# Technical Appendix:

# Review and Critique of the PacifiCorp 2010 Wind Integration Study

## Introduction and Summary

PacifiCorp ("the Company") bases its wind integration costs in the test year on the results of its 2010 Wind Integration Study ("the Wind Study"). This document examines a number of the important technical flaws undermining the accuracy and results of the Wind Study. The Wind Study is quite complex, more than 60 pages long and includes dozens of charts, tables and graphs.

This analysis documents three overarching problems with the Company's Wind Study: (1) use of a flawed study design; (2) failure to incorporate the advice from outside experts who participated in the collaborative process; and (3) numerous execution errors and biases, most notably use of an unreliable method to simulate missing wind data and double counting of several wind farms.

The specific errors that resulted in excess power costs being included in the test year are as follows: (1) overstatement of reserve requirements needed for wind integration of approximately 100 to 170 MW; (2) double counting of contingency reserves; and (3) must-run modeling of the Currant Creek and Gadsby CTs. These are addressed in Adjustments 1 and 2 shown on Table 1 of the testimony.

## Wind Integration Costs in the Test Year

Wind Integration costs are an important element of total Net Power Cost ("NPC") in the Company test year. The Company models several different cost components related to wind integration. These include inter-hour costs, intra-hour costs, BPA wind integration charges and contingency reserves associated with the wind resources. The intra-hour costs are comprised of costs associated with additional reserve requirements (called "regulating margin") and costs related to must-run operation of certain gas plants. Contingency reserves are based on the regional requirement to maintain reserves sufficient to cover 5% of wind generation.[1] The BPA charges come directly from the BPA Wind Integration tariff. The remaining costs flow from the Company's 2010 Wind Integration Study ("Wind Study") results as modeled in GRID.

**The Collaborative Process**

The Company established a "collaborative process" ostensibly to design the Wind Study so it represented a consensus of views among interested parties. To evaluate whether the process was effective and accomplished these goals, the comments of the parties were reviewed and participants to the process were contacted: Mr. Ken Dragoon[2] and Mr. Brendan Kirby.[3] An unsuccessful attempt was made to contact Dr. Michael Milligan of NREL (another expert participant). However, his comments were carefully reviewed and additional discovery was conducted related to his meetings with the Company.

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[1] Contingency reserves are not always considered part of Wind Integration costs, but they are costs related to wind generation included in the test year.

[2] Mr. Dragoon was author of the Renewable Northwest Project comments in the process and formerly performed wind integration studies used by the Company in its IRP.

[3] Mr. Kirby is a private consultant who retired from the Oak Ridge National Laboratory and now consults for numerous clients including the Electric Power Research Institute (EPRI), The National Regulatory Research Institute (NRRI), the American Wind Energy Association (AWEA), the National Renewable Energy Laboratory ("NREL"), and others

***Conclusion No. 1: The Company failed to reflect the views and criticisms of the participant to the collaborative process.***

The Company failed to reflect many of the most important suggestions of the various parties and did not reflect the input from some of the best qualified experts who participated, notably, Dr. Milligan, Mr. Dragoon, Mr. Kirby and Dr. Michael J. Schilmoeller.[4]

Initially, a number of the participants commented that there was a lack of time to fully evaluate the study or stated they would withhold judgment until it was filed in a regulatory proceeding.[5] However, it appears the Company proposed an early completion date for the study so that it could be included as an update in the Oregon and Washington rate cases.[6] That issue aside, there were three major problems in the Company's approach to the process.

First, a number of parties suggested the Company organize an expert Technical Review Committee ("TRC") to assist and oversee the study design.[7] The Company rejected this suggestion, and instead hired a consulting firm, The Brattle Group, as a "Technical Advisor." The primary basis for this decision was lack of time to perform the analysis if a TRC was used. However, Mr. Duvall indicated during a February 21, 2010 teleconference that the Technical Advisor's primary role was to supply PacifiCorp with additional manpower because the Company was shorthanded. This clearly is not a reasonable substitute for an independent TRC.

[4] Dr. Schilmoeller was author of the Northwest Power and Conservation Council ("NPCC") comments.

[5] Comments, Utah DPU (March 11, 2010) Utah Association of Energy Users (March 12, 2010), Industrial Customers of Northwest Utilities (March 12, 2010). Utah Clean Energy (March 16, 2010).

[6] The Company did not complete the study on time for either case and it was not used.

[7] The Western Resource Advocates March 12, 2010 comment, Utah Clean Energy March 16, 2010 comment, and the NREL March 2010 letter to PacifiCorp. NREL reiterated this in its comments on April 23, 2010.

Because the Company has a financial interest in the revenue stream it derives from the results of its Wind Study, the lack of an independent TRC calls the objectivity of the process into question.

Second, the Company indicated early on in the process that it would not supply workpapers to participants in order that they might examine and evaluate the Company's analyses. This decision further undermined the objectivity and verifiability of the process. No party was in a position to know how the Company actually performed the study, or whether the data used and analyses performed were reasonable or accurate.[8]

Finally, the Company did not implement some of the most important comments made by the experts in relation to the study design. Instead, the Company failed to perform suggested analyses or provided inappropriate comparisons when questions were raised. Consequently, the Company cannot rely on the process used as a basis to suggest the Wind Study is objective or verifiable. Instead, the primary value of the process is that it reveals fatal flaws in the Company study.

It is clear from this review that the process participants acted in good faith in providing comments and suggestions. Numerous comments were well thought out, detailed and pointed out serious problems in the Company's study design. The Company's failure to incorporate these suggestions resulted in flaws in the study that are now very apparent.

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[8] The Industrial Customers of Northwest Utilities pointed out this problem in their March 12, 2010 comments.

**Review of the Workpapers and Filing Documents**

To properly evaluate the Wind Study, a detailed review of the supporting workpapers is required. This is crucial because the Company acknowledged numerous serious errors in its prior wind integration study.[9] None would have been discovered without a careful third-party workpaper review. The workpapers include more than 100 spreadsheets, data files and other documents. These were reviewed and additional discovery was performed related to these documents.

**Wind Integration Modeling in GRID**

Intra-hour wind integration requires additional spinning reserves[10] (called "regulating margin") for wind integration. This is capacity online, but rendered unavailable for sale into the market or to serve load, thereby increasing NPC. GRID models 530 MW[11] of regulating margin during the test year to provide reserves for load and wind variations. In addition to the 525 MW regulating margin, the Company assumes a need to run Currant Creek and the Gadsby CT's around the clock at minimum capacity to provide these additional reserves.

As with wind integration costs, the Company has stated it cannot identify the actual amount of regulating margin being used.[12] As explained below, because regulating margin is a

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9 ICNU 2.10 WUTC Docket No. UE-100749 identified 11 serious errors in the prior study.

10 A simple analogy can help to understand spinning reserves. A car may have a 150 hp engine, but only needs 75 hp to drive at 70 mph. The remaining hp are "reserves" available, to climb a hill or pass another car. Likewise, spinning reserves are provided by generators running at less than their full capacity. These reserves are available to respond to an increase in load or outage of a generator.

11 See Attachment 746-700 C23-8.

12 See WIEC 8.14 WPSC Docket No. 20000-384-ER-10.

performance-based criteria, there is no formula or "rule" to indicate how it should be determined or how much was in fact truly required in the past.[13]

Utilities are required to carry enough regulating margin to achieve a Control Performance Standard 2 ("CPS2") result of 90% or better. This means it must maintain enough reserves so Area Control Error ("ACE") falls within the WECC and NERC prescribed limits at least 90% of the time. Over the period 2004-2009, the Company achieved CPS2 result of 96.5%.[14] With this level of performance, the Company substantially exceeds the 90% requirement.

For purposes of the Wind Study, the Company described its approach to determining the regulating margin requirements as follows:

> *A dense data set of ten-minute interval wind generation and system load drives the calculation of the marginal reserve requirement in two components: (1) regulation, which is developed using the ten-minute interval data, and (2) load following, which is calculated using the same data but estimated using hourly variability. The approach for calculating incremental operating reserve necessary to supply adequate capacity for regulation and load following at levels required to maintain current control performance…..PacifiCorp's definitions for regulation and load following are based on PacifiCorp's operational practice, and not intended to describe the operational practices or terminology used by other power suppliers or system operators…..For purposes of the Study, the regulation calculation compares observed ten-minute interval load and wind generation production to a ten minute interval estimate, and load following compares observed hourly averages to an average hourly forecast.*[15]

The Company computed a load and wind forecast for ten minutes forward ("Regulation") and 60 minutes forward ("Load Following") periods and compared the results to the actual or simulated data. This is intended to simulate actual operations where operators must decide in advance how much capacity to have on line, given the uncertainties of load and wind. The

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[13] See WIEC 8.14 and 8.15 WPSC Docket No. 20000-384-ER-10.
[14] See WIEC 8.8 WPSC Docket No. 20000-384-ER-10.
[15] Wind Study, pp 10-11

forecast "errors" (the deviation between forecast and actual) were then measured for each ten minute and sixty minute period. The Company assumed it needs to maintain sufficient reserves to compensate for 97% of the errors in the expected load and wind generation during the upcoming hour and in each ten minute period within that hour. Put another way, the Company assumed it must provide reserves larger than all but the largest 3% of forecast errors it might experience.

It is impractical, and uneconomic to hold enough reserves to compensate for *every possible* forecast error (i.e. 100% reliability). The Company chose 97% based loosely on the historical CPS2 performance, as the Company stated it averaged CPS2 close to 97% from 2004-2009.[16]

***<u>Conclusion No. 2: The 97% CPS2 Target Is Overstated</u>***

The 97% target clearly exceeds the 90% WECC requirement, thereby increasing the amount and cost of reserves being carried on the system. In this case, the Company appears to have confused a result with a goal. It would not be appropriate to set a goal of 97%, and the Company indicates it has not done so.[17] In the May 5, 2010 comments of the Northwest Power and Conservation Council ("NPCC"), it was pointed out the BPA used 95% as the target value in its wind integration study.

For ratemaking purposes, 97% is inappropriate. The goal is not to for CPS2 to average 97%, but rather that it exceed 90%. Because there will always be some variation about the

[16] Wind Study, p 19. Based on the data in WIEC 8.8, the actual historical level of performance was 96.5%. Consequently, the Company "rounded up" the requirement, another subtle bias. In fact, the assumed average CPS2 of 97% exceeded the actual monthly average results 64% of the time from 2004-2010.

[17] See WIEC 8.10 WPSC Docket No. 20000-384-ER-10.

average value, the logical approach is select a target that provides a sufficient buffer so that after normal deviations, the ranges of results fall above 90%. The use of the 2010 actual CPS2 levels of 95.2% for PACE and 95.5% for PACW provides a more reasonable CPS2 target for this study.

The figure below shows the monthly "CPS2 buffer" (the actual CPS2 less 90). Over the seven year period the smallest buffer for PACE was 2.6%, while average CPS2 for PACE was 96.5. Consequently a 2.6% reduction to the average CPS2 (94.1%) would still assure the minimum CPS2 would exceed 90%. For PACW, the smallest buffer was 1.1% (again based on an average of 96.5%). Consequently, for PACW an average CPS2 of 95.4% would still produce a minimum CPS2 better than 90% for PACW. The 2010 average figures of 95.2% for PACE and 95.5% for PACW exceed those levels and therefore provide a more than adequate buffer.

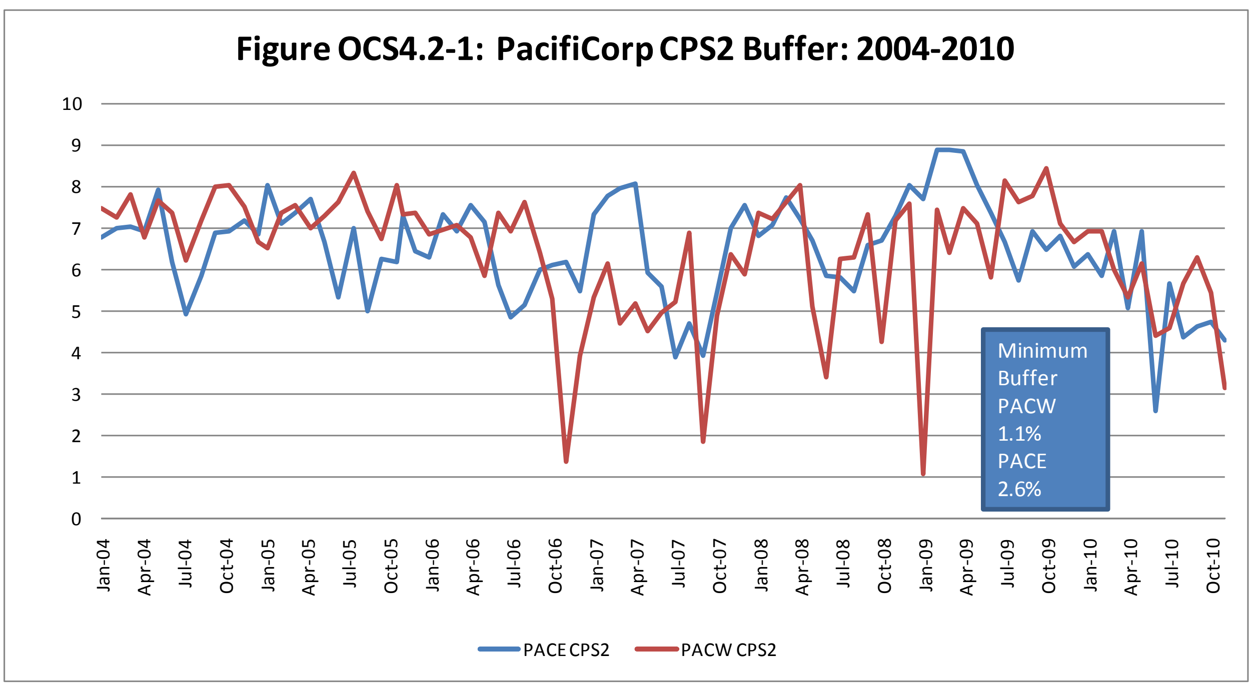

Figure OCS4.2-1: PacifiCorp CPS2 Buffer: 2004-2010

**Simulation of Wind Generation Data**

The Company decided to model wind conditions over the 2007-2009 period but lacked sufficient wind data to incorporate all of its 2011 wind generators. Most of the Company's 2011 fleet of wind resources was not even online from 2007 to 2009. In fact, the Company states that actual data exists for only 425 MW of the 1833 MW wind capacity modeled in the study, or 23%.[18] The remainder had to be simulated for all or part of the three year period.

***Conclusion No. 3: The Wind Study Double Counts Wind Capacity***

In several cases, the Company included data for a wind project more than once in its database. For example, Rolling Hills was included as a standalone 99 MW simulated wind farm, and also included in the Glenrock wind farm data.[19] Rock River was included as a standalone simulated wind farm, but was also included as part of the Foote Creek wind farm output.[20] Goodnoe and Leaning Juniper were also included as part of the PacifiCorp intra-hour wind integration requirement even though BPA supplies wind integration services for these two projects[21] and $3 million dollars for BPA's charges are already included in the test year.[22]

While acknowledging these mistakes in the previously referenced data responses, the Company argued that the study results remain valid because they made other compensating errors, namely failing to include other wind projects. In effect, the Company is suggesting that

[18] Wind Study p 7.
[19] Data Request OCS 8.15
[20] In Data Request OCS 8.16 the Company agreed Rock River was included with Foote Creek, but denied it was also included on a stand-alone basis. In Data Request OCS 20.14 the Company admitted that Rock River was also included as a stand-alone resource.
[21] Data Request OCS 8.13
[22] See Confidential Attachment 746-700 C23-8.

total wind capacity, rather than size and location of the projects are what matters. This assumption is contradicted, however, by the great lengths the Company went to in order to simulate the data for specific projects. Further, duplicating plants overstates the integration requirements because it eliminates the short-term diversity that wind plants typically exhibit. No matter what, the Company is acknowledging multiple errors in its study by inclusion of wind farms' costs more than once, and (in their view) by exclusion of a substantial number of other wind farms located elsewhere on their system.

While the Wind Study report states that it modeled 1833 MW[23] of installed wind generation, it actually included 1994 MW. The table below shows that the Company should have included only 1688 MW of wind capacity in the test year. The basis for the Company's assertion that there is no double counting is essentially a contention that non-owned wind farms receiving free wind integration services from the Company under the OATT tariff[24] should be counted as part of the Company retail revenue requirements. Two regulatory Commissions have already rejected the Company's assertion that retail customers should pay for integration of wholesale transmission customers.[25] Even including those projects, the Company study overstates requirements by 39 MW, largely due to ignoring the fact that the SCL Stateline contract expires in December, 2011, thus eliminating the need to provide integration services for the 150 MW project.

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23 In some workpapers, the Company states it is including 1750 MW.

24 Long Hollow, Campbell and part of the State Line project.

25 Idaho Public Utilities Commission Docket No. PAC-E-10-07, Order 32196, Page 30. Washington Utilities and Transportation Commission ("WUTC") Docket No. UE-100749, Order No. 6, paragraph 125, page 48.

**Table OCS 3.1 Wind Integration Study**

| Facility | Nameplate Capacity MW | MW in OCS Test Year | MW in Wind Study |
|---|---|---|---|
| Chevron Wind QF | 17 | 17 | - |
| Combine Hills | 41 | 41 | 41 |
| Dunlap I | 111 | 111 | 111 |
| Foote Creek | 33 | 33 | 137 |
| Glenrock | 99 | 99 | 232 |
| Glenrock III | 39 | 39 | - |
| Goodnoe | 94 | - | 94 |
| High Plains | 99 | 99 | 99 |
| Leaning Juniper 1 | 101 | - | 101 |
| Marengo I | 140 | 140 | 140 |
| Marengo II | 70 | 70 | 70 |
| McFadden Ridge | 29 | 29 | 29 |
| Mountain Wind 1 QF | 61 | 61 | 61 |
| Mountain Wind 2 QF | 80 | 80 | 80 |
| Oregon Wind Farm QF | 45 | 45 | - |
| Power County QF | 22 | 22 | - |
| Pioneer Wind Park I & II* | 25 | 25 | - |
| Rock River I | 50 | 50 | 50 |
| Rolling Hills | 99 | 99 | 99 |
| Seven Mile | 99 | 99 | 99 |
| Seven Mile II | 20 | 20 | 20 |
| Spanish Fork 2 QF | 19 | 19 | 19 |
| Stateline (Half Year) | 75 | 75 | 150 |
| Three Buttes | 99 | 99 | 99 |
| Top of the World | 200 | 200 | 200 |
| Wolverine Creek | 65 | 65 | 65 |
| Sub-total | 1,829 | 1,635 | 1,994 |
| *Non-owned wind* | | | |
| PACE Non-compensating | 144 | - | - |
| PACW Non-compensating | 123 | - | - |
| Other - compensating | 53 | 53 | - |
| Total | 2,149 | 1,688 | 1,994 |

***<u>Conclusion No. 4: Flaws in the Simulated Wind Data Invalidate the Wind Study Results</u>***

The most serious problem with the Wind Study stems from the use of simulated data for most of the resources modeled (including three of the double counted projects). This introduced substantial bias in the results because the simulated data was far more variable than the actual data, which has the effect of increasing NPC significantly. This problem is so pernicious that it renders the Wind Study in its current form as of little value to the Commission.

The Company lacked actual ten minute wind generation data for most of its projects for 2007-2009. By 2009, however, it did have some actual ten minute data for most, though not all, projects. To fill in the missing data, the Company used a regression modeling technique called "Bootstrapping" to simulate the missing data.

As an example, the Company did not have complete actual data for the entire Marengo project until late June 2008, when Marengo 2 was completed.[26] To fill the gap, the Brattle Group performed regressions to predict the output of Marengo from the output of Combine Hills, for which the Company did have actual data for all three years. These regressions were applied to the actual 2007 – June 2008 Combine Hills output to generate predicted output for Marengo during those months.

The Company believed that simply applying the regression equation results would produce simulated output that lacked the random intra-hour variability of the "real" data. Consequently, they applied the Bootstrap technique to produce random variations in the 2007 to June 2008 Marengo data. This method adds a random error term (derived from the original regression analysis) to the regression equation prediction in order to simulate what actual results

[26] The Company did have actual data for the first phase of this project starting in August 2007.

might have looked like. While the Bootstrap methodology is well established in statistical practice,[27] the Company misapplied it and, having done so, next presented a misleading comparison to validate it.[28]

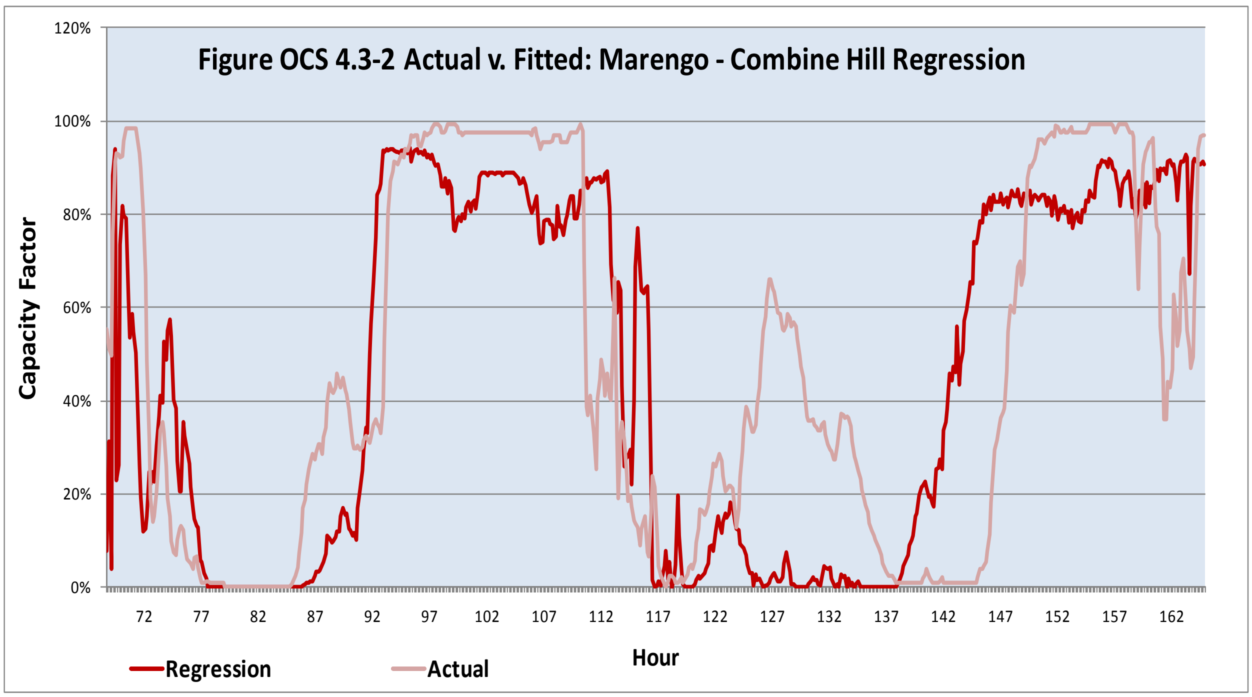
**Flawed Regression Equations**

Brattle Group's regression equations included many variables that were not statistically significant.[29] Usually only a few of the variables used were statistically significant. However, the equations employed always contained seven variables. Based on a conference call with the Company and Brattle, it appears that the reason for this was to allow the process of generating the dozens of equations to be automated. One serious problem with the regressions was the multi co-linearity of the independent variables, meaning the individual coefficients cannot be determined accurately. Again, it appears time constraints drove the decision process.

The Company's Bootstrap technique (and the resulting problems) can be visualized from results of the Marengo-Combine Hill regression. Figure OCS 4.3-.2 below plots the regression model prediction versus actual for a single week 2009.[30] At times, there were large discrepancies between the regression model prediction and the actual data. This is not surprising nor by itself a fatal flaw. The difference between the regression equation prediction and the actual result are the regression errors or "residuals." Simulation of the residuals is the cornerstone of the Bootstrap technique. The Company's initial realization of the simulated wind

[27] An Introduction to the Bootstrap, Bradley Efron, Robert J. Tibshirani, Chapman & Hall/CRC 1993
[28] Wind Study Table 6. This will be discussed shortly.
[29] Interewest Energy Alliance questioned the Company's use of these regression equations in its August 25, 2010 Comments.
[30] The specific time is not identified to protect the confidentiality of the data. This follows the Company's approach as shown on page 49 of the Wind Study

data was the sum of the regression prediction for the period, plus a randomly selected residual term, developed from the original regression equation. The Company suggests this was necessary because otherwise the output of the two projects (and the intra-hour forecast errors) would move in lockstep and the predicted output for the simulated project would be too staid.[31] While this premise was correct, the Company used the wrong technique and introduced far worse problems in applying it.




**Incorrect Bootstrapping Methodology**

Bootstrapping was introduced by Dr. Bradley Efron of Stanford University, in 1979.[32] It is clear from his textbook that Bootstrapping of *time series data*, such as the ten minute interval wind data, requires use of special techniques. Dr. Efron states that for a time series "…*we cannot simply resample from the individual observations as this would destroy the correlation we are*

[31] Wind Study, page 49.
[32] An Introduction to the Bootstrap, Bradley Efron, Robert J. Tibshirani, Chapman & Hall/CRC 1993

*trying to capture*."[33] This is because the time dependence between observations is completely lost in the simple bootstrapping process as applied by the Company.[34] ***The basic problem is the Company ignored the fact that the wind generation data it was using was a time-series.*** The Company failed to account for the problem that larger prediction errors tended to follow each other. Likewise positive and negative errors tend to occur in clumps. Rather they treated the errors as independent random variables with no relationship from one observation to the next. This is a textbook error in their analysis that may stem from the lack of capability of the statistical software the Brattle Group used.[35]

This problem can be seen directly by review of the Company's data and results. The first figure below shows the regression residuals from the Company's Marengo capacity factor equation (based on the Combine Hills actual data) for the same period as above. While large positive or negative errors in the prediction of capacity factors occurred frequently, there is a very strong tendency for large positive errors to follow each other, while large negative errors tend to do the same. It is clear from the data that there is a definite time pattern to the residuals. The regression either under or over predicted the capacity factor for extended periods of time. This problem is called "serial correlation of the residuals."

In the Company simulation this was ignored. Rather, as is shown in Figure OCS4.3-4 below, the Company selected a randomized sample to develop the residuals it used for the

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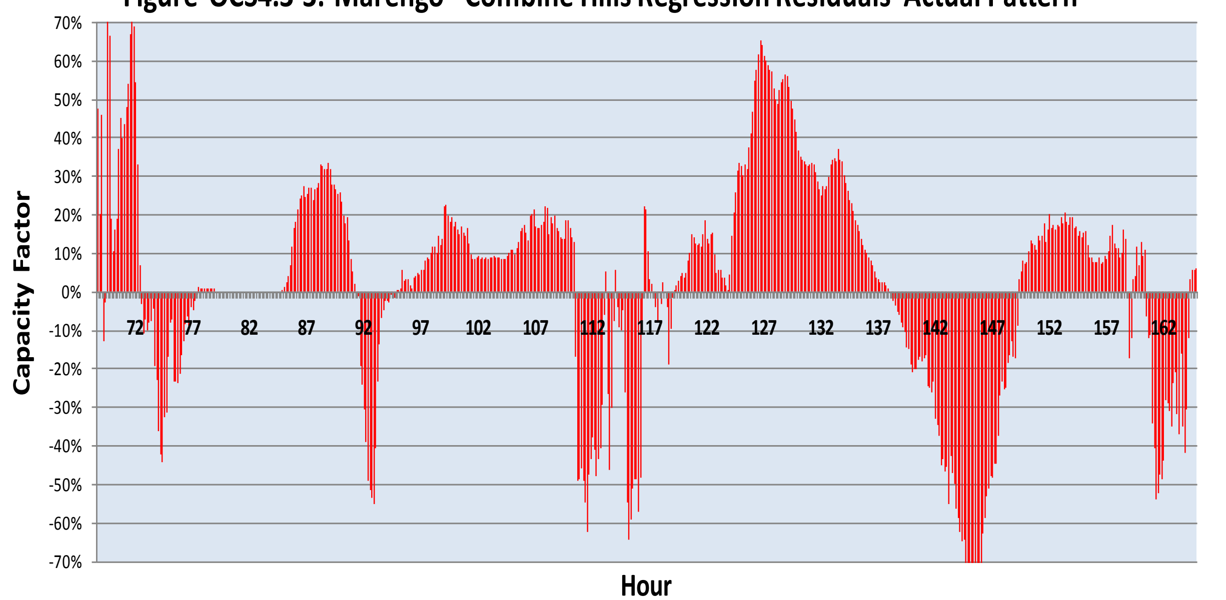
[33] Id. Electronic Version, Location 1931. Dr. Efron devotes Chapter 8 to issues such as time series modeling. Section 8.6 contains a description of a proper technique, such as the "Moving Block" Bootstrap methodology for time series data.

[34] The Company's "Non-Linear Three Step Median Smoother" technique fails to preserve the time series structure of the data, thus is an inadequate response to the problem.

[35] The Stata package used by Brattle lacks the ability to perform the Block Bootstrap technique applicable to time series data. Journal of Statistical Software, Dec. 2007, "A review of **Stata** 9 and 10 time series forecasting capability" by Robert Alan Yaffee, New York University, page 15.

simulation. Initially, the Company tried a simple random sampling, but later changed that to a technique it called a Non-Linear Three Step Median Smoother,[36] as shown in Figure OCS4.2-5 below. Neither approach produces a pattern of residuals that show similarity to the actual results. Consequently, it could frequently happen that a large under-forecast would be followed by a large over-forecast in the Company's simulation. This, of course, greatly magnifies the intra-hour variability in the simulated data and therefore greatly increased the need for regulating margin reserves, in turn increasing NPC.

**Figure OCS4.3-3: Marengo - Combine Hills Regression Residuals -Actual Pattern**

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[36] Wind Study, page 51. The Company also added another step, based on selecting residuals based on the "bin" or predicted project output. This was of little consequence because as shown above, there is little apparent correlation between forecast errors and the level of output predicted. This also further invalidated the treatment of the results of the simulation as a time series.

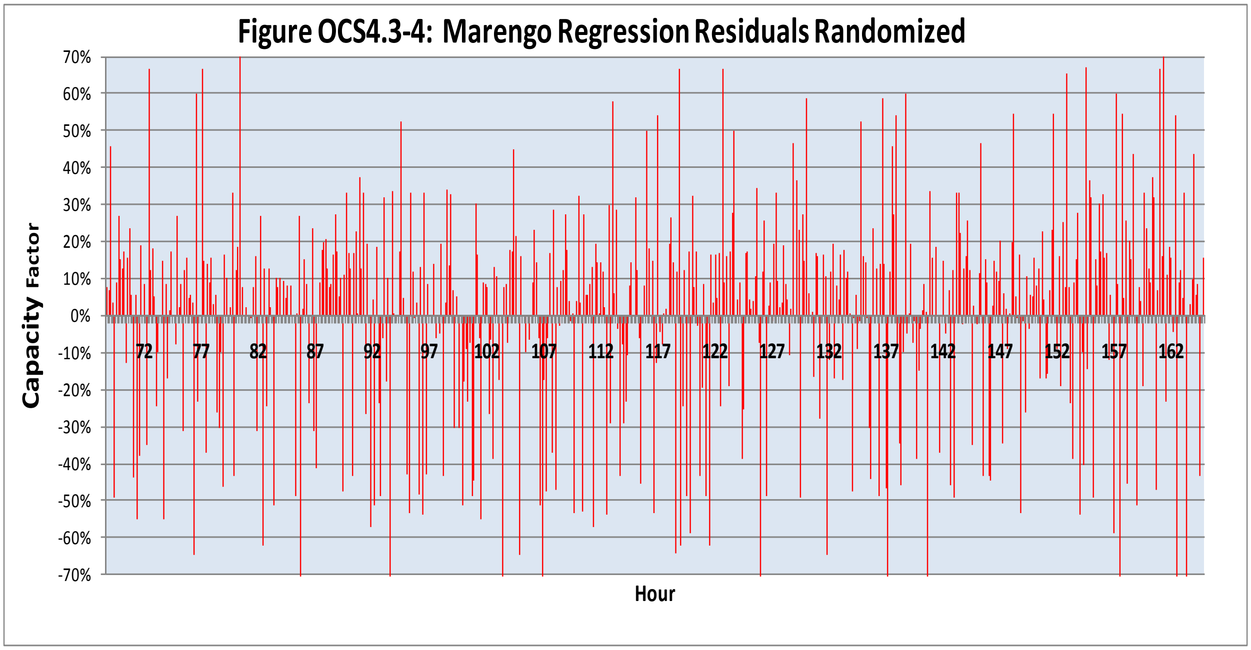


Figure OCS4.3-4: Marengo Regression Residuals Randomized

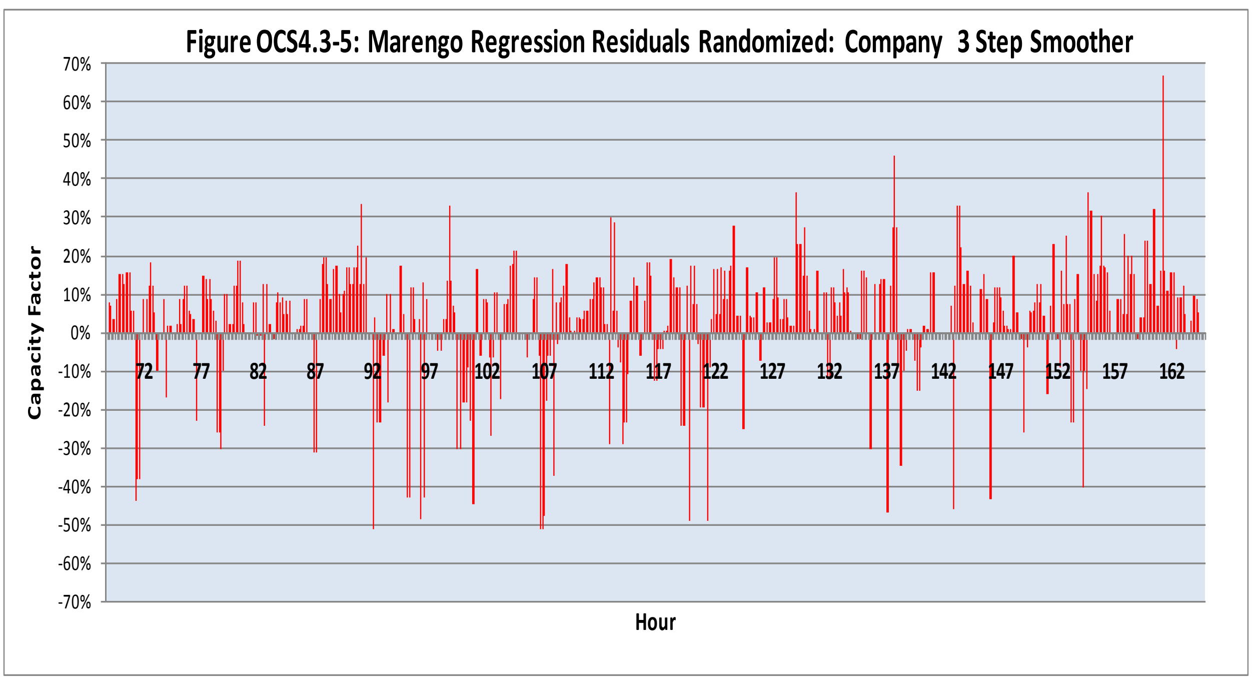


Figure OCS4.3-5: Marengo Regression Residuals Randomized: Company 3 Step Smoother

In reviewing the workpapers it became apparent that the largest errors occurred when there was a sign change in the residuals (i.e. an under-forecast followed by an over-forecast.)

Note that in the actual pattern of residuals, sign changes occurred only a handful of times. In the randomized residual, sign changes occurred dozens of times. In the Three Step Smoother method shown in Figure OCS4.3-5, sign changes occurred with far greater frequency than in the actual pattern of residuals shown in shown in Figure OCS4.3-3.

The basic problem is that in randomizing the data (necessary for the Bootstrap simulation), the correlation between observations was lost and the wind data ceased to be a time series, even though it was treated as such in all of the Company's subsequent modeling. Even after introducing the Bootstrapping technique, the Company continued to consider the data as a time series.[37] In effect, the Company made the same mistake that students are warned about in Dr. Efron's textbook, as quoted above.

**A Simple Analogy**

One way to understand this problem is to consider an analogy. If one starts with a new deck of cards, they are in a definite order. Any card drawn is a good predictor of the next card in the deck. A five will be followed by another five or a six, for example.[38] The difference between the face value of one card and the next is quite small. This order is, of course, destroyed by shuffling the deck. Once the deck is shuffled, the difference between one card and the next is random, and much larger than when the deck was new. In the regression model, the serially correlated residuals may be thought of as the "un-shuffled deck" (which exhibits substantial ordering) while the Company's Bootstrapped residuals are the deck after it has been shuffled

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[37] Id.

[38] This is also the method used for forecasting wind energy in the next period. The last observation is assumed to predict the next one.

many times. The Company destroyed the ordering of the original data in applying its technique. This greatly exaggerated the intra-hour variability of the wind projects because, just as with the new deck of cards, there is a definite order in the regression errors.

The Company was requested to produce the Durbin-Watson[39] statistics for the regressions but they were not provided.[40] As a result, the Company's data was used to replicate the regressions. In the regressions that were performed, serial correlation of the residuals was always present. This should have been expected based on the observations contained in the Wind Study on page 39, where the presence of serial correlation in the capacity factor data was discussed. In regression analysis, if one starts with serially correlated data nearly any regression produced from it is quite likely to exhibit serial correlation in the residuals. This is why statisticians have gone to great length to devise methods for dealing with such situations.[41]

**Result of the Flawed Simulation**

Owing to this problem, the simulated data exhibits far more intra-hour variability than the actual data. Below is a pair of charts showing the actual and simulated Marengo 1 data for one week in 2008. The wildly oscillating simulated data exhibits a much different and far less

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[39] This is the classic test for serial correlation. I also examined Residual Correlograms and the Box Q-test statistics.

[40] See Data Request OCS 8.25

[41] In Data Request OCS 8.25 the Company erroneously suggests that in its Tobit regression model the meaning of the Durbin-Watson statistics is unclear because observations are "censored." This simply is incorrect because the censoring simply limits the values of observations to be positive. This does not change the time series character of the data and has no real impact on the regression results. Indeed, my analysis indicated little practical difference between the Tobit and Ordinary Least Squares regression results. Further, the Company continued to treat the data as a time series and refer to it as such in the Wind Study. See pages 37 and 52. In the later reference, the residuals are characterized as a time series.

predictable pattern than the actual data. While the actual data also shows some large swings and a certain degree of unpredictability, it is minor in comparison to the simulated data.

**Figure OCS4.3-6: Marengo - Actual Early 2008**

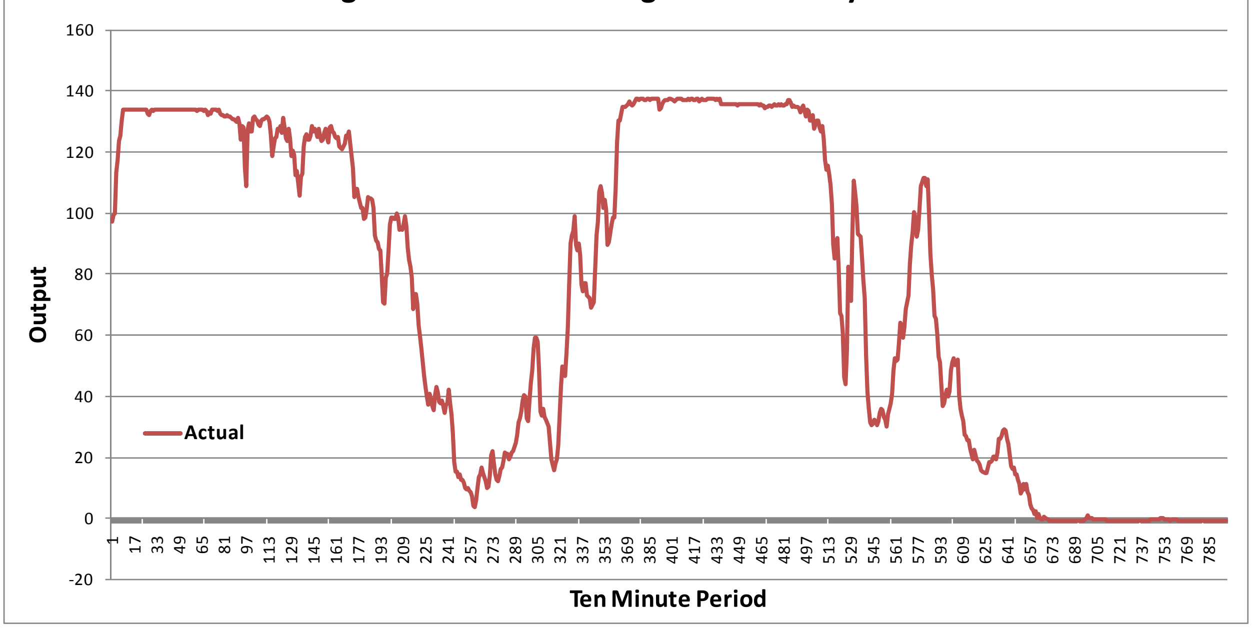
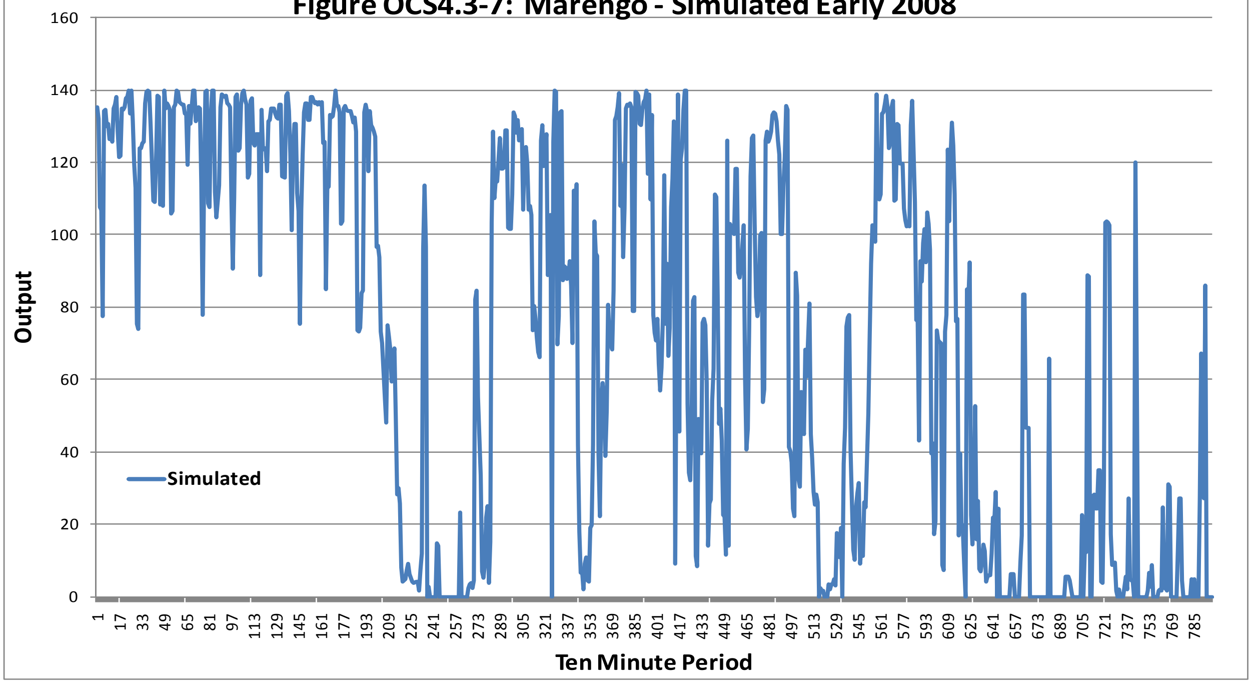


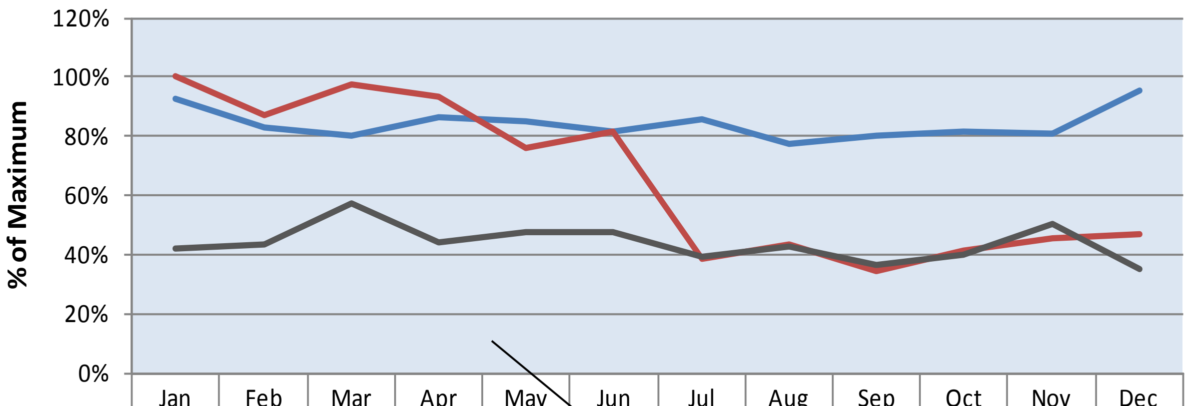

**Figure OCS4.3-7: Marengo - Simulated Early 2008**



This excessive variability greatly increased the amount of reserves required for wind integration, which increases NPC needlessly. The figure below compares the monthly Regulation (ten minute ahead) errors for PACW for 2007-2009. Results are indexed so that the maximum value is 100 to respect possible confidentiality.

The figures show that the Regulation errors are cut in half starting in July 2008. It is not coincidental that July 2008 was the first month in which all of the wind data for PACW was actual rather than simulated.[42] Similar results occurred for PACE, as is shown in Exhibit OCS4.4. The data clearly shows that as more actual and less simulated data was used, the results of the Wind Study showed an obvious decline in the amount of reserves required.

**Figure OCS4.3-8: PACW Wind Regulation Reserves**




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2007 | 93% | 83% | 80% | 86% | 85% | 82% | 86% | 77% | 80% | 82% | 81% | 95% |
| 2008 | 100% | 87% | 97% | 93% | 76% | 81% | 39% | 44% | 34% | 41% | 45% | 47% |
| 2009 | 42% | 44% | 57% | 44% | 47% | 48% | 39% | 43% | 36% | 40% | 50% | 35% |

[42] Goodnoe switched from simulated to actual one month earlier. Goodnoe should not have been included because BPA provides integration services for that project.

**Predisposition to Use Simulated Data**

Another problem apparent from the workpapers is that the Company was predisposed to use the simulated rather than actual data, even if both were available.[43] In the case of Marengo, the first project at the site came on line in August 2007. Thus, the Company had actual data available for many months but still used the simulated data.[44] It would have been more accurate to have used the actual data once it was available. Further, the actual data for Marengo 1 would have been a far better predictor for Marengo 2 than the Combine Hills regression which was used by the Company.

***Conclusion No. 5: Participants Questioned the Simulated Data Throughout the Process***

Participants to the process questioned and even objected to the Company's use of the simulated data throughout the process. The early comments from the Utah Division of Public Utilities[45] and Mr. Dragoon suggested that alternatives be investigated.[46] Further, NPCC also expressed concern about the simulated wind data:

> *PacifiCorp should independently validate the Brattle Group's synthetic wind data. PacifiCorp can prepare simple comparisons of real and synthetic data for sites with incomplete data without significant effort.*[47]

Dr. Milligan of NREL and Mr. Kirby, NREL consultant, stated early on:

> *The PacifiCorp proposed method of synthesizing data based on time-lagged data from existing wind plants would work if wind always blew from the same direction, at the same*

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[43] Further, in the case of Rolling Hills and Rock River, the Company used both actual and simulated data at the same time.
[44] See Data Request OCS 3.3
[45] March 11, 2010 comments.
[46] April 23, 2010 comments.
[47] May 6, 2010 Comments of NPCC.

> *speed, and remained coherent over long distances. Since wind does none of these things previous studies have found that time lagged synthesized wind data is not very good.*[48]

Parties continued to question and object to the simulated data in the later comments as well. The Utah DPU continued to voice concerns about the use of simulated data as late as August, 2010.

> *The Division has continued concerns that approximately half of the wind data (as illustrated in Figure 1) are developed by the technical advisor rather than by using actual anemometer data that are available. The report indicates that use of such estimated data poses significant methodological hurdles. It is unclear why these hurdles were considered less onerous than the use of actual anemometer data.*[49]

The Interwest Energy Alliance's August 25, 2010 comments also questioned the regression equations and the Bootstrapping methodology used by the Company:

> *Using six time-lagged values tends to smooth results so the consultants added back in a sizeable random error term. Section 2.4.2 (Simulation Process) indicates that the Brattle Group iteratively adjusted the simulated data to accomplish a pre-determined result.*
>
> *With this significant data manipulation built into the process it is not clear if the results represent either individual wind plants or if they represent the actual behavior of the aggregation. It is not clear if the outputs are properly correlated.*

Finally, the Company had a conference call with Dr. Michael Milligan of NREL in August 2010. According to the Company's document describing the meeting:

> *Dr. Milligan suggested that PacifiCorp investigate the application of a Tobit*[50] *model for future validation of simulated wind development….PacifiCorp and Brattle Group staff*

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[48] NREL April 23, 2010 comments.

[49] Utah DPU August 26, 2010 Comments.

[50] The Tobit Regression is the type of model employed by the Company. The Tobit model simply replaces negative capacity factor values with zero. This can occur when the farm is not producing, but rather using station service.

*then described the effort to validate modeled data by comparing calculated reserve requirements from both actual data and simulated data for various wind plants.*[51]

WIEC conducted discovery related to this meeting. One request was for all documents the Company relied upon or provided Dr. Milligan. However, the Company provided only a link to its web site where participant comments to the Wind Study were provided.[52] It appears, however, that the analysis referenced in the above quoted passage refers to Table 6 of the Wind Study.[53] This analysis purports to show that the reserve requirements for a specific wind farm (Goodnoe) developed from actual data for a specific time frame (the month of May in 2007-2009) were reasonable compared to those developed using the regression methodology.

**A Misleading and Erroneous Analysis of the Simulated Data Included in the Wind Study**

Review of the Wind Study Table 6 workpapers[54] reveals that the results quoted in Table 6 are inappropriate for three reasons. First, the comparison performed used actual and simulated data for one wind farm (Goodnoe) for May 2007, May 2008 and May 2009. The problem, however, is that Goodnoe was not in operation in May 2007.[55] As a result, the Company substituted simulated data for actual in May 2007, thus ensuring that there was no difference between actual and simulated data for one third of period studied.[56]

51 *2010 Wind Integration Study Consultation Session Conference Call with Michael Milligan, page 1*

52 See WPSC Docket No. 20000-384-ER-10, WIEC 17.8
53 Wind Study p. 9
54 WPSC Docket No. 20000-384-ER-10, Attachment to WIEC 12.18 Confidential
55 PacifiCorp does not even provide integration services for Goodnoe.
56 The Company admitted this in Data Request OCS 8.19.

Second, the residual simulation method used was quite different from the methodology actually employed in the Wind Study. The residuals used were sampled from those in the smallest half of the data.[57] Limiting the residuals used results in discarding the observations most responsible for determining reserve requirements in its actual study.

Finally, the Company scaled the errors down by as much as 90%. For these reasons, the Company's analysis simply does not represent a fair test of the reasonableness of the simulation method. In any case, the direct comparisons shown above vividly illustrate the problems in the Company analysis. Given how simple it is to compare graphs of the actual and simulated data (as NPCC and Dr. Milligan suggested), it is puzzling that the Company selected this complex and inappropriate analysis to demonstrate the reliability of its modeling.

**Possible Solutions**

Given these issues, it is necessary to find a way to correct the Company study. One solution investigated was to rely solely on 2009 data. Doing so would *reduce but not eliminate* the reliance on simulated data. Exhibit OCS 4,5 shows this solution is problematic for PACE.[58] It compares the errors resulting from the actual and simulated PACE data for December 2009. The chart shows that while there was 35% more wind generation represented by the actual data than by the simulated data, the simulated Regulation and Load Followings errors greatly exceeded those produced by the actual data. Indeed, the simulated data for Top of the World

[57] That is the 25th through 75th percentile of the residual distribution. These are the residuals closest to the midpoint of the distribution.

[58] For PACW all of the major wind resources were on line in 2009, so use of the 2009 data would be feasible, absent the other problems in the Company study, such as the double counting of Goodnoe and Leaning Juniper.

project alone was responsible for 47% of the intra-hour variability in the data used for 2009. Further, additional errors and biases made reliance on the Company's data less practical. In the end, the best solution is to develop data which produce realistic intra-hour variability results.

***<u>Conclusion No. 6: Additional Errors and Data Problems Bias the Wind Study Results</u>***

Numerous additional errors were found in the workpaper review. A simple math error produced extremely large forecasting errors for the last hour of each month in 2009 for both PACE and PACW. The Company acknowledged these 24 errors[59] but contends the size of the error is less than the rounding (5 MW) used, and, as in the case of the double counting, did not provide a correction.[60]

Another group of errors resulted from the Company use of data for individual months as if there were a continuous time series. For example, the hour ahead and ten minute forecasts for load and wind for January 1, 2009 were based on data from January 31, 2008. This problem occurred in every month from January 2008 through December 2009, producing large errors in the hour ahead and ten minute ahead forecasts.[61]

Finally, the load data itself is questionable. For example, on March 10, 2009, the Company showed a 1000 MW change in PACW loads in a ten minute period.[62] Similar problems occurred in other months.[63] Again, these data anomalies produced very large forecast

[59] See WPSC Docket No. 20000-384-ER-10,WIEC 10.5 and 10.6
[60] Id.
[61] WPSC Docket No. 20000-384-ER-10WIEC 12.4
[62] See Data Request OCS 3.3
[63] Data Requests OCS 8, 9, 8.10, 8.11

errors for specific hours. The Company has provided no corrections for these problems and indicated it did not take steps to validate the load data used.[64]

***<u>Conclusion No. 7: The Company Did not Address Design Flaws Pointed out by the Experts</u>***

The Company also failed to accept many of the more significant suggestions offered by the participating experts. One of the more serious issues was that the Company failed to use a "load net wind" design, and instead relied on a "two-dimensional" methodology.

Unlike other forms of generation, wind generation is intermittent and control is limited to reducing (wasting) output much like spilling water over the dam at a hydro plant. In this respect, wind acts more like load which is also not under the Company's control. A number of the parties, including Dr. Milligan of NREL[65] and Mr. Dragoon[66] suggested the Company should model the difference between load and wind ("load net wind"). This is, in fact, a standard method for wind integration studies. This would have been a fairly simple change to implement – it would have only required combining the spreadsheets containing the load and wind modeling into a single spreadsheet. The Company did not do so, but instead relied on an equation that related the load and wind errors as follows:

**Load Less Wind Error = Square Root ((Load Error)^2+(Wind Error)^2)**

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[64] Id.
[65] PacifiCorp summary of August 26, 2010 Consultation Conference Call with Dr. Milligan, page 2.
[66] Renewable Northwest Project, August 26, 2010 comments.

The above equation was criticized by various experts. While it applies in special cases,[67] it is not proven, however, to apply as broadly as the Company assumed.[68] Mr. Dragoon actually provided data showing the formula did not apply.[69]

**Double Counting of Reserves for Load Following and Regulation**

Several parties questioned the combination of the 60 minute (or "Load Following") and 10 minute ("Regulation") errors using the same equation as above. The criticism was that the reserves made available for Load Following should also be available for Regulation. It was suggested this resulted in a double counting of reserves or an overstatement of Regulation requirements.[70] However, the Company treated these errors as independent and completely unrelated, essentially providing enough reserves to cover both types of errors as if they were independent and additive. A more proper approach would be to simply look at the most significant errors in ten or sixty minute periods and provide enough reserves to cover all but the largest 4.5%, consistent with a 95.5% CPS2 score.

Another concern is that the Company overstated the Regulation errors because it used a rolling 60 minute average persistence forecast (i.e. the average over the preceding hour).[71] Use of the most recent ten minute average would greatly reduce the magnitude of the Regulation errors in the Wind Study.

[67] It applies if errors are measured at one standard deviations and the load-wind correlation is zero. This author has used this in the context of standard deviations and zero correlation.

[68] The Company analyzed the 98.5$^{th}$ and 1.5$^{th}$ percentiles to define the 97 percent error bandwidth.

[69] August 12, 2010 Comments of Renewable Northwest Project.

[70] May 6, 2010 Comments of Utah Clean Energy; August 25, 2010 Comments of Interwest Energy Alliance; August 26, 2010 Comments of Renewable Northwest Project. Dr. Milligan's comments at the June 21, 2010 and August 26, 2010 also address the double counting of regulation and load following reserves.

[71] Renewable Northwest Project's April 23, 2010 comments went a step further suggest the Regulation Errors should be based on an hourly schedule that assumed zero imbalance for the hour.

**Must-run Assumptions**

Finally, questions were raised about the must-run assumptions related to the Currant Creek and Gadsby CTs. There is some justification for this assumption in the case of the PaR model used in the Wind Study, but it is not justified for GRID. The Wind Study states that PaR does not consider reserve requirements in making commitment decisions.[72] The Company assumed that these resources should run "around the clock" to provide reserves. If so, this assumption was based on a serious limitation in the PaR model (which undermines its usefulness for this application.) However, GRID does not have such a drawback, and considers reserve requirements in modeling commitment decisions.[73]

The Company was asked to provide operational support for the must-run designations. However, in operations, these units are not considered "must-run." The Company indicated the "must-run" assumption was a *modeling rather than operational decision*.[74] The hourly dispatch for the CTs and Currant Creek for the period ending November 30, 2010 was reviewed to determine the validity of must-run assumption. The data showed no evidence that the CTs were running around the clock. In fact, Exhibit OCS 4.6 shows the CTs started up more than 300 times during the year and generally cycled on a daily basis. Consequently, there is no basis for the must-run assumption for the Gadsby CTs.

For Currant Creek, however, it was apparent that the number of full shutdowns of the plant had been reduced in recent months. However, it was frequently the case that at least one of

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[72] p. 25

[73] Given that gas units are modeled with screens in GRID, a check could easily be added to insure sufficient capacity is on line to provide necessary reserves.

[74] WPSC Docket No. 20000-384-ER-10, WIEC 1.42

the Currant Creek CTs did shut down at night limiting plant output to half of its full capacity.[75] Given the reduction in the number of starts, a better modeling approach for Currant Creek might be as two identical units, while maintaining the must-run status for one (CT1A), but allowing the second resource (CT1B) to cycle.[76]

***Conclusion No. 8: Alternative Analyses Support Much Lower Reserve Requirements***

To provide a realistic range of results, two wind integration analyses were prepared based on data for 2009 and 12 months ending November 30, 2010 (the test year in the current PCAM case.) Another analysis correcting the errors and adjusting the Company study to reflect criticism made by the various experts was also performed. Additional analyses were performed as well, with results listed in Table OCS4.3-2 below.

**2009 Analysis**

By the end of 2009, the great majority of the wind capacity in the June 30, 2012 test year was already on line, greatly reducing the need for simulated data. For PACW, the Oregon Wind Farms QFs were the only resources in the 2011 test year not online throughout 2009, though there was a partial year of operation in 2009 for these projects. For PACE, there was a full year of data for 2009 for most of the resources and a partial year of data for some. Using additional data from the 2011 Wyoming PCAM case (WPSC Docket No. 20000-389-EP-11), by the end of

[75] Currant Creek has 2 identical CTs, (1A and 1B) which can run independently. Either can power the Steam Generator. In nearly all respects the plant can be run as two independent units with similar efficiency. See WIEC 4.43 and 5.43 from Docket 20000-277-ER-07.

[76] Screening analysis shows another alternative is to simply treat the plant as a must-run for certain months.

the November 30, 2010 PCAM test year, all but a few small QF's included in the June 30, 2012 test year in this case were online.

Among the PACE projects lacking complete 2009 data, were Top of the World (the largest), followed by Dunlap and Three Buttes. High Plains and McFadden were online for a few months in 2009.

Actual data were used when available. In cases where the data were not available, Efron's Moving Block Bootstrap[77] technique was used in order to correct the problems in the Company's approach. The regressions were estimated from the available 2010 data. The Moving Block Bootstrap is similar to the Company's method, but instead of drawing a single residual from the random sampling,[78] one selects a block of residuals to maintain their time dependence over an extended period of time. Exhibit OCS 4.7 shows an example of the technique employed.

Analysis of the simulation results suggested they were not very sensitive to the length of the block selected. A two day block length (288 ten minute observations) was used based on this analysis.[79] This approach was used to fill in the missing data for Top of the World, Three Buttes, High Plains and McFadden, Dunlap and the Oregon Wind Farm QFs for 2009.

Efron points out that application of the Moving Block Bootstrap is less sensitive to specification of the regression model employed. There is little physical basis or statistical evidence to suggest a strong variation in the regression results based on a monthly or seasonal basis. Consequently, a single regression for the various projects was used instead of monthly

[77] An Introduction to the Bootstrap, Bradley Efron, Robert J. Tibshirani, Chapman & Hall/CRC 1993, Section 8.6

[78] Or three as later modified by the Company in its "Non-Linear 3-step Median Smoother" adjustment.

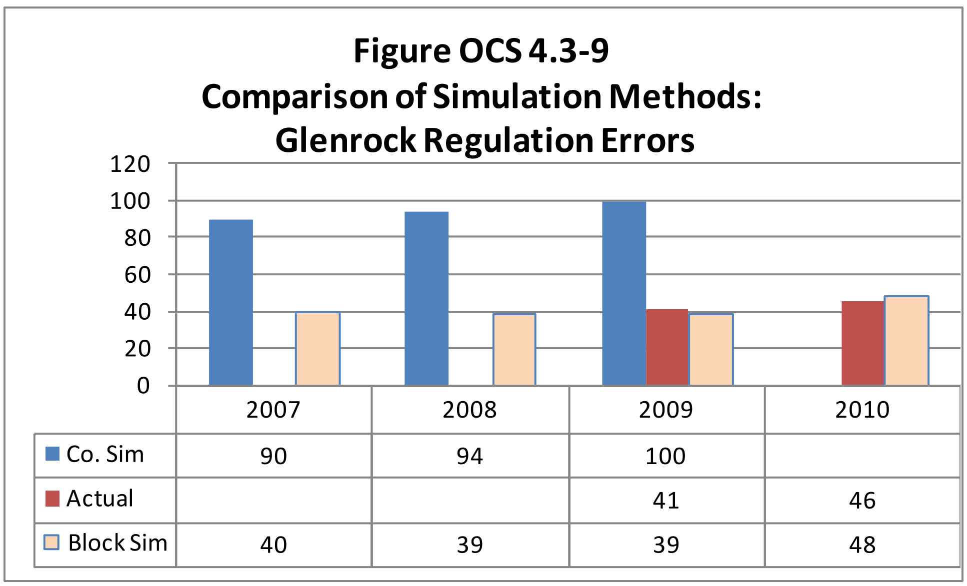
[79] See Exhibit OCS 4.9, which will be discussed shortly.

regressions. The correlation between the projects was examined. The predictor project selected was the closest project where data was available. Seven Mile Hill was used to model Dunlap, as the two are about 10 miles apart. Glenrock was used to model Top of the World and Three Buttes (again they are less than 10 miles apart), and Leaning Juniper was used for the Oregon Wind Farm simulations. High Plains and McFadden were simulated based on Foote Creek which is again within about 10 miles. These selections also usually presented the best intra-hour correlations.

Exhibit OCS 4.8 presents the regression equation results. For McFadden and the Oregon wind farms, there was a full year of data available to estimate the equations. For High Plains, there were obvious data quality problems in 2010. Because High Plains is located adjacent to McFadden, and there is a high correlation in the hourly output for the two projects, McFadden was scaled up to produce the High Plains results. This provides an estimate that would overstate integration requirements because scaling of this sort does ignore the diversity of wind generation, even within a single site. However, lacking better data, this was the best compromise available. For all projects, there were thousands of observations available for estimating the regression spanning a period of 3-12 months.

**Statistical Superiority of Moving Block Bootstrap is Demonstrated**

Exhibit OCS 4.9 compares statistical results for the simulated versus actual data and demonstrates that the Moving Block Bootstrap simulations did a very good job of replicating the actual data (and correlations with the nearby wind farms) once it became available. On average, the predicted Load Following and Regulation errors based on the Moving Block Bootstrap were within a few percent of the actual results for McFadden, the Oregon Wind Farm, Dunlap, Three Buttes, Top of the World[80] and Glenrock.[81] In contrast, the Company method greatly overstated the load following and regulation errors. For example, for Glenrock over the period 2007-2009, the Company method predicted Regulation errors averaging more than twice the actual result. For 2010, the Moving Block Bootstrap result was within 4% of the actual figure. Figure OCS 4.3-9 below compares the results for the Moving Block simulation to the Company method and the actual results for 2009 and 2010 for Glenrock. All figures are indexed to 100 to respect possible confidentiality.




| | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|
| Co. Sim | 90 | 94 | 100 | |
| Actual | | | 41 | 46 |
| Block Sim | 40 | 39 | 39 | 48 |

## 2010 Analysis

The 2010 Analysis relied on actual data for the 12 months ended November 30, 2010, the test year from the current Wyoming PCAM proceeding. Because Three Buttes, McFadden and

[80] These were the projects for which simulated data was used.

[81] Glenrock has actual data available in both 2009 and 2010, and for this reason was used to test the model using 100 simulations. Results are shown in Exhibit OCS 4.9.

the Oregon wind farms had twelve full months of data available, there was no need to use simulated data. There was also some actual data for Dunlap and Top of the World as well, further reducing the reliance on simulated data. For the period where actual data was not available, the Moving Block Bootstrap method was used again.

One problem, however, was that some of the 2010 data supplied by the Company was clearly erroneous. High Plains and Marengo showed several months with perfectly constant output – an impossibility for a wind farm. Wolverine showed output more than 100 MW in excess of the rated maximum capacity for the last few months of the study. The problems were pointed out to the Company, and it was requested that more accurate data be provided. The Company did not do so, and suggested further discovery. After additional requests were made, the Company still did not provide accurate data and indicated it would not stand by the data it provided.[82] .

**Resolution of Data Quality Problems**

Based on the above referenced responses provided by the Company in discovery, it was apparent they would not stand by any of the 2010 data supplied, nor supply corrections. To validate the data, the ten minute observations were tested against hourly logs to determine if there were discrepancies. For the resources tested, significant errors were apparent in only a few percent of the data once problems with time synchronization (such as daylight savings time or time zones) were accounted for. Problems were apparent for High Plains, Wolverine and Marengo. As discussed above, the problem with High Plains was simple to deal with by scaling

[82] WIEC 7.4, Docket No. 20000-389-EP-11

the results for McFadden, albeit at the likely cost of overstating integration requirements. For Wolverine and Marengo, the hours when the hourly average of ten minute data deviated by more than 10% from the hourly generator logs were identified.[83] Data for those hours were based on the hourly average. Analysis indicates this is a reasonable approximation for limited applications such as this.

While any remaining data quality problems are a concern, the likely impact is to increase the variability of the time series data. Consequently, they would tend to overstate reserve requirements and in turn NPC. In the end, the more that actual data were relied upon, the lower the integration requirements tended to be, even with the Moving Block Bootstrap simulation technique.

**<u>Results of 2009 and 2010 Analysis</u>**

Table OCS 4.3-2 below shows the System Regulating Margin Requirement is 418 to 425 MW, some 100 MW less than assumed by the Company. The results for the 2009 and 2010 data are within a few percent. For GRID modeling purposes, the average, 421.5 MW was used. These results were based on the actual 2010 CPS2 results of 95.5%. This was the actual CPS2 for the PCAM test period and substantially exceeds the WECC 90% requirement. Use of this regulating margin requirement produces Adjustment 1 shown on Exhibit OCS 4.2 and is included in Adjustment 1 on Table 1 of my direct testimony.

[83] For Wolverine, no adjustment was needed prior to October 2010. Simply using the original data produced a change in integration requirements of 1 MW or less.

**Table OCS 4.3-2**
**Wind Integration Results**

| Scenario/Data Period Ending | CPS2 | PACE MW Reg. Reqmt. | CPS2 | PACW MW Reg. Reqmt. | CPS2 | System MW Reg. Reqmt. | NPC ($M) Change*** |
|---|---|---|---|---|---|---|---|
| Dec. 31, 2009 | 95.3% | 267 | 95.6% | 151 | 95.5% | 418 | $ - |
| Nov. 30, 2010 | 95.3% | 275 | 95.6% | 150 | 95.5% | 425 | $ - |
| Nov. 30, 2010* | 95.3% | 282 | 95.6% | 157 | 95.5% | 439 | $ 1.76 |
| Company Study** | 97.0% | 337 | 97.0% | 196 | 97.0% | 533 | $ 11.41 |
| Additional Corrections | 97.0% | 241 | 97.0% | 136 | 97.0% | 362 | $ (4.97) |
| Company Study @ 90 | 90.0% | 237 | 90.0% | 140 | 90.0% | 377 | $ (5.17) |

***Included Non-Owned (Long Hollow, SCL and Campbell)**
****( 746-700 23 C.8 - Public Record)**
*****As compared to OCS proposed results**

Table OCS 4.3-2 also shows results for Nov. 30, 2010 based on including the non-owned wind farms that do not compensate PacifiCorp for integration services: Long Hollow, a small portion of Stateline, and the new Campbell wind farm. Modeling these projects would increase reserve requirements by only 19 MW and NPC by only $1.63 million on a total Company basis, based on their actual 2010 output.

**Contingency Reserves**

The 5% contingency reserves modeled in GRID amounts to a double counting of requirements. The primary purpose of contingency reserves is to cover forced outages. However, the actual and simulated wind energy data already reflects the variability due to actual outages at wind farms.[84] In the June 21, 2010 meeting, Dr. Milligan questioned the need for

[84] See WPSC Docket 20000-384-ER-10, WIEC 8.7

contingency reserves.[85] Because wind projects consist of dozens of independent turbines, each with fairly low outage rates, the likelihood of losing a large amount of output at once is very small. The 5% requirement will always be more than satisfied based on the regulating reserves included above. Reversing the 5% contingency reserves produces Adjustment 2 shown on Exhibit OCS 4.2 and is included in Adjustment 1 on Table 1.

**Additional Results Based on Experts' Recommendations**

An additional analysis was performed to address the most significant expert criticisms that the Company ignored in its Wind Study. This analysis relied on the Company's study to implement these corrections. First, only data from the Company's 2009 simulations were used in order to minimize (though not eliminate) dependence on the simulated data. The double counted wind farms were removed as well.[86] Second, the load and wind data was combined into a single analysis, and the load net wind Load Following and Regulation errors were computed. The double counting of reserves was addressed by selecting the largest error in any ten minute period (whether Load Following or Regulation) instead of using the equation the experts objected to. These corrections result in a total Load and Wind regulating margin requirement of 362 MW or about 170 MW less than assumed by the Company. However, this result still assumed a 97% CPS2 result, so it is arguably conservative. Finally, reliance on the Company's simulated data further serves to bias the results.

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85 *"Wind does not change quickly enough to constitute a contingency reserve, which is typically modeled as capacity that is "set aside" and never used…"* PacifiCorp note from June 21, 2010 meeting with NREL.

86 Because the Company refused to acknowledge the Rock River double count until late into the process, I was unable to make that correction. .

Table OCS 4.3-2 also shows results based on a 90% CPS2 target using the Company study uncorrected. The 90% CPS2 scenario is useful for comparison purposes as it illustrates the importance of the CPS2 assumption in the analysis. It demonstrates that even with all the reductions to reserve requirements suggested by the experts, the results would be quite similar to use of the Company study with CPS2 at 90%.

**Conclusions**

This analysis documents and supports several important conclusions. First, the PacifiCorp 2010 Wind Integration Study is seriously flawed and overstates regulating margin requirements by approximately 100-170 MW. Second, much of this bias is the result of the Company's reliance on unrealistic simulated wind generation data. Third, the Company's must-run assumptions for the Gadsby CTs are unsupported and contrary to actual operations. The must-run assumption for Currant Creek is only partially correct. Fourth, the Company failed to take advantage of the comments and suggestions made during the collaborative process which would have helped it to avoid numerous problems and biases in its study. Finally, the Commission should require the Company to organize a Technical Review Committee to direct its future wind integration studies and require the Company to produce accurate ten minute wind generation data for all projects it includes in the test year.