

**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 AARON ANDERSON
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 Aaron Anderson. I am a senior mechanical engineer and project
5 manager in the Renewable Energy Group at Burns & McDonnell Engineering
6 Company, Inc. ("Burns & McDonnell"). My business address is 9400 Ward Parkway,
7 Kansas 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 undergraduate degrees in Physics and Mechanical Engineering, a master's
12 degree in Engineering Management, and I am a registered Professional Engineer in
13 multiple states. I have 13 years of professional experience and have been with
14 Burns & McDonnell for 11 years. As part of my responsibilities at Burns &
15 McDonnell, I conduct shadow flicker analyses for proposed wind farms.

16

17 I specialize in financial and engineering analyses of wind energy projects, and have
18 directly managed nearly 20,000 megawatts of renewable energy development
19 throughout the world. A copy of my curriculum vitae is provided as **Exhibit 1.**

20

21 **II. PURPOSE OF TESTIMONY**

22

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 by Prevailing Wind Park, LLC ("Prevailing Wind
26 Park") to assist with permitting and noise modeling and to conduct a shadow flicker
27 analysis for the Project. I conducted shadow flicker modeling for the Project's
28 proposed layout and prepared the associated shadow flicker analysis, which is
29 provided in Appendix N of the Project's Facility Permit Application ("Application").

30

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

32 A. The purpose of my testimony is to discuss the methodology and the results of the
33 shadow flicker modeling conducted for the Project.

34

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

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

- 37 • Exhibit 1: Curriculum Vitae

38

39 **Q. Please identify the sections of the Application that you are sponsoring for the**
40 **record.**

41 A. I am sponsoring the following sections of the Application:

- 42 • Section 15.5: Shadow Flicker
- 43 • Appendix N: Prevailing Wind Park Shadow Flicker Analysis

44

45 **III. SHADOW FLICKER AND APPLICABLE STANDARDS**

46

47 **Q. Could you please explain what shadow flicker is?**

48 A. Yes. Like any tall structure, wind turbines cast a shadow when the sun is visible.
49 When the wind turbine blades rotate and pass in front of the sun, a flickering or
50 flashing effect may occur when the shadows of the rotating blades cause alternating
51 changes in light intensity at a given stationary location, a receptor, such as the
52 window of a home. This recurring change in light intensity is known as shadow
53 flicker.

54

55 Shadow flicker occurs only under very specific conditions. For example, shadow
56 flicker can only occur when the sun is shining and the turbine is in operation (i.e.,
57 when the turbine blades are rotating). Moreover, shadow flicker is generally most
58 notable when a turbine is facing a receptor, as this results in the widest-possible
59 shadow being cast. Shadow flicker intensity and frequency at a given receptor are
60 determined by a number of interacting factors, such as sun position, wind direction,
61 turbine and receptor locations, time of day, and other similar factors. The intensity

62 of shadow flicker varies significantly with distance, and as separation between a
63 turbine and receptor increases, shadow flicker intensity will generally diminish by a
64 corresponding amount as shadows diffuse and become imperceptible.

65

66 **Q. Are you aware of any federal, state, or local shadow flicker regulations for the**
67 **Project?**

68 A. Shadow flicker impacts are not currently regulated in applicable state or federal law,
69 nor are there requirements in the current Charles Mix County or Hutchinson County
70 ordinances. The Bon Homme County ordinance also does not specify a standard,
71 but indicates that the county may require the installation of a shadow flicker control
72 system under certain circumstances. My understanding is that Prevailing Wind Park
73 has committed to limit shadow flicker at non-participating residences in the Project
74 Area to no more than 30 hours per year.

75

76 **IV. SHADOW FLICKER ASSESSMENT**

77

78 **Q. What was the purpose of the shadow flicker modeling and analysis discussed**
79 **in the Assessment included as Appendix N to the Application?**

80 A. The purpose of the shadow flicker analysis was to estimate the potential annual
81 frequency of shadow flicker associated with the operation of the Project wind
82 turbines at existing non-participating and participating occupied residences.

83

84 Modeling was completed for two representative turbine models: GE 3.8-137 and
85 Vestas V136-3.6. Although up to 61 turbines are expected to be installed, modeling
86 was conducted for each turbine model at all 63 potential turbine locations of the
87 proposed configuration to ensure that any location selected has been considered in
88 the shadow flicker analysis and represented in the results of such analysis.
89 Modeling was done to assess shadow flicker durations at 138 receptors (i.e.,
90 residences) located in and around the Project Area.

91

92 **Q. Could you provide an overview of the methodology used in conducting the**
93 **shadow flicker modeling?**

94 A. I used WindPRO, an industry-leading software package for the design and planning
95 of wind energy projects, to predict the expected amount of shadow flicker with
96 respect to every wind turbine location. The WindPRO software is able to incorporate
97 the sun's path, topography of the Project Site, locations of receptors and turbines,
98 wind turbine specifications, and the anticipated wind speed and direction distribution
99 to calculate shadow positions and orientations at one-minute intervals over a
100 complete year. The WindPRO model also utilizes topography data to consider any
101 natural land features between a turbine and a receptor that may block shadows from
102 being seen at a receptor. Any shadow flicker caused by each turbine is then
103 aggregated for each receptor for the entire year.

104
105 I modeled two different turbine models, the GE 3.8-137 turbine model and the Vestas
106 V136-3.6 turbine model, at each potential turbine location in the proposed layout.
107 The GE 3.8-137 wind turbines were modeled with a rotor diameter of 137 meters
108 and a hub height of 110 meters. The Vestas V136-3.6 wind turbines were modeled
109 with a rotor diameter of 136 meters and a hub height of 105 meters

110
111 At distances beyond 10 rotor diameters, shadow flicker effects are generally
112 considered low, as shadows diffuse and become imperceptible. Thus, a distance
113 equal to 10 times the rotor diameter of each turbine (1,370 meters/4,495 feet for the
114 GE 3.8-137 model and 1,360 meters/4,462 feet for the V136-3.6 model) was
115 modeled as the maximum distance at which shadow flicker was considered relevant;
116 receptors greater than this distance from a given turbine were not evaluated.

117
118 **Q. What assumptions were included in your model?**

119 A. My modeling was performed using a conservative approach, with some Project
120 Area-specific conditions. For example, each receptor was modeled in "green house"
121 mode, meaning each receptor was modeled as having windows on all sides and

122 effectively causing the home to be susceptible to flicker effects in all directions. The
123 model also accounted for topography.

124
125 We first modeled all receptors without any consideration for obstacles. Obstacles
126 located between a receptor and a turbine, such as trees or buildings, may reduce or
127 eliminate the duration and/or intensity of shadow flicker.

128
129 Second, we then included obstacles in the WindPRO model, including trees and
130 outbuildings, for only those receptors that exceeded 30 flicker hours per year and/or
131 30 minutes per day. Such receptors are indicated by an asterisk (*) in Appendix B
132 and Appendix F of the Shadow Flicker Analysis, respectively. No obstacles were
133 considered or modeled for any other receptors.

134
135 I reviewed the obstacles near the applicable receptors and visually estimated the
136 type and characteristics of each obstacle using publicly-available desktop aerial
137 imagery. Trees and groups of trees were assumed to be 12 meters tall, barns and
138 other outbuildings were assumed to be 4 meters tall, and grain bins were assumed
139 to be 6 meters tall. Only obstacles in reasonable close proximity to a receptor (i.e.,
140 those that might be expected to influence flicker durations) were considered.

141
142 Due to the conservative approach of the analysis, the actual duration and intensity
143 of shadow flicker experienced at each receptor is expected to be less than those
144 reported in the Shadow Flicker Analysis.

145

146 **Q. Could you summarize the results of the shadow flicker modeling?**

147 A. In the case of both turbine models considered for the proposed configuration, 3 of
148 the 138 known receptors (one non-participant and two participants) exceed 30 hours
149 per year of shadow flicker. The one participant that is above 30 hours per year is
150 Receptor 76 (“REC-076”) located in Charles Mix County. With the V136-3.6 model,
151 the modeled annual shadow flicker duration at this receptor is 33.93 hours. With the

152 GE 3.8-137 model, the modeled annual shadow flicker duration at this receptor is
153 34.73 hours.

154

155 **Q. You noted that your modeling assumed “green house” mode for each**
156 **residence. Do you believe that shadow flicker levels for Receptor 76 would be**
157 **reduced if you re-ran the model for that receptor using realistic assumptions,**
158 **e.g., actual window configuration instead of green house mode?**

159 A. Yes. I would expect the amount of shadow flicker to be reduced at Receptor 76
160 under more realistic modeling assumptions. For example, rather than modeling the
161 home as having windows on all sides that are always perpendicular to the sun, actual
162 window locations would be considered along with the actual angle of the sun.

163

164 **Q. Are there mitigation measures that can be employed to reduce shadow flicker?**

165 A. Yes. Mitigation measures include, but are not limited to installation of exterior or
166 interior screening and installation of vegetation, such as trees or bushes.

167

168 **V. CONCLUSION**

169

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

171 A. Yes.

172

173

174 Dated this 30th day of May, 2018.

175

176

177

Aaron Anderson

178 Aaron Anderson