ANALYSIS
OF
CAISO PARTICIPATING
INTERMITTENT RESOURCE
PROGRAM (PIRP) FORECASTING
METHODOLOGY

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Introduction

The California Independent System Operator (CAISO) Participating Intermittent Resources Program (PIRP) was released to production on August 18, 2004. PIRP was a new integration approach that allows intermittent resources (i.e., wind and other resources with an intermittent primary energy source) to become competitive market players in California.

A key ingredient to implementing the new scheduling methodology was the near real time, state-of-the-art forecasts. Scheduling Coordinators (SC) representing wind generation facilities or "Participating Intermittent Resource" (PIR) use these hourly forecasts as the energy schedules submitted to CAISO. The wind Forecasting Service Provider (FSP), AWS Truewind, provides the wind generation forecasting services.

Currently, there are eleven wind projects in California totaling over 600 MWs of installed capacity participate in PIRP. This is approximately 22% of the total wind generation installed in the State. The program is rapidly expanding with several more projects in California due to join the program by the end of 2007

The PIRP creates conditions for wind generators to schedule their energy production into California forward energy market without incurring ten-minute imbalance charges.[1]Deviations of actual hourly energy production from the scheduled amounts are accumulated for an entire month instead of being settled on an hourly basis. The net deviations for the entire month are a small amount and this reduces the financial risk to the SC's that are scheduling the energy for the participating wind generators.

The success of the PIRP program is highly dependent on the accuracy of the Hour Ahead (HA) forecast. Once a wind farm is qualified to participate in PIRP, the SC must provide an HA balanced schedule to the CAISO two hours and thirty minutes before the operating hour equal to HA forecast provide by the FSP. This allows the PIR to be eligible for the Settlements netting for the respective operating hour.

This purpose of this study is to analyze the accuracy of the HA forecast and to investigate ways to improve the HA forecast and minimize the potential settlements costs for wind generation facilities.

[1] Other charges that are avoided include CT 114 Replacement Reserve, CT 4470/4480 Uninstructed Deviation Penalties, CT 4487 Allocation of Excess Cost for Instructed Energy, CT 1697 FERC MOO MLCC, CT 1797 RA MLCC Tier 1 Allocation and FERC MOO Capacity system allocation. An explanation for these charges are found at http://www.caiso.com/184f/184fc7d85030.pdf

Abstract

The CAISO conducted a study to evaluate the differences between each PIRP wind generator's production data and the corresponding FSP MW forecast. The goal was to investigate (1) the accuracy of the forecast and (2) to look for trends in the data that can lead to minimizing the financial impact of the deviations on the PIR Hour-Ahead schedule. Market Participant felt that the goal of driving the net deviations to zero by the end of the month resulted in significant errors in accuracy of the hourly forecasts. The forecasting methodology appeared to overcorrect hourly forecasts to compensate for previous forecast errors to achieve the goal of reducing the overall monthly Mean Absolute Production Error to less than 12%. This method of forecast corrections could create an intra-hour deviation, lead to a higher Grid Management Charge (GMC), although the monthly netting scheme would indeed balance to zero.

Methodology

Each Participating wind generator's data was individually studied. In order to maintain the confidentiality of the data, each set of data can was only be shared with the individual PIR although it is possible to share percentages of accuracy without revealing raw production data. The original study plan called for an evaluation of the Mean Absolute Production Error MAPE based on the following formula

$$MAPE = \frac{\sum_{\substack{1-hr\_avaialable\_periods \\ in\_the\_Calendar\_Month}} \left[\frac{MW\_Forecast - MW\_Actual\_\mathrm{Pr}oduction}{PMax} \right]}{1\_hr\_Available\_Periods\_in\_the\_Calendar\_Month} \%$$

After a review of the hourly data, we decided that a more representative study would be to analyze the data at a more granular level such as ten minute intervals. Using this methodology the study used the settlement data by taking the hourly forecast and divided it by six for ten minute granularity. The forecast is then compared against the settlement quality meter data. Uninstructed Energy (UIE) is then calculated by measuring the delta between the MW forecast and MW production.

UIE = MW_ Forecast (Schedule) - MW_Actual_Production

Per Cent Average Error for the interval = UIE/MW_Actual_Production * 100

This data then can be integrated up to any time period for accurate calculation of error.

Findings

The following table represents the findings for calendar year 2005 and the first 6 months of 2006.

		2005 Jan-Dec	2006 Jan-June
1	Total # 10 Min Intervals	539,508	285,480
2	# of Periods deviation >0	41%	44%
3	# of Periods deviation = 0	14%	10%
4	# of Periods deviation < 0	45%	46%
5	Min Deviation	-25.6 / -6.7	-21.4 / -6.1
6	Max Deviation	24.1 / 6.5	23.3 / 6.5
7	Mean	-0.006	0.050
8	Average Deviation	0.94	1.04
9	Pos UIE	252,344	154,919
10	Neg UIE	-255,703	-140,672
11	Absolute Deviation sum	508,046	295,591
12	Total production – MWh	1,265,328	678,986
13	% Netted Deviation of production	-0.3%	2.1%

As shown in the table, of the eleven wind farms studied there were over 500,000 periods observed in 2005 and 285,000 in the first half of 2006.[2]

Line 2 of the table shows the percentage of time where the Uninstructed Energy (UIE) is greater than the forecast (actual energy production was greater than forecast production). Net deviations were zero or a "Perfect Forecast", 14% and 10% of the periods observed respectively. Line 4 represents the percentage of time when the wind farms had a negative UIE or when the forecast is greater than the actual MWh produced.

This data shows that in 2005 there was a tendency to over forecast (UIE is less than forecast) with a 4% delta between the over/under forecast error. Line 10 (Neg UIE) shows that the MWh produced compared to the forecast is indeed less than the positive UIE indicating that the forecast tended to be greater than the MWh produced. In 2006 the number of perfect forecasts declined from 14% to 10 %, but the delta between the over/under forecast is much closer (2%). However the tendency of the forecast for 2006 is to be under the MWh being produce. This is observed by comparing lines 9 and 10 of 2006.

[2] For comparison purposes the maximum number of 10min periods for eleven wind farms in a year is 578,160.

The table shows the minimum and maximum deviation in MWh from the forecast with the average deviation for each direction however; the mean of these deviations (the sum of the deviations divided by the number of periods) are -0.06 and 0.050 MWh per year respectively. This again demonstrates that the tendency of the forecast in 2005 was to over forecast where in 2006 the tendency was to under forecast.

Reviewing the abs sum (absolute sum) reveals the MWh deviation from the "perfect" forecast. This number can also be equated to the amount of deviations that are used to calculate the CAISO Grid Management Charge (GMC) whereas the difference between the positive and negative UIE would represent the amount of imbalance energy that would be charged at the weighted average MCP.

Data by Area

The eleven wind farms studied are located in four different wind regions within the CAISO control. One of the farms is located in the Tehachapi area while a second farm is located in the Altamont area. The other nine farms are located either in the San Gorgonio or the Solano area. In order to maintain the confidentiality of the two individual farms the Tehachapi farm was rolled into the San Gorgonio area and the Altamont was compiled within the Solano area.[3]

Using the same metrics as above the following data is presented:

2005	San Gorgonio			Solano	
1	Total # 10 Min Intervals	404,874		Total # 10 Min Intervals	134,634
2	# of Periods deviation >0	41%		# of Periods deviation >0	40%
3	# of Periods deviation = 0	13%		# of Periods deviation = 0	15%
4	# of Periods deviation < 0	42%		# of Periods deviation < 0	45%
5	Min Deviation / Average deviation	-10.2 /-5.4		Min Deviation / Average Deviation	-26 /-10.3
6	Max Deviation / Average Deviation	10.0 / 5.3		Max Deviation / Average Deviation	24 / 9.9
7	Mean	-0.002		Mean	-0.018
8	Average Deviation	0.76		Average Deviation	1.48
9	Pos UIE	154,178		Pos UIE	98,165
10	Neg UIE	-155,059		Neg UIE	-100,645
11	Absolute Deviation sum	309,236		Absolute Deviation sum	198,810
12	Total production – MWh	793,598		Total production – MWh	471,729
13	% Netted Deviation of production	-0.1%		% Netted Deviation of production	-0.5%

[3] It is recognized that the Tehachapi area wind characteristics may vary dramatically from the San Gorgonio area but the study of the individual farm found it fit well into the overall averages of the San Gorgonio area farms. A similar result was also seen with the Altamont farm.

Comparing the data in the two areas it appears the delta between the number of occurrence of negative and positive deviation is less in the San Gorgonio area where the 100 % accuracy rate is slightly better in the Solano area. Based on the limited data collected it can be seen that the forecast appears to be performing at the same consistency and accuracy in both areas for 2005.

2006	San Gorgonio			Solano	
1	Total # 10 Min Intervals	208,338		Total # 10 Min Intervals	77,142
2	# of Periods deviation >0	44%		# of Periods deviation >0	42%
3	# of Periods deviation = 0	9%		# of Periods deviation = 0	13%
4	# of Periods deviation < 0	46%		# of Periods deviation < 0	44%
5	Min Deviation /Average	-10.2 /-5.1		Min Deviation / Average	-21 /-8.9
6	Max Deviation / Average	9.4 / 4.9		Max Deviation / Average	23 / 10.7
7	Mean	0.017		Mean	0.140
8	Average Deviation	0.87		Average Deviation	1.49
9	Pos UIE	91,922		Pos UIE	62,997
10	Neg UIE	-88,442		Neg UIE	-52,230
11	Absolute Deviation sum	180,364		Absolute Deviation sum	115,227
12	Total production – MWh	461,220		Total production – MWh	217,766
13	% Netted Deviation of production	0.8%		% Netted Deviation of production	4.9%

Again looking at the indicators for 2006, there is a strong similarity between the two wind areas. There is a large increase in the net deviation percentage of production in the Solano area. Detailed investigation into the data revealed one wind farm with a high rate of telemetry data error causing degradation in the forecast. When the wind farm causing the deviation is removed from the calculation the Solano metrics are again is very similar to that of San Gorgonio.

Conclusion

The original contract with the FSP was to provide a forecast that had a monthly deviation of less than 12%.

As evidenced from the # of periods greater than and less than zero values along with the positive and negative deviations values, it is easy to see that the forecast are centering around a forecast netting to zero with the cumulative average deviation from zero being only 0.94 and 1.04 for 2005/2006 respectively.

Financially this translates to a small net deviation that the PIRP units would have to pay at the Weighted Average MCP. However in order to reach the monthly goal of small netted deviation there have been swings in the hourly forecast that cause a intra-hour deviations. This can be seen by the count of positive and negative deviations. The financial implication of the positive and negative UIE directly affects the amount of Grid Management Charge (GMC) a participant would pay.

A very good example of the forecast swing can be seen at one wind farm. Integrating from an hourly forecast to a weekly forecast, the first week the forecast percent average accuracy is calculated at 4%, the second -1%, the third -2%, the fourth 1% and the fifth week at -2% with the overall monthly average deviation was 0.25%. In this scenario, the monthly UIE netted to less than 165 MWh the GMC charges would have been base on 3000 cumulative MWh.

Based on the study the CAISO is working closely with the FSP to develop the best hourly forecast that would reduce the amount of intra-hour deviations. It is our recommendation that we change the PIRP forecasting methodology to produce the best forecast possible for each specific hour and that we do not bias the forecast to produce a zero net deviation of actual energy from schedule at the end on the month. The monthly net deviation number will increase but it should still be a small number. The 10-minute deviations from schedule should reduce and this should result in lower GMC charges for the participants.[4]

Legend:
Total Count --- The total number of 10 min periods of PIRP data studied
# of 10 min periods >0 --- % of time where the UnInstructed Energy (UIE) was greater than 0 or Production greater than forecast.
# of 10 min periods = 0 --- % of time where the UnInstructed Energy (UIE) was equal to 0 or Production equal to forecast.
# of 10 min periods < 0 --- % of time where the UnInstructed Energy (UIE) was less than 0 or Production less than forecast.
Min. Deviation --- Greatest UIE from forecast in negative direction.
Max. Deviation --- Greatest UIE from forecast in positive direction.
Mean --- arithmetic average of positive and negative deviation.
Average Deviation --- Average Deviation from the mean (absolute value).

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[4] Based on data shared by AWS Truewind at the April 16th meeting regarding how errant data is affecting the forecast and meeting participant feedback, adjusting the intra-hour forecasts may not be the most prudent action at this time. Further study is required.

Pos UIE --Total Quantity of positive deviations.
Neg UIE --Total Quantity of negative deviations.
Abs sum – Sum of the absolute values of Pos and Neg UIE.
Total Production during PIRP periods
% Netted Deviation of Production --- Arithmetic sum of Pos & Neg UIE divided by total production.