BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

In the Matter of the Complaint by Juhl Energy LLC against NorthWestern Corporation dba NorthWestern Energy for Establishing a Purchase Power Agreement	Docket EL16-021

PREFILED RESPONSE TESTIMONY

OF LUKE P. HANSEN

ON BEHALF OF NORTHWESTERN ENERGY

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Witness Information

Q. Please state your name and business address.

A. My name is Luke P. Hansen, and my business address is 11 East Park, Butte, Montana 59701.

Q. By whom are you employed and in what capacity?

A. I am employed by NorthWestern Energy ("NorthWestern") as an analyst in Energy Supply.

Q. Please summarize your educational and employment experiences.

A. I graduated from Montana Tech in 2003 with a Bachelor of Science degree in Business and Information Technology. Prior to joining NorthWestern, I was a supervisor of Gas Supply at Cascade Natural Gas. I joined NorthWestern in November 2013 as an Energy Supply Analyst. In this position, I assist in the development of the Electric Supply Resource Procurement Plans for NorthWestern's service territories and the Montana Renewable Portfolio Standard Compliance filing. I am the NorthWestern employee who is trained to use the PowerSimm™ ("PowerSimm") software with which NorthWestern models its electricity supply.

Purpose of Testimony

Q. What is the purpose of your testimony in this docket?

A. I describe the PowerSimm modeling software, explain why NorthWestern chose PowerSimm™ to model its electric supply portfolios, and rebut Juhl Energy, Inc. ("Juhl's") witness, Roger Schiffman's assertions about the transparency of the PowerSimm model. I identify and support the avoided cost energy rate that NorthWestern calculated for the Juhl's proposed Qualifying Facility ("QF") projects ("Projects") using the PowerSimm model and discuss other issues that affect and influence the avoided cost rate for energy sold by QFs.

<u>PowerSimm Model</u>

Q. What is PowerSimm?

A. PowerSimm is software that NorthWestern uses to model costs and risks to its portfolio. PowerSimm uses a stochastic modeling approach that considers uncertainty to quantify the effects of variation in load, renewable generation, and market prices on a simulated portfolio. The modeling simulations are performed on an hourly time series in order capture the changes that renewable generation and market prices have in relation to NorthWestern's portfolio.

Because weather and load, weather and renewable generator output, and weather, load, renewable generation and commodity prices have historical relationships and are dependent on each other, PowerSimm maintains the structural relationships that have been observed in the historic data throughout the simulation process. Maintaining those structural relationships allows PowerSimm to probabilistically quantify the variability in simulated future conditions. PowerSimm models the impact of load variability, renewable generation, and market prices on the distribution of possible portfolio-level costs.

PowerSimm models load, renewable generation units, thermal generation units, and commodity prices. The simulation engine starts with weather, which drives load and renewable generation. The load and renewable generation determine the spot prices, which in turn drive the economic dispatch of thermal generation units. The difference between total thermal and renewable generation load determines a net position of the portfolio.

NorthWestern employs PowerSimm to model all new electric energy resources, including company-owned, power purchase agreements, and QFs, for inclusion in NorthWestern's portfolios. PowerSimm performs unit level simulation that is aggregated to a portfolio level. The unit level simulation allows NorthWestern to model the effect that alternative resources have on its energy supply portfolio and allows for detailed analysis of potential additional resources to the portfolio.

Q. Why does NorthWestern use PowerSimm instead of more common generation and transmission modeling software?

A. Previously, NorthWestern used GenTrader® for resource planning and evaluation. In its comments on NorthWestern's electric resource procurement plans for 2007, 2009, and 2011, the Montana Public Service Commission ("MPSC") questioned the use of GenTrader®. When it began preparing its 2013 Montana electricity resource procurement, NorthWestern contacted software vendors and evaluated the capabilities of many alternatives. NorthWestern chose PowerSimm™ ("PowerSimm") from Ascend Analytics ("Ascend") because of the capability of the model, the consulting ability of Ascend Analytics, the validation steps that Ascend performs, and the vendor support Ascend offers.

Q. What specific characteristics of PowerSimm led to NorthWestern's choice?

A. Several characteristics of PowerSimm stood out. First, it incorporated stochastic uncertainty better than the alternatives. It uses and provides an expanded set of variables. NorthWestern felt it provided the most robust solution for modeling load, supply portfolio resources, commodity prices, and portfolio costs while maintaining fundamental relationships between these variables and weather.

<u>NorthWestern's Current Avoided Cost</u>

Q. Describe the inputs NorthWestern used to model Juhl Wind's proposed projects.

A. The inputs entered into PowerSimm are historic weather, historic load, historic commodity prices for energy, coal, natural gas, historic hourly and forecasted monthly peak and total renewable generation, thermal generation attributes, projected load growth, and projected commodity prices for natural gas, electricity, and coal. These inputs are described in more detail below.

The inputs for NorthWestern's load are hourly historic load and forecasted monthly peak and demand values for its South Dakota service territory. The historic hourly load determines the load shape to match forecasted monthly demand and peak demand values throughout the simulation process. NorthWestern forecasts its monthly load by escalating the historical demand profile by projected future growth.

Renewable generation units include the wind resources that are either contracted for or owned by NorthWestern. Each renewable asset is defined by its historical hourly production profile and monthly peak and total generation projection. The hourly generation provides the daily production profile throughout the simulation. The monthly forecasts are the average of the historical monthly generation and the peak production is defined by the monthly historical peak generation.

The thermal generation units included in this calculation are the thermal generation resources that are in NorthWestern's energy supply portfolio. The thermal generation units' resource definition consists of startup costs, ramp rates, outage history, heat rates, emissions, and fuel delivery costs. The unique operating characteristics and costs of each thermal resource are reflected through the parameters that are defined in PowerSimm allowing the model to accurately dispatch or utilize such resource.

Table 1 below lists all of the generation assets entered into the model for NorthWestern's portfolio.

Table 1

South Dakota Supply Portfolio					
		Max. Delivery (MWh)	Avg. Delivery (MWh)	Min. Delivery (MWh)	
Wind	Titan (non-dispatchable)	25	11	0	PPA
	Oak Tree (non-dispatchable)	20	8	0	PPA
	Beethoven (non-dispatchable)	76	33	0	Owned
Coal	Neal 4 (Must Run)	17	17	17	Contracted Min
	Coyote (Must Run)	20	20	20	Contracted Min
	Big Stone (Must Run)	44	44	44	Contracted Min
	MUST RUN	**202**	**133**	**81**	
Coal	Neal 4 (Dispatchable)	41	33	0	Avg Heat Curve
	Coyote (Dispatchable)	23	15	0	Avg Heat Curve
	Big Stone (Dispatchable)	67	11	0	Avg Heat Curve
Peaking	Aberdeen #2	58	1	0	Full Load
	Huron #2	40	0	0	Full Load
	Huron #1	10	0	0	Full Load
	Aberdeen #1	20	0	0	Full Load
	DISPATCHABLE	**259**	**60**	**0**	
	Total Supply	**461**	**193**	**81**	

Finally, commodity prices for natural gas, electricity, and coal are developed and entered into PowerSimm. The market price forecasts for natural gas and electricity are a combination of current forward market prices and the application of long-term price escalation factors. NorthWestern projected natural gas prices by starting with Intercontinental Exchange ("ICE") forward market quotes through October 2017 and escalated them forward at the annual escalation rate from the 2016

Energy Information Administration ("EIA") Annual Energy Outlook ("AEO") for natural gas. NorthWestern projected market prices for electricity by using ICE quoted prices December 2018 and then escalated those values at the 2016 EIA AEO escalation rate for natural gas. NorthWestern uses the natural gas escalation rates to forecast its electric price to maintain consistency in escalation factors and because natural gas generation is often the marginal unit in the market. NorthWestern used natural gas and electricity price quotes from the October 4, 2016 ICE forward market prices in this docket.

NorthWestern used its internal coal price forecasts for Big Stone, Coyote, and Neal. The internal coal forecasts for Coyote, Big Stone and Neal extend to 2021, 2024, and 2025 respectively. For periods after the end of the internal forecasts, NorthWestern escalated the projected prices using the 20-year average inflation escalator for Gross Domestic Product as provided by the U.S. Bureau of Economic Analysis.

Q. What happens after the inputs are uploaded in the PowerSimm™ modeling?

A. PowerSimm calculates the hourly dispatch of NorthWestern's supply portfolio. The model performs 100 simulations for every hour of the 20-year period. First, PowerSimm simulates weather. Then the model uses the simulated weather to simulate load and renewable generation output.

The historical relationships between weather and load and weather and renewable generation are maintained throughout the simulation process. Using weather, load, and renewable generation output, PowerSimm simulates market prices. Using market prices, the model economically dispatches the thermal generation units. The model calculates the net position—i.e. whether the portfolio needs energy or has an excess of energy—using the total output of the thermal and renewable generation units and load. The same process is repeated with Juhl's projects added to NorthWestern's supply portfolio.

Q. How do the simulation results lead to the calculation of the avoided energy cost?

A. NorthWestern compares the net position of the existing supply portfolio without the Projects to the net position of the supply portfolio with them to determine their effect on NorthWestern's supply portfolio. For example, if the Projects deliver energy to NorthWestern when NorthWestern's supply portfolio is short (i.e. generation is less than load), the avoided energy cost is the market purchase price of electricity that NorthWestern would otherwise have purchased. Alternatively, if the Projects deliver energy to NorthWestern when NorthWestern's supply portfolio is long (i.e. generation is greater than load) and the market price is higher than the variable cost of the highest economically dispatchable resource used to serve load, the avoided energy cost is the variable cost of the dispatchable resource that was serving load. Finally, if the Projects deliver energy to NorthWestern when NorthWestern's supply portfolio is long and the market price is lower than the variable cost of any dispatchable resource, the avoided energy cost is zero. The LaFave Response Testimony supports why it is appropriate to attribute no avoided cost value to Juhl Wind production under this scenario.

Table 2 below summarizes the different supply portfolio conditions under which Juhl Wind could deliver energy to NorthWestern and the avoided energy cost rate that NorthWestern would pay it under each scenario.

Table 2

Condition	Condition Definition	Avoided Cost energy rate paid for Crazy Mountain
Situation 1	Generation < load.	Market purchase price
Situation 2	Generation > load and market price> avoidable resource with the highest variable cost.	Variable costs of the dispatchable resource with the highest variable costs
Situation 3	Generation > load and market price < variable cost of the avoidable resources.	Zero

To summarize, the Projects' monthly production that offsets purchases is multiplied by the corresponding market purchase price to determine the amount paid to Juhl during this condition. The Projects' production that occurs when NorthWestern's net position is long i.e., has excess generation, is totaled for each month and is multiplied by the variable cost of the highest cost dispatchable resource during times when the market sales price is higher than the variable cost of the highest cost dispatchable resource to determine the amount paid to Juhl. The Projects' monthly production delivered during times that the portfolio is long and the market sales price is lower than the variable cost of any dispatchable resource is valued at zero because it does not allow NorthWestern to avoid any cost.

Next, NorthWestern totals monthly avoided cost energy values for the Projects for each year and divides the total by their yearly annual production to calculate an annual avoided cost energy rate for the Projects. NorthWestern then calculates the net present value of this stream of annual rates and levelizes it over 20 years to determine the Projects' avoided energy cost rate for this filing.

Q. What is the cost for energy that NorthWestern can avoid by purchasing the output of the Juhl Wind projects?

A. The cost for energy that NorthWestern can avoid by purchasing the output of the Projects is $28.49 per megawatt-hour ("MWh") for the contract term of 2017-2036. Recent information from SPP has made a 2017 commercial operation date unlikely and due to this, NorthWestern is also providing a levelized rate for energy from 2018-2037. The levelized energy rate for the contract term of 2018-2037 is $29.63 per MWh. Both rates are 20-year levelized rates. Exhibit__(LPH-1) details this calculation of the avoided cost using the PowerSimm modeling for both contract terms of 2017-2036 and 2018-2037.

Q. Why did NorthWestern use the October 4, 2016 ICE forward prices as the basis for the natural gas and electric price forecasts used in this docket?

A. As described and supported in the Prefiled Response Testimony of Bleau J. LaFave ("LaFave Response Testimony"), Juhl has not established a legally enforceable obligation. Given this fact, in order to obtain the most current information for purposes of calculating an avoided cost rate, NorthWestern selected the date closest to when NorthWestern's testimony was due that allowed adequate time for NorthWestern to run the model and prepare the corresponding testimony.

Q. Why are the forecasts NorthWestern proposed for natural gas and electricity prices appropriate to use in this case?

A. The natural gas and electric forecasts used in this docket are a combination of near term market transactions and long-term escalation rates. NorthWestern bases the forecasts on real market prices and the EIA forecasted escalation rate. These forecasts represents the most current reliable, fundamental information of market forecasts applicable to NorthWestern.

Using prices from the closest liquid electric trading point, SPP North, provides short-term future prices based on current market expectations. Applying the EIA escalation rate to the remaining years results in a market-based forecast using publicly available information. This calculation is valid, easily replicated, and transparent. Additionally, NorthWestern uses this forecasting methodology for the evaluation of NorthWestern's recent planning and evaluation decisions.

Q. Juhl witness Roger Schiffman contends that NorthWestern has not been transparent with its use of PowerSimm. Do you agree?

A. No, I do not agree. Juhl filed Mr. Schiffman's testimony prior to asking its first set of Data Requests on August 17, 2016. NorthWestern provided all available data and explained its use of PowerSimm in its responses to that discovery. Just as Juhl could not provide the ABB/Ventyx data to NorthWestern, NorthWestern cannot provide Ascend's data to Juhl. If Juhl wants access to Ascend's intellectual property, that can be arranged for a fee paid to Ascend. NorthWestern and Ascend are willing to support independent parties in their review and access to PowerSimm. Ascend hosts PowerSimm in a private cloud. The most cost-effective approach to reviewing PowerSimm inputs will be to have Ascend staff serve as user experts on behalf of the independent party. With Ascend serving as the operational tour guide, independent parties will be able to readily review portfolio configuration and modeling assumptions.

Ascend will work cooperatively with the independent parties if they have a desire to review input assumptions. The reviewer will have the ability to view relevant input configurations for the avoided cost study through the PowerSimm user interface used to generate the results; including market forward curves, generation asset characteristics, wind generation history, weather, and other applicable inputs.

The fee for the guided tour of PowerSimm will be an estimated $3,000. Creating a software tour requires creation of an independent reviewing environment that costs $2,000 in labor effort to establish. There will be approximately another $1,000 for a two hour review session run by two Ascend staff members billed at Ascend standard commercial consulting rates (approximately $250/hr * 2hr *2 staff) for a total cost of $3,000 for the preliminary review. The review sessions will be conducted at either Ascend's offices in Bozeman or Boulder or remotely at the options of the reviewer.

If there is a request to run analyses to look at particular output results, computing resources are available at $5,000 per month for three computer workstations and $500 per month per terabyte of database storage. Standard commercial consulting rates also apply for Ascend staff performing or assisting with running these analyses.

Q. Does this conclude your response testimony?

A. Yes, it does.

CERTIFICATE OF SERVICE

I, the undersigned, hereby certify that on the 17th day of October, 2016, true and correct copies of the foregoing, PREFILED RESPONSE TESTIMONY OF LUKE P. HANSEN ON BEHALF OF NORTHWESTERN ENERGY and exhibit in Docket No. EL16-021, were served on the following via electronic mail:

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NORTHWESTERN CORPORATION
d/b/a NORTHWESTERN ENERGY

Jonathan M. Oostra

WACC 7.24% nominal, annual

Summary: NPV and Annualized $/MWh of Avoided Costs

NPV Of Avoided Costs	$ 82,130,168
Levelized Payment	$ 28.49

Summary Table: Annual Wind QF Generation and Avoided Costs

Year	Generation (MWh)	Generation offsetting internal production (MWh)	Offset Purchases (MWh)	Average Offsetting Generation Avoided Cost ($/MWh)	Average Offset Purchase Price ($/MWh)	Total Offsetting Generation Avoided Cost ($)	Total Avoided Cost of Purchases ($)	Total Avoided Cost ($)	Average Avoided Cost ($/MWh)
2017	277,156	125,955	151,201	$ 16.83	$ 22.45	$ 2,120,144	$ 3,394,856	$ 5,515,000	$ 19.90
2018	277,190	106,838	170,352	$ 15.68	$ 22.12	$ 1,675,452	$ 3,768,301	$ 5,443,753	$ 19.64
2019	277,190	94,385	182,805	$ 16.97	$ 24.27	$ 1,601,882	$ 4,437,440	$ 6,039,323	$ 21.79
2020	277,190	110,031	167,159	$ 20.48	$ 26.69	$ 2,253,903	$ 4,461,455	$ 6,715,358	$ 24.23
2021	277,190	99,391	177,799	$ 20.10	$ 28.09	$ 1,997,478	$ 4,993,631	$ 6,991,109	$ 25.22
2022	277,190	91,466	185,724	$ 21.74	$ 28.72	$ 1,988,765	$ 5,333,590	$ 7,322,356	$ 26.42
2023	277,190	89,955	187,235	$ 24.06	$ 30.52	$ 2,164,300	$ 5,713,630	$ 7,877,930	$ 28.42
2024	277,190	97,672	179,518	$ 24.29	$ 32.23	$ 2,372,236	$ 5,785,211	$ 8,157,447	$ 29.43
2025	277,190	84,714	192,476	$ 25.78	$ 33.77	$ 2,183,658	$ 6,500,488	$ 8,684,146	$ 31.33
2026	277,190	88,479	188,712	$ 26.77	$ 34.27	$ 2,368,457	$ 6,467,748	$ 8,836,205	$ 31.88
2027	277,190	79,027	198,164	$ 26.49	$ 34.35	$ 2,093,657	$ 6,807,303	$ 8,900,960	$ 32.11
2028	277,190	67,248	209,943	$ 28.66	$ 34.52	$ 1,927,174	$ 7,247,965	$ 9,175,139	$ 33.10
2029	277,190	70,534	206,656	$ 28.12	$ 35.10	$ 1,983,363	$ 7,253,591	$ 9,236,954	$ 33.32
2030	277,190	68,590	208,600	$ 28.32	$ 35.76	$ 1,942,291	$ 7,459,284	$ 9,401,575	$ 33.92
2031	277,190	60,583	216,607	$ 28.23	$ 36.72	$ 1,710,301	$ 7,954,864	$ 9,665,165	$ 34.87
2032	277,190	55,351	221,840	$ 30.34	$ 38.43	$ 1,679,440	$ 8,524,610	$ 10,204,050	$ 36.81
2033	277,190	60,299	216,891	$ 30.20	$ 39.79	$ 1,821,276	$ 8,631,037	$ 10,452,313	$ 37.71
2034	277,190	53,248	223,942	$ 30.31	$ 41.14	$ 1,613,732	$ 9,214,079	$ 10,827,812	$ 39.06
2035	277,190	55,170	222,020	$ 31.89	$ 41.89	$ 1,759,455	$ 9,301,412	$ 11,060,868	$ 39.90
2036	277,190	49,697	227,494	$ 30.93	$ 42.32	$ 1,537,351	$ 9,626,734	$ 11,164,085	$ 40.28

WACC 7.24% nominal, annual

Summary: NPV and Annualized $/MWh of Avoided Costs

NPV Of Avoided Costs	$ 85,401,559
Levelized Payment	$ 29.63

Summary Table: Annual Wind QF Generation and Avoided Costs

Year	Generation (MWh)	Generation offsetting internal production (MWh)	Offset Purchases (MWh)	Average Offsetting Generation Avoided Cost ($/MWh)	Average Offset Purchase Price ($/MWh)	Total Offsetting Generation Avoided Cost ($)	Total Avoided Cost of Purchases ($)	Total Avoided Cost ($)	Average Avoided Cost ($/MWh)
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2037	277,190	49,272	227,919	$ 32.14	$ 43.48	$ 1,583,644	$ 9,910,586	$ 11,494,230	$ 41.47