EXH. PKW-20C
DOCKETS UE-22___/UG-22___
2022 PSE GENERAL RATE CASE
WITNESS: PAUL K. WETHERBEE

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, **Complainant,** **v.** **PUGET SOUND ENERGY,** **Respondent.**	**Docket UE-22____** **Docket UG-22____**

NINETEENTH EXHIBIT (CONFIDENTIAL) TO THE PREFILED DIRECT TESTIMONY OF

PAUL K. WETHERBEE

ON BEHALF OF PUGET SOUND ENERGY

REDACTED VERSION

JANUARY 31, 2022

Puget Sound Energy
Collaborative on Wind Forecasts for Ratemaking
UE-190529 & UG-190530
March 2021

Introduction

In Puget Sound Energy's (PSE) 2019 general rate case, the Washington Utilities and Transportation (Commission) ordered PSE to hold collaborative discussions with the Commission Staff (Staff) regarding production from PSE's wind generation resources. The specific requirement in the order was:

> "Although we agree with Staff that the Company should investigate the root cause of its declining output with the dual goal of generating more accurate forecasts and producing more wind power, we decline to adopt Staff's recommendation to impose a moratorium on capacity factor changes in the AURORA model. We do, however, expect PSE to work collaboratively with Staff prior to its next GRC to examine whether other issues may be contributing to declining output at its facilities, including maintenance practices and turbine degradation."[1]

In response to this order, PSE held a series of workshops with two members of Commission Staff. These meetings were held online on January 20, February 10, March 17, and March 26, 2021.

January 20 Workshop

The agenda of the January 20, 2021 meeting was:

1. Review purpose of the collaborative based on the 2019 general rate case order;
2. Hear from UTC Staff about specific concerns related to resource performance, and develop an issues list;
3. Establish a plan for completing the collaborative in the first half of 2021; and
4. Review historical generation.

The outcome of the first meeting was agreement as to the timeline and subject matter to be covered in the collaborative. The group agreed to a target completion date of June 1, 2021 and agreed to these five goals:

1. Address the differences between preconstruction annual energy forecasts and actual generation, a common issue industry wide;
2. Better understand the inputs, assumptions and outputs of the 2016 Vaisala forecasts;
3. Discuss how often long-term wind forecasts should be reviewed and revised;

[1] Dockets UE-190529 & UT-190530, Final Order 08 at 249.

4. Identify the differences between short-term and long-term forecasts and how they should be used; and
5. Evaluate the current forecasts against actual generation.

Subsequent to the January 20 meeting, PSE provided Staff with some industry reading related to wind generation forecasting. Specifically, these documents were:

1. Paper titled "Examining Project Underperformance," American Wind Energy Association WINDPOWER 2006 Conference by Steve Jones, Director of Utility and Investor Services and Gordon Randall, Senior Data Analyst at Global Energy Concepts, June 5, 2006;
2. Paper titled "Framework for the Categorisation of Losses and Uncertainty for Wind Energy Assessments" by DNV KEMA Energy & Sustainability; and
3. Presentation titled "How Have Projects Performed? Comparing Performance with Pre-Construction Energy Estimates," AWEA Wind Resource Assessment Workshop by Steve Jones of Global Energy Concepts, September 18, 2017.

February 10 Workshop
Items on the agenda for the February 10 meeting were:

1. Wind forecast data and modeling;
2. Wind forecasting time horizons;
3. Pre-construction estimates vs. actuals;
4. 2010 DNV loss calculations; and
5. 2016 Vaisala forecasts.

Information discussed at the February 10 meeting included the following items.

- Forecasters use different methods and data depending on the time horizon of the forecast. Pre-construction wind forecasts rely mostly on long-term climatology and do not incorporate shorter term oscillations or the effect of climate changes.
- Preconstruction forecasts are based on a compilation of historical data from different sources, including 2-5 years of data from meteorological towers and longer term historical data from sites closer to the ground. The ground data is statistically compared to the onsite data for correlation. Data from these sources are compiled into long-term synthetic wind speed data series (wind speed estimates). These estimates are not forward looking and do not account for climatological changes over time.
- PSE's wind production did not meet pre-construction energy estimates due to several factors not considered in the original pre-construction wind energy assessment. Pre-construction energy estimates did not adequately account for the impact of location bias for wind measurement equipment or for various losses that accrue from environmental factors (e.g., high/low temperatures, icing, extreme wind speeds), parasitic factors (e.g., electrical line loss), operational factors (e.g., blade fouling, wake management, yaw error) and offsite outage events (e.g., transmission outages or curtailments, wildfires).
- The fact that actual generation has been below estimates in preconstruction forecasts has been observed throughout the industry.

- In 2010 PSE retained DNV to:
    - Review historical production data of PSE resources
    - Reevaluate production loss calculations with current assumptions
    - Revise annual energy production estimates.
- The DNV contract did not account for the impacts of known atmospheric oscillations on local wind speed, nor did it account for impacts from climate change. DNV's analysis provided improved energy loss estimates based on then-current industry best practices.
- DNV adjusted the preconstruction forecasts downward based on their updated production loss estimates. Subsequent to the 2010 DNV forecast, PSE's actual wind generation was closer to forecast, but still consistently below.
- In 2016 PSE retained Vaisala to
    - Normalize the actual production dataset
    - Review long-term climate variability
    - Evaluate site wind speeds on 15 km resolution
    - Calculate turbine production with new wind speeds
    - Review and correct for historical availability and curtailment
- Vaisala compared 80 months of actual production to a 36 year synthetic data series and included the possibility of future climate varying from the historical climate.
- Actual wind production is now much closer to the revised forecast, and PSE does not currently see a need to update again.

The February 10 workshop covered the information required by the five goals established at the first workshop. At the end of the meeting Staff requested additional information about the performance of PSE's wind facilities, specifically the challenges associated with performance and how performance is improved and measured.

March 17 Workshop
Items on the agenda for the March 17 meeting were:

1. Maintenance delivery practices;
2. Performance metrics and monitoring;
3. Major component failure history.

Information discussed at the March 17 meeting included the following items.

- Wind turbines are not typically dispatched individually, but rely upon their onboard control system to start or stop generating in accordance with the prevailing local wind speed and ambient condition (e.g., temperature).
    - The turbines will automatically operate in the range of 3-25 meters/second wind speed.
    - The turbines can be controlled to a set point via the facility controller, and/or individual turbines can be shut down for maintenance purposes.
- Wind farm maintenance is broken into multiple zones, including the turbines, balance of plant, and building, roads, and grounds. Each maintenance zone may have a different service provider and delivery mechanism.
    - For PSE, turbine maintenance is performed by the turbine manufacturer under the terms of a long-term contract.

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  - Balance of plant maintenance may be performed by PSE or a contractor, depending on the facility location and distance from a PSE base.
  - Buildings, roads, and grounds are maintained by local contractors.
- Turbine maintenance agreements with the service providers are "full wrap" agreements, meaning that all routine maintenance and inspection, corrective maintenance and equipment replacements, certain equipment upgrades, and a skilled labor force are provided for a fixed annual price.
  - The annual price paid for services under these agreements does not vary with the services performed. The annual price puts the risk of equipment failure and replacement squarely on the service provider in a "warranty-like" agreement.
  - Performance incentives are included in the agreements to encourage the service provider to pursue services in a manner that minimizes the impact on production.
  - PSE intends to pursue competitive bids from select service providers when the current maintenance agreements reach their end dates.
- Service provider incentives may be based on annual energy production or on the percent availability during times when there is sufficient wind to produce energy.
  - Availability incentives are the most common in the wind industry.
  - Each type of incentive is successful in securing timely and effective maintenance services.
- Major component replacements go in waves with some years with relative few and other years with many. Overall, component replacements vary considerably between the wind facilities.
  - Hopkins Ridge has seen the highest overall number of gearbox replacements, while Wild Horse has had the highest number of generator replacements.
  - Lower Snake River has not had high replacements of any individual component, although the numbers are starting to trend up somewhat with more time in service.
  - Lower Snake River has also experienced a few main bearing replacements. The turbine used there has a single main bearing, while turbines at Hopkins Ridge and Wild Horse have two main bearings to share hub loads.
  - None of PSE's facilities has required blade replacements.
  - Major component replacements are scheduled to cause minimal impact and do not necessarily result in lost energy production.
- The availability factor for an electric generating plant is the amount of time the plant is ready to produce (or producing) electrical energy in a given period, expressed as a percentage of total time in the period. Thus, if the plant was ready to produce electrical energy for 46 hours in a 48 hour period, its availability would be 95.8%.
- The target for turbine availability performance is [redacted]%, and each of the wind farms has stayed close to that target, with the exception of Wild Horse in 2020.
  - PSE is working with the service provider to identify and resolve the controllable causes of this lower availability, and it is not expected to further decline.
  - Some of the lower availability at Wild Horse in 2020 can be attributed to local wildfires, and the impact of smoke from the California wildfires. At times, worker safety required the facility to be secured (shut down) and personnel were sent home.

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  - Another contributing cause of lower availability at Wild Horse (and higher equipment replacement rates) is the challenging wind regime at the site. Wild Horse is located in hilly terrain with complex ground effects causing high turbulence and increased turbine waking than with a flatland wind farm.
  - There has been lower performance in certain years due to the impact of serial defects, force majeure events like lightning, or challenges of the wind regime. Problems related to serial defects identified early on have been resolved.
- The target for turbine forced outages is [redacted]%, and each of the wind farms has stayed close to that target, again with the exception of Wild Horse in 2020.
  - High forced outage rates are being discussed with the service provider in an effort to resolve any controllable issues.
  - Again, the challenging wind regime at Wild Horse may also be a factor in forced outages as with turbine availability.

March 26 Workshop

Items on the agenda for the March 26 meeting were:

1. Review original five goals of collaborative and whether they have been achieved;
2. Identify conclusions of collaborative;
3. Review draft summary document; and
4. Plan for finalizing and signing off on summary document.

Conclusions

PSE and Commission Staff in the collaborative workshops reached the following conclusions.

1. PSE's 2016 Vaisala wind forecasts provide reasonable estimates of the normalized generation[2] from PSE's wind facilities, and their use in power cost projections in future general rate cases and power cost only rate cases is appropriate.
2. PSE's wind production did not meet pre-construction energy estimates due to several factors not considered in the original pre-construction wind energy assessment. Pre-construction energy estimates did not adequately account for the impact of location bias for wind measurement equipment or for various losses that accrue from environmental factors, parasitic factors, operational factors and offsite outage events.
3. The DNV analysis of 2010 provided improved energy loss estimates based on then-current industry best practices, but DNV did not account for the impacts of known atmospheric oscillations on local wind speed, nor did it account for impacts from climate change.
4. The Vaisala analysis of 2016 built on the DNV forecast to account for variable weather conditions and historical production, and has proven to be an accurate long-term wind forecast.
5. PSE does not have a predetermined time frame for updating long-term forecasts, and a predetermined time frame is not necessary. PSE could revisit the forecast if the variation between forecast and actual production widens due to plant economics, and/or climatological or other factors outside management control.

[2] Use of normalized long-term wind forecasts is consistent with the use of normalized long-term hydro generation in power cost projections.

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6. Energy generation at PSE's wind resources does not show a declining trend. It has varied from year to year and the long term average is slightly below the 2016 Vaisala forecast as indicated in Figure 1. This is illustrated for each of the resources individually in Figures 2-5.

Figure 1: PSE Annual Wind Energy Production 2007-2020

Figure 2: Hopkins Ridge Annual Wind Energy Production

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Figure 3: Wild Horse Annual Wind Energy Production

Figure 4: Wild Horse Expansion Annual Wind Energy Production

Figure 5: Lower Snake River Annual Wind Energy Production

7. Metrics for turbine availability and forced outages are generally staying close to targets for all three wind farms.
    a. No substantive reduction or downward trend in monitored performance metrics has been identified with time in service.
    b. Average annual availability performance, measured through the life of the facilities, is above 97% for all three facilities
        i. Hopkins Ridge average is REDACTE[redacted]%
        ii. Wild Horse average is REDACTE[redacted]%
        iii. Lower Snake River average is REDACTE[redacted]%.
8. PSE manages its costs and risks effectively by having maintenance agreements with or service providers that place the risk of equipment failure and replacement on the service providers in "warranty-like" agreements.