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

I. INTRODUCTION AND QUALIFICATIONS

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

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

Q. Briefly describe your educational and professional background and your current work for Geronimo Energy.

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

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

II. PURPOSE OF TESTIMONY

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

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

Q. What is the purpose of your testimony?

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

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 Application that you are sponsoring for the record.

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

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

III. SHADOW FLICKER AND APPLICABLE STANDARDS

Q. Could you please explain what shadow flicker is?

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

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

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

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

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

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

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

IV. SHADOW FLICKER ASSESSMENT

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

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

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

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

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

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

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

A. Our analysis of potential shadow flicker from the Project on nearby receptors indicates that the effects are expected to be minor and below Crocker's stated goal. The average number of hours of shadow flicker per year ranges between 5.5 hours/year for participating landowners, and 3.7 and 4.6 hours/year for non-participating landowners, depending on the turbine model. The maximum number of hours per year of shadow flicker for participating landowners is between 20.6 and 27.3 hours per year, and between 12.6 and 16.3 hours per year for non-participating, depending on the turbine model. Thus, no residences are expected to experience over 30 hours per year of shadow flicker.

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

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

V. MITIGATION

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

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

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

VI. CONCLUSION

Q. Does this conclude your Direct Testimony?

A. Yes.

Dated this 15th day of December, 2017.

Michael Morris