

**Date:** December 22, 2014  
**To:** PacifiCorp  
**From:** 2014 Wind Integration Study Technical Review Committee (TRC)  
**Subject:** PacifiCorp 2014 Wind Integration Study Technical Memo

### **Background**

The purpose of the PacifiCorp 2012 wind integration study as identified by PacifiCorp in the Introduction to the 2015 IRP, Appendix H – Draft Wind Integration Study, is to estimate the operating reserves required to both maintain PacifiCorp’s system reliability and comply with North American Electric Reliability Corporation (NERC) reliability standards. PacifiCorp must provide sufficient operating reserves to meet NERC’s balancing authority area control error limit (BAL-001-2) at all times, incremental to contingency reserves, which PacifiCorp maintains to comply with NERC standard BAL-002-WECC-2.<sup>1,2</sup> Apart from disturbance events that are addressed through contingency reserves, these incremental operating reserves are necessary to maintain area control error<sup>3</sup> (ACE), due to sources outside direct operator control including intra-hour changes in load demand and wind generation, within required parameters. The wind integration study estimates the operating reserve volume required to manage load and wind generation variation in PacifiCorp’s Balancing Authority Areas (BAAs) and estimates the incremental cost of these operating reserves.

PacifiCorp currently serves 1.8 million customers across 136,000 square miles in six western states.

According to a company fact sheet available at

[http://www.pacificorp.com/content/dam/pacificorp/doc/About\\_Us/Company\\_Overview/PC-FactSheet-Final\\_Web.pdf](http://www.pacificorp.com/content/dam/pacificorp/doc/About_Us/Company_Overview/PC-FactSheet-Final_Web.pdf), PacifiCorp’s generating plants have a net capacity of 10,595 MW, including about 1,900

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<sup>1</sup> NERC Standard BAL-001-2: <http://www.nerc.com/files/BAL-001-2.pdf>

<sup>2</sup> NERC Standard BAL-002-WECC-2 (<http://www.nerc.com/files/BAL-002-WECC-2.pdf>), which became effective October 1, 2014, replaced NERC Standard BAL-STD-002, *which was* in effect at the time of this study.

<sup>3</sup> “Area Control Error” is defined in the NERC glossary here: [http://www.nerc.com/pa/stand/glossary\\_of\\_terms/glossary\\_of\\_terms.pdf](http://www.nerc.com/pa/stand/glossary_of_terms/glossary_of_terms.pdf)

MW of owned and contracted wind capacity, which provides approximately 8% of PacifiCorp's annual energy. PacifiCorp operates two BAAs in WECC, referenced as PACE (PacifiCorp East) and PACW (PacifiCorp West). The BAAs are interconnected by a limited amount of transmission, and the two BAAs are operated independently at the present time, so wind generation in each BAA is balanced independently.<sup>4</sup> PacifiCorp has experienced continued wind growth in each BAA, and has been requested to update its wind integration study as part of its IRP. The total amount of wind capacity in PacifiCorp's BAAs, which was included in the 2014 wind integration study, was 2,544 MW.

### **TRC Process**

The Utility Variable-Generation Integration Group (UVIG) has encouraged the formation of a Technical Review Committee (TRC) to offer constructive input and feedback on wind integration studies conducted by industry partners for over 10 years. The TRC is generally formed from a group of people who have some knowledge and expertise in these types of studies, can bring insights gained in previous work, have an interest in seeing the studies conducted using the best available data and methods, and who will stay actively engaged throughout the process. Over time, the UVIG has developed a set of principles which is used to guide the work of the TRC. A modified version of these principles was used in the conduct of this study, and the same version was used for the conduct of the TRC process for the 2012 wind integration study. A copy is included as an attachment to this memo. The composition of the TRC for the 2014 PacifiCorp study was as follows:

- Andrea Coon - Director, Western Renewable Energy Generation Information System (WREGIS) for the Western Electricity Coordinating Council (WECC)
- Matt Hunsaker - Manager, Operations for the Western Electricity Coordinating Council (WECC)
- Michael Milligan – Principal Researcher for the Transmission and Grid Integration Team at the National Renewable Energy Laboratory (NREL)
- J. Charles Smith - Executive Director, Utility Variable-Generation Integration Group (UVIG)
- Robert Zavadil - Executive Vice President of Power Systems Consulting, EnerNex

The TRC was provided with a study presentation in July of 2014, and met by teleconference on 2 occasions during the course of the study, which was completed in November 2014. PacifiCorp provided presentations on the status and results of the work on the teleconferences, with periodic updates

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<sup>4</sup> PacifiCorp and the CAISO began operating an energy imbalance market (EIM) on Oct. 1, 2014, which will likely make wind integration somewhat easier. With the EIM, there would seem to be more impetus for this policy to be reviewed and potentially revised going forward. The TRC recommends that this topic be explored in future work.

during the course of the study, and engaged with the TRC in a robust discussion throughout the work. The teleconferences were followed up with further clarifications and responses to requests for additional information. While the conclusions appear justified by the results of the study, the TRC review should not be interpreted as a substitute for the usual PUC review process.

## **Introduction**

The Company should be acknowledged for the diligent efforts it made in implementing the recommendations by the TRC from the 2012 wind integration study in the 2014 study, as summarized in Table H.1. For example, the company modeled the reserve requirements on an hourly basis in the production cost model, rather than on a monthly average basis; the regulating margin reserve volumes accounted for estimated benefits from PacifiCorp's participation in the energy imbalance market (EIM) with the California Independent System Operator (CAISO); and a discussion on the selection of a 99.7% exceedance level when calculating regulation reserve needs was provided, including a description of how the WIS results inform the amount of regulation reserves planned for operations. Sensitivity studies were performed, including the modeling of the regulating reserves on a monthly basis, and demonstrating the impact of separating the reserves into different categories. The 2014 wind integration study report thoroughly documents the company's analysis.

As pointed out in the report, there is a small but meaningful difference in the integration costs between the 2012 study and the 2014 study. The 2012 value of \$2.55/MWh of wind generation, using monthly reserves in PaR, is slightly less than the 2014 value of \$3.06/MWh, using hourly reserves in the Planning and Risk (PaR) production cost model, with the major difference attributed to the modest increase in the cost of electricity and natural gas. When modeling reserves on an hourly basis in PaR, the intra-hour reserve cost is higher than when modeling reserves on a monthly basis. This is due to more reserves being shifted from relatively lower-priced hours to relatively higher-priced hours.

## **Analytical Methodology**

- The first paragraph on p. 24 of the revised Appendix H, entitled "Application of Regulating Margin Reserves in Operations" is a critical aspect of this study, albeit a little late to the interactions between Pacificorp and the TRC. In effect, it means that the results of this study are and have been applied in operations, which is very unique in the universe of wind integration analysis since nearly all other studies are forward looking and utilize synthesized data and other assumptions. While this paragraph sufficiently addresses the points raised by the TRC in the late summer of 2014, it should receive more prominence in the report. A comparison of the interaction between the 2012 study methodology and PacifiCorp operations with the 2014 study methodology and Pacificorp operations should be included at the front of the document.

## **Assumptions**

- The assumptions generally seem reasonable. PAC does a good job of laying out the process they use for the modeling and analysis. They have also provided discussion of the previous suggestions (from the 2012) study made by the TRC.
- The report addresses the issue of the 99.7% coverage of variability, and says that the operators are expected to have sufficient reserves to cover all variability all of the time. It would be interesting to contrast the company's policy of ensuring 100% reserve compliance with actual system performance. In the November TRC call there was some helpful discussion on this issue. One item discussed was that using 99.7% provides some margin of error in case a lower value, such as 95%, is used in the study but insufficient if the actual variability of wind/load were to increase. It would be nice to see this discussion reflected in the report, which would provide some additional justification for the 99.7 percentile. The reason this point is raised is to magnify the point that PAC makes in the report; that there is a tradeoff between economics and reliability. Holding the system to an extremely high effective CPS performance will be somewhat costly, and it is not clear what impact this is having on wind integration costs.
- The use of actual historical wind production data is excellent, and something that many studies are unable to do. This means that the PAC study is somewhat unique and PAC is to be commended for doing this work. At the same time, the report provides some illumination on the difficulties in using actual data, because data recovery rates can compromise the time series. PAC has done a good job in analyzing and correcting these inevitable data gaps, and this should not have a significant impact on the study results.

## **Results**

- Table H.15 documents a comparison of the monthly versus hourly reserve modeling, and shows that a constant monthly reserve is less costly than reserves modeled on an hourly basis. The explanation provided is useful, but may leave out some factors such as non-linearity in reserve supply curve. In addition, the shifting of reserves from lower price hours to higher price hours only seems to apply to the East area, as the West area exhibits the opposite characteristic.

## **Discussion and Conclusions**

- Table H.17 shows that the total reserves increase with consideration of regulation and following separately. It should be noted that while the arithmetic sum of the reserves does increase, it would not necessarily lead to higher costs as some of the following reserve could be obtained from non-spinning and quick-start resources which cost little to have on standby for such purpose.
- Based on the information provided by PacifiCorp, the methodology used in the wind integration study appears to be reasonable. Based on the draft study report, the findings and conclusions

appear sound. The findings appear to be useful to inform the Integrated Resource Planning process.

### **Recommendations for Future Work**

Wind Integration modeling presented is unique in how it is integrated with the operating process at PacifiCorp. There are some sensitivity studies which could be done to shed additional light on the results and provide some useful insights:

- Future work should explore balancing area cooperation between PACE and PACW under the EIM framework.
- Regulating margin implies reserve capacity available on very short notice (ten minute or less). The ramping and following reserve categories do not all require fast response. Future sensitivity studies could be done to compare the results from PaR to use of the RSS formula.
- It might be useful to perform some additional sensitivities on natural gas price. For example, integration costs would be expected to increase with gas prices, yet at higher gas prices PAC would be getting a larger benefit from wind energy.
- A sensitivity analysis with carbon tax assumptions could also provide some useful insight and results.

### **Concurrence provided by:**

Andrea Coon – Director of WREGIS, WECC

Matt Hunsaker - Manager, Operations, WECC

Michael Milligan - Principal Researcher, Transmission and Grid Integration Team, NREL

J. Charles Smith - Executive Director, UVIG

Robert Zavadil - Executive Vice President, EnerNex