APPENDIX G

Shadow Flicker Analysis Report

WIND ENERGY INTEGRATION

SHADOW STUDY

DICKINSON REFINERY WIND TURBINE PROJECT

DICKINSON, NORTH DAKOTA

OCTOBER 2021

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Methodology v2021.0

CONTENTS

LIST OF EXHIBITS

1. INTRODUCTION

One Energy modeled potential shadow flicker at the proposed turbine sites. The modeling was performed to measure the impact of the turbines on the surrounding community.

The model used in this report was completed using the proposed turbine siting locations presented below; all results are only representative of these locations. One Energy's TAILS 3.0 software, which was developed by One Energy using both proprietary methods and industry standards, was used to complete the modeling. This Shadow Study was prepared using Prudent Wind Industry Practice and One Energy's Shadow Methodology version 2021.0. See Exhibit A for more information.

2. SITE OVERVIEW

Marathon Petroleum Corporation (MPC) owns a total of 345.85 acres in Dickinson, North Dakota within Stark County. The MPC property is sufficient for siting utility-scale wind turbines. The land currently owned by MPC is outlined in green in Figure 1. One Energy's siting for all five turbines is in accordance with Prudent Wind Industry Practices and represents safe siting for nearby residents, public road users, and MPC employees.

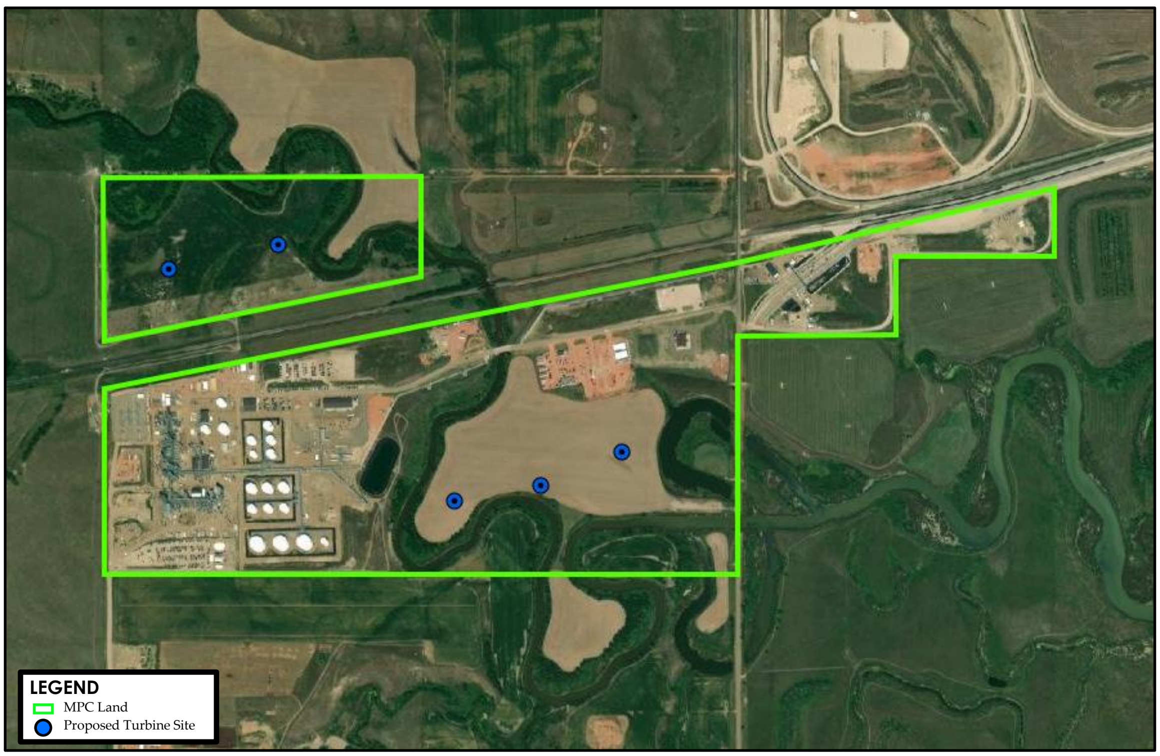

Figure 1: Satellite Image of MPC facility in Dickinson, ND

3. ZONES OF INTEREST

One Energy identified 27 "Zones of Interest" around the project area, shown in Figure 2. The Zones of Interest (Zones) are regularly inhabited structures and may also be referred to as "Receptors" within the industry. Zones are used in feasibility studies to measure the potential impact of the turbines on the surrounding community. For this study, only private residences or community buildings were included. All of the identified Zones are private residences and no community buildings were identified nearby.

In areas where there are clusters of structures, such as a neighborhood, a few of the structures have been chosen at varying positions along the edges closest to the turbines. These Zones are expected to represent the nearby structures and are taken to be the worst-case scenario for the cluster of structures. Information on the Zones identified can be seen in Table 1.

Figure 2: Zones of Interest Satellite Image

MPC – DICKINSON: ZONES OF INTEREST INFORMATION					
Zone of Interest	Latitude	Longitude	Zone Size (Area, ft^2)	Distance from Closest Turbine (ft)	Description
R-1	46.8708	-102.9532	5,856	10,767	House
R-2	46.8718	-102.9345	9,644	6,922	House (3)
R-3	46.8531	-102.9368	3,617	6,351	House
R-4	46.8482	-102.9345	4,209	6,757	House
R-5	46.8367	-102.9249	6,458	8,331	House (3)
R-6	46.8776	-102.9236	6,157	7,031	House (4)
R-7	46.8666	-102.9174	16,878	2,737	House
R-8	46.8753	-102.9147	3,918	5,644	House (4)
R-9	46.8463	-102.9123	5,425	3,655	House
R-10	46.8478	-102.9092	2,939	2,781	House
R-11	46.8385	-102.9075	3,498	5,881	House (2)
R-12	46.8769	-102.9088	10,893	6,074	House
R-13	46.8750	-102.9076	7,136	5,421	House
R-14	46.8701	-102.9005	6,932	4,264	House
R-15	46.8466	-102.8964	16,727	3,176	House
R-16	46.8466	-102.8935	7,104	3,455	House
R-17	46.8332	-102.8937	5,167	8,067	House (3)
R-18	46.8381	-102.8750	16,770	8,582	House

R-19	46.8418	-102.8720	16,663	8,195	House (4)
R-20	46.8450	-102.8718	4,941	7,588	House (2)
R-21	46.8459	-102.8701	5,920	7,801	House (6)
R-22	46.8758	-102.8847	4,392	8,120	House (30)
R-23	46.8772	-102.8740	5,619	9,945	House (9)
R-24	46.8768	-102.8638	6,953	11,540	House (10)
R-25	46.8766	-102.8554	4,478	13,136	House (3)
R-26	46.8756	-102.8525	4,069	13,539	House (8)
R-27	46.8700	-102.8525	3,681	12,527	House (8)
Number of structures that the Zone represents is indicated in parentheses next to the description (if more than one).					

Table 1: Zones of Interest Information

4. SHADOW STUDY

Most private residences experience no shadow flicker and of those that do, all residences experience less than 12 hours. This is less than the industry standard of 30 hours. In addition, all private residences modeled to experience shadow flicker are greater than 2,000 feet from the turbines and at this distance the perception of shadow flicker is likely less noticeable due to light dispersion and elongated shadows. These effects make the model even more conservative in its estimated hours of shadow flicker.

MPC – DICKINSON: SHADOW FLICKER STUDY RESULTS				
Zone of Interest	Distance from closest turbine (ft)	Annual Hours of Shadow Flicker		
		Total Modeled Hours	Hours Excluding Cloudy Days	Hours Excluding Cloudy and Partly Cloudy Days
R-1	10,767	8	6	4
R-2	6,922	21	15	10
R-3	6,351	14	10	7
R-4	6,757	9	7	5
R-5	8,331	0	0	0
R-6	7,031	0	0	0
R-7	2,737	8	6	4
R-8	5,644	0	0	0
R-9	3,655	0	0	0
R-10	2,781	0	0	0
R-11	5,881	0	0	0
R-12	6,074	0	0	0
R-13	5,421	0	0	0
R-14	4,264	0	0	0
R-15	3,176	0	0	0
R-16	3,455	0	0	0
R-17	8,067	0	0	0
R-18	8,582	0	0	0
R-19	8,195	21	16	11
R-20	7,588	24	18	12
R-21	7,801	17	13	9
R-22	8,120	1	1	0
R-23	9,945	10	7	5
R-24	11,540	3	2	2
R-25	13,136	12	9	6
R-26	13,539	7	5	3
R-27	12,527	4	3	2

Table 2: Shadow Flicker Study Results

Based on the shadow model results, shadow flicker will not exceed acceptable limits at any private residences. The residences with the most amount of shadow flicker hours are Zones R-20 and R-19 with 12 and 11 hours of possible shadow flicker per year when factoring in cloudy and partly cloudy days, respectively. The model is designed to be conservative and thus overestimates the hours of shadow flicker.

5. CONCLUSIONS

The Shadow Study concluded that private residences are expected to experience minimal hours of shadow flicker per year based on the conservative methodology used in the study. One Energy believes a *Wind for Industry®* project at the MPC facility will not have a significant shadow impact on the surrounding community.

NOTES:

One Energy's Shadow Methodology version 2021.0 can be seen in Exhibit B.

This report presents the model results as required by the PSC.

One Energy validated the Shadow Model results using an alternate software package. The results of this comparison can be seen in Exhibit C.

Two third party reviews of the study were completed and can be seen in Exhibit D.

EXHIBIT A

SHADOW STUDY RESULTS

Project	MPC Dickinson
Site	Dickinson, ND
Turbine	2.35 MW - 103 m rotor diameter
Hub Height	80 m
Wind Data	LiDAR Dataset

WIND TURBINE SHADOW STUDY RESULTS

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SHADOW FLICKER STUDY RESULTS

Zone of Interest	Distance to closest turbine (ft)	Possible Hours of Shadow Flicker Per Year	Hours (Excluding Cloudy Days)	Hours (Excluding Cloudy and Partly Cloudy Days)
R-1	10,767	8	6	4
R-2	6,922	21	15	10
R-3	6,351	14	10	7
R-4	6,757	9	7	5
R-5	8,331	0	0	0
R-6	7,031	0	0	0
R-7	2,737	8	6	4
R-8	5,644	0	0	0
R-9	3,655	0	0	0
R-10	2,781	0	0	0
R-11	5,881	0	0	0
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R-15	3,176	0	0	0
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R-18	8,582	0	0	0
R-19	8,195	21	16	11
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R-25	13,136	12	9	6
R-26	13,539	7	5	3
R-27	12,527	4	3	2

KEY						
Hours	0-30	30-60	60-90	90-120	120-150	150+
Color						

MPC Dickinson Zones of Interest

CONCLUSIONS

Based on the shadow model results, shadow flicker will not exceed acceptable limits at any private residences. The residences with the most amount of shadow flicker hours are Zones R-20 and R-19 with 12 and 11 hours of possible shadow flicker per year when factoring in cloudy and partly cloudy days. There will be no significant impacts on the surrounding area.

EXHIBIT B

SHADOW **METHODOLOGIES**

SHADOW
METHODOLOGIES

Publish Date: April 15, 2021

Version 2021.0

CONTENTS

GLOSSARY

Long-Term: Describes a consecutive period of the most recent 30 years.

Measure-Correlate-Predict (MCP): A statistical technique that is used to create a simulated, long-term dataset by relating a concurrent short, measured target dataset to a long-term reference dataset.

Prudent Wind Industry Practices: The practices, methods, specifications and standards of safety, performance, quality, dependability, efficiency, and economy generally recognized by industry members in the US as good and proper. Other practices, methods, or acts which, in the exercise of reasonable judgment by those reasonably experienced in the industry in light of the specific projects and facts known at the time a decision is made, would be expected to accomplish the result intended at a reasonable cost and consistent with applicable laws, reliability, safety, and expedition. Prudent Wind Industry Practices are not intended to be limited to the optimum practices, methods, or acts to the exclusion of all others, but rather to be a spectrum of good and proper practices, methods, and acts.

Shadow Flicker: The effect caused by the shadows of the spinning rotor and rotating blades.

Site MCP Dataset: A long-term MCP dataset created with the Site Dataset and the closest available reanalysis grid-point to the site.

Site-Specific Feasibility Studies: Studies of shadow flicker, ice shedding, and sound propagation at the project site. These studies indicate any impacts or lack thereof to the surrounding community.

TAILS 3.0: One Energy's proprietary software used to model turbine icing, shadow flicker, and wake loss.

Zones of Interest: Regularly inhabited structures, or clustered groups of structures, roughly within a one-mile radius of the turbine(s). Zones may include private residences, businesses, and public areas.

1. INTRODUCTION

One Energy considers many factors when siting a *Wind for Industry*® project. The safety of the surrounding community is the most important factor considered when siting wind turbines. A project will not proceed if the wind turbines cannot be safely sited within the bounds and conditions given. In addition to safety, energy production optimization is a key factor considered when siting wind turbines. Feasibility modeling is discussed in this document.

The objective of this methodology is to allow for explanation of each section within One Energy's Shadow Report. Each section states what variables and key pieces of information are presented within the Shadow Report. The deliverables within the formal shadow document from each section are designated in bold text throughout this document.

This Shadow Methodology is version 2021.0.

2. SITE OVERVIEW

Within this section, the current landscape of the proposed project site is described, focusing on parcel information.

The following information is presented in Site Overview:

1) **Aerial imagery of the proposed project siting parcel(s) and project facility parcel(s)**
2) **Size of project parcel(s)**
3) **Ownership of parcel(s)**

3. ZONES OF INTEREST

In order to ensure safety and minimize potential effects from the turbines on the surrounding area, One Energy identifies "Zones of Interest" near the turbine(s). The Zones of Interest are regularly inhabited structures roughly within a one-mile radius of the turbines. Zones may include private residences, businesses, and public areas. In areas where there are clusters of structures, such as a neighborhood, a few structures are chosen at representative positions along the edges closest to the turbine(s). These Zones are expected to represent the nearby structures and are taken to be the worst-case scenario for the cluster of structures. If a Zone of Interest represents more than one structure, it is noted within the Shadow document.

The Zones of Interest are used in the feasibility studies models (see Section 5: Feasibility Study). The impact of the turbine(s) on each Zone of Interest is calculated in each of the models. The models account for the Zone of Interest's location relative to the turbine(s) and the wind distribution of the site. The size of each Zone of Interest is approximated using satellite imagery and is generally overestimated.

The following information is presented in Zones of Interest:

1) **Aerial imagery of all zones and turbine siting for reference**
2) **A table of the Zones of Interest including:**
    a. **Latitude/Longitude**
    b. **Zone size (area)**
    c. **Distance from the closest turbine**
    d. **Zone description**

4. FEASIBILITY STUDY

Feasibility studies are completed during the development process as part of the due diligence of a project. These studies indicate the impact of the surrounding community and logistics for project construction.

A. SHADOW MODEL

One Energy's Shadow Model is another of the models within One Energy's proprietary software suite, TAILS 3.0, and predicts the annual number of hours of shadow flicker that would be experienced at the Zones of Interest near the turbine location(s).

Wind turbines, like all structures, create a shadow that moves across the ground throughout the day and year. Wind turbines, unlike most structures, have a rotor (including blades) that move. This rotation can create a moving shadow, commonly known as shadow flicker. This moving shadow, when observed from inside a building, can appear as a "flicker" where the shadow alternates between on and off as the rotor spins. This does not present any medical risk to the public with utility-scale wind turbines, but, in high enough exposure, can be considered an annoyance.

With respect to quantifying annoyance, there is not a uniform national standard. For reference only, local level and international standards range in annual limits from as high as 87 hours to as low as 30 hours.

The following information is presented in the Shadow Model:

1) **Table with the total hours of modeled shadow at each Zone of Interest, as well as adjusting the total hours dependent on 'cloudy' and 'cloudy and partly cloudy' days**
2) **Figure of 'excluding cloudy and partly cloudy' shadow hours based on hour of day at Zones of Interest above specified annual number of hours**
3) **Figure of 'excluding cloudy and partly cloudy' shadow hours based on month of year at Zones of Interest above specified annual number of hours**
4) **One-page summary sheet (as exhibit)**

Inputs

The inputs for the Shadow Model are: 1) Long-Term data relating to cloud cover obtained from the MERRA2 node closest to the site; 2) Turbine location (latitude and longitude); 3) Turbine model specifics; 4) Zone of Interest location (latitude and longitude), elevation, and size (in meters); and 5) Time Zone.

Methodology

The Shadow Model within TAILS 3.0 calculates the total time per year a Zone of Interest could experience shadow flicker.

The software uses the input locations to determine the distances and angles between the turbine and each Zone of Interest. The model takes the location on the earth, time of year, angle of the sun, and height of the turbine and tabulates how often each Zone of Interest could be in the shadow of the turbine(s). The output from the program details the date and time of each shadow flicker occurrence throughout the year at each Zone of Interest. The program totals these occurrences to give a worst-case scenario for the maximum possible annual hours of shadow flicker. Due to the assumptions of the program, the total number of hours per year of shadow flicker is overestimated.

The Shadow Model assumes weather conditions are always clear (cloud cover is less than 30%) and the rotor is positioned to create the longest shadow length. To more accurately assess the expected shadow flicker, the modeled hours of shadow flicker are reduced by the percentage of annual cloudy days. The shadow flicker results from the model are shown in three ways: clear, excluding cloudy days, and excluding cloudy and partly cloudy days. The applied cloud cover data is derived from MERRA2, which collects and re-analyzes data from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) to report the hourly mean cloud fraction. Each hourly recording during daylight hours is categorized as "Clear," "Partly Cloudy," or "Cloudy" based on the percentage of cloud cover. A timestamp is considered partly cloudy if it has between 30% and 80% cloud cover. Above 80% cloud cover indicates a cloudy hour, and below 30% cloud cover indicates a clear hour.

Model Assumptions and Limitations

- During the initial model run, no attempt is made to predict cloud cover or other weather conditions that might prevent the sun from casting a shadow at a specific location. The hours of shadow flicker are adjusted for cloudy and partly cloudy days after the model is run.
- No attempt is made to predict the angle of the turbine rotor due to the wind direction. It is assumed the rotor is always in the worst-case position, i.e., perpendicular to the sun's rays on the area of interest, which would cast the largest shadow area.
- It is assumed the blades are always perpendicular to the line between the area of interest and the turbine. This is conservative in that when the sun is higher or lower than the line between the area of interest and the turbine, the blade area cross section is effectively an ellipse of less area than the circle used in the analysis.
- No attempt is made to account for obstructions, e.g., trees, tall shrubs, or other buildings, that might block the flicker from the area of interest during the model run, though locations of shadow are reviewed manually after to determine any effect on nearby structures.
- It is assumed all shadow flicker is observed, even if it strikes a windowless wall on the side of the building.
- No attempt is made to de-rate the potential flicker due to the sun being low in the sky or due to the distance between the turbine and the area of interest.
- No attempt is made in this analysis to account for the rotational speed or pitch of the turbine blades and the associated scattering of light.
- No attempt is made to predict the intensity of the shadow based on frequency, brightness, or distance.
- Daylight savings time and other local time adjustments are not considered. Every minute of every day is analyzed, so the total flicker estimate includes these adjustments. For minute-to-minute predictions, the time must be adjusted per these local time adjustments.
- For computational simplicity, a rectangular Zone of Interest is modeled as the largest circle inscribed within a square. This allows the model to use an angle offset method instead of boundary checking. The user should keep this in mind when defining the size of the Zone of Interest. If the Zone of Interest is long and narrow, this could be overly conservative and the user may want to shorten the longer side. If the Zone of Interest is a square, the user may want to increase the dimensions so that the circle contains the same area as the desired square Zone of Interest.

5. CONCLUSIONS

One Energy considers many factors when siting wind turbines. The shadow model is completed to measure the impact of the turbines on the surrounding community.

EXHIBIT C

MODEL VALIDATION

EXHIBIT C: SHADOW FLICKER MODEL VALIDATION

One Energy used its proprietary internal software called TAILS 3.0 to conduct a Shadow Flicker Study for the Dickinson facility. To validate these results, One Energy utilized Continuum 3.0, an open-source software.

Table 1 and Table 2 provide the latitude and longitude for the identified Zones of Interest and the proposed turbine locations, illustrated in Figure 1. These Zones of Interest were analyzed in the Continuum 3.0 study and are the same that were analyzed in the TAILS 3.0 study. The distance from the closest turbine for each Zone is also shown.

MPC – DICKINSON: TURBINE LOCATIONS (WGS 84)		
	Latitude	Longitude
WTG01	46.859654°	-102.913217°
WTG02	46.860222°	-102.909532°
WTG03	46.854388°	-102.903689°
WTG04	46.854733°	-102.900790°
WTG05	46.855505°	-102.898077°

Table 1: Turbine Coordinates

MPC – DICKINSON: ZONES OF INTEREST INFORMATION			
Zone of Interest	Latitude	Longitude	Distance from Closest Turbine (ft)
R-1	46.8707547	-102.9532124	10,767
R-2	46.8718075	-102.9345305	6,922
R-3	46.8531083	-102.9368052	6,351
R-4	46.8481924	-102.9344951	6,757
R-5	46.836729	-102.9248599	8,331
R-6	46.8775686	-102.9236172	7,031
R-7	46.8665933	-102.9173887	2,737
R-8	46.875283	-102.9146991	5,644
R-9	46.8463008	-102.9123338	3,655
R-10	46.8477556	-102.9091822	2,781
R-11	46.8384786	-102.9074884	5,881
R-12	46.8768657	-102.9088157	6,074
R-13	46.8750226	-102.9076073	5,421
R-14	46.8701484	-102.9005029	4,264
R-15	46.8465686	-102.8963672	3,176
R-16	46.8465603	-102.8935206	3,455
R-17	46.8331528	-102.893731	8,067
R-18	46.8380784	-102.8749741	8,582
R-19	46.8418359	-102.8720146	8,195
R-20	46.8449914	-102.8718344	7,588
R-21	46.8459156	-102.8701321	7,801
R-22	46.8758109	-102.8847488	8,120
R-23	46.8772171	-102.8739695	9,945
R-24	46.876777	-102.8638329	11,540
R-25	46.8765988	-102.8553936	13,136
R-26	46.875619	-102.8524625	13,539
R-27	46.8699597	-102.8525247	12,527

Table 2: Information for Zones of Interest

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Figure 1: Zones of Interest and Proposed Turbine Locations Relative to Dickinson Facility

SHADOW FLICKER STUDY

After inputting the locations of the Zones and turbines in Continuum 3.0 and TAILS 3.0, the models predict the annual number of hours of shadow flicker that would be experienced at the Zones.

Annual Shadow Flicker

Table 3 shows the annual number of hours of shadow flicker for each Zone output by Continuum 3.0 and TAILS 3.0, as well as the difference between the output. A positive difference indicates that Continuum 3.0 predicted less hours of shadow than TAILS 3.0 while a negative difference indicates that TAILS 3.0 predicted less hours of shadow than Continuum 3.0.

This shows the worst-case scenario for each model. Hours of shadow flicker on cloudy or partly cloudy days were not excluded from the analysis. If cloudy and partly cloudy days were included, then the number of hours of shadow flicker would decrease by approximately 50%.

MPC – DICKINSON: SHADOW FLICKER STUDY RESULTS			
Zone of Interest	Annual Hours of Shadow Flicker		
	TAILS 3.0	Continuum 3.0	Difference
R-1	8	0	8
R-2	21	1	20
R-3	14	0	14
R-4	9	2	7
R-5	0	0	0
R-6	0	0	0
R-7	8	9	-1
R-8	0	0	0
R-9	0	0	0
R-10	0	0	0
R-11	0	0	0
R-12	0	0	0
R-13	0	0	0
R-14	0	0	0
R-15	0	0	0
R-16	0	0	0
R-17	0	0	0
R-18	0	0	0
R-19	21	24	-3
R-20	24	17	7
R-21	17	13	4
R-22	1	0	1
R-23	10	10	0
R-24	3	2	1
R-25	12	9	3
R-26	7	4	3
R-27	4	2	2

Table 3: Shadow Flicker Study Results

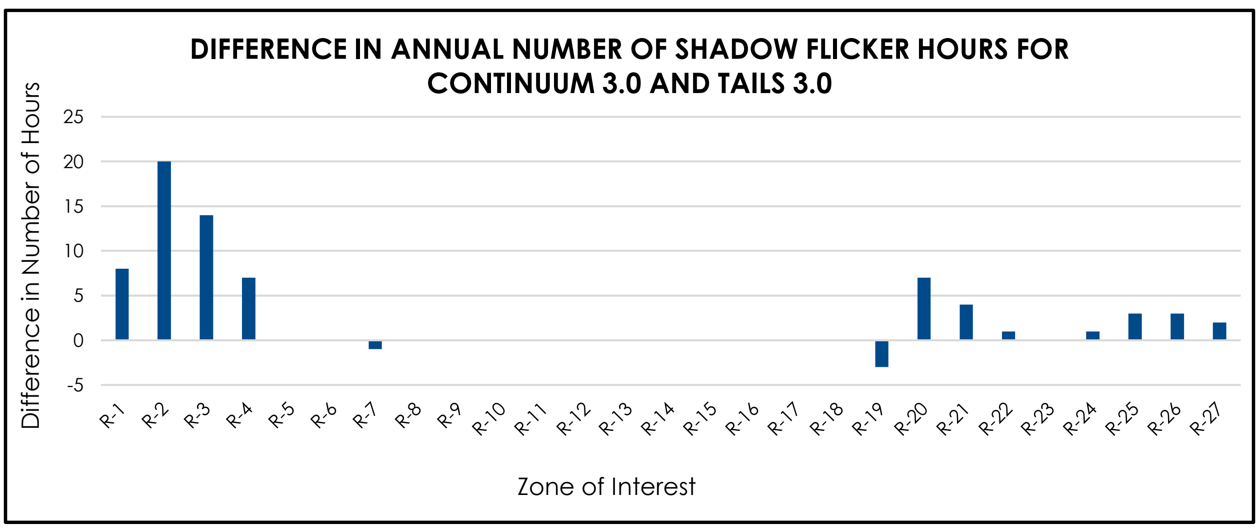

Figure 2: Difference in Annual Number of Shadow Flicker Hours

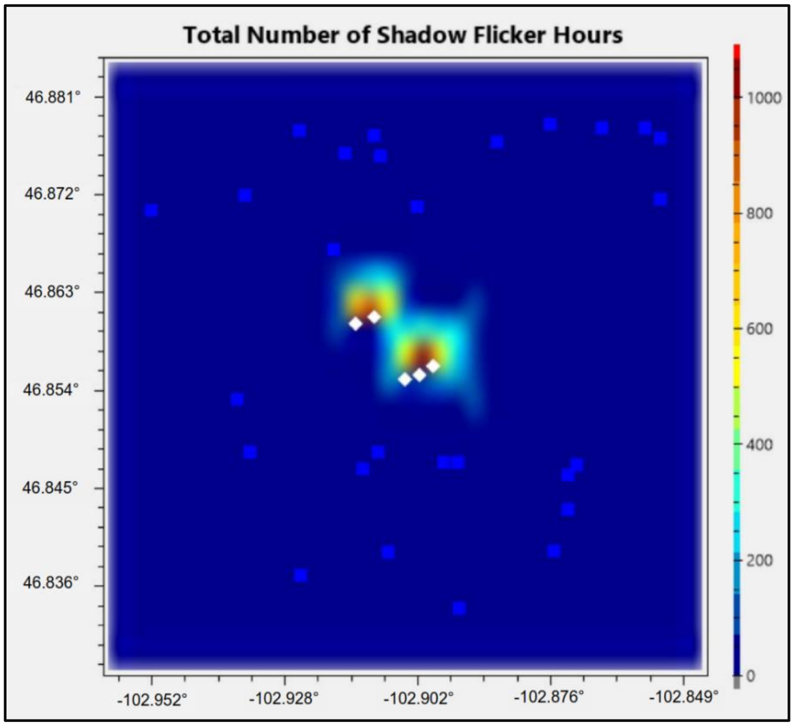

Figure 3: Total Number of Shadow Flicker Hours

Positive values in the difference column indicate that TAILS 3.0 modeled higher values of shadow flicker than Continuum 3.0 and was therefore more conservative. Negative values in the difference column indicate that Continuum 3.0 modeled higher values of shadow flicker than TAILS 3.0. In all but two instances where there was a difference in the results, TAILS 3.0 generated more hours of shadow flicker than Continuum 3.0 at the modeled Zones and was therefore more conservative.

It is noted that TAILS 3.0 includes hours of shadow flicker that occur during twilight hours, not just the time between sunrise and sunset, as with Continuum 3.0. This allows TAILS 3.0 to report a higher value of shadow flicker at certain Zones.

CONCLUSIONS

Continuum 3.0, the open-source software, was run for comparison against One Energy's in-house software. The results show that TAILS 3.0 is a more conservative shadow flicker model than Continuum 3.0, which is primarily due to additional shadow impact during the twilight time periods.

EXHIBIT D

THIRD PARTY REVIEWS

Ben Mallernee

From: Liz Walls <liz.walls@arcvera.com> on behalf of Liz Walls
Sent: Tuesday, August 31, 2021 10:17 AM
To: Jessica Grosso; Ben Mallernee; Carly Good; Erin Roekle
Subject: Dickinson Shadow and Sound study review

Jessica,
I have completed my review of the updated turbine locations of the Dickinson wind project and the subsequent impact on the shadow and sound modeling studies. I updated my sound and shadow model with the updated coordinates and also ran a sound model simulation with each receptor 100 feet closer to the wind project.

I compared my results to those published in One Energy's updated reports (Sound study, dated 8/25/2021; Shadow study, dated 8/23/2021). I found consistent results with my modeled results including the simulation with the sound receptors 100 feet closer to the project.

At this point, I do not have any additional questions or requests. Both the sound and shadow studies may be deemed complete and ready for submission. Our previously-issued letter still reflects our opinion on the results of the shadow flicker and sound modeling at Dickinson so we will not be issuing a new letter.

Kind regards,
Liz

Liz Walls | Software Development Lead and Senior Renewable Energy Engineer
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ARCVERA RENEWABLES

16 July 2021

To whom it may concern,

ArcVera Renewables has been engaged to review One Energy Solutions sound and shadow flicker studies for Marathon Petroleum Company's Dickinson Wind Energy Project. ArcVera Renewables is not affiliated with Marathon Petroleum Company or any One Energy company or employee.

ArcVera Renewables has previously reviewed One Energy's published methodologies for sound propagation and shadow flicker studies. During those reviews, ArcVera Renewables concluded that the methodologies were based on sound scientific and engineering principles and were consistent with prudent practices. Those same methodologies were used in this case.

ArcVera Renewables has, as a result of this engagement, reviewed the site-specific reports prepared for this project. The review has concluded that One Energy substantially used its published methodologies and that the reports are free of any material defect or error.

It is ArcVera Renewables conclusion that the reports presented by One Energy Solutions for the Dickinson Wind Project are reasonable, prudent, and free of material error.

Sincerely,

John Bosche
President

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1 September 2021
Letter of Review

DVDZ Consulting has been engaged to review One Energy Solutions' sound and shadow flicker studies for the Marathon Petroleum Company (MPC) Dickinson Wind Energy Project. DVDZ Consulting has previously served as an Independent Engineer for the various capital providers for One Energy's projects. DVDZ Consulting is not affiliated with any One Energy company or employee.

DVDZ Consulting has previously reviewed One Energy's published methodologies for shadow flicker and sound propagation studies. During those reviews DVDZ Consulting concluded that the methodologies were based on sound scientific and engineering principles and were consistent with standard wind energy industry practices. Prior to modeling either shadow flicker or sound propagation, One Energy conducts a detailed search for receptors that could be impacted by either phenomenon. This search can include review of satellite data, street-level imagery, or even site visits to verify the nature of a structure and determine if the structure should be included in the site-specific studies.

To assess the potential of shadow flicker, One Energy uses a proprietary model that was internally developed (TAILS 3.0). This model is similar to the software used by the wind energy industry as a whole. For example, a specific industry-standard software (WindPro) uses the same inputs and produces similar outputs as One Energy's propriety shadow flicker software. However, TAILS 3.0 is much more conservative and produces an overestimated (or worst-case) scenario for shadow flicker. An example of the conservative nature of TAILS 3.0 can be seen in the study results. Research suggests that shadow flicker is unnoticeable at distances over 2 km from a given turbine, but One Energy includes assessments for structures up to 3 km in their study.

The sound propagation model used by One Energy to predict the turbine-generated sound pressure level at a given receptor is based on a standard model that is used in some national codes (e.g. New Zealand). This model has been reviewed in the scientific literature and has been found to adequately represent measured sound pressure levels at given distances from a point source. However, different assumptions will affect the accuracy / conservativeness of this model. While there are other methods available in the literature, this commonly used sound propagation model is accurately described by the One Energy methodology and appears to be accurately implemented.

These same previously reviewed methods were used in the assessment of shadow flicker and sound propagation for the MPC project near Dickinson, North Dakota. Considering shadow flicker, the TAILS 3.0 model suggests that no residential receptors will experience a significant amount of worst-case shadow flicker. The resulting pattern of predicted shadow flicker across the community is consistent with expectations based on research and previous projects. Importantly, all identified private residences are expected to receive less than 30 hours of *realistic* (including cloud-cover) shadow flicker a year, with most locations expected to receive no shadow flicker at all. For example, of the 27 receptors identified, 14 are not expected to experience any shadow flicker from the current turbine configuration. Of the remaining 13 receptors, 11 are greater than 2 km from the closest turbines where shadow flicker is has not been documented as noticeable. The two remaining receptors are modeled to experience less than 10 hours of flicker per year. ***These results suggest that shadow flicker generated by the turbines will have little, if any, impact on the surrounding community.***

Similarly, One Energy adhered to their published methods in assessing the impacts of modeled turbine noise on the community. Based on the modeling performed by One Energy, the noise produced by turbines associated with this project will fall below the PSC requirement of 45 dBa within 100 ft of a residence. Review of One Energy's modeling results indicated that turbine-related noise no higher than 38.4 dB will be experienced at a given receptor (R-10, in this case). One Energy also highlights these results in Figure 3 of their report where they show the maximum extent of the 45 dB sound propagation level. This level is mostly limited to the MPC property, and no residence is within 100 ft of this level. ***These results suggest that noise generated by the turbines will have little, if any, impact on the surrounding community.***

In reviewing the site-specific reports prepared for this project as well as the scientific literature supporting these various topics, DVDZ Consulting has concluded that One Energy effectively used its published methodologies and that the reports represent standard industry practices. Further, the results are consistent with output produced by commercially available software and peer-reviewed research that has been presented in the scientific literature. A full list of references consulted for this report is available upon request. It is the conclusion of DVDZ Consulting that the reports presented by One Energy Solutions for Marathon's Dickinson Wind Project are reasonable, prudent, and align with practices that have been determined by the industry to maintain the safety and well-being of the community.

About

DVDZ consulting is led by Dr. W. Scott Gunter. Gunter is currently an Assistant Professor of Meteorology at the University of Louisville. Gunter's credentials include a Bachelor of Science degree from Mississippi State University where he graduated with honors in 2008. Gunter continued his education in graduate school at Texas Tech University as a Master's student, where his research initially focused on hurricane structure and evolution using high resolution radar data. After acceptance into the Ph.D. program at Texas Tech, Gunter's research focus shifted to severe storms. Working with Dr. John Schroeder, Gunter's designed a field project to collect and analyze wind profile and turbulence data from severe thunderstorms. This project also involved a thorough comparison of different types of wind measurements, including tall tower, radar, and sodar. Dr. Gunter was an active operator of the TTUKa mobile Doppler radars and heavily involved in deployments and data collection efforts within wind farms with the National Wind Institute. Scott completed his PhD studies in 2015 after the publication of several peer-reviewed manuscripts and numerous conference presentations. Dr. Gunter is currently an Assistant Professor of Meteorology at the University of Louisville in Kentucky where he teaches courses ranging from Climate Science to Synoptic Meteorology. In addition to teaching, Dr Gunter engages in research related to the observed characteristics of the wind and comparisons of wind measurement platforms. His education and experience have led to participate in a consulting role for the wind energy industry. Gunter began consulting in 2016 and officially formed DVDZ Consulting in 2017. He has since used his expertise to evaluate numerous small scale wind projects, their associated data, and the methods used in the modeling of the wind resource and environmental conditions.