PROJECT SITING
METHODOLOGIES

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CONTENTS

GLOSSARY

Decibels (dB): The unit used to measure sound pressure levels. A-weighted decibels (dBA) may be used due to the relative loudness of sound as perceived by the human ear. This A-weighting weights the decibels by frequencies that can be heard by the human ear and are standard for use in measurement of environmental noise.

Icing: An event in which ice buildup occurs on a turbine blade.

Ice Shedding: An event in which the ice buildup on a turbine blade is released and falls from the structure.

Inflow Angle (α): Angle at which the wind will be approaching the turbine.

LiDAR: A remote sensing instrument used to collect wind data, short for Light Detection and Ranging. The data collected by LiDARs are volume measurements as opposed to point measurements.

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.

Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA2): A satellite-derived long-term reanalysis data source from NASA. Contains 30+ years of global hourly reanalysis data, which include wind speed, direction, and temperature.

Micrositing: Any turbine siting change that does not exceed one arcsecond from the original siting location. This term is adopted from the FAA.

Original Equipment Manufacturer (OEM): The manufacturer that makes components used in other companies' products.

Private Residence Setback: A setback used for private residences. This setback defined as 2.5x the maximum turbine tip height.

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.

Rotor Radius Setback: A setback used for property lines, railroads, low trafficked roads, and medium voltage transmission lines. The setback is 1.05x the rotor radius.

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.

Wake Loss: When obstacles upwind create a wake that reduces the wind available at the downwind wind turbines. Wake loss results in a reduction of energy production.

Waked Sector: The directional sector(s) in which wake will affect a turbine.

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. Other siting factors, including site considerations and feasibility modeling, are discussed in this document.

The objective of this methodology is to allow for explanation of each section within One Energy's Siting Report. Each section states what variables and key pieces of information are presented within the Project Due Diligence Package **Appendix 3: Project Siting**. The deliverables within the formal siting document from each section are designated in bold text throughout this document.

This Project Siting Methodology is version 2021.1.

2. SITE OVERVIEW

Within this section, the current landscape of the proposed project site is described, focusing on parcel information and current governmental jurisdictions ranging from local to state.

The following information is presented in Project Siting Section 2 – 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)**
4) **Overseeing municipality(s)**

3. PROJECT TECHNOLOGY

This section details the specifications of the proposed turbine used within this project.

TURBINE INFORMATION

The specific wind turbine model is necessary to know before siting. The tower height and rotor diameters can impact required setbacks from various structures, including the turbine themselves.

The following information is presented in Project Siting Section 3 – Turbine Information:

1) **A table with the following information:**
    a. **Turbine Manufacturer**
    b. **Nameplate capacity**
    c. **Hub height**
    d. **Rotor diameter and radius**

4. PROJECT SETBACKS

Setbacks are defined as required distances a turbine must be from specific objects in order to ensure safe and optimized siting. Different objects have different setbacks that must be adhered to, and the setbacks are dependent on the turbine hub height and rotor diameter. One Energy defines three setbacks for use within wind turbine siting: 1) Rotor Radius, 2) Turbine-Clearance, and 3) Private Residence.

- The Rotor Radius setback is defined as 1.05x the rotor radius.
- The Turbine-Clearance setback is defined as 1.1x the maximum tip height (hub height plus rotor radius).
- The Private Residence setback is defined as 2.5x the maximum tip height (hub height plus rotor radius).

For additional information and validation of the Private Residence setback, see One Energy white paper "*Determining Wind Turbine Siting Setbacks*" [1].

The following information is presented in Project Siting Section 4 – Project Setbacks:

1) **A table of the project-specific defined setback distances:**
    a. **Rotor Radius**
    b. **Turbine-Clearance**
    c. **Private Residence**

5. SITING CONSIDERATIONS

Many factors can affect siting of a *Wind for Industry*® project on a specific parcel. These factors include state and/or local zoning ordinances, underground pipelines, floodplains, wetlands, in-service microwave paths, proximity to airports and airspaces regulated by the FAA, the terrain of the siting parcel, among others. This section describes these considerations and how One Energy handles siting a project.

A. ZONING

Zoning regulations may be necessary to adhere to depending on the siting parcel chosen and any jurisdictions that may have precedent. All relevant local and state laws are investigated and observed when siting. Some items that may be found within zoning codes may include siting setbacks, height restrictions, or noise ordinances that must be adhered to while siting a project. A Zoning Memo is prepared by in-house counsel to identify all applicable local and state jurisdictions and any pertinent findings impacting project viability.

The following information is presented in Project Siting Section 5A – Zoning:

1) **Zoning Jurisdiction**
2) **Pertinent Local zoning findings (if applicable)**
3) **Pertinent State regulation findings (if applicable)**
4) **Zoning Memo (as exhibit)**

B. PIPELINE

One Energy uses the National Pipeline Mapping System [2] and the United States Energy Information Administration (EIA) interactive maps [3] for approximate gas transmission and hazardous liquid, petroleum, and natural gas pipeline locations. The National Pipeline Mapping System is a graphical viewer of pipelines within a specified vicinity put together by the Pipeline and Hazardous Materials Safety Administration, under the jurisdiction of the United States Department of Transportation. The EIA maps are created using publicly available data collected from the Federal Energy Regulatory Commission (FERC) and other external sources.

The following information is presented in Project Siting Section 5B – Pipeline:

1) **Map of nearby pipelines**

C. FLOODPLAIN

One Energy uses the FEMA National Flood Hazard Layer (NFHL) [4] to perform a search of local floodplains. The FEMA NFHL is a compilation of effective Flood Insurance Rate Map databases and Letters of Map Revisions. It is part of FEMA's Map Service Center (MSC) which is the official public source for flood hazard information.

The following information is presented in Project Siting Section 5C – Floodplain:

1) **Map of nearby floodplains**

D. ENVIRONMENTAL

One Energy makes all reasonable attempts to be good environmental stewards throughout the entire life of a project. During siting, the following factors are considered as an environmental screening process. One Energy will adhere to all additional environmental studies if required by local or state regulations.

The following information is presented in Project Siting Section 5D – Environmental:

1) **Map of indicated wetlands on project parcel**
2) **Table of any protected endangered species within the county of the project (may be contained within an IPaC report)**
3) **Indication if specific environmental studies must be performed per local or state regulations**

Wetlands

One Energy uses the United States Fish & Wildlife Service National Wetlands Inventory (NWI) database [5] to perform a search of any indicated wetlands on the project parcel that may affect siting and civil design. The detection of a wetland by the NWI does not necessarily indicate a wetland is present. Site conditions and land use change over time, and there is a margin of error in the analysis of high-altitude imagery used to create the NWI database.

If the NWI indicates the suspected presence of a wetland near the expected turbine siting, detailed on-the-ground inspection is completed during the Site Visit, and preliminary siting will remain outside of the area(s) suspected as a wetland. During the Site Visit (Section 6: Site Visit), the vegetation type and other wetland indicators are investigated. If the NWI indicated area is suspected to be a wetland, all siting and design work will be completed outside of suspected areas and One Energy will adhere to state and federal law, including possible delineation.

Wildlife & Avian Study

One Energy uses the United States Fish & Wildlife Service Environmental Conservations Online System (ECOS) database [6] to perform a search for any species that is endangered near the project vicinity. The United States Fish & Wildlife Service also has a Critical Habitat database within its ECOS that denotes final and proposed critical habitats for species listed under the Endangered Species Act that is used for initial planning. An informal Information for Planning and Consultation (IPaC) report, provided through ECOS, may be completed using the intended siting land. During this stage, this IPaC report is informal, and no information is sent to United States Fish & Wildlife. The information contained within the report is for internal purposes and includes the same information collected prior regarding critical habitats and nearby endangered species. A list of endangered species is displayed by county.

Additional studies will be completed if required by state or federal law.

E. MICROWAVE

An internal study is conducted that includes a database search of the Federal Communications Commission (FCC, [7]) to find nearby microwave paths and determine if the proposed turbine siting will impact known communication signals. One Energy makes all reasonable efforts to site wind turbines outside of registered microwave paths.

The Fresnel Zone clearance must be calculated to perform the internal microwave beam path analysis. A Fresnel Zone is an ellipse around the microwave path containing the energy of the signal being transmitted. Sixty percent of the information transmitted through the microwave path is contained within the first Fresnel Zone. The second Fresnel Zone, commonly used to calculate necessary clearance for minimal microwave path interference, is considered a conservative estimate and is used by One Energy for turbine siting. The equation for the radius of the Fresnel Zone is calculated using the following equation:

$$F_{\mathrm{n}} = \sqrt{\frac{n\lambda d_1 d_2}{d_1 + d_2}} \qquad \textit{Equation 1}$$

where F_n is the nth Fresnel Zone radius in meters, n is the Fresnel Zone number, λ is the wavelength of the microwave beam in meters, and d_1 and d_2 are the distances from each end of the microwave path to the point of interest in meters.

The point along the path where the turbine is located is necessary to determine the values for d_1 and d_2 for the Fresnel Zone calculation. A perpendicular line from the turbine to the beam path is determined, and the intersection on the beam path is the point of intersection, x. The values for d_1 and d_2 are then measured from the end points of the beam to point x. The distance from point x to the turbine is then determined to be of length y. The turbine is deemed out of the microwave path if:

$$F_2 < y - r \qquad \textit{Equation 2}$$

where y is the distance from point x to the turbine in meters, and r is the rotor radius in meters. Figure 1 is an illustration of each variable.

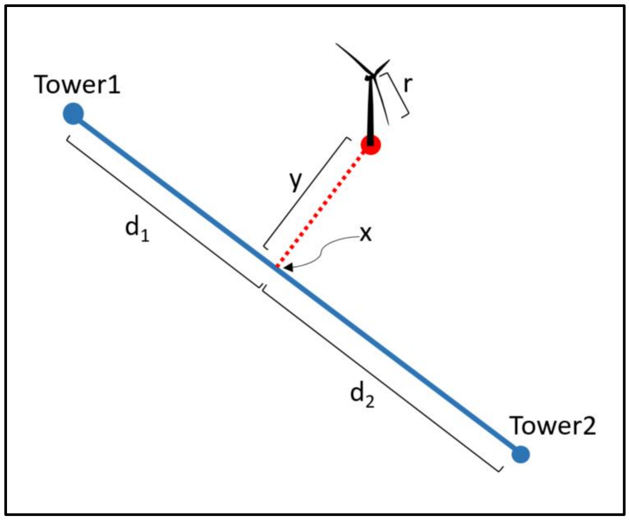

Figure 1: Microwave Schematic for Variables

Microwave tower locations are found from the FCC Universal Licensing System database based on the coordinates of the turbine(s). The area around the turbine(s) is searched for any fixed point-to-point microwave paths. The radio service codes for the towers specifically searched for are MG (Microwave Industrial/Business Pool), CF (Common Carrier Fixed Point-to-Point Microwave Service), MW (Private Operational Fixed Point-to-Point Microwave – Public Safety Service), AS (Aural Studio Transmitter Link), and AI (Aural Intercity Relay). The range of frequencies of the microwave towers One Energy searches for is 0.9 GHz to 30 GHz.

One Energy completes this internal microwave beam path analysis to determine if the potential turbine locations will have an impact. One Energy will contract out an external third-party preliminary screening if it is deemed necessary. The internal microwave study is periodically updated to check for new paths until a Notice of Proposed Construction has been filed with the Federal Aviation Administration (FAA).

The following information is presented in Project Siting Section 5E – Microwave:

1) **Image of project parcel with any microwave paths included**
2) **Table of nearby microwave paths with the call signs, locations of towers, and length of path**

F. FAA

The Federal Aviation Administration (FAA) has rules and regulations regarding tall structures. According to 14 CFR Part 77 [8], any construction or alteration of objects exceeding 200 feet above ground level, along with other considerations, must file notice with the FAA. States may also have regulations regarding tall structures. All One Energy projects obtain a Determination of No Hazard (DNH) from the FAA prior to beginning erection of the turbine(s) and to comply with a state's tall structures act, if applicable.

Once given approval from a customer, One Energy will file all necessary information with the FAA (Notice of Proposed Construction), and with state authorities (if applicable). All Notices of Proposed Construction are filed in One Energy's name to maintain customer anonymity.

Preliminary Screening

One Energy utilizes the FAA's Notice Criteria Tool to assess the initial viability of obtaining a Determination of No Hazard with the FAA due to restrictions surrounding an airport. Any state tall tower requirements will be investigated during this process. When necessary, One Energy can conduct an in-house aviation study that includes an assessment of potential restricted airspace in accordance with 14 CFR Part 77. The internal study is done to assess the probability of obtaining a DNH for a project. If necessary, One Energy will contract an airspace consultant for further examination.

This search is done to assess the probability of obtaining a DNH for a project.

The following information is presented in Project Siting Section 5F – FAA:

1) **Table with necessary information of Notice of Proposed Construction**
    a. **Locations for turbine(s) filed**
    b. **Date filed and date received DNH**
2) **Table with information about state's tall structures permitting (if applicable)**
    a. **Locations for turbine(s) filed (if applicable)**
    b. **Date filed and date received approval (if applicable)**

G. TOPOGRAPHIC ANALYSIS

The topography of the siting parcel must be taken into consideration when siting wind turbines, not only for wind flow effects but also for civil design. Assessment of the terrain within the project parcel vicinity is completed and considered when siting. One Energy uses the topographic maps provided by the United States Geological Survey (USGS). The 7.5-minute (1:24,000-scale) quadrangle series have a contour interval of five feet. These maps show changes in elevation that can affect wind flow, such as hill and ridgeline effects, which will alter the wind distribution.

The following information is presented in Project Siting Section 5G – Topographic Analysis:

1) **USGS associated topographic quadrangle**
2) **Image of parcel-specific topography in finer resolution**

6. SITE VISIT

During the development process, a Site Visit to the proposed facility and land parcels is required. Many important items can be learned by physically inspecting the property and features that may be unique to this project. Data collection for multiple groups within One Energy is completed during this site visit, and not all information gathered will be used within the siting process. Some of the information gained will aid in electrical design, civil design, and delivery of turbine components.

A qualified site visitor from One Energy will drive around the exterior of the customer facility and any project siting parcels. Narrated video is recorded during the drive with pertinent information.

Main items that are necessary to find for the Project Planning and Technology group include:

- Identification of any new built structures that are not visible in satellite imagery
- Identification and confirmation of the customer's inhabited structures

- Inspection of nearby Zones of Interest, noting any significant obstructions between the Zone and the project site and if the Zone appears to be inhabited
- Investigation of any designated wetland areas, noting vegetation and any water features
- Investigation of forest density and height (if applicable)
- Investigation of tall obstructions for turbines and/or a LiDAR deployment

Main items that are necessary to find for the Engineering and Construction group include:

- Identification of any low power lines crossing roads that may be used for turbine component transportation
- Identification of any significant elevation changes at railroad crossings
- Identification of load ratings of bridges considered for turbine component transportation
- Identification of any design needs for turbine component transportation such as road improvements, turn radius widening, and access road locations
- Identification of customer's existing electrical infrastructure and substation location (if coordinated with the customer, also including a walkdown of the substation area and identification of the customer's meter point)
- Identification of the expected interconnection tie-in location and potential locations for switching station

For more information on the Engineering and Construction process, see methodology for Appendix 10: Engineering and Construction Plan.

The following information is presented in Project Siting Section 6 – Site Visit:

1) **Date of Site Visit and One Energy employee(s) involved**
2) **Key Project Planning and Technology-necessary findings**

7. PROJECT SITING

Wind turbine siting is an iterative process. During different stages of development, siting may be adjusted as new information is uncovered. Zones of Interest, state and local setbacks, microwave paths, environmental factors, and One Energy-imposed setbacks are all taken into consideration to optimize safety and energy production while minimizing effects on the community.

In addition to any state or local setbacks that will be adhered to, One Energy uses internal setbacks as defined in Section 4: Project Setbacks. The more restrictive setback of the state/local or One Energy standard setbacks will be applied. Table 1 shows the standard setback distances One Energy adheres to as reference and what each setback is applied to. After the setbacks are applied to the project parcel(s) and all other siting considerations are accounted for, the remaining available land is used for turbine siting. The turbines are sited to maximize energy production (minimize wake loss effects) within the available land.

***WIND FOR INDUSTRY®* STANDARD SETBACKS**		
SETBACK	**SETBACK DISTANCE**	**APPLICABLE SETBACKS**
Rotor Radius Setback	1.05 x blade length	Property lines Railroads Low-traffic roads Local transmission lines (medium-voltage) Wetlands

		Critical Habitats
Turbine Clearance Setback	1.1 x maximum tip height	Customer-owned facility Underground pipelines High-traffic roads High-voltage transmission lines
Private-Residence Setback	2.5 x maximum tip height	Private residences Businesses

Table 1: Project Siting Setbacks

The following information is presented in Project Siting Section 7 – Project Siting:

1) **A table of the latitude/longitude and elevation of all final wind turbine locations**
2) **Figure with location(s) of turbine(s) and project parcel(s)**
3) **Figure with location(s) of turbine(s), project parcel(s), and all relevant setbacks adhered to**
4) **Any One Energy-imposed setbacks not met with detailed documentation (if applicable)**

PRELIMINARY

The Preliminary Siting occurs during the Initial Evaluation stage of project development. During this stage, not all factors that may impact turbine siting are investigated. Primarily, only state and local setbacks, One Energy-imposed setbacks, floodplains, microwave paths, and FAA criteria are considered.

The Preliminary Siting that is proposed within the Initial Evaluation is not definitive and is shown to indicate that turbine siting can be reasonably completed within a project parcel. Project parcels may change or locations within the parcel may be excluded due to customer requests or as additional information becomes available, which can ultimately affect turbine siting.

FINAL

The Final Siting occurs during the Project Due Diligence stage of project development. During this stage, all siting factors are considered in-depth, along with feasibility studies and energy production optimization. If project siting is on customer-owned land, confirmation from the customer about land uses is required. If the project parcel is not owned by the customer, all reasonable efforts must be made to assess risks associated with the ability for One Energy to obtain the project parcel.

A Notice of Proposed Construction is filed with the FAA under One Energy's name after the Final Siting is confirmed and permission is given by the customer.

MICROSITING

Micrositing of the Final Siting may occur after the completion of a Project Due Diligence Package but before construction has started. Micrositing is the slight adjustment of turbine location(s) that may happen due to the results of a formal survey of the project parcel. Factors that may be found during the formal survey and may slightly change the Final Siting include, but are not limited to, any wetlands not previously noted, local topography, transportation logistics, civil design logistics, and any other issues that would impact the turbine siting.

If the microsited location of the turbine(s) is greater than one arcsecond (approximately 100 feet but varies with latitude) from the location used to file the FAA Determination of No Hazard, One Energy must refile with the FAA with the updated turbine coordinates. If micrositing occurs after the Project Due Diligence Package is completed, an amendment must be made to **Appendix 3: Project Siting**.

8. 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 Project Siting document.

The Zones of Interest are used in the feasibility studies models (see Section 8: Feasibility Studies). 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 Project Siting Section 8 – Zones of Interest:

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

9. FEASIBILITY STUDIES

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. TURBINE ICING MODEL

A wind turbine, like any structure, can develop ice buildup during a freezing precipitation event. At some point this ice will release from the wind turbine and fall to the ground. The area immediately under the turbine will experience the most ice impacts as the ice falls straight down. Wind turbines can also introduce movement to the ice shedding process. While a wind turbine will not operate with large ice accumulation, it will operate with small amounts of ice accumulation. As the turbine blades rotate, ice can be launched from the blades. Pieces of ice under 15 pounds pose the greatest risk of being thrown the farthest.

One Energy's Turbine Icing Model is one of the models within One Energy's proprietary software suite, TAILS 3.0, and assesses the likelihood of ice impacts due to the turbine(s). The Turbine Icing Model simulates the distance and frequency of potential ice impacts surrounding the turbine(s). The model also calculates the frequency and probability of an ice impact at the Zones of Interest. The model accounts for the Zone of Interest's location relative to the turbine, the Zone's size, and the wind distribution of the site. The model does not calculate the icing frequency, it only calculates the distances ice would be displaced.

The following information is presented in Project Siting Section 9A – Icing Model:

1) **Figure and table showing specified distances from each turbine and the probability of impact at the specified distances**
2) **Figure of the probability of impact by distance from one of the turbines**
3) **Table with model impact statistics, including the maximum distance of impact and the 99.9th percentile distance of impact**
4) **Table of modeled ice impacts at each Zone of Interest throughout the lifetime of the project**
5) **One-page summary sheet (as exhibit)**

Inputs

The inputs included in the Turbine Icing Model are: 1) Turbine location; 2) The specifics of the turbine model, including but not limited to rotor radius and tower height; 3) Zone of Interest location (latitude and longitude), elevation, and size (in meters); 4) The Site MCP Dataset; and 5) Number of icing events per year.

Methodology

The Turbine Icing Model uses the site's wind distribution (wind direction in 1° increments and wind speed in 0.5 m/s increments), and a Monte Carlo simulation to select at random the point of ice separation from the blade, and the size and weight of the ice sheet. The model uses these factors and predicts the ice piece's trajectory until it hits the ground. The user can also account for the aerodynamics of the ice sheets by selecting the drag coefficient and the shape parameter of the ice sheet. Typically, 10,000 ice throws are simulated per turbine to determine the distribution of ice impact locations.

The software generates the X and Y coordinates of each individual ice impact relative to the turbine(s). The ice impacts are plotted graphically and the Zone of Interest impacts are summarized. Each impact is also grouped into 50 meter radial distances from the turbine and the impact probability over project lifetime is calculated for each distance interval.

The program calculates the number of ice impacts for a worst-case scenario (an underhand ice throw). Due to the assumptions of the software as explained below, the total number of impacts is overestimated. Conditions such as the number of icing events per year and the obstacles in the path (trees, other buildings, etc.) of a piece of ice's trajectory make it likely that a Zone of Interest will experience significantly fewer ice impacts per year than modeled. This model does not estimate how often ice throw occurs and only models the distance the ice is physically thrown.

Model Assumptions and Limitations

- Only small pieces of ice are considered. The ice piece weight is randomly selected to be between 0.5 pounds and 15 pounds.
- It is assumed that there are 10 days of icing per year.
- It is assumed that 100 small pieces of ice per blade break off and are thrown on each icing day totaling 300 small pieces per icing day.
- The path of travel of the ice is available but not used within this study. The model output used is the location of the point of ice impact on the ground.
- The weight and aerodynamic drag of the ice greatly affects its path of flight. The aerodynamic drag coefficient of the ice can be changed but is currently assumed to be 0.8.

- There is a known relationship between the size and shape of a piece of ice and its aerodynamic properties. The program uses a parameter to determine this relationship. This parameter can be adjusted but is currently assumed to be 0.5. This conservatively assumes pieces of ice have less drag and will travel farther than in reality.
- It is assumed that the site area is generally flat.
- No attempt is made to take obstacles, such as trees, into account in the analysis.
- Tip speed is based on the maximum rotations per minute (RPM) of the turbine model and is assumed to be constant, regardless of wind speed.
- No attempt is made to assess the force of the impact of the ice.
- No attempt is made to predict breakup or shedding of the ice during flight.
- The wind direction and speed data are gathered from a a representative wind data time series and then the direction is binned from 0-360° in 1° intervals while the wind speed is binned from 0-25 m/s in 0.5 m/s intervals. These distributions are represented in a wind resource matrix as a percentage of time throughout the year.
- No attempt was made to filter the wind direction or speed data to only use the months when icing would be expected.

B. 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. 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 Project Siting Section 9B – 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 could 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 is 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.

C. SOUND MODEL

One Energy's proprietary Sound Propagation Model package is used to predict the sound pressure levels at each Zone of Interest near the turbine location(s). Sound propagation through the atmosphere is dependent on conditions such as wind and temperature, atmospheric turbulence, terrain type, elevation changes, and obstructions. Wind turbines create sound when they are generating electricity due to the rotating blades, generator, and cooling fans. The sound pressure level is usually expressed in decibels (dB). Another common method of expressing sound levels is dBA. This measure quantifies the decibels using the A-weighted scale, which is intended to match human hearing.

The Sound Propagation Model uses measured outdoor sound data as reference and the sound power level of the turbine provided by the turbine manufacturer to determine the sound propagation as a function of radial distance from the turbine. The results are the expected sound pressure levels at each Zone of Interest.

One Energy examines if there are state or local noise regulations that pertain to the project. One Energy determines the sound pressure levels of the turbine(s) and the effects on the area's existing sound levels with or without an existing regulation. One Energy will make all reasonable efforts to comply with local noise regulations or a variance will be obtained.

The following information is presented in Project Siting Section 9C – Sound Model:

1) **Figure of sound observation locations**
2) **Table of observed sound measurements including the maximum measured dBA, minimum measured dBA, average measured dBA, and the modeled dBA**
3) **Table including the modeled sound levels in dBA at each Zone of Interest**
4) **Table of the long-term observations and turbine impacts (if applicable)**
5) **One-page summary sheet (as exhibit)**

Inputs

The main inputs for the Sound Propagation Model are: 1) Turbine location(s) (latitude and longitude); 2) Zone of Interest location; 3) Turbine-model specifics, including but not limited to, total Sound Power Level (in accordance with IEEE standards); 4) Observations at 4-8 specific points around the turbine location(s).

Methodology

A site-specific sound study is completed using turbine specifications provided by the manufacturer and field measurements. The expected sound level is modeled for each Zone of Interest. The sound pressure level (L_p) at a distance away from the turbine is calculated using the following equation:

$$L_p = L_w - 10\log_{10}(2\pi R^2) - \alpha R \qquad \text{[Equation 3]}$$

where R is the distance from the turbine in meters, α is the absorption coefficient (estimated at 0.005 dBA/m), and L_w is the sound power level of the turbine in dB(A). For multiple turbines, the total sound pressure level at a location is calculated using the following equation:

$$L_\Sigma = 10 \cdot \log_{10}\left(10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}} + \cdots + 10^{\frac{L_n}{10}}\right) dB \qquad \text{[Equation 4]}$$

Where L_n is the sound pressure level at the location due to the individual turbine n.

A model of the sound pressure levels and their propagation is created using the data from Equation 3 and Equation 4 (if necessary) to determine the sound pressure level at each Zone of Interest. The Zone of Interest locations are overlaid onto the model based on their distance from the turbine.

Four to eight sound observations are recorded using a Class 1 Sound Level Meter, such as a Casella 63-X, to determine the current ambient sound levels. One Energy determines the sound observation locations based on the locations of the Zones of Interest. Each sound observation deploys the sound meter for 10 minutes and the average decibel level from those 10 minutes is determined to be the ambient sound level at that location. The measured site sound levels are then compared to the modeled sound levels produced by the turbine(s).

In addition to the 10-minute observations, a longer sound measurement campaign may be completed. The sound meter is deployed for a minimum of 48 hours near the project site to determine ambient sound levels at varying times (daytime, nighttime, etc.) and the maximum sound level. The results of this measurement campaign will be used to determine if the turbine(s) will have substantial impact on the ambient sound of the area. Because this study requires access to the site, One Energy will need approval from the customer/landowner. If access to the site is denied, an explanation will be provided in the Project Siting document.

Model Assumptions and Limitations

- The Zones of Interest are represented by a single point on a 100-foot (30.5-meter) grid resolution.
- A total project area of 10,000 feet x 10,000 feet (3,048 meters x 3,048 meters) is modeled.
- An absorption coefficient of 0.005 dBA/meter is used in the Sound Propagation Model.

- The model is conservative in that it assumes the turbine is running at maximum wind speed and makes no attempt to account for decreased sound pressure level from the turbine at lower wind speeds.

D. TRANSPORTATION

The purpose of this preliminary transportation study is to verify the viability of delivering turbine components to the project location. The transportation study consists of two parts: a regional study and a local study. The regional study includes interstate and highway travel and the local study includes travel from the highway to the proximity of the site. Major elements considered in the regional study are overpass heights, bridge crossings, and construction zones. Major elements considered in the local study are the same as the regional study plus turning radii, overhead wires, raised railroad crossings, and culvert crossings.

Regional studies will be primarily focused on highway transportation. One Energy will make reasonable assumptions as to where turbine components will be arriving from (generally an international shipping port, a domestic manufacturer, or the One Energy laydown yard) in order to estimate a route to the project site. One Energy will primarily use past, known transportation routes to make the assumptions. One Energy will reach out to the state's Department of Transportation to confirm highway accessibility for overweight/oversize components.

Local studies will review the potential route from the nearest acceptable highway exit to expected project entrance. If possible, this part of the route will be driven during the Site Visit to identify any potential issues. Third-party consultations regarding bridge capacities may also be used in this study, but no county officials or county engineers will be contacted during this phase so the project can remain confidential.

The route determined during this transportation study is used to confirm feasible site access. Actual transportation routes are the responsibility of the external transportation company. The transportation company is responsible for obtaining all the necessary permitting for transportation. One Energy will coordinate any necessary road improvements prior to turbine component delivery.

The following information is presented in Project Siting Section 9D – Transportation:

1) **Preliminary regional component route(s)**
2) **Preliminary local component route(s)**
3) **Figure with routes indicated and any major elements identified**

10. CONCLUSIONS

One Energy considers many factors when siting wind turbines. Turbine siting is an iterative process that considers many factors while optimizing turbine placement. Throughout the siting process, standard One Energy setbacks, customer needs, and regulatory requirements will be adhered to. The result of the Project Siting document is the project turbine coordinates. These coordinates are used in all engineering drawings.

REFERENCES

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[4] *FEMA National Flood Hazard Layer*. United States Department of Homeland Security: FEMA, www.fema.gov/flood-maps/national-flood-hazard-layer.

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[7] *Universal Licensing System*. United States Federal Communications Commission, https://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp.

[8] Aeronautics and Space, 14 C.F.R. § 77.