

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY CROCKER WIND FARM, LLC FOR A
PERMIT FOR A WIND ENERGY FACILITY AND A 345 KV TRANSMISSION LINE IN
CLARK COUNTY, SOUTH DAKOTA, FOR CROCKER WIND FARM

SD PUC DOCKET EL-17-___

PREFILED TESTIMONY OF MICHAEL MORRIS
ON BEHALF OF CROCKER WIND FARM, LLC

December 15, 2017

1 **I. INTRODUCTION AND QUALIFICATIONS**

2
3 **Q. Please state your name, employer, and business address.**

4 A. My name is Michael Morris. I am the Director of Resource Analysis at Geronimo
5 Energy ("Geronimo"). My business address is 650 Edinborough Way, Suite 725,
6 Edina, MN 55436.

7
8 **Q. Briefly describe your educational and professional background and your
9 current work for Geronimo Energy.**

10 A. I have a bachelor's degree (2006) in Meteorology and a master's degree (2008) in
11 Meteorology from the University of Oklahoma.

12
13 I am a member of the American Meteorological Society and have been working in
14 the renewable energy industry since 2008. I have been responsible for siting,
15 design, and resource assessment activities for over 5,000 megawatts of projects in 8
16 states. My areas of expertise include atmospheric remote sensing, numerical
17 modeling and statistical analysis of weather data. A copy of my curriculum vitae is
18 provided as Exhibit 1.

19
20 **II. PURPOSE OF TESTIMONY**

21
22 **Q. What is Geronimo's role, and your role, with respect to the Crocker Wind Farm
23 Project (the "Project")?**

24 A. Geronimo is assisting Crocker Wind Farm, LLC ("Crocker") with all aspects of
25 development of the Project. I conducted shadow flicker modeling for the Project's
26 proposed layout and prepared an associated Shadow Flicker Assessment
27 ("Assessment"), which is provided in Appendix F of the Project's Energy Facility
28 Permit Application ("Application").

29
30 **Q. What is the purpose of your testimony?**

31 A. The purpose of my testimony is to discuss the methodology and the results of the
32 shadow flicker modeling conducted for the Project. In addition, I will discuss how the
33 modeling demonstrates that the Project will comply with industry standards, as well
34 as commitments made by Crocker concerning shadow flicker.
35

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

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

- 38 • Exhibit 1: Curriculum Vitae

39

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

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

- 43 • Section 9.5.6: Shadow Flicker
- 44 • Appendix F: Crocker Wind Farm Shadow Flicker Assessment

45

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

47

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

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

54

55 Shadow flicker at a receptor may only occur when: (1) the sun is shining with no
56 cloud cover present; (2) the turbine is operating; (3) the turbine blades are
57 positioned on a line between the receptor and the sun; and (4) the receptor is close
58 enough to the turbine to distinguish the shadow created by the blades. Thus,
59 Shadow flicker intensity and frequency at a given receptor are determined by a
60 number of interacting factors, such as: sun angle and sun path; turbine and receptor

61 locations; cloud cover and degree of visibility; wind direction; wind speed; obstacles;
62 contrast; and local topography.

63
64 **Q. Are you aware of any federal, state, or local shadow flicker regulations for the**
65 **Project?**

66 A. There are no federal, state, or local shadow flicker regulations for the Project.

67
68 **Q. Has Crocker made a commitment regarding Project shadow flicker levels?**

69 A. Crocker plans to meet a goal of 30 hours of shadow flicker per year or less at
70 existing nonparticipating and participating occupied residences.

71
72 **IV. SHADOW FLICKER ASSESSMENT**

73
74 **Q. What was the purpose of the shadow flicker modeling and analysis discussed**
75 **in the Assessment included as Appendix F to the Application?**

76 A. The purpose of the shadow flicker analysis was to model the potential level of flicker
77 associated with the operation of the Project at existing nonparticipating and
78 participating occupied residences. Modeling was completed for four representative
79 turbine models: Gamesa G126 2.625 MW; GE 2.5-116; Vestas V110 STE 2.0 MW;
80 and Vestas V136 3.45 MW. Although the Project will be up to 400 MW, so turbines
81 would be constructed at only a subset of the 120 locations within the proposed
82 configuration, modeling was conducted for each turbine model at all 120 locations to
83 ensure that any location selected would meet Crocker's shadow flicker goal.
84 Modeling was done to assess levels at 69 receptors (i.e., residences) located within
85 one mile of the Project.

86
87 **Q. Could you provide an overview of the methodology used in conducting the**
88 **shadow flicker modeling?**

89 A. We used EMD WindPRO 2.9.285, an industry standard software package for the
90 design, assessment, and optimization of wind farms, to predict the expected amount
91 of shadow flicker at locations within and around the Project. The WindPRO

92 SHADOW module is able to incorporate the sun's position, topography of the wind
93 farm site, locations of receptors, wind turbine specifications, and the observed wind
94 direction distribution to calculate shadow positions and orientations at one-minute
95 intervals for a calendar year. WindPRO 2.9.285 calculates the number of hours per
96 year, as well as the maximum minutes per day, during which a given receptor could
97 realistically expect to be exposed to shadow flicker from nearby wind turbines. The
98 modeling incorporated the proposed turbine layout, 69 receptors identified by a
99 review of aerial imagery provided by the Farm Service Agency's National Agricultural
100 Imagery Program as well as field visits, and site-specific meteorological data.

101
102 Our initial modeling run, which did not include site-specific terrain or obstructions,
103 and assumed receptors were transparent in all directions (known as "greenhouse"
104 mode), indicated that four participating receptors may experience shadow flicker
105 levels over 30 hours per year. We then conducted a second modeling run, also in
106 "greenhouse" mode, but with site-specific terrain effects and tree stands identified in
107 aerial imagery added, to confirm that levels at all residences were 30 hours per year
108 or less.

109
110 **Q. Could you summarize the results of the shadow flicker modeling?**
111 A. Our analysis of potential shadow flicker from the Project on nearby receptors
112 indicates that the effects are expected to be minor and below Crocker's stated goal.
113 The average number of hours of shadow flicker per year ranges between 5.5
114 hours/year for participating landowners, and 3.7 and 4.6 hours/year for non-
115 participating landowners, depending on the turbine model. The maximum number of
116 hours per year of shadow flicker for participating landowners is between 20.6 and
117 27.3 hours per year, and between 12.6 and 16.3 hours per year for non-participating,
118 depending on the turbine model. Thus, no residences are expected to experience
119 over 30 hours per year of shadow flicker.

120

121 **Q. Based on your experience and expertise, is limit of 30 hours per year of**
122 **shadow flicker at existing occupied residences a reasonable shadow flicker**
123 **commitment?**

124 A. Yes. Thirty hours per year represents less than 1 percent of daylight hours per year.
125 Additionally, since shadow flicker normally occurs during the hours immediately
126 following sunrise and immediately preceding sunset the overall impact is muted due
127 to the use of interior artificial lighting during these hours, reducing the contrast.
128 Further, 30 hours per year has been a commitment made in siting proceedings in
129 neighboring jurisdictions (e.g., the North Dakota Public Service Commission and the
130 Minnesota Public Utilities Commission), and also has legal precedent based on a
131 German court case.

132

133 **V. MITIGATION**

134

135 **Q. Has the Project made any commitments as to how it will deal with any**
136 **complaints regarding shadow flicker?**

137 A. Yes. In the event that Crocker receives complaints about shadow flicker from the
138 Project, Project representatives will implement the following procedure:

- 139 • Log the contact in Crocker's complaint database to track resolution efforts;
- 140 • Prepare site-specific assessment of shadow flicker impacts, noting the time of
141 day, season, and expected duration of future flicker impacts;
- 142 • Meet with the landowner to discuss the site-specific assessment, educate
143 landowners on landowner driven mitigation strategies (e.g. modification of interior
144 lighting) and discuss concerns;
- 145 • Assess the residence to determine if on-site mitigation measures, including but
146 not limited to, installation of exterior screening (e.g., planting vegetation) or
147 interior screening (e.g., curtains or blinds), are appropriate for the level of impact
148 and effectively address the concern;
- 149 • Work with the landowner to develop a mitigation plan; and
- 150 • Implement the mitigation plan.

151

152 **VI. CONCLUSION**

153

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

155 A. Yes.

156

157 Dated this 15th day of December, 2017.



158

159

160 Michael Morris