AN ORENDA WHITEPAPER

Rural Siting of Wind Turbines:

Improve Performance and Mitigate Risk

ORENDA
ENERGY SOLUTIONS

Rural Siting of Wind Turbines - Improve Performance and Mitigate Risk

Wind power is a clean energy source that can be implemented in a way that is compatible with the existing environment. Determining the best site for a wind turbine has to take many factors into consideration, including wind turbine performance, health and safety, and the surrounding environment.

For the small-medium wind market, defined as land-based turbines rated to generate 5kW–100kW of power, Orenda believes that it is responsible to locate turbines in rural areas. This provides the greatest opportunity to maximize wind turbine performance in a manner that is low-impact and meets local siting regulations.

The following details wind turbine siting considerations that are applicable to the small-medium wind market.

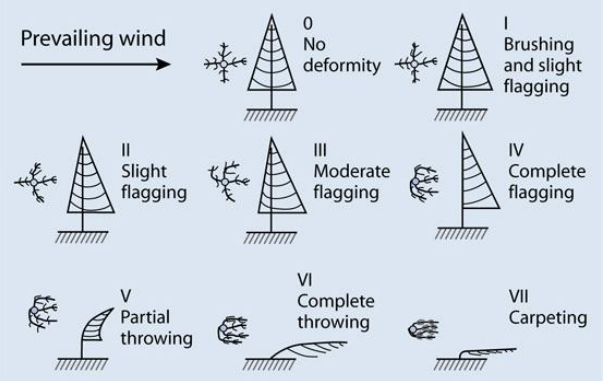
Wind Turbine Performance

Suitable wind conditions are a primary consideration for any proposed wind turbine site. The ideal location has steady wind at a moderate speed (>5 m/s average) with low turbulence. Although it is not necessary to find a perfect site, optimal locations include shorelines, smooth hills, plateaus, or any high area of land with minimal obstructions.

The large buildings that occupy urban areas create turbulent wind conditions that are unsuitable for horizontal axis wind turbine installations. Even when an appropriate open space can be located, ongoing commercial and residential development make it risky to plan an urban wind turbine installation.

In rural areas, trees and individual buildings can obstruct wind flow and create turbulence, but these factors are more stable and typically easy to plan around with the additional space provided by rural locations. Trees can also be beneficial in selecting a wind turbine site: consistent deformities in trees can be a great indication of long-term wind patterns. Specifically, the Griggs-Putnam Index of Deformity is an empirical method which estimates prevailing wind speed by examining the growth pattern of trees at a particular site.

Griggs-Putnam Index of Deformity



Griggs-Putnam Index of Deformity

Index	I	II	III	IV	V	VI	VII
Wind mph	7-9	9-11	11-13	13-16	15-18	16-21	22+
Speed m/s	3-4	4-5	5-6	6-7	7-8	8-9	10

Health and Safety

Accidents can happen in any industry, and although severe incidents are rare, the wind industry is no exception. In the United Kingdom, 1,500 incidents were reported over five years, most of which were minor and did not result in injury—none of the incidents recorded involved an injury to the member of the public.[1] The majority of injuries are caused by occupational hazards not unique to the wind industry; falls, confined spaces, electrical, fire, and other similar hazards experienced by workers occur in green industries as well as in traditional industries.[2]

There have been rare cases where wind turbine failures have resulted in fires, parts falling to the ground, or ice dropping from blades. These incidents decrease with new wind turbine technologies, but as a safety precaution, it is important for wind turbines to be located in low human foot-fall traffic areas. It is not only responsible to do this—most jurisdictions have setback requirements that dictate how close a turbine can be to roads and residences. It is much easier to meet these obligations in rural areas.

Advanced wind turbine technologies help decrease risk to workers and the public. Computerized control systems allow Orenda turbines to track key safety information, including wind speed and direction, temperatures, cable twist, hydrostatic brake condition and generator RPM. The following technologies are also used by Orenda to minimize health and safety risk: hydraulic towers that allow maintenance to be performed at ground level, braking systems that use seven levels of redundancy to control the turbines under high-speed wind conditions, and built-in lightning rods that reduce dangers from severe weather. Combined with siting wind turbines in rural locations, these technologies mitigate the majority of health and safety risks.

Environmental Concerns

By creating clean energy that does not produce harmful emissions or hazardous waste, wind projects contribute to creating a healthier environment for both humans and wildlife. The primary environmental concerns—wildlife safety, visual and sound impacts, and space requirements for construction and maintenance—can be overcome by taking the time to develop a low-impact site plan.

Wildlife

Bird and bat collisions with wind turbines can occur, but the extent of bird and bat fatalities varies widely by facility and region.[3] Buildings, cars and cats contribute to significantly more bird deaths than wind turbines. Overall, wind turbines are responsible for less than 0.01% of bird deaths caused by humans and pets as shown in the following chart.[4]

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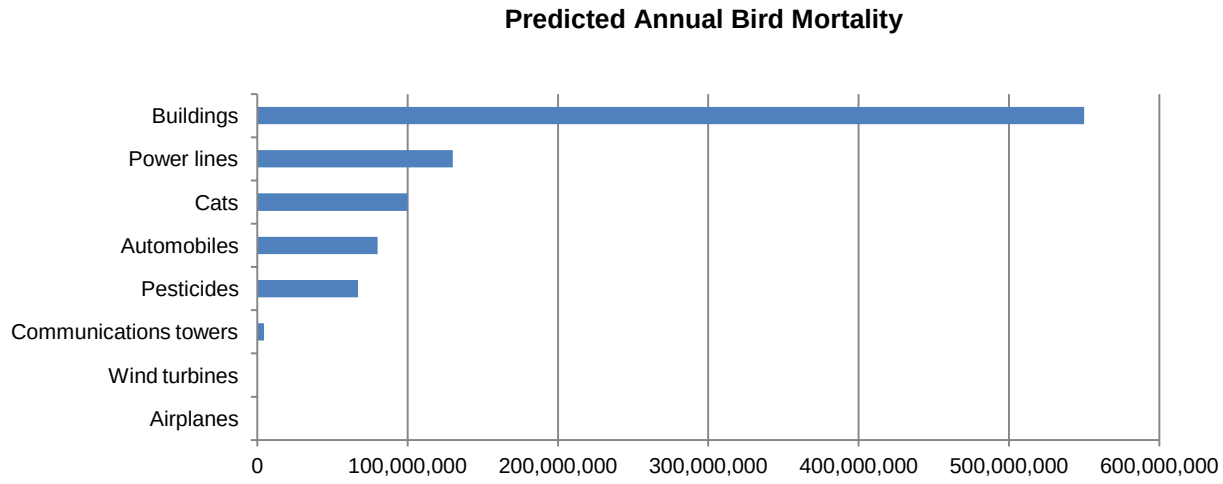
[1] Edward Malnick and Robert Mendick, "1,500 accidents and incidents on UK wind farms," *The Telegraph*, 11 Dec. 2011, http://www.telegraph.co.uk/news/uknews/8948363/1500-accidents-and-incidents-on-UK-wind-farms.html (accessed 12 Dec. 2012).

[2] Occupational Safety and Health Administration, "Green Job Hazards," http://www.osha.gov/dep/greenjobs/index.html (accessed 12 Dec. 2012).

[3] National Wind Coordinating Collaborative, "Wind Turbine Interactions with Birds, Bats, and their Habitats: A Summary of Research Results and Priority Questions," http://www.nationalwind.org/publications/bbfactsheet.aspx (accessed 13 Dec. 2012)

[4] Erickson, Wallace P.; Johnson, Gregory D.; Young, David P. Jr. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. In: Ralph, C. John; Rich, Terrell D., editors 2005. Bird Conservation Implementation and Integration in the Americas:



In the early days of wind turbine facilities, some projects were developed in poor locations with little consideration for wildlife impacts. For example, an early wind facility in Altamont, California was built along a major bird migration corridor and has more raptor (bird of prey) fatalities than any other wind facility.[5] Avoiding bird and bat migration corridors is a simple step that can be taken to mitigate the risk of bird and bat fatalities. Newer turbines have different structural components that may also contribute to lower rates of bird and bat fatalities, such as monopole towers instead of lattice towers that provide more places for birds to perch.

In 2007, the National Wind Coordinating Collaborative released a Mitigation Toolbox that provides guidance, including siting suggestions, for wind developers to reduce the impact on birds and bats.[6] Many jurisdictions also have their own requirements with steps for developers to take to protect wildlife. Orenda takes wildlife considerations seriously and makes technology choices and siting recommendations that minimize risk.

Visual and sound impacts

The appearance of wind turbine installations is subjective; opinions will vary depending on the personality of the individual. However, shadow flicker is a specific occurrence that happens when the blades of a turbine pass in front of the sun to create a repetitive shadow. The frequency and extent of shadow flicker will depend on the region, with areas of lower latitudes and higher sun angles experiencing less shadow flicker. It is most problematic for individuals when it occurs through the window of a building.

Shadow flicker can be determined with computer models prior to wind turbine installation, and one of the easiest solutions is to use an appropriate setback distance from residences that would otherwise be affected. Vegetative screens, such as an area of rapidly growing trees, can also be used. These mitigation measures are easily implemented in rural locations where wind turbine locations are more flexible.

Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California, Volume 2 Gen. Tech. Rep. PSW-GTR-191. Albany, CA: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station: p. 1039.

[5] Center for Biological Diversity, "Protecting Birds of Prey at Altamont Pass," http://www.biologicaldiversity.org/campaigns/protecting_birds_of_prey_at_altamont_pass/ (accessed 13 Dec. 2012)

[6] National Wind Coordinating Collaborative, "Mitigation Toolbox," http://www.nationalwind.org/assets/publications/Mitigation_Toolbox.pdf (accessed 13 Dec. 2012)

In terms of sound, wind turbines are generally quiet. No sound produced by wind turbines results in hearing loss or any other risk to human health.[7] For some people in close proximity to a wind turbine, it may be annoying if a "whooshing" sound—caused by air passing by the blades—is audible. For this reason, it is important to include sound considerations in a siting assessment. Wind direction, weather conditions and sound barriers can all impact audibility. Most mechanical sounds of modern turbines have been greatly reduced with soundproofing techniques.

The below data demonstrates that the sound generated by a typical wind farm at 350m is similar to the sound level of rural night-time background noise or a quiet bedroom.

Source/Activity	**Indicative noise level dB (A)**
Threshold of hearing	0
Rural night-time background	20-40
Quiet bedroom	35
Wind farm at 350m	35-45
Car at 40mph at 100m	55
Busy general office	60
Truck at 30mph at 100m	65
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

Source: The Scottish Office, Environment Department, Planning Advice Note, PAN 45, Annes A: Wind Power, A.27, Renewable Energy Technologies, August 1994

As with visual considerations, mitigation measures to reduce sound impacts are easier to accommodate in rural areas where more space is available.

Space requirements

Wind turbines from some manufacturers require access roads to be built so cranes can be used to assemble the tower, and after the turbine is installed, cranes may also be used to lower and raise the tower during routine servicing and maintenance. Orenda turbines use a hydraulic tower system that allows the turbine to be lowered and raised without large equipment; no additional roads are required.

Many jurisdictions have requirements for a fence to be placed around the base of a wind turbine, but other than this space, land can be used for agricultural purposes right up to the base of an Orenda wind turbine.

[7] American Wind Energy Association, "Wind Turbines and Health," http://www.awea.org/learnabout/publications/upload/Wind-Turbines-and-Health-Factsheet_WP11.pdf (accessed 13 Dec. 2012)

Summary

There are many siting considerations to be made during the initial stages of a wind turbine project, including wind conditions, health and safety, wildlife concerns, visual and sound impacts, and space requirements. A rural location provides more opportunities to maximize the environmental benefits in a low-impact manner, while providing for optimal wind resource, which is why Orenda only sites turbines in rural areas.

Fitting into the small wind segment, Orenda turbines are rated to generate 50kW of power at a wind speed of 10 m/s. The hydraulic tower, extensive safety features and warranty reserve on Orenda turbines make them an ideal choice for rural land owners, including agricultural farmers and small-scale wind farm developers.

To learn more about wind turbine siting considerations and technology, contact Orenda:

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