

**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

1 **I. INTRODUCTION AND QUALIFICATIONS**

2

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

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

8

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

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

14

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

20

21 **II. PURPOSE OF TESTIMONY**

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

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

29

30 **Q. What is the purpose of your Direct Testimony?**

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

36

37 **Q. What exhibits are attached to your Direct Testimony?**

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

- 39 • Exhibit 1: Curriculum vitae

40

41 **Q. Please identify the sections of the Energy Facility Application (“Application”)**
42 **that you are sponsoring for the record.**

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

- 44 • Section 15.3: Sound
- 45 • Appendix M : Prevailing Wind Park Project Sound Study

46

47 **III. WIND TURBINE SOUND AND APPLICABLE STANDARDS**

48

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

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

59

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

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

66

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

73

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

76 A. Sound energy travels through air as a pressure wave. The human ear perceives the
77 amplitude the sound pressure wave, and also its frequency (pitch). Human hearing
78 is sensitive to sound fluctuations over an enormous range of pressures, from about
79 20 micropascals (the “threshold of human hearing”) to about 20 pascals (the
80 “threshold of pain”). The frequency of a sound is the rate at which it fluctuates in
81 time, expressed in Hertz (“Hz”), or wave cycles per second.

82

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

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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

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

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

133

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

136 A. We conducted ambient sound level monitoring at representative locations
137 throughout the Project Area to quantify the existing sound levels and to identify
138 existing sources of sound around the Project. Ambient measurements were made at
139 16 locations to determine the existing background sound level. The locations of the
140 16 monitoring sites are identified in the Sound Study. Monitoring locations were
141 selected because they were accessible and representative of existing ambient
142 sound levels in the vicinity of noise-sensitive receivers.

143

144 Monitoring was conducted on March 12 and 13, 2018. Equivalent average (“ L_{eq} ”)
145 sound levels, and the sound level exceeded 90 percent of the time (“ L_{90} ”) were
146 calculated. Comparing these metrics demonstrate how the sound level varies with
147 time over the monitoring period and are used to quantify the character of the area as
148 it pertains to sound. L_{eq} represents the equivalent-continuous sound level over a
149 given time period. The L_{90} is a common exceedance sound level value and
150 represents the sound level with minimal influence from short-term, loud transient
151 sound sources. The L_{90} represents the sound level exceeded for 90 percent of the
152 time period during which sound levels are measured. The L_{90} value is regarded as
153 the most accurate tool for measuring relatively constant background noise and for

154 minimizing the influence of isolated spikes in sound levels (such as a barking dog or
155 door slamming).

156

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

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

163

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

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

178

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

183

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

190
191 Further discussion of the methodology used is provided in the Sound Study
192 (Appendix M of the Application).

193

194 **Q. Could you summarize the results of the analysis?**

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

198

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

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

214

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

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

223

224 **V. CONCLUSION**

225

226 **Q. Does this conclude your Direct Testimony?**

227 A. Yes.

228

229 Dated this 30th day of May, 2018.

230 

231 Chris Howell