BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY PREVAILING WIND PARK, LLC FOR A PERMIT FOR A WIND ENERGY FACILITY IN BON HOMME, CHARLES MIX, AND HUTCHINSON COUNTIES, SOUTH DAKOTA, FOR PREVAILING WIND PARK ENERGY FACILITY

SD PUC DOCKET EL 18-026

PRE-FILED DIRECT TESTIMONY OF CHRIS HOWELL
ON BEHALF OF PREVAILING WIND PARK, LLC

May 30, 2018

I. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name, employer, and business address.

A. My name is Chris Howell. I am a Senior Noise Specialist and Project Manager of the Environmental Services division at Burns & McDonnell Engineering Company, Inc. ("Burns & McDonnell"). My business address is 9400 Ward Parkway, Kansas City, Missouri, 64114.

Q. Briefly describe your educational and professional background and your current work for Burns & McDonnell.

A. I have a bachelor's degree in Mechanical Engineering and am a member of the Institute of Noise Control Engineering. I have 17 years of professional experience and have been with Burns & McDonnell for 15 years.

I am the noise lead for Burns & McDonnell and have conducted noise analyses for large-scale wind farms in multiple states. I specialize in generation and noise analyses, and manage general environmental permitting teams. I have extensive experience conducting noise modeling for large wind farms. A copy of my curriculum vitae is provided as **Exhibit 1**.

II. PURPOSE OF TESTIMONY

Q. What is Burns & McDonnell's role, and your role, with respect to the Prevailing Wind Park Energy Facility ("Project")?

A. Burns & McDonnel was retained to assist with permitting, shadow flicker analysis and sound modeling. I conducted acoustic modeling of the Project's proposed layout and prepared an associated Sound Study, which is provided in Appendix M of the Project's Facility Permit Application ("Application").

Q. What is the purpose of your Direct Testimony?

A. The purpose of my testimony is to discuss the methodology and results of the acoustic modeling Burns & McDonnell conducted for the Project. In addition, I will discuss how the modeling demonstrates that the Project will comply with applicable acoustic regulations and commitments made by Prevailing Wind Park, LLC ("Prevailing Wind Park").

Q. What exhibits are attached to your Direct Testimony?

A. The following exhibits are attached to my Direct Testimony:

- Exhibit 1: Curriculum vitae

Q. Please identify the sections of the Energy Facility Application ("Application") that you are sponsoring for the record.

A. I am sponsoring the following portions of the Application:

- Section15.3: Sound
- Appendix M : Prevailing Wind Park Project Sound Study

III. WIND TURBINE SOUND AND APPLICABLE STANDARDS

Q. Please provide an overview of the sound that may be generated by modern utility-scale wind turbines, such as those that will be used by the Project.

A. The sound commonly associated with a wind turbine is described as a rhythmic "whoosh" caused by aerodynamic processes. This sound is created as air flow interacts with the surface of rotor blades. As air flows over the rotor blade, turbulent eddies form in the surface boundary layer and wake of the blade. These eddies are where most of the "whooshing" sound is formed. Additional sound is generated from vortex shedding produced by the tip of the rotor blade. Air flowing past the rotor tip creates alternating low-pressure vortices on the downstream side of the tip, causing sound generation to occur.

Advancement in wind turbine technology has reduced distinct tonal sounds by reshaping turbine blades and adjusting the angle at which air contacts the blade.

Pitching technology allows the angle of the blade to adjust when the maximum rotational speed is achieved, which allows the turbine to maintain a constant rotational velocity. Therefore, sound emission levels remain constant as the velocity remains the same.

Wind turbines can create noise in other ways as well. Wind turbines have a nacelle where the mechanical portions of the turbine are housed. The current generation of wind turbines uses multiple techniques to reduce the noise from this portion of the turbine: vibration isolating mounts, special gears, and acoustic insulation. In general, all moving parts and the housing of the current generation wind turbines have been designed to minimize the noise they generate.

Q. Please provide an overview of how humans perceive sound, and how perceived levels are measured.

A. Sound energy travels through air as a pressure wave. The human ear perceives the amplitude the sound pressure wave, and also its frequency (pitch). Human hearing is sensitive to sound fluctuations over an enormous range of pressures, from about 20 micropascals (the “threshold of human hearing”) to about 20 pascals (the “threshold of pain”). The frequency of a sound is the rate at which it fluctuates in time, expressed in Hertz (“Hz”), or wave cycles per second.

The compressive decibel scale is used to make the numbers more manageable for discussion. Sound pressure is converted to sound levels in units of decibels (“dB”), which can be weighted and expressed in different ways. The most common weighting scale used in environmental noise analysis and regulation is the A-weighted decibel (“dBA”). This weighting mechanism emulates the human ear’s varying sensitivity to the frequency of sound. The human ear is much more sensitive to medium frequencies (1,000 to 8,000 Hz) than to very low or very high frequencies. The A-weighted level represents the sum of the energy across the normal audible frequency spectrum for humans (20 to 20,000 Hz), weighted by frequency as the human ear would do.

In terms of human perception, a 10-dB change in sound levels is a perceived doubling (or halving, if the sound is decreasing) of loudness. A 5-dB change is considered "clearly noticeable," and a 3-dB change is considered "just barely noticeable." Changes in broadband sound level of less than 3 dB are generally not considered to be noticeable.

Q. How does the sound from wind turbines fit within the range of sound audible to humans?

A. Sound pressure levels at the base of a 1.5 megawatt ("MW") or greater wind turbine are typically between 55 and 60 dBA. For comparison, typical conversational speech between two people standing three feet apart is between 55 and 65 dBA, so one could hold a conversation at the base of a wind turbine. As sound spreads from a turbine, the sound level diminishes. At 45 to 50 dBA, it would sound approximately half as loud as conversational speech, and between 30 and 40 dBA it is comparable to background sound levels in a rural area.

Q. Are you aware of any federal or state sound level regulations for wind energy conversion facilities located in South Dakota?

A. There are no federal or state noise regulations that apply to this Project.

Q. Have Bon Homme, Charles Mix, and/or Hutchinson counties established sound level requirements for wind energy facilities?

A. Bon Homme County has adopted a zoning ordinance that limits sound levels of WES to 45 dBA at occupied receptors unless the owner provides a written waiver. Neither Charles Mix nor Hutchinson County has a noise limit for wind energy systems. Conservatively, the Bon Homme County ordinance sound level limit was used as a design goal for all areas of the Project.

IV. ACOUSTIC ANALYSIS

Q. What was the purpose of the acoustic modeling and analysis discussed in the Sound Study?

A. The purpose of the Sound Study was to measure background sound levels in the Project Area, and determine through analysis whether the sound generated by the Project will comply with applicable noise standards. Consistent with these goals, the Sound Study describes the results of Burns & McDonnell's measurement of existing background sound levels in the Project Area and describes the results of an acoustic modeling analysis we conducted, which demonstrates that Project sound levels will meet Bon Homme County's 45 dBA noise standard at occupied receptors.

Q. Please discuss your analysis of existing ambient (or background) sound levels in the Project Area.

A. We conducted ambient sound level monitoring at representative locations throughout the Project Area to quantify the existing sound levels and to identify existing sources of sound around the Project. Ambient measurements were made at 16 locations to determine the existing background sound level. The locations of the 16 monitoring sites are identified in the Sound Study. Monitoring locations were selected because they were accessible and representative of existing ambient sound levels in the vicinity of noise-sensitive receivers.

Monitoring was conducted on March 12 and 13, 2018. Equivalent average ("L_{eq}") sound levels, and the sound level exceeded 90 percent of the time ("L_{90}") were calculated. Comparing these metrics demonstrate how the sound level varies with time over the monitoring period and are used to quantify the character of the area as it pertains to sound. L_{eq} represents the equivalent-continuous sound level over a given time period. The L_{90} is a common exceedance sound level value and represents the sound level with minimal influence from short-term, loud transient sound sources. The L_{90} represents the sound level exceeded for 90 percent of the time period during which sound levels are measured. The L_{90} value is regarded as the most accurate tool for measuring relatively constant background noise and for minimizing the influence of isolated spikes in sound levels (such as a barking dog or door slamming).

Q. What were the results of your monitoring and analysis of the existing background sound levels?

A. Common sources of ambient sound included high speed traffic, birds, farm equipment, and noise from the wind. Ambient sound levels throughout the Project Area were typical for a rural area, and generally ranged from 21.5 dBA to 45 dBA $L_{90.}$

Q. Could you provide an overview of the methodology used in conducting the acoustic modeling analysis for the Project?

A. Our modeling utilized conservative assumptions and was conducted in accordance with the international standard (ISO 9613-2), which is used for projecting outdoor sound levels from specific sources. Specifically, ISO 9613-2 assumes downwind sound propagation between every source and every receiver; consequently, all wind directions are taken into account. This is a conservative method because, in the model, each receiver is downwind of every source, a scenario that cannot physically occur. Additionally, the modeling did not include attenuation for sound propagation through wooded areas, existing barriers, and shielding, and assumed that all turbines were operating at maximum power output (and therefore, maximum sound levels) at all times to represent worst-case noise impacts from the wind farm as a whole. These assumptions were made to maintain the inherent conservativeness of the model and to estimate the worst-case modeled sound levels.

Modeling was completed for both the GE 3.8-137 and Vestas V136-3.6 turbine models. Although turbines would be constructed at only up to 61 of the 63 potential turbine sites, modeling was conducted for each turbine model at all 63 locations to confirm that any location selected would meet the 45 dBA design goal.

Cumulative sound levels from all 63 proposed turbines were calculated for each of the 138 discrete receivers that surround the Project. The model was developed using a software program called CadnaA. The model takes into account source sound power levels, air absorption, ground absorption and reflection, and terrain. Each receiver was assumed to have a height of 1.52 meters (5 feet) above ground level.

Further discussion of the methodology used is provided in the Sound Study (Appendix M of the Application).

Q. Could you summarize the results of the analysis?

A. For both turbine models, predicted sound levels from the Project are less than 45 dBA at all residences. The highest modeled sound level was 41.9 dBA. Thus, the results show the Project will comply with the Bon Homme County noise standard.

Q. Are you aware of any post-construction noise studies for other wind farms that support the accuracy and conservativeness of the pre-construction noise modeling you conducted for the Project?

A. Yes. There are a number of studies that support the accuracy and assumptions used in the Sound Study, and we have conducted many post-construction measurement studies on projects for which we predicted sound impacts. For example, the Research Study on Wind Turbine Acoustics ("RSOWTA"), conducted by RSG et al, (*Massachusetts Study on Wind Turbine Acoustics*, 2016) for the Massachusetts Clean Energy Center and the Massachusetts Department of Environmental Protection, compared modeling results with monitoring results for a range of conditions for five different wind turbine installation sites. The RSOWTA concluded that the same general parameters used in our modeling would predict conservative real-life results. Our own post-construction studies have demonstrated that our pre-construction conservative prediction methods typically exceed actual operational sound levels of proposed projects.

Q. How accurate is your analysis of the anticipated sound levels generated by the Project?

A. The methods used in this study to develop the potential sound impacts of this Project are consistent with those used in most of our predictive studies. We perform many acoustical studies per year, with nearly half requiring post-construction compliance demonstration. In-house and third-party monitoring has routinely demonstrated that our prediction methods are conservative, and monitoring results are typically between 1 and 3 dBA lower than our predictions.

V. CONCLUSION

Q. Does this conclude your Direct Testimony?

A. Yes.

Dated this 30th day of May, 2018.

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Chris Howell