts with different forecast horizons are shown.

Normalised Error in 15% range !

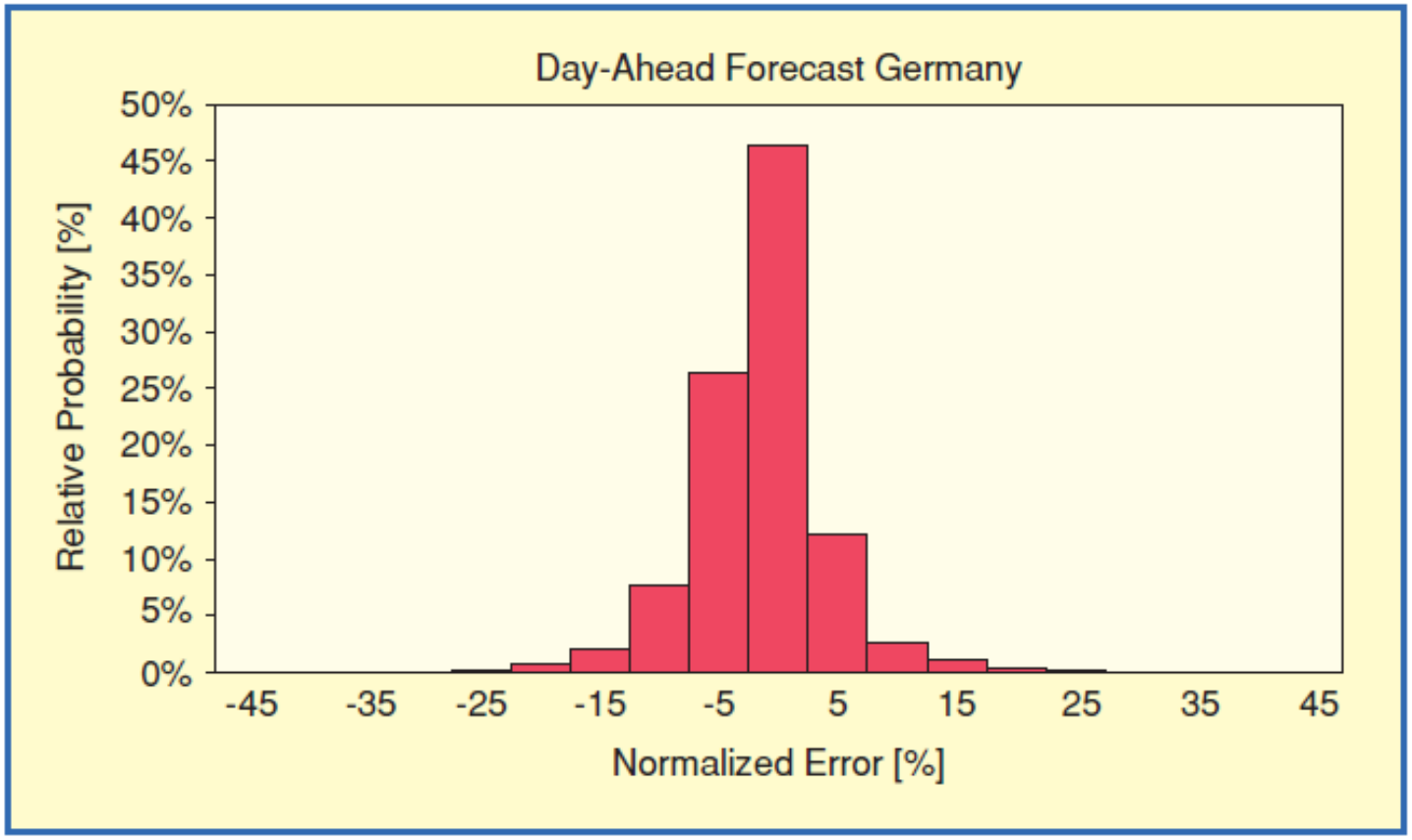
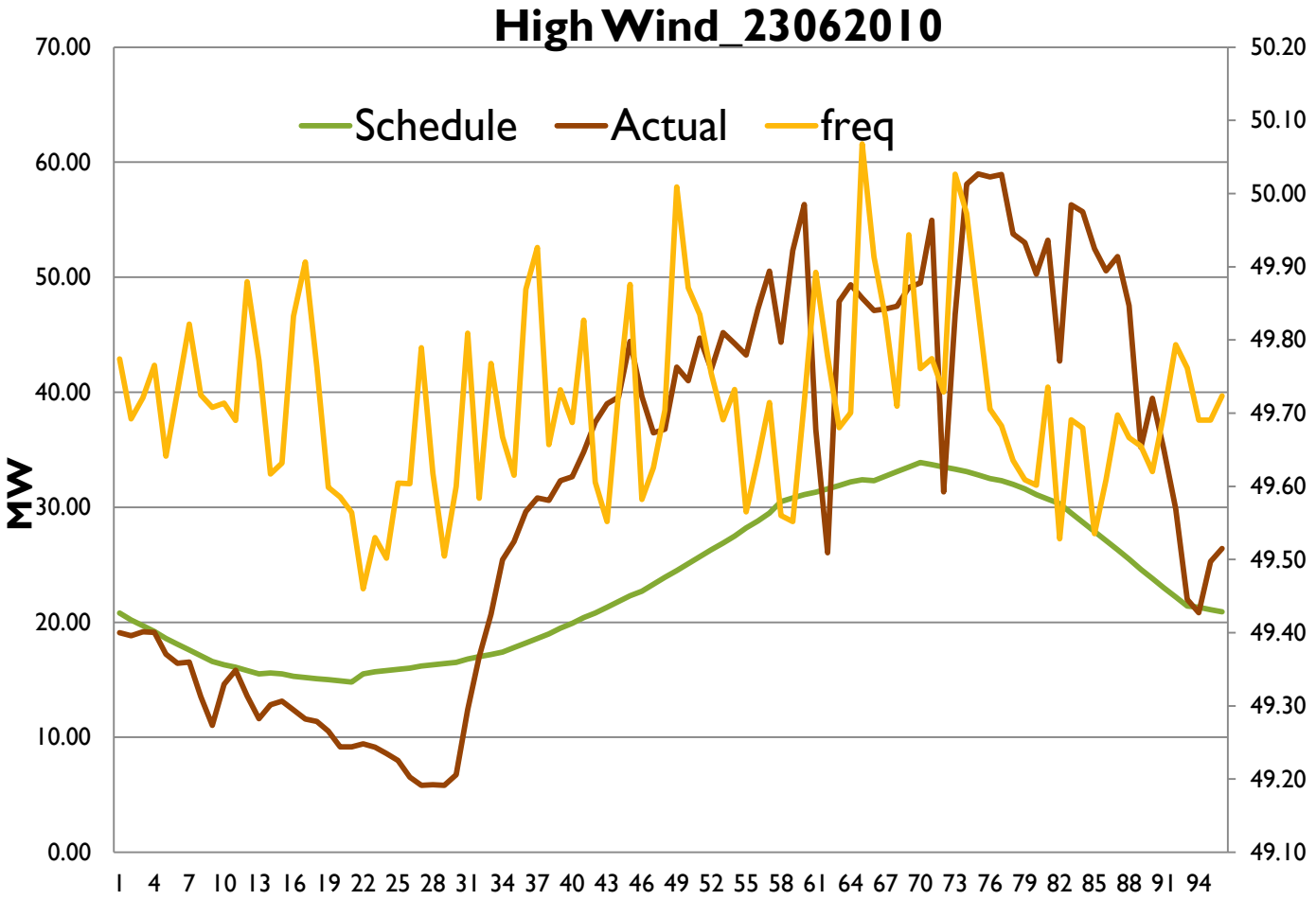
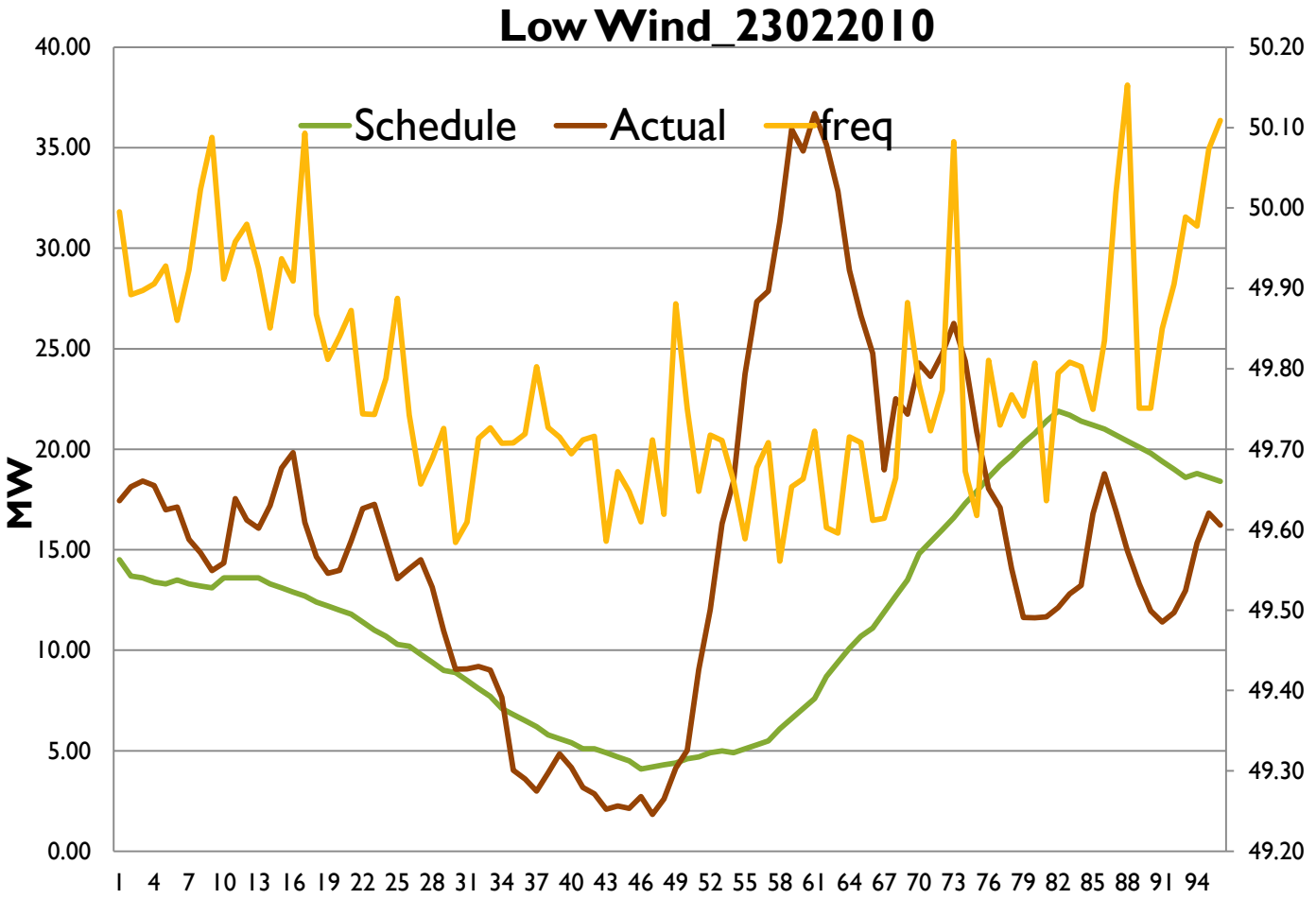


figure 7. Frequency distribution of the difference between forecast and monitored power output.

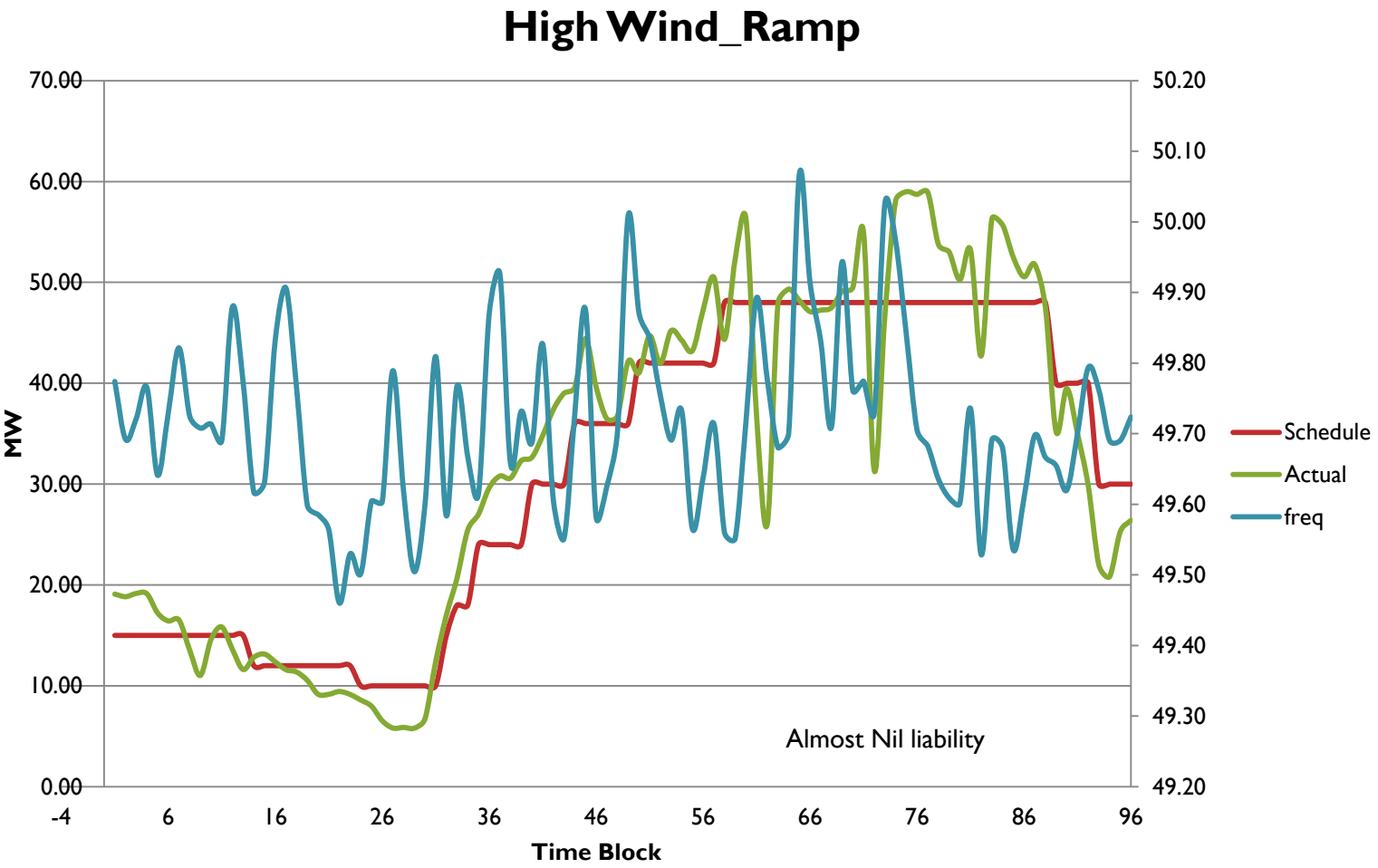
Case Study for implication on Wind Generator



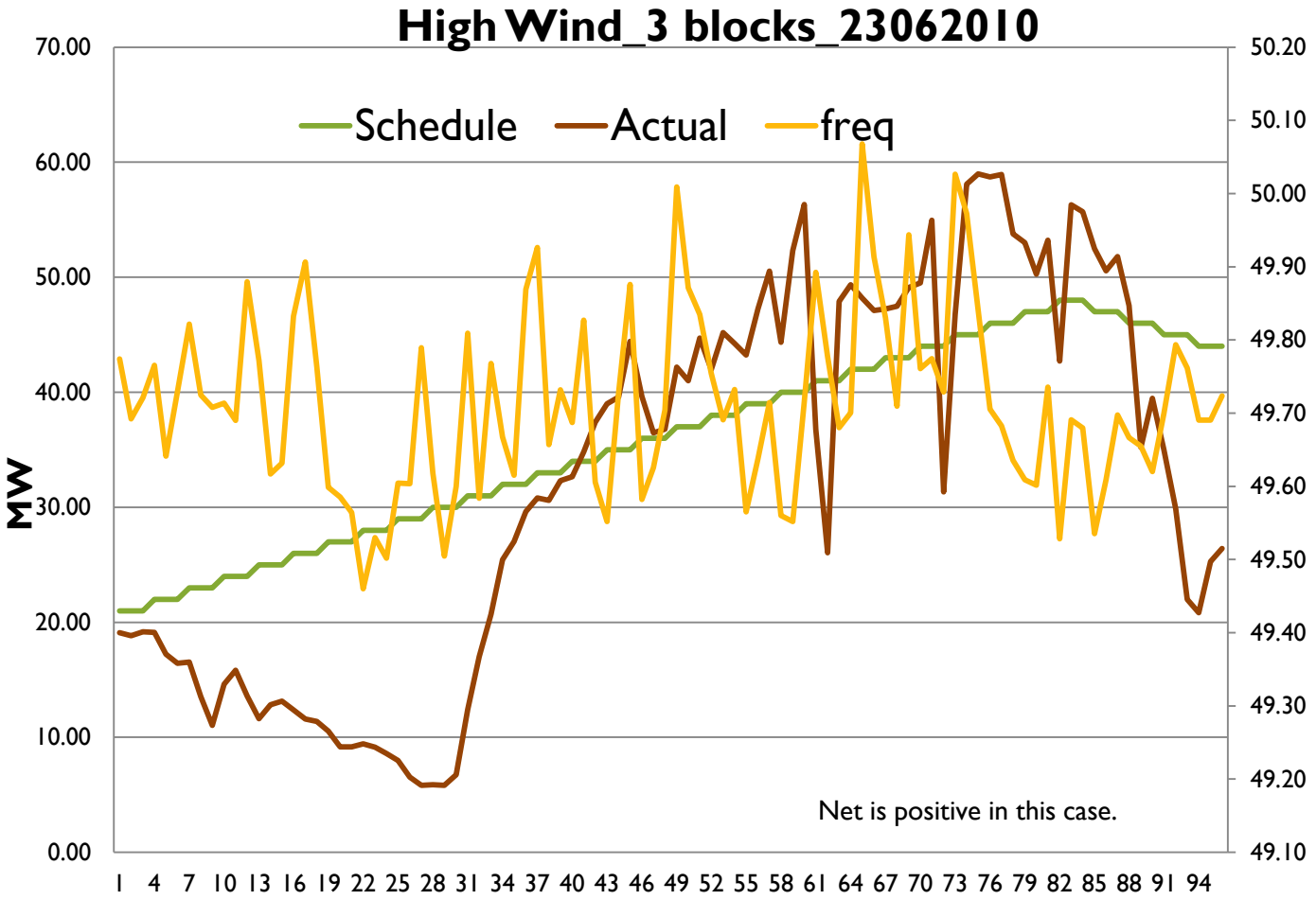
Low Wind 23.02.2010



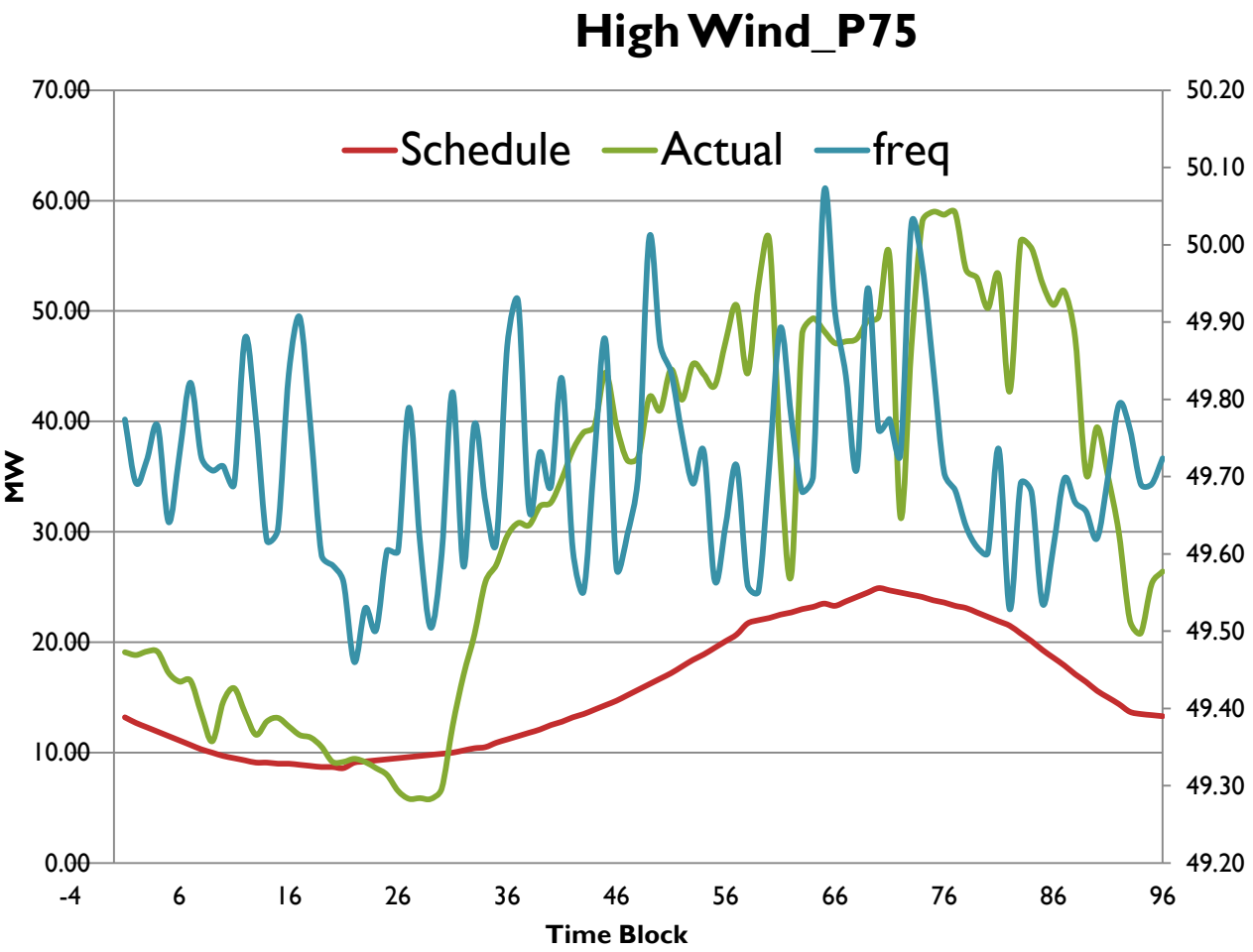
Ramp up down change schedule



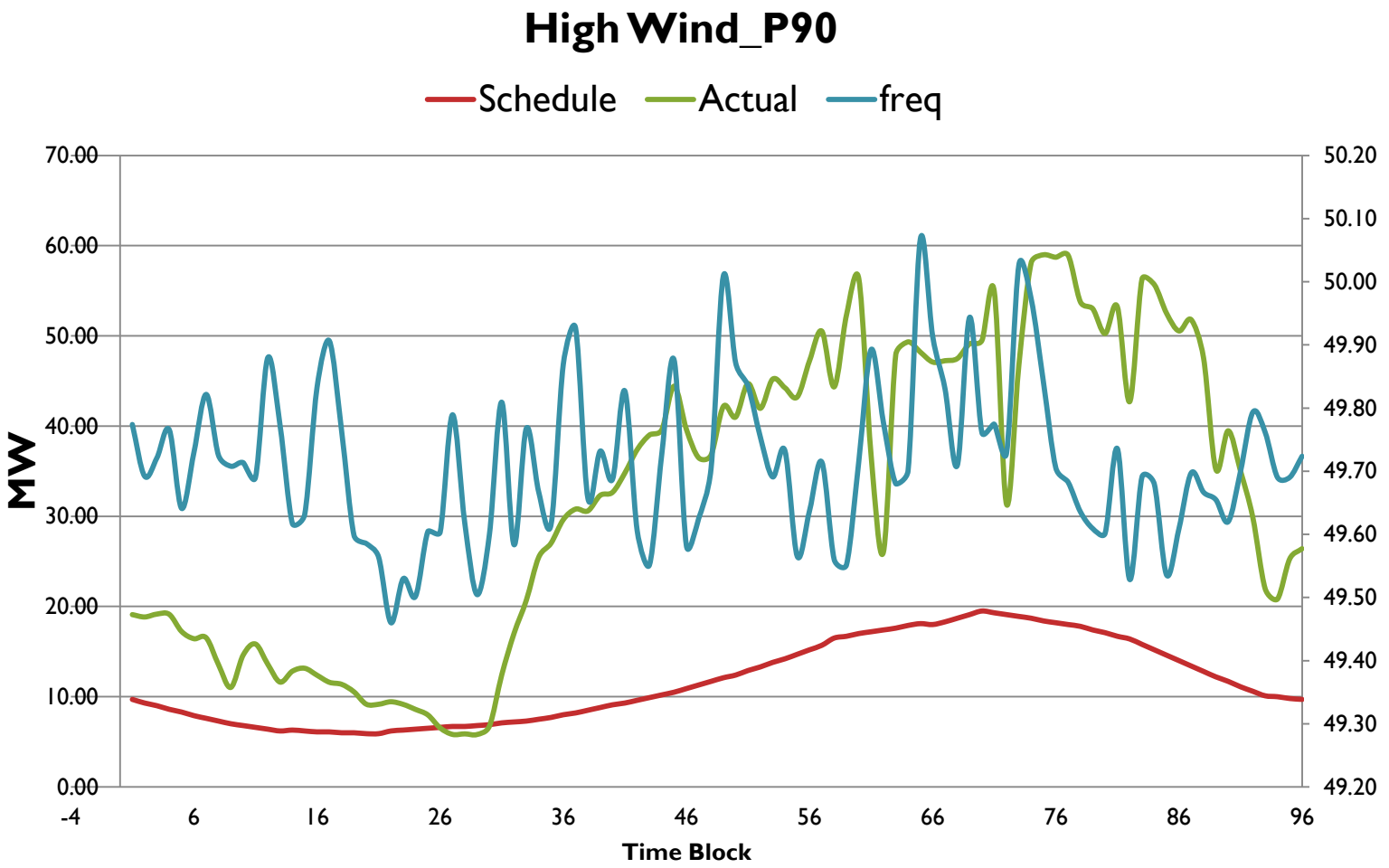
Suggestion


High Wind_3 blocks_23062010
Schedule
Actual
freq
MW
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
50.20
50.10
50.00
49.90
49.80
49.70
49.60
49.50
49.40
49.30
49.20
49.10
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
Net is positive in this case.

P-75


High Wind_P75
Schedule
Actual
freq
MW
Time Block
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
50.20
50.10
50.00
49.90
49.80
49.70
49.60
49.50
49.40
49.30
49.20
-4
6
16
26
36
46
56
66
76
86
96

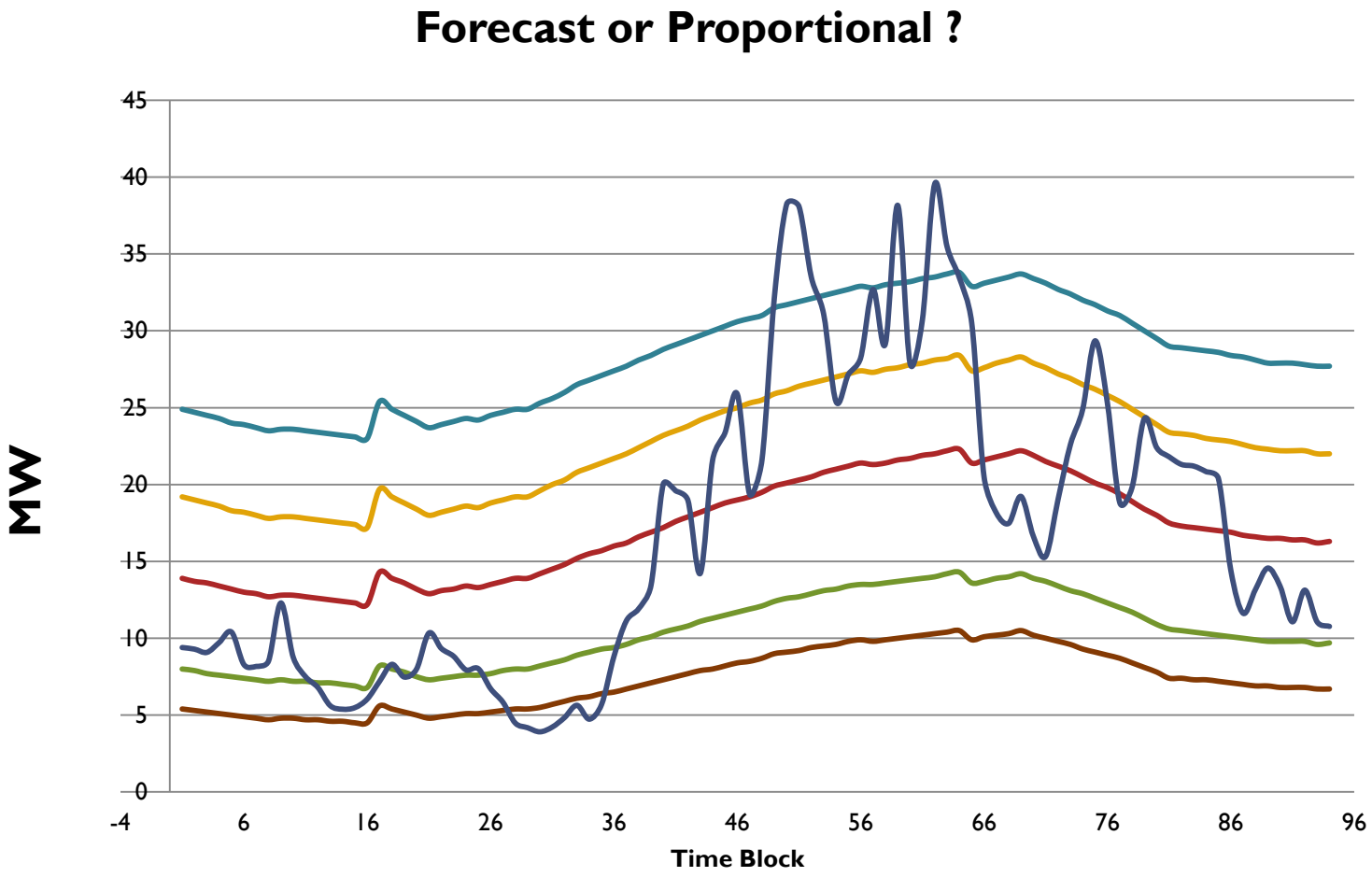
P-90


High Wind_P90
Schedule
Actual
freq
MW
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
50.20
50.10
50.00
49.90
49.80
49.70
49.60
49.50
49.40
49.30
49.20
-4
6
16
26
36
46
56
66
76
86
96
Time Block

Forecast or ?

Microsoft Office
Excel Worksheet

Forecast?


Forecast or Proportional ?
MW
45
40
35
30
25
20
15
10
5
0
-4
6
16
26
36
46
56
66
76
86
96
Time Block

Conclusion

- **Is the forecast Good, Bad, or Ugly?**
  - The wrong question
- **How do we make it better?**
  - A better question
- **How do we obtain fullest value of a good forecast**
  - An even better question!
- **Does it really matter?**
  - You bet! (especially for those on the fast wind lane)

Commercial- One day (Rs.)

Case	Capped UI Income	Amount receivable (+)/ Payable (-) by Generator	Loss due to capping	Total Impact of forecasting errors
High Wind_P90	562669	-448841	1252393	-734565
High Wind_P75	371194	-54664	-826206	-509676
High Wind_P50	95623	-42092	-212839	-159308
Low Wind_P50	102560	-26219	-228278	-151937
High Wind Ramp	0	-3476	0	-3476
High Wind_3block gradual	0	26925	0	26925
Cash Flow from Energy actual @ Rs 5 per kWh				Rs 3875950

- Thank You.

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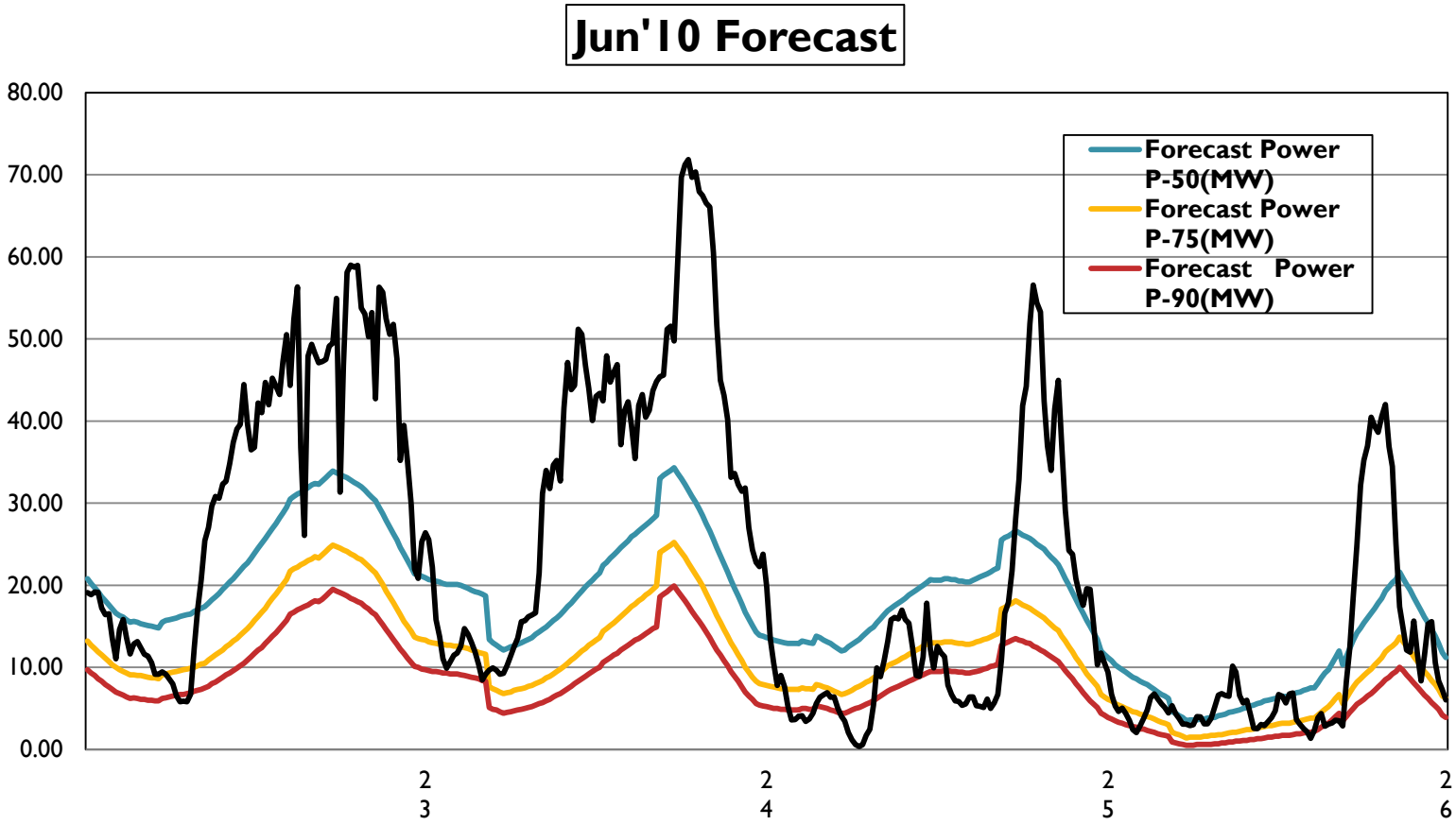
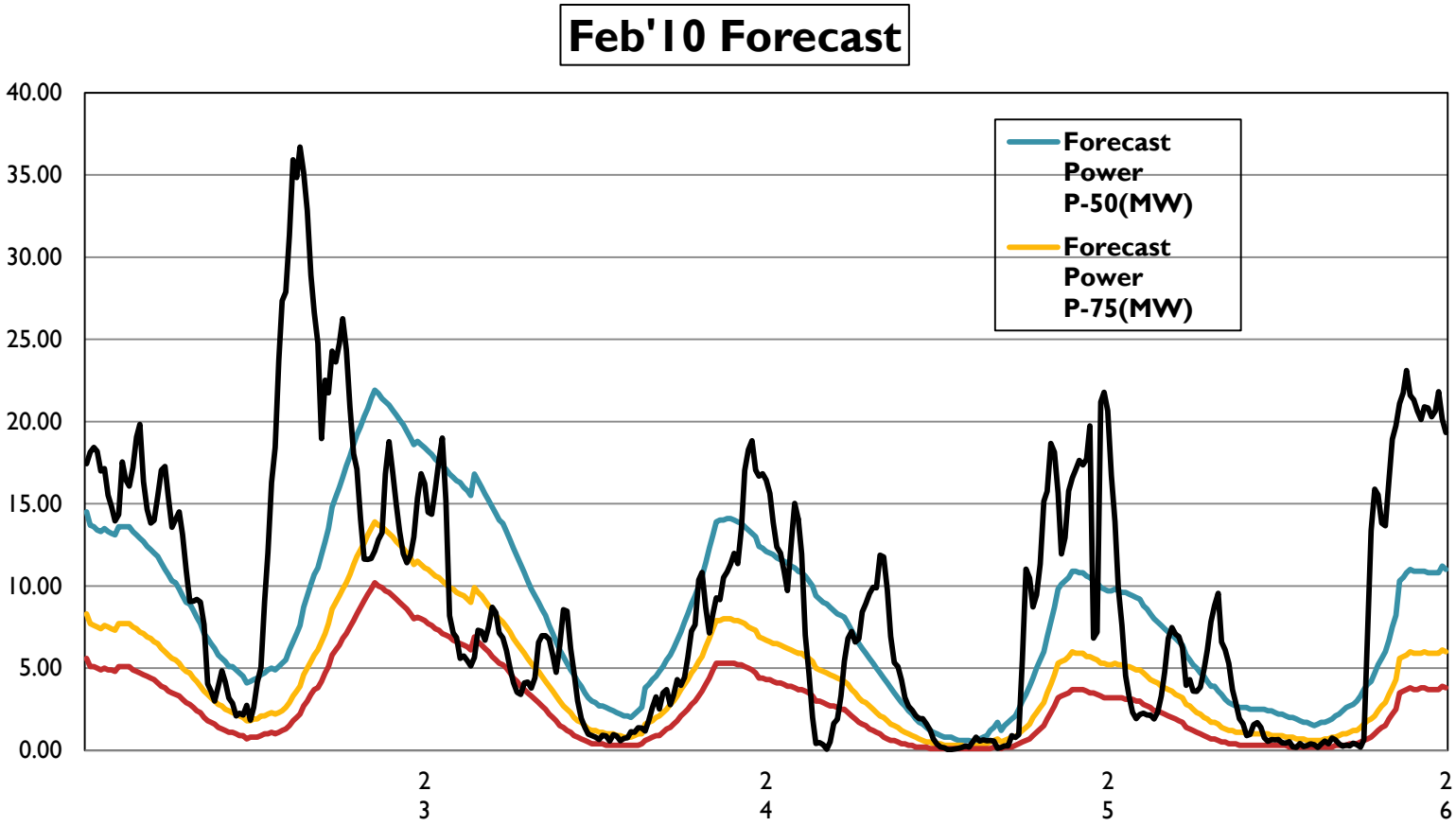

Jun'10 Forecast
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
23
24
25
26
Forecast Power P-50(MW)
Forecast Power P-75(MW)
Forecast Power P-90(MW)


Feb'10 Forecast
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
23
24
25
26
Forecast Power P-50(MW)
Forecast Power P-75(MW)

- Sixteen potential input variables from the ARPEGE Numerical Weather Prediction model are considered. These include wind speed and direction from 10m, 50m, and, 850/700 hPa levels. Also temperature, wind gust, geopotential, humidity and sea level pressure forecasts are considered.