PUBLIC HEALTH AND SAFETY

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This document is one of a series of reports and guides that are all part of the NYSERDA Wind Energy Tool Kit. Interested parties can find all the components of the kit at: www.powernaturally.org. All sections are free and downloadable, and we encourage their production in hard copy for distribution to interested parties, for use in public meetings on wind, etc.

Any questions about the tool kit, its use and availability should be directed to:
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In addition, other reports and information about Wind Energy can be found at www.powernaturally.org in the on-line library under "Large Wind."

NOTICE

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Public Health and Safety

Public health and safety issues associated with wind energy projects are different from other forms of energy generation since a combustible fuel source, fuel storage, and generation of toxic or hazardous materials are not present. However, wind energy projects do share similar electrical infrastructure requirements with conventional power generation facilities such as medium-voltage power lines and substation equipment. Unique concerns for wind turbines relate to the configuration of the equipment: blade throws, ice shedding, fire, and tower collapses. While most of these are extremely unusual events, public agencies generally address these potential occurrences by establishing reasonable setbacks from residences and public corridors based on the size of the turbine and blades.

Blade Throw

A turbine blade can break due to improper design, improper manufacturing, improper installation, wind gusts that exceed the maximum design load of the turbine structure, impact with cranes or towers, or lightning. The distance a blade piece can be thrown from a turbine depends on its mass, shape, speed at the time it breaks from the machine, the orientation of the blade at the time of the throw, and the prevailing wind speed.

Although a few instances of blade throws were reported during the early years of the wind industry, these occurrences are now rare, due in large part to better testing, design, and engineering of commercial wind turbines. Testing and design of blades is discussed in more detail later in this paper.

Fire

Wind turbines have caught fire; however, this is an extremely rare event. Typically, a turbine fire is allowed to burn itself out while staff personnel and fire personnel maintain a safety area around the turbine and protect against the potential for spot ground fires that might start due to sparks or falling material. Power to the section of the project with the turbine fire is also disconnected. An effective method for extinguishing a turbine fire from the ground does not yet exist, and the events do not last long enough to warrant aerial attempts to extinguish the fire. However, since the public typically does not have access to the private land on which the turbines are positioned, the public's well-being should not be at risk.

Tower Collapse

Although turbine tower collapses are rare, there are reported instances of tower collapse due to various circumstances. The reasons for collapses vary depending on conditions and tower type, but have included blade strikes, rotor overspeed, cyclonic winds, and poor or improper maintenance (torque bolts). In cases where information is available, the majority of the major components (rotor, tower, and nacelle) have fallen to within 1 to 2 hub-height distances from the base. As with turbine fires, members of the public do not typically have access to the private lands on which wind farms are located. As of May 2005, no member of the public has been killed or injured by a failure of a wind turbine.

Ice Shedding

Ice can accumulate on the blades, nacelle, and tower during certain extreme cold-weather conditions. Many times turbines will shut down in icing conditions because the wind vane and/or anemometer sensors become frozen, rendering the turbine inoperable. Ice formation can also reduce power production, which is sensed by the control system that subsequently halts turbine operation. As the ice melts it will fall to the ground in the vicinity of the turbine.

During operable wind speeds and when the turbine has not yet been shut down automatically or manually, ice can break off the blades and be thrown from the turbine (instead of dropping straight down). The distance traveled by a piece of ice depends on the position of the blade when the ice breaks off, the location of the ice on the blade when it breaks off, the rotational rate of the blade when the ice breaks from the blade, the mass of the ice, the shape of the ice (e.g., spherical, flat, smooth), and the prevailing wind speed.

No injuries have been reported as a result of ice throws, however, manufacturers and blade designers continue to research materials and methods that could be employed to reduce the possibility of ice accumulation and subsequent throws. Design features such as the use of black blades and the applications of special coatings have been used at some cold-weather sites. The best practices to reduce the possibility of ice throws include establishment of setback safety zones around the turbines and modifications to the turbine operation during periods of icing, as listed below:

- Turbine Controls – In addition to accumulating on the blades, icing also affects the wind speed and direction sensors on the nacelle that provide information to the control system of the turbine. If the sensors become iced up, the control computer detects no wind speed and/or no change in the wind direction and then stops turbine operation automatically. When ice melts from the sensor, the control computer automatically returns the turbine to operation. Icing on the blades also results in reduced performance, unusual loads, or vibrations that are detected by the control system and trigger an automatic stop. In these cases, the turbine remains off-line until an operator inspects and manually restarts the turbine. If the turbine is not operating, ice from the blades, nacelle, and tower falls to the ground in the immediate vicinity of the machine.

- Operator Intervention – Project operators can halt operation of certain turbines (or the entire project) during icing events to prevent ice throws and equipment damage. Provided some wind is available, site operators can manually 'bump' the rotor for a few slow rotations to make the blades flex and relieve some of the ice build-up. Under these conditions, the slow rotor speed will again result in ice falling to the ground in the immediate vicinity of the machine.
- Safety Zones – Establishing adequate setback areas from inhabited buildings, roads, and power lines significantly reduces the risk of injury or damage in the event of ice throws. Research into quantifying ice throws is limited, probably due to the fact that there have been no reported injuries associated with these events. The most complete study to date has been performed in the UK by C. Morgan, et al. The study quantified the risk of possible strikes from ice throws, in terms of distance from the turbine. The study does not propose specific setback distances but provides information to help establish setbacks that are comparable to other levels of risk. For moderate icing conditions (5 icing days per year) setback distances of 750 ft to 1150 ft correspond to potential strike risks of 1 in 10,000 to 1 in 1,000,000 per year, respectively. (The probability of being struck by lightning is 1 in 1,000,000 per year). This study assumes a wind turbine with a 50-m (164-ft) rotor.

Another factor to consider when assessing the risk of ice throws from wind turbines is that the power grid is also impacted by ice formation and power to the project may be interrupted by the utility due to repair work or actual outages. Turbine operations stop immediately when grid power is lost, thereby reducing ice throw risks.

The people most at risk from falling ice are the site personnel, as most ice falls from the blades, nacelle, and rotor near the base of the tower. Most project developers have strict rules established for personnel and operations during icing events to prevent worker injury and to protect the public.

Vandalism

Though not unique to wind turbine installations, the potential for vandalism or trespassing can also cause safety concerns. Wind turbines may attract more attention than other structures. Project developers report incidences of unauthorized access on their sites ranging from curiosity seekers to bullet holes in blades. Permits usually require fencing and postings at project entrances to prevent unauthorized access. Other requirements intended to reduce personal injury and public hazards include locked access to towers and electrical equipment, warning signs with postings of 24-hour emergency numbers, and fenced storage yards for equipment and spare parts. Fencing requirements will depend on existing land uses such as grazing. Some communities have established information kiosks along roadsides to channel curious sightseers out of road traffic and into an area that is a safe distance from the turbines.

Working with Local Emergency Response Teams

Project developers commonly work with local emergency response teams to provide information or training on tower rescues and other wind-specific concerns. Falls, injuries from heavy or rotating equipment, and injuries from electricity represent the types of events that can occur at a wind energy facility. The height of the nacelles provides an additional challenge for medical responders. The national Occupational Safety and Health Administration (OSHA) regulations, in addition to state worker safety regulations, cover all of the worker safety issues associated with electricity, structural climbing, and other hazards present in a wind farm.

Mitigation Through Setbacks

Many concerns associated with safety, noise, and aesthetics can be addressed by placing distance between the wind turbines and people, property lines, roads, and scenic areas. Although no consensus on appropriate distances or types of setbacks exists, there are several common themes that appear in a number of wind energy regulations in place as of May 2005.

Most local government requirements include setback specifications for the distance between the wind turbine and structures (residences and other buildings), property lines, and roads. A few agencies have also defined setbacks from railroads and above-ground transmission lines. The most common way to define a setback distance is in terms of a multiple of the turbine height (for example 1.5 times the wind turbine height). Other options are to specify a fixed distance or a combination of a fixed distance and a multiple of the turbine height. When specifying the structure height, it is important to define whether the height is the top of the nacelle or the highest point reached by the rotor blade (maximum tip height, or MTH).

Examples

Wind turbine setbacks from residences

- Fenner/Stockbridge, NY – 1.5 x MTH
- Martinsburg, NY – 1500 ft
- Contra Costa County, CA – 2 x MTH
- Palm Springs, CA – 1200 ft

With regard to setbacks from structures and residences, some permitting agencies differentiate between houses and buildings on the property leased for the project, and houses and buildings on *adjacent* parcels. The implication is that a greater distance is appropriate from structures on adjacent parcels since those properties have less control over the development than the landowner. A waiver of such requirements is typically granted if written permission is provided from the neighboring landowner.

Examples

Wind turbine setbacks from property lines

- Fenner/Stockbridge, NY – 1.5 x MTH
- Martinsburg, NY – 300 ft (rear and side lot lines)
- Contra Costa County, CA – 3 x MTH or 500 ft, whichever is greater (from all boundaries)
- Cook County, MN – tower height
- Wasco County, OR – at least 5 rotor diameters

Setbacks from property lines may vary for side and rear lot lines but are generally specified in the same way as setbacks from residences. Setbacks from property lines can pose a challenge for small wind turbines since these installations tend to occur on smaller landparcels. To address this issue, some agencies define setbacks for *commercial* wind turbines only. Small turbines are either exempt or evaluated on a case-by-case basis. Turbines should be exempt from property line setbacks if the adjacent property contains a wind turbine from the same plant, or the adjacent property is a participant in the project through a land lease and/or wind access agreement. This is an important consideration particularly in New York, since turbine layouts and plant infrastructure can result in many parcels of land being utilized for one project.

Setbacks from roads are typically greater for major highways than for local roads. In some cases, scenic setbacks have been required from particular state highways in close proximity to designated wind development areas.

When establishing setbacks, the intended effect must be balanced with economic considerations for the project and overall permitting objectives. For example, a setback decision made by a Town Board in Addison, Wisconsin, had the effect of reducing the number of proposed turbines by more than two-thirds for a wind project in their jurisdiction. The project developer proposed a setback of 650 ft around each turbine (approximately 2.5 x MTH) to address concerns raised about noise, safety and visual impacts. The Town Board decided to expand the setback to a minimum of 1000 ft from any residences, road right-of-ways, or property boundaries. The developer had a limited ability to re-position the turbines on the remaining leased property while still maintaining an acceptable energy output from the project. As a result, the number of proposed turbine sites was reduced from 28 to approximately 8 and the developer dropped the project because it was uneconomical.

Safety in Design, Construction, and Operation

Wind turbines and wind power projects are inspected by the utilities (for grid and system safety) prior to being energized and during operation. In the design phase, state and local laws require that licensed professional engineers review and stamp the structural elements (tower, foundation, roads, building, etc.) and the electrical collection system.

Depending on the local requirements and permits, building inspectors can inspect the project. Finally OSHA has the authority to inspect working conditions.

Wind turbines and wind energy project installations are designed to meet numerous applicable standards. Many of these standards are common to a wide range of industrial equipment and electrical and structural installations. All engineered structures and power generating equipment in the United States must meet a number of codes and standards as dictated typically by the local municipalities and the interconnecting utilities. At the top level of these are the National Building Code and the National Electrical Code. All, or part, of these codes are typically included in municipal permitting regulations. These codes include standards for earthquakes, structural integrity, electrical specifications, and power quality. Local municipalities may have noise, environmental, and safety codes as well. The interconnecting utility may also have its own set of design requirements that pertain to power factor, voltage, frequency and the like. These are often based on applicable Institute of Electrical and Electronic Engineers (IEEE) standards.

Others pertain to wind-turbine-specific design standards, including the International Electrotechnical Commission (IEC) standards for design and safety. The IEC standards are contained in Sections 61400 and can be found at http://www.awea.org/standards/iec_stds.html. Some of the areas addressed in the wind-turbine-specific design standards include, but are not limited to, wind regime definitions, load cases, and safety factors. The overall certification requirements are codified in an individual standard, as are the detailed methodologies for testing power performance, acoustic noise emissions, power quality, and blade structure.

For example, the IEC 61400 group of wind turbine standards includes a section on blade testing. Testing to these standards is conducted by both independent agents and by the blade and turbine vendors themselves. The test standards include procedures for both fatigue and maximum-strength tests. The fatigue testing typically includes long-duration testing (one to three months) by continuously cycling the load on the blade. The maximum strength test is designed to mimic an extreme load event. In each case the blade is either proof tested to a predetermined load or tested to failure, depending on the goals of the test. Blade tests are carried out at the NREL/NWTC facility in Boulder, Colorado, in the U.S., at the Risø National Laboratory in Denmark, the Technical University at Delft in the Netherlands, and CRES in Greece. In addition, LM in Denmark, a blade manufacturer, maintains its own blade test facilities as does turbine manufacturer Vestas (NEG Micon has its own facility, which is now also Vestas).

Three certifying bodies have established procedures for reviewing manufacturer's designs and confirming compliance with these standards: Underwriters Laboratory, Germanischer Lloyd, and Det Norske Veritas. All wind turbines must meet the design and safety requirements in order to be certified by one of these bodies. Certification to these standards is a nearly universal requirement for a wind power project to be built or financed.

Additional Resources

NWCC Siting Subcommittee (1998) Permitting of Wind Energy Facilities: A Handbook. Washington, National Wind Coordinating Committee

Morgan, C., E. Bossanyi, et. al. (1998) Assessment of Safety Risks Arising From Wind Turbine Icing. BOREAS IV Conference Paper, Finland.

The Germanischer Lloyd, Det Norske Veritas, and Underwriter's Laboratory standards are available from these entities. For information about these certifying bodies, see the following web sites: http://www.gl-group.com/start.htm and http://www.dnv.com/ and http://www.ul.com/.