EXH. PKW-21
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____**

TWENTIETH EXHIBIT (NONCONFIDENTIAL) TO THE PREFILED DIRECT TESTIMONY OF

PAUL K. WETHERBEE

ON BEHALF OF PUGET SOUND ENERGY

JANUARY 31, 2022

Clearwater Wind Integration Study Report

Puget Sound Energy

December 2021

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In 2020, Puget Sound Energy (PSE) contracted Energy and Environmental Economics, Inc. (E3) to determine how bringing new renewable plants online might affect their balancing area's (BA) need for ancillary services.

PSE is a member of the real-time Western Energy Imbalance Market (EIM).[1,2] The EIM allows PSE to purchase and sell electricity with other Balancing Authorities (BAs) to reduce annual costs.[3] In order to be able to purchase and sell electricity in the EIM, BAs are required to pass several real-time resource sufficiency tests. These tests include showing that the BA has sufficient flexibility on internal resources to manage unexpected changes in their net load (load minus wind minus solar) relative to what was forecast ahead of the hour, when entering the EIM. The EIM dictates the amount of flexibility that BAs must hold to cover net load forecast error via a flexibility product known as the EIM's flexible ramping product (FRP).[4] Forecast error can be affected by both net load changing rapidly within an hour and uncertainty, in that forecasts are imperfect in anticipating what load, wind and solar output will be for each minute of the upcoming hour. If a BA does not have enough flexibility to meet the FRP in a given EIM market interval, they are not allowed to buy or to sell in the EIM in that interval, thus reducing the BA's potential net monetary savings.

[1] https://www.westerneim.com/Pages/About/default.aspx
[2] https://www.powermag.com/how-does-the-western-energy-imbalance-market-work/
[3] https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx
[4] http://www.caiso.com/informed/Pages/StakeholderProcesses/CompletedClosedStakeholderInitiatives/FlexibleRampingProduct.aspx

PSE contracted with E3 to determine how the Clearwater Wind phase 1 project would affect PSE's flexible ramping needs. E3 developed its RESERVE model[5] to derive ancillary services needs in heavily renewable electricity systems. RESERVE can model the uncertainty component of the 15-minute EIM market FRP in an approximate fashion using load, wind and solar forecast data and actual data.

At the time E3 performed the study, the Clearwater Wind facility was not operational, and the Skookumchuck wind plant was under construction. Therefore, E3 developed simulated wind plant production data for all of PSE's wind plants expected to be online in 2023 using a National Renewable Energy Laboratory (NREL) database.[6] This simulated wind data included time-correlated values for PSE's forecast and actual wind output at each project location, with actual data available in every 5-minute interval, as well as an hour-ahead forecast of hourly wind output. E3 benchmarked the NREL wind profiles to actual operational data for existing PSE plants and adjusted the capacity factor and mean average error of all the simulated wind plants to match observed and projected data provided by PSE. E3 also acquired historical PSE forecast and actual load for the same time window as the wind forecasts and scaled it to projected 2023 levels of load using the ratio of historical to 2023 annual energy consumption to account for expected PSE load growth.

[5] https://www.ethree.com/tools/reserve-model/
[6] https://www.nrel.gov/grid/wind-toolkit.html

E3 then ran two cases with this data to calculate PSE flexible ramping requirements using RESERVE: 1) the base-case portfolio of PSE wind resources (which excluded the Clearwater Wind facility, but included Skookumchuck, Vantage, and Wild Horse wind) and PSE load, and 2) this base case portfolio *plus* the Clearwater Wind facility. By comparing the two cases, E3 is able to assess the increase in FRP for each time interval that would occur as a result of adding Clearwater Wind.

At the time of the study, Clearwater Wind 1 was expected to be a 375 MW facility, though PSE is now planning to be an offtaker for only 350 MW of wind from Clearwater Wind 1. As a result, E3 scaled down the incremental reserves needs by the ratio of 350 MW over 375 MW. While the FRP is a net load-based product, there is generally minimal covariance between wind and load uncertainty. As a result, E3 believes this is not an approximation that will have a large effect on the results of planning analyses involving Clearwater Wind 1.

The scaled increase in FRP uncertainty component headroom and footroom needed to accommodate Clearwater is shown in Table 2 and Table 1 on a month-hour average basis. With the addition of the 350 MW Clearwater Wind plant, E3 estimated that annual average headroom needed for FRP uncertainty increased by 40 MW, and the annual average footroom increased by 45 MW. Together **this result implies that the normalized *total* growth (headroom + footroom) is 24% of**

Difference in Average Modeled CAISO FRP Headroom (MW)																									
	Hour of Day																								Month Avg
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1	30	5	9	20	-2	-1	5	-4	12	12	47	34	32	45	22	23	11	4	33	19	35	26	16	22	19
2	17	5	9	10	23	16	29	40	29	30	9	25	19	5	24	17	6	1	-21	37	69	23	18	8	19
3	13	16	25	24	36	43	46	59	67	54	29	20	42	7	15	28	62	11	21	31	40	15	17	30	31
4	64	53	61	37	22	43	59	77	71	43	58	41	46	49	32	54	42	71	44	35	32	22	23	41	47
5	47	45	40	42	55	71	68	40	60	34	17	40	51	68	46	18	27	67	57	40	6	23	46	77	45
6	56	97	47	14	56	85	85	39	47	32	38	33	46	53	50	41	69	69	84	57	52	52	50	19	53
7	48	84	85	60	97	85	89	37	48	39	36	34	69	63	31	33	56	72	134	81	77	49	60	62	64
8	80	120	66	49	55	48	70	74	42	31	43	27	37	34	54	83	95	110	106	78	80	73	81	89	68
9	33	71	39	36	31	45	61	90	103	63	10	21	61	44	30	49	67	70	70	41	19	46	86	54	52
10	35	41	39	13	24	14	20	39	84	69	35	31	7	19	34	34	31	29	24	25	29	27	27	25	31
11	20	15	47	17	20	31	38	28	40	47	61	41	14	41	24	13	5	-1	17	27	11	17	16	51	27
12	38	10	23	26	36	41	16	6	8	51	44	2	9	23	22	26	13	27	27	23	44	41	39	39	26
Hr Avg	40	47	41	29	38	43	49	44	51	42	36	29	36	38	32	35	40	44	50	41	41	35	40	43	40

Table 2: Difference in Modeled CAISO 15-Minute Flexible Ramping Product Headroom with the Addition of 375 MW Clearwater Wind Facility

Difference in Average Modeled CAISO FRP Footroom (MW)																									
	Hour of Day																								Month Avg
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1	34	65	39	39	37	28	14	8	12	17	4	42	46	31	26	50	43	40	68	51	40	23	25	51	35
2	67	34	35	19	20	24	27	4	11	16	36	32	7	34	65	21	69	54	43	69	43	37	54	64	37
3	71	29	23	51	43	18	18	16	5	13	15	-27	-14	3	9	1	40	70	79	71	51	29	77	109	33
4	75	77	58	57	68	84	63	64	20	44	82	52	28	29	8	17	-6	11	41	79	87	66	72	89	53
5	33	65	52	60	57	37	12	18	44	20	9	20	6	14	25	47	61	90	58	52	56	59	66	71	43
6	49	69	79	51	16	9	2	32	88	25	80	80	41	44	27	106	74	69	85	88	44	49	69	46	55
7	76	67	65	45	44	12	18	10	42	60	38	27	4	9	68	163	123	88	81	68	75	82	62	51	57
8	85	80	53	78	54	17	21	50	37	85	78	27	61	46	75	102	151	85	124	75	72	43	71	64	68
9	33	64	71	59	41	39	47	17	-3	29	30	38	49	18	21	33	27	66	59	68	60	78	50	57	44
10	67	56	56	17	16	14	32	19	16	2	18	14	6	15	-8	14	56	49	84	60	51	46	39	58	33
11	25	32	50	32	27	19	16	29	18	20	16	49	40	23	13	66	63	45	10	35	18	32	56	50	33
12	34	25	58	67	62	38	41	38	42	36	25	53	40	41	48	50	42	69	56	50	44	30	23	42	44
Hr Avg	54	55	53	48	41	28	26	25	28	31	36	34	26	25	31	56	62	61	66	64	54	48	55	63	45

Table 1: Difference in Modeled CAISO 15-Minute Flexible Ramping Product Footroom with the Addition of 375 MW Clearwater Wind Facility

the nameplate capacity of Clearwater Wind (40 MW average headroom + 45 MW footroom divided by 350 MW wind nameplate capacity). As the table indicates, the largest increase in modeled FRP headroom and footroom needs occurs in summer

months, but the overall increase is relatively evenly distributed throughout the year.