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

I. INTRODUCTION AND QUALIFICATIONS

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

A. My name is Aaron Anderson. I am a senior mechanical engineer and project manager in the Renewable Energy Group 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 undergraduate degrees in Physics and Mechanical Engineering, a master's degree in Engineering Management, and I am a registered Professional Engineer in multiple states. I have 13 years of professional experience and have been with Burns & McDonnell for 11 years. As part of my responsibilities at Burns & McDonnell, I conduct shadow flicker analyses for proposed wind farms.

I specialize in financial and engineering analyses of wind energy projects, and have directly managed nearly 20,000 megawatts of renewable energy development throughout the world. 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 & McDonnell was retained by Prevailing Wind Park, LLC ("Prevailing Wind Park") to assist with permitting and noise modeling and to conduct a shadow flicker analysis for the Project. I conducted shadow flicker modeling for the Project's proposed layout and prepared the associated shadow flicker analysis, which is provided in Appendix N 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 the results of the shadow flicker modeling conducted for the Project.

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 15.5: Shadow Flicker
- Appendix N: Prevailing Wind Park Shadow Flicker Analysis

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. When the wind turbine blades rotate and pass in front of the sun, 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 recurring change in light intensity is known as shadow flicker.

Shadow flicker occurs only under very specific conditions. For example, shadow flicker can only occur when the sun is shining and the turbine is in operation (i.e., when the turbine blades are rotating). Moreover, shadow flicker is generally most notable when a turbine is facing a receptor, as this results in the widest-possible shadow being cast. Shadow flicker intensity and frequency at a given receptor are determined by a number of interacting factors, such as sun position, wind direction, turbine and receptor locations, time of day, and other similar factors. The intensity of shadow flicker varies significantly with distance, and as separation between a turbine and receptor increases, shadow flicker intensity will generally diminish by a corresponding amount as shadows diffuse and become imperceptible.

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

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

IV. SHADOW FLICKER ASSESSMENT

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

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

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

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

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

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

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

Q. What assumptions were included in your model?

A. My modeling was performed using a conservative approach, with some Project Area-specific conditions. For example, each receptor was modeled in "green house" mode, meaning each receptor was modeled as having windows on all sides and effectively causing the home to be susceptible to flicker effects in all directions. The model also accounted for topography.

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

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

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

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

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

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

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

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

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

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

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

V. CONCLUSION

Q. Does this conclude your Direct Testimony?

A. Yes.

Dated this 30th day of May, 2018.

Aaron Anderson

Aaron Anderson

AARON ANDERSON, PE

Senior Mechanical Engineer

Aaron is a senior mechanical engineer and project manager in Burns & McDonnell's Renewable Energy Group, a top-5 firm in the wind industry according to *Engineering News-Record*. Mr. Anderson specializes in financial and engineering analyses of wind energy projects, and has directly managed nearly 20,000 megawatts of renewable energy development throughout the world. Mr. Anderson holds undergraduate degrees in Physics and Mechanical Engineering, an M.S. in Engineering Management, and is a registered Professional Engineer in multiple states.

EDUCATION

- BS, Physics
- BS, Mechanical Engineering
- MS, Engineering Management

REGISTRATIONS

- Professional Engineer (KS, IL, MI)

11 YEARS WITH BURNS & MCDONNELL

13 YEARS OF EXPERIENCE

Nimbus Wind Farm Permitting Studies | Scout Clean Energy

Arkansas | 2018

Role: Aaron was Burns & McDonnell's project manager on an engagement to provide permitting-related consulting services during the development of the proposed Nimbus Wind Farm. These services included shadow flicker and noise assessment studies. The results of these studies were used by Scout to pursue special use permits for the project. ***Responsibilities:*** shadow flicker analysis and noise assessment study.

Thunder Spirit II Wind Farm Owner's Engineer | ALLETE Clean Energy

Adams County, North Dakota | 2018

Role: Aaron was Burns & McDonnell's project manager on an owner's engineer assignment for ALLETE Clean Energy during the development, design, and construction of Phase 2 of the Thunder Spirit II Wind Farm. ***Responsibilities:*** shadow flicker study; noise assessment study; commercial negotiation support; contract exhibit preparation, including scope and specification development; detailed engineering reviews; project controls support; construction management support and power curve testing support.

Lone Tree Wind Farm | Leeward Renewable Energy Development

Illinois | 2017

Role: Aaron was Burns & McDonnell's project manager on an engagement to provide various consulting services to Leeward during the development of the proposed Lone Tree Wind Project. These services included shadow flicker evaluations, noise assessment studies, wind turbine siting support, transmission interconnection evaluations, and decommissioning evaluations. Burns & McDonnell also provided support during public hearings as the shadow flicker, noise assessment, and decommissioning studies were evaluated. ***Responsibilities:*** shadow flicker analysis; noise assessment study; GIS support and transmission interconnection studies; and decommissioning studies.

Mendota Hills Wind Farm | Leeward Renewable Energy Development

Illinois | 2017

Role: Aaron was Burns & McDonnell's project manager on an engagement to provide various consulting services to Leeward during the proposed repower of their existing Mendota Hills Wind Project. These services included shadow flicker evaluations, noise assessment studies, wind turbine siting support, transmission interconnection evaluations, and

AARON ANDERSON, PE

(continued)

decommissioning evaluations. Burns & McDonnell also provided support during public hearings as the shadow flicker, noise assessment, and decommissioning studies were evaluated. ***Responsibilities:*** shadow flicker analysis; noise assessment study; GIS support and transmission interconnection studies; and decommissioning studies.

Milligan Wind Farm Permitting Studies | Aksamit Resource Management

Nebraska | 2016

Role: Aaron was Burns & McDonnell's project manager on an engagement to provide permitting-related consulting services during the development of the proposed Milligan Wind Farm. These services included shadow flicker and noise assessment studies. The results of these studies were used by Aksamit to pursue special use permits for the project. ***Responsibilities:*** shadow flicker analysis and noise assessment study.

Prevailing Winds Wind Farm Permitting Studies | Prevailing Winds, LLC

South Dakota | 2016

Role: Aaron was Burns & McDonnell's project manager on an engagement to provide permitting-related consulting services during the development of the proposed Prevailing Winds Wind Farm. These services included shadow flicker and noise assessment studies. The results of these studies were used by the project company to pursue special use permits for the project, and Burns & McDonnell also provided support during public hearings as the shadow flicker and noise assessment studies were evaluated. ***Responsibilities:*** shadow flicker analysis and noise assessment study.

Broken Bow 2 Wind Farm Owner's Engineer | Sempra U.S. Gas & Power

Custer County, Nebraska | 2015

Role: Aaron was Burns & McDonnell's project manager on an owner's engineer assignment for Sempra U.S. Gas & Power who was developing a 75-MW wind energy project in central Nebraska. ***Responsibilities:*** noise assessment studies; shadow flicker analyses; preparation and administration of the balance-of-plant contractor RFP; balance-of-plant evaluation and contractor selection; commercial negotiation support; contract exhibit preparation, including scope and specification development; detailed engineering reviews on all aspects of the project, including all engineering drawings and studies; project controls support; construction management support; and power curve testing support.

Tucannon River Wind Farm Owner's Engineer | Portland General Electric

Columbia County, Washington | 2014

Role: Aaron was a key technical and commercial consultant on an owner's engineer assignment for Portland General Electric who was developing a 116-turbine, 267-MW wind energy project in Columbia County, Washington. ***Responsibilities:*** contractual negotiations support for the turbine supply, balance of plant, and service & maintenance agreements; detailed engineering reviews on all aspects of the project, including all engineering drawings and studies; shadow flicker evaluations; project controls support; and other related activities.

Stoneray Wind Farm Shadow Flicker Study | EDF

Nebraska | 2013

Role: Aaron was Burns & McDonnell's project manager on an engagement to provide a shadow flicker evaluation during the development of the proposed Stoneray Wind Farm. ***Responsibilities:*** shadow flicker analysis.