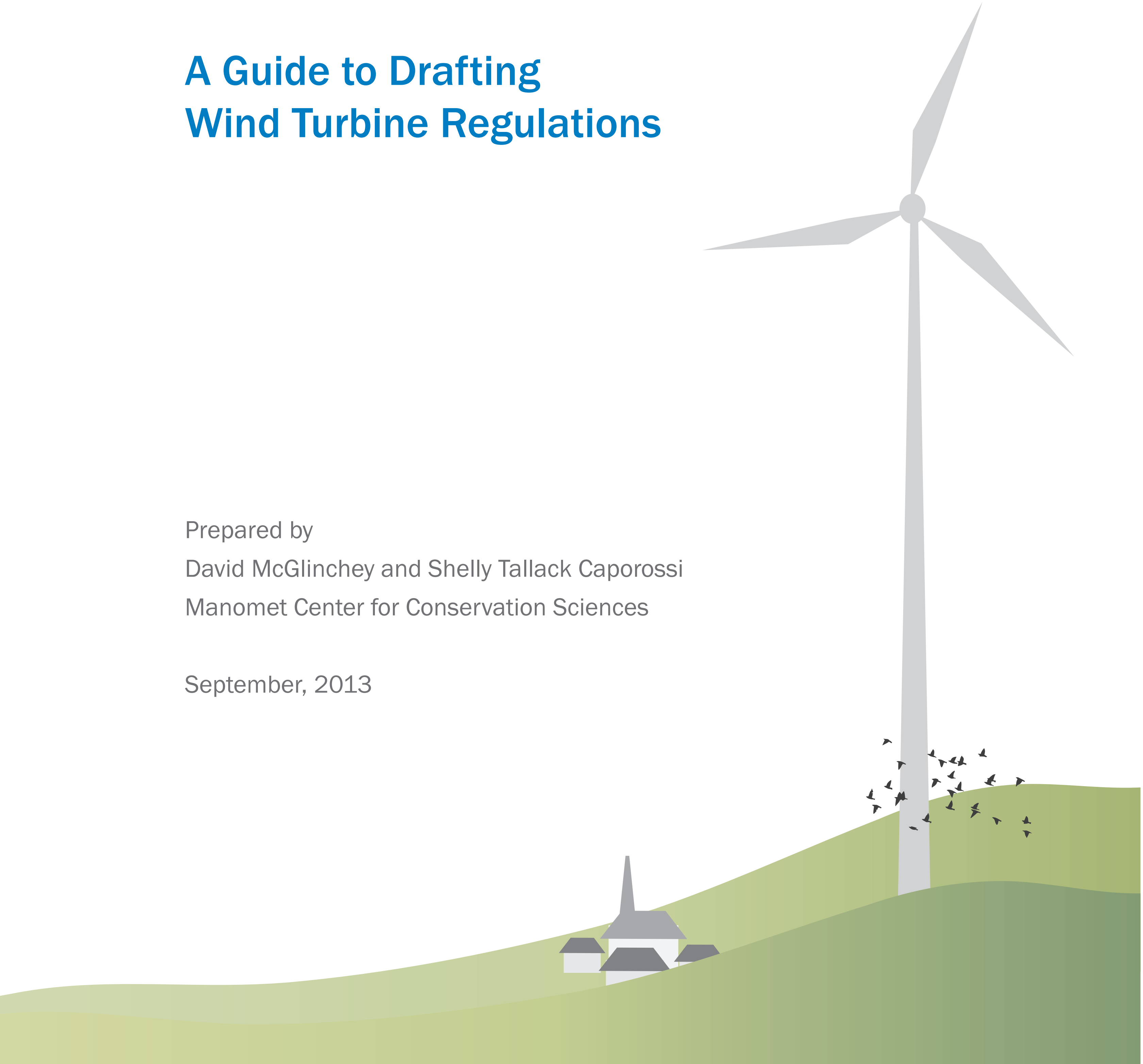
A Guide to Drafting Wind Turbine Regulations



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Executive Summary

This guide is intended as a resource for community level planners who face the task of drafting or revising land-based wind turbine regulations for their municipality. It was developed after Manomet Center staff worked with town planning officials and committees who expressed frustration at the daunting task of drafting wind turbine regulation language.

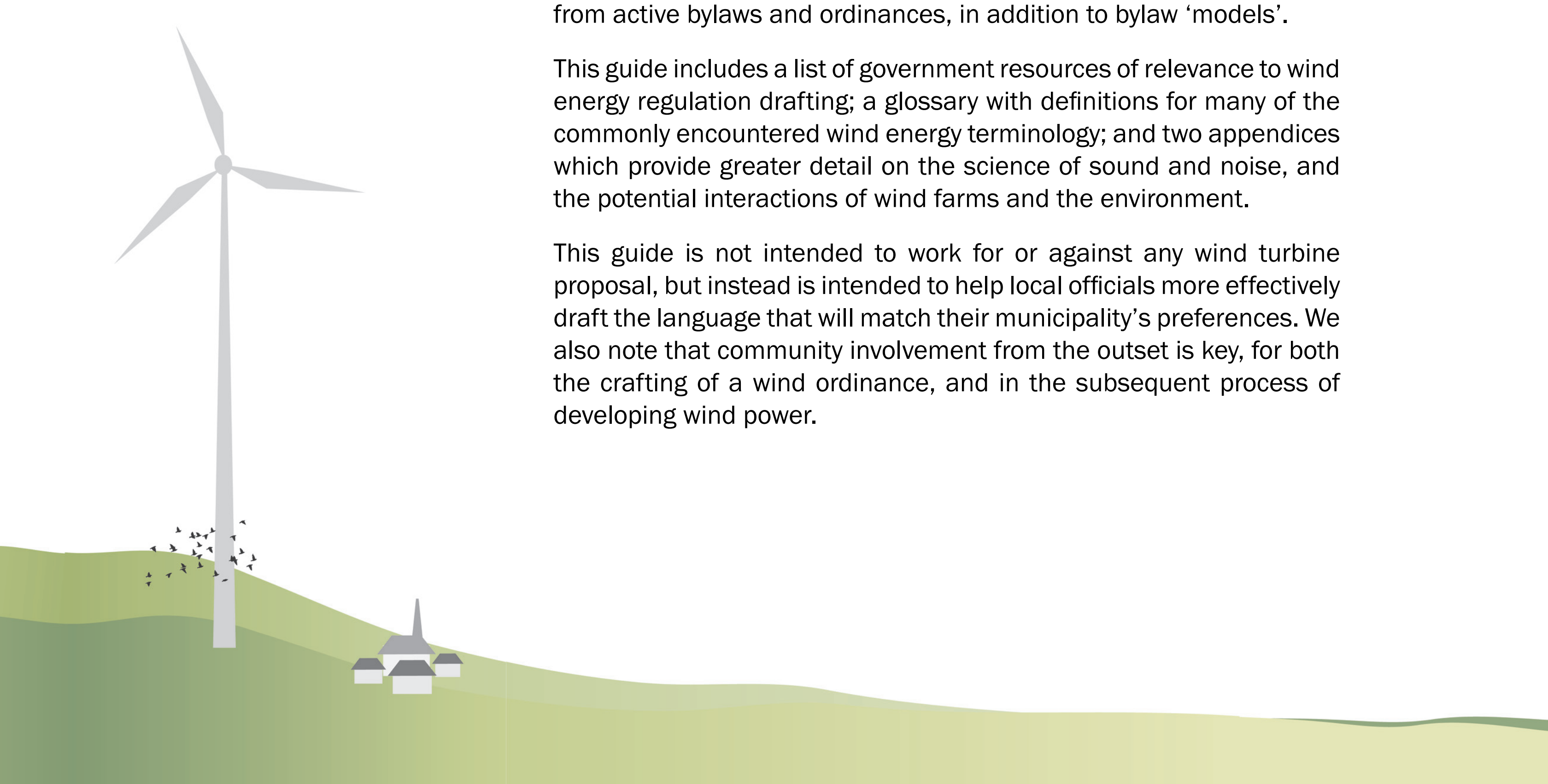
The most important lesson learned from the process is the need for incorporating clear and specific language to avoid confusion and to minimize the potential for loose interpretation of the regulation's intent.

This guide focuses on what Manomet perceives to be the most common issues of concern when municipalities attempt to develop land-based wind turbine regulations for their community, specifically: sound, shadow-flicker, setbacks, height, lighting, scenic impacts, signage and advertising, planning for decommission, and wildlife impacts.

To demonstrate how different levels of regulatory restriction can be achieved on each issue, this guide presents examples of language from active bylaws and ordinances, in addition to bylaw 'models'.

This guide includes a list of government resources of relevance to wind energy regulation drafting; a glossary with definitions for many of the commonly encountered wind energy terminology; and two appendices which provide greater detail on the science of sound and noise, and the potential interactions of wind farms and the environment.

This guide is not intended to work for or against any wind turbine proposal, but instead is intended to help local officials more effectively draft the language that will match their municipality's preferences. We also note that community involvement from the outset is key, for both the crafting of a wind ordinance, and in the subsequent process of developing wind power.



How to use this Guide

This guide is intended as a resource for local officials who face the task of drafting or revising land-based wind turbine regulations for their municipality.

It should be noted that every municipality is different and thus, specific wind development issues will vary from location to location. As such, this guide is not exhaustive or prescriptive, but it does highlight key wind development issues and provides suggestions for addressing each of these.

This guide should not be mistaken for professional legal advice, but it does provide examples of regulatory language that can be inserted into a wind turbine law to achieve different objectives on a specific issue.

This guide is not intended to work for or against any wind turbine proposal, but instead is intended to help local officials more effectively implement their municipality's preferences.

This guide advocates for community involvement from the outset, for both crafting a wind bylaw and during subsequent local wind power development processes. Any potentially controversial planning process works better and will receive most support from the community when all relevant parties are included early in the process. Bylaw drafters are encouraged to engage the community leaders who should be involved in this process and solicit their opinions.

A glossary has been included to provide definitions for many of the commonly encountered terminology when addressing land-based wind farms.

Wind 1 and Wind 2: the two 1.65 MW town-owned wind turbines built in Falmouth, MA. Photo credit: Mark Wilson.

Appendices have also been prepared, which offer detail on the science of sound and noise (Appendix A) and the potential interactions of wind farms and the environment (Appendix B).

Legal approaches

The barriers to wind energy development in the United States are more cultural, regulatory, economic or political obstacles than questions about wind quality or engineering feasibility.

This Guide was produced in direct response to municipal-level land use officials who told Manomet staff that drafting wind turbine regulations was a complex challenge that represented a significant departure from their usual planning projects.

We reviewed a variety of approaches to regulating the siting of wind turbines in order to develop a handbook of options for wind turbine bylaw drafters.

Ambiguous language pitfalls

In any regulatory language, ambiguity can cause problems. We recommend avoiding words that are open to wide interpretation at the review level, depending on the perspectives of opposing parties. Examples of ambiguous words or phrasing:

"... **Significant** adverse impact ..."

"... **Excessive** noise generated ..."

"... **Additional benefits** [must] outweigh any increased **adverse** impacts ..."

"... **significant** additional benefits..."

"...**substantial** evidence ..."

"... [that which is] **reasonably** necessary ..."

"... shall be designed to **minimize** land clearing and fragmentation ..."

"... in a manner that does not have **significant** negative impacts on ..."

Throughout this document, we present sample language on different issues, with varying levels of specificity; we recommend adopting the most specific style of language whenever possible.

By right or by special permit

Municipalities have a preference for regulating wind turbines through **special permits** rather than allowing them to be developed **by right**. 'By right' refers to a use permit that requires compliance with existing regulations, but does not require special permission. In contrast, a special permit enables a community to review the location, site development or conduct of wind turbine developments, since these can give rise to conflicts with bordering properties; these special permits are not the automatic right of any applicant.

The form of this requirement and the conditions to meet it differ in implementation, but are always developed with the same basic goal: to regulate wind turbines on a case-by-case basis and with an examination of their particular merits and issues. Regulations overwhelmingly regulate commercial scale wind energy conversion systems through the use of a special permit. Some regulations extend that to all wind turbines, while others allow a carve-out for residential scale wind turbines (as defined in the bylaw). Some regulations that provide for special permits also include the reasoning and goals for that tool.

Example of a special permit

"A Special Permit may be granted if the Special Permit Granting Authority finds that: (a) the specific site is an appropriate and approved location for such use; (b) the use is not expected to adversely affect the neighborhood; (c) there is not expected to be any appreciable hazard to pedestrians, vehicles or wildlife from the use; (d) adequate and appropriate infrastructure will be provided for the proper and safe operation of the Community-Scale Wind Facility; and (e) the requirements of section 616-3-616.10 are complied with in all respects."

Town of Duxbury Zoning Bylaw § 616.3
Duxbury, MA

Other bylaws do not include goals in their requirement for a special permit, intending either that the conditions set forth in the bylaw will satisfy any such concerns or cross-referencing a purpose section usually placed at the beginning of the bylaw.

Wind overlay districts

It is possible to further restrict the area of a town or city that can be developed.

A Wind Overlay District (WOD) is a clearly defined area that is preapproved for wind development. No building of wind turbines can take place outside of the town's Wind Overlay District and no building can take place within the Wind Overlay District unless by either a Special Permit or a General Permit, depending on the WOD.

Interaction of wind turbine regulations and other regulations

Wind turbine regulations are not developed in a regulatory vacuum. Federal and State regulations should be reviewed and thoroughly understood before a municipality drafts their own ordinance or guidelines.

The interaction of other pre-existing codes and wind turbine regulations varies widely among municipalities. Some towns and cities rarely mention other regulatory concerns in their wind turbine regulation, while others explicitly require applicants to follow specific regulations for specific concerns. Local regulations tend to defer to overarching State or Federal authorities for issues such as:

- the structural safety of the wind turbine itself,
- certification by the manufacturer that the wind turbine does not improperly interfere with the electromagnetic spectrum,
- ensuring that storm water runoff complies with environmental regulations*,
- adherence to wetlands and environmental codes and historical district regulation*.

By far, the most popular explicitly mentioned codes are building codes or structural safety codes, noise and Federal Communications Commission (FCC) regulations regarding electromagnetic interference. There are two approaches to placing references to other regulatory codes within the statute.

The first is the **catchall provision**, which is generally placed either at the beginning of the statute or at the beginning of the special permit outlines (if the municipality is regulating wind turbines through special permits). Towns typically use a catch-all provision to incorporate pre-existing code or regulation into the new regulations. Such a provision highlights the different concerns the town wants addressed prior to erection.

The second mechanism towns use in order to incorporate other regulatory codes in the statute, is by **explicit mentions** in each area of regulatory concern.

Example of a catchall provision

"Proposed Wind Turbines shall comply with all applicable local, state, and federal requirements including, but not limited to all applicable electrical, construction, noise, safety, environmental and communications requirements."

Cohasset Zoning Bylaws § 19.4.1.
Cohasset, MA

Example of an explicit mention

"Wetlands: Wind energy conversion facilities shall be located in a manner consistent with all applicable local and state wetlands regulations. Wetland buffer areas may be used for the purposes of providing a clear area."

Town of Chester Bylaws § 5.6.4.
Chester, MA

* These are sometimes also addressed in local regulations.

Common issues to address

Every municipality and potential wind turbine site will have its own specific suite of considerations to address, and these may be environmental, economic or cultural.

However, certain issues surface time and again when attempting to evaluate the potential impacts and thus, the acceptability of prospective wind turbine developments. This guide outlines the most common issues, though not in order of priority; the relative importance of each issue will differ on a case-by-case basis.

Wind 1 and Wind 2: the two 1.65 MW town-owned wind turbines built in Falmouth, MA. Photo credit: Mark Wilson.

Sound

One of the most common – and controversial – issues that arises with wind turbine siting is the sound or noise produced by the machines. There is a distinction between the two: sound is a measurable physical phenomenon, while noise is unwanted or annoying sound, which is highly subjective and varies from person to person. However, sound levels generated by wind turbines are not sufficient to damage hearing, or to cause other direct adverse health effects*.

Although the sound produced by wind turbines can easily be measured, the sound that will be experienced at a given distance from a wind power site will vary considerably based upon factors such as wind farm design, the types of turbines used, topography and meteorological conditions. Different residents also report differing levels of sensitivity to the same noise levels, making regulation complex and challenging.

Most bylaws also require the developer to consult the state-level Department of Environmental Protection (or equivalent) for guidance on noise measurement.

For a more in-depth explanation of the science of wind turbine sound and noise, please refer to the Appendix A.

Detailed bylaw

"The commercial wind energy conversion facility and associated equipment shall conform to Massachusetts noise regulations (310 C.M.R 7.10) and the provisions of the Gloucester Code of Ordinances Chapter 13: Noise. An Analysis, prepared by a qualified acoustical engineer, shall be present to demonstrate compliance with these noise standards and be consistent with the Department of Environmental Protection guidance for noise measurement."

The City of Gloucester Massachusetts Zoning Ordinance § 5.22.7

Gloucester, MA

General noise requirement

"The wind energy conversion facility and associated equipment shall conform to Massachusetts noise regulations (310 CMR 7.10). An analysis, prepared by a qualified engineer, shall be presented to demonstrate compliance with these noise standards and be consistent with Massachusetts Department of Environmental Protection guidance for noise measurement."

Town of Chester Wind Energy Conversion Facilities Bylaw § 5.7.4
Chester, MA

Bylaw more stringent than state code

"In all residential districts the maximum decibel level at the property line shall be 50 decibels. In all non-residential districts the maximum decibel level at the property line shall be 65 decibels."

City of Taunton Zoning Ordinance § 8.6
Taunton, MA

* CMOPH, (2010). The potential health impacts of wind turbines. Ontario Ministry of Health and Long-term care: Chief Medical Officer of Public Health: 14 pp.

Shadow / Flicker

Shadow flicker occurs when the rotating wind turbine blades cause alternating changes in light intensity and it is measured at various distances from the turbine.

Flicker does not present a health hazard – the speed of the rotating blades are not sufficiently fast to induce an epileptic seizure*. However, individuals living in affected residences have described this phenomenon as a nuisance or an annoyance.

This effect occurs when the sun is low and the rotating turbines are positioned between a location and the sun. As a result, shadow flicker is predictable and can sometimes be mitigated with tree or bush plantings, or suspended turbine operation.

Some municipalities have attempted to set shadow flicker thresholds using the duration of shadow flicker that affects a certain location. These regulators (and a study from the Massachusetts Departments of Environmental Protection and Public Health) cite a German standard of 30 hours of annual shadow flicker*.

Note: All of the local regulations reviewed for this docment included ambiguous language (e.g."significant adverse impact") that could cause conflict at the review level.

Placing burden on applicant

"Shadow/Flicker Wind facilities shall be sited in a manner that minimizes shadowing or flicker impacts. The applicant has the burden of proving that this effect does not have significant adverse impact on neighboring or adjacent uses through either siting or mitigation."

Model As-of-right Zoning Ordinance or Bylaw § 3.10.5
Boston, MA

Placing burden on applicant but prevents rejection for existence of flicker

"Shadow/Flicker – Community-Scale Wind Facilities shall be sited in a manner that minimizes shadowing or flicker impacts caused by motion of the rotor blades as they pass in front of the sun. The applicant has the burden of proving that this effect does not have significant impact on the neighboring or adjacent uses through either siting or mitigation. It is acknowledged that a degree of shadow/flicker effect results from any wind turbine, and that the existence of some "shadow flicker" alone shall not be cause for the refusal to permit a Community-Scale Wind Facility."

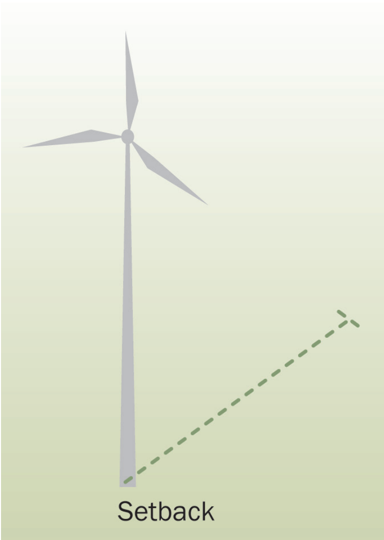
Town of Duxbury Community Scale Wind Facilities Bylaw § 616.6.1
Duxbury, MA

* Massachusetts Clean Energy Center, (2013). Learn About Clean Energy: Shadow Flicker, http://www.masscec.com/content/shadow-flicker. Webpage last accessed: 07.03.2013.

Setbacks

Setbacks are one of the most crucial regulatory tools of wind turbine siting, because they influence many different issues, including visual impact, noise, flicker and safety. Setback is often determined by the distance from the base of the tower to the nearest lot line*.

When determining the minimum setback from the nearest property line, bylaws will often reference the height of the wind turbine. This is typically done from the mean natural grade of the ground supporting the pad(s) to the tip of a blade in vertical position measured along the vertical axis of the tower.



Different setbacks to the nearest structure and nearest property line

"Community-Scale Wind Facilities and or Monitoring or Meteorological Towers shall be set back a minimum distance equal to 1.1 times the overall height of the Wind Facility from the nearest property line and private or public way and a minimum distance equal to two (2) times the overall height of the Wind Facility from the nearest existing residential or commercial structure not owned by the applicant seeking to permit the Community-Scale Wind Facility and or Wind Monitoring or Meteorological Towers."

Town of Duxbury Community Scale Wind Facilities Bylaw § 616.4
Duxbury, MA

Same setback to the nearest structure and nearest property line, also allowing special districts or overlays to fall within setback zone

"Wind Turbines shall be set back a distance equal to 1.1 times the overall height of the wind turbine from the nearest existing residential or commercial structure and from the nearest property line and private or public way. The setback zone can fall within the limits of Wetlands Protection Overlay and the Flood Hazard Overlay Districts."

Town of Duxbury Community Scale Wind Facilities Bylaw § 616.4
Duxbury, MA

Most restrictive setback (tower height)

"Setbacks from adjacent parcels. A minimum setback for each wind facility shall be maintained equal to two times the overall wind turbine height, or 300 feet, whichever is greater, from all boundaries of the site on which the wind facility is located."

Town of Williamstown, Massachusetts: Chapter 70, Zoning Bylaws § 70-G.4.c
Williamstown, MA

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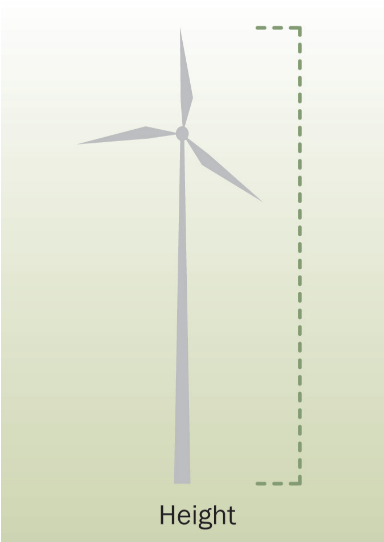
* AWEA, (2013). Learn About Wind Power: State Ordinances. American Wind Energy Association, http://www.awea.org/learnabout/smallwind/CommunityWindPolicy.cfm. Last accessed: 07.13.2013.

Height

The height of a wind turbine is critical to its performance and power generation, because stronger and more consistent winds occur at greater heights*. As such, it is in the interest of the wind developer to build taller wind turbines. Similar to setbacks, however, the height of the turbine can influence a variety of other impacts, most notably the visual impact.

The permissible height of a turbine varies between locations because of pre-existing restrictions in the municipality and – if an airport is nearby – the relevant Federal Aviation Administration (FAA) standards.

When measuring, turbine height is usually defined and measured from the natural grade to the tip of the rotor blade at its highest point; this is often referred to as blade-tip height or maximum tip height. In contrast, tower height refers to the height above grade of the fixed portion of the tower, measured to the top of the nacelle and excluding the wind generator.



No exceptions, height measured to rotor hub instead of blade tip

"Wind facilities shall have a maximum height of 350-feet, as measured from the natural grade to the top of the hub were the rotor attaches."

Town of Cohasset Zoning Bylaws § 19.3.3.1
Cohasset, MA

Restrictive, bans guy wires

"No monopole or attached accessory antenna on a monopole shall exceed 120 feet in height as measured from natural ground level at the base of the pole. No monopole shall be constructed which requires guy wires. Monopoles shall not be located on buildings."

Foxborough Zoning By-Laws § 7.2.4
Foxborough, MA

Permissive, allowing for exceptions to improve turbine performance

"Wind facilities shall be no higher than 400 feet above the current grade of the land, provided that wind facilities may exceed 400 feet if:

(a) the applicant demonstrates by substantial evidence that such height reflects industry standards for a similarly sited wind facility;

(b) such excess height is necessary to prevent financial hardship to the applicant, and

(c) the facility satisfies all other criteria for the granting of a site plan approval and a building permit under the provisions of this section."

Town of Dixmont Wind Energy Facility Ordinance § 5.d
Dixmont, ME

additional example overleaf...

* Maps published by the National Renewable Energy Laboratory in 2011 for wind resources at 30 m and 80 m; http://www.windpoweringamerica.gov/wind_maps.asp. Last accessed 07.13.2013.

Height (continued)

Allowing for exceptions with maximum height

Note: wording is ambiguous and thus, is not ideal, e.g. "significant" and "substantial"

"Wind Turbines shall be no higher than 350 feet above existing average grade, measured to the tip of the rotor blade at its highest point. The SPGA may allow said height to exceed to a maximum of 525 feet, but only if the applicant can demonstrate that:

(a) The additional benefits of a higher wind turbine outweigh any increased adverse impacts resulting therefrom.

(b) A higher wind turbine will result in significant additional benefits in terms of energy production and efficiency.

(c) As shown by substantial evidence, such increased height reflects the industry standard for a wind turbine with a similar rates nameplate capacity and

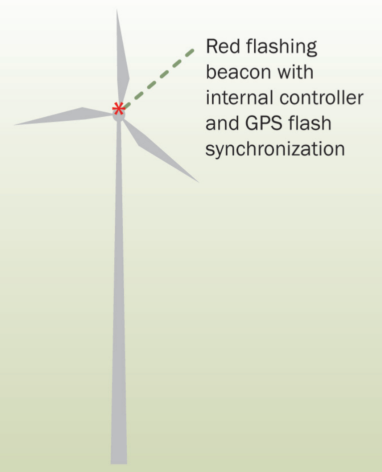
(d) That the proposed wind turbine satisfies all other criteria for the granting of a special permit as set forth in this section."

Zoning By-Law Town of Douglas, Massachusetts § 6.7.5
Douglas, MA

Lighting

Turbine lighting is often required for airplane safety. In some situations, however, it can be an annoyance to neighbors and a hazard to wildlife. For example, lighting on operation and maintenance buildings, electrical substations and other attendant features of a wind farm installation that have outdoor lighting, such as, flood lighting.

Most regulatory language explicitly requires turbine developers to comply with federal FAA regulatory language. It could further require that the best available technology is used. For example, it is possible to install radar-triggered lighting (e.g. OCAS, The Obstacle Collision Avoidance System, and similar) that activates only when approaching aircraft are detected, thereby minimizing light pollution at other times. These technologies have been approved by aviation authorities in Norway, Sweden, Canada and the US and are installed in more than 60 locations in Europe and North America.



Lighting

Bans lighting unless required by law

"Wind Turbines shall not be artificially lighted, except to the extent required by law, and strobe or other intermittent lights are prohibited unless required by law."

Town of Dixmont Wind Energy Facility Ordinance § 5.d
Dixmont, ME

Bans lighting unless required by law, simplest language

"Wind Energy Facilities shall not be artificially lighted, except to the extent required by the Federal Aviation Administration or other applicable authority that regulates air safety."

An Ordinance Amending the Valley Township Zoning Ordinance in order to provide for the installation and use of wind energy facilities within the Township § 431.A.5
Valley Township, Montour County, PA

Lighting (continued)

Bans lighting unless required by law, requires FAA documentation

"A small wind energy system shall not be artificially lit unless such lighting is required by the Federal Aviation Administration (FAA). If lighting is required, the applicant shall provide a copy of the FAA determination to establish the required markings and/or lights for the small wind energy system".

Small Wind Energy Ordinance § 22.4.8
Nelson County, VA

Compliance with FAA requirements, requires documentation

§ 6.6.5 Night lighting of towers shall be prohibited unless required by the FAA. Lighting shall be limited to that needed for emergencies and/or required by the FAA.

§ 6.9.7 Lighting and Signage.

a. Wind turbines shall be lighted only if required by the Federal Aviation Administration (FAA). The proponent shall provide a copy of the FAA's determination to establish the required markings and/or lights for the structure.

b. Lighting of equipment, structures and any other facilities on site shall be shielded from abutting properties.

City of Salem Zoning Ordinance
City of Salem, MA

Bans lighting unless required by law, includes specific lighting and plan

§ 14.1.3 "Wind Turbines shall not be artificially lighted, except to the extent consistent with Federal Aviation Administration recommendations or other applicable authority that regulates air safety or as is otherwise required by another governmental agency with jurisdiction over the WTG."

§ 15.2.7 "Light Pollution. The WTG shall be designed to minimize the amount of nighttime light pollution. The Applicant shall provide a plan showing lighting on and around all Wind Turbines and associated facilities. Lighting on Wind Turbines shall be illuminated to Federal Aviation Administration (FAA) minimal standards using only red rather than white lights, if possible. The minimum number of Wind Turbines will be illuminated, per FAA rules. Lighting shall be shielded from ground view to FAA maximum standards."

Town of Montville Wind Turbine Generator Ordinance
Town of Montville, ME

Bans lighting unless required by law, requires plan, precludes changes without approval

§ 5.I "Notwithstanding the requirements of this Section, replacement in kind or modification of a Wind Energy Facility may occur without Town Board approval when there will be [...] (3) no additional lighting or change in facility color; ...."

Within an Application for Special Use for individual WECs, there shall be a:

§ 11.A.8 "Lighting Plan showing any FAA-required lighting and other proposed lighting. The application should include a copy of the determination by the Federal Aviation Administration to establish required markings and/or lights for the structure, but if such determination is not available at the time of the application, no building permit for any lighted facility may be issued until such determination is submitted."

§ 13.D "Lighting of Tower: No tower shall be lit except to comply with FAA requirements. Minimum security lighting for ground level facilities shall be allowed as approved on the Site plan."

§ 29.F "Exterior lighting on any structure associated with the system shall not be allowed except that which is specifically required by the Federal Aviation Administration."

Model Wind Energy Facility Local Law for St. Lawrence County Municipalities (DRAFT)
St. Lawrence County, NY

Scenic impacts

Concerns over the scenic or visual impacts of wind turbines on the landscape are common. In order to reduce the visual disturbance of a wind turbine development, some regulations require visual impact assessments to be undertaken and submitted as part of the application. Some municipalities also restrict the paint colors and surface types used in installations, and visual setbacks can also be imposed.

Requires demonstration that visual impact will be minimized, but language is vague and not ideal

"Design Standards: 1. Visual Impact - The proponent shall demonstrate through project siting and proposed mitigation that the wind energy conversion facility minimizes any impact on the visual character of surrounding neighborhoods and the community. This may include, but not be limited to, information regarding site selection, turbine design, buffering, lighting and cable layout."

Town of Chester Wind Energy Conversion Facilities Bylaw § 5.7.4
Chester, MA

Requires visual impact study, visual impact mitigation, specific colors and surface types for the turbine, restricts signage and advertising, encourages screening

11.A.16.b - Visual Impact: Applications shall include a visual impact study of the proposed WECS as installed, which may include a computerized photographic simulation, demonstrating any visual impacts from strategic vantage points. Color photographs of the proposed Site from at least two locations accurately depicting the existing conditions shall be included. The visual analysis shall also indicate the color treatment of the system's components and any visual screening incorporated into the project that is intended to lessen the system's visual prominence.

13.e - All applicants shall use measures to reduce the visual impact of WECSs to the extent possible. All structures in a project shall be finished in a single, non-reflective matte finished color or a camouflage scheme. Individual WECSs within a Wind Overlay Zone• shall be constructed using wind turbines whose appearance, with respect to one another, is similar within and throughout the Zone, to provide reasonable uniformity in overall size, geometry, and rotational speeds. No lettering, company insignia, advertising, or graphics shall be on any part of the tower, hub, or blades.

And for Small WECs

29 d - D. The system's tower and blades shall be painted a non-reflective, unobtrusive color that blends the system and its components into the surrounding landscape to the greatest extent possible and incorporate non-reflective surfaces to minimize any visual disruption.

E. The system shall be designed and located in such a manner to minimize adverse visual impacts from public viewing areas (e.g., public parks, roads, trails). To the greatest extent feasible a small wind energy system shall use natural landforms and vegetation for screening.

Model Wind Energy Facility Local Law for St. Lawrence County Municipalities (DRAFT)
St. Lawrence County, NY

Allows the option for visual setbacks

E. Environmental and Visual Effects.

Optional add-on: Visual setbacks. WECS should be set back from the tops of visually prominent ridgelines and designed and located to minimize adverse visual impacts to neighboring residential areas. WECS shall not be installed in any location that would substantially detract from or block the view of all or a portion of a recognized scenic vista as viewed from any public viewing areas such as public parks, roads, trails, or open space.]

Model Municipal Wind Siting Ordinance. Center for Climate Change Law at Columbia Law School,
New York, NY.

Signage and advertising

As a means of reducing the visual disturbance of a wind turbine development, some regulations restrict visual signage and advertising associated with the project.

Refers to existing regulations, safety and encourages signs on renewable energy

"Signs on the facility shall comply with the City of Salem's sign regulations and be limited to those needed to identify the property and the owner and warn of any danger, and educational signs providing information on the technology and renewable energy usage.

[...] Warning signs indicating voltage must be placed at the base of all ground/base mounted electrical equipment."

City of Salem Zoning Ordinance § 6.9.7
City of Salem, MA

Requires plan, safety and contact information, restricts other signs

§ 5.C "A complete assessment of the proposed use of public ways in the Town in connection with the construction of the WEF, including [...] the need to remove or modify (permanently or temporarily) signs, ..."

§ 5.I "An Application for a WEF Site Permit shall include a sign plan meeting the requirements in this section.

(1) The plan shall provide reasonable signage at the WEF, identifying the Project Parcels as being part of the WEF and providing appropriate safety notices and warnings.

(2) No advertising material or signage other than warning, equipment information or indicia of ownership shall be allowed on the Wind Turbines. This prohibition shall include the attachment of any flag, decorative sign, streamers, pennants, ribbons, spinners or waving, fluttering or revolving devices, but not including weather devices.

(3) The address and phone number of the Owner/operator and Licensee shall be posted on all access points from public roads."

§ 5.K "Warning signs shall be placed on each tower, all electrical equipment, and each entrance to the WEF."

Town of Dixmont Wind Energy Facility Ordinance
Dixmont, ME

Restricts advertising, requires safety signage (detailed)

§ 13.C "No advertising signs are allowed on any part of the Wind Energy Facility, including fencing and support structures."

§ 14.C "Appropriate warning signs shall be posted. At least one sign shall be posted at the base of the tower warning of electrical shock or high voltage. A sign shall be posted on the entry area of fence around each tower or group of towers and any building (or on the tower or building if there is no fence), containing emergency contact information, including a local telephone number with 24 hour, 7 day a week coverage. The Town Planning Board may require additional signs based on safety needs."

§ 29.J "At least one sign shall be posted on the tower at a height of five feet warning of electrical shock or high voltage and harm from revolving machinery. No brand names, logo or advertising shall be placed or painted on the tower, rotor, generator or tail vane where it would be visible from the ground, except that a system or tower's manufacturer's logo may be displayed on a system generator housing in an unobtrusive manner."

Model Wind Energy Facility Local Law for St. Lawrence County Municipalities (DRAFT)
St. Lawrence County, NY

Restricts signs, requires safety signage (succinct)

"All signs, temporary and permanent, are prohibited on the small wind energy system, except:

a) Manufacturers/installer identification on the wind turbine, or

b) Appropriate warning signs and placards."

Small Wind Energy Ordinance § 22.4.7
Nelson County, VA

Planning for decommission

The planning and siting of a wind turbine facility must necessarily include a plan to decommission and remove it when it reaches the end of its useful life. A financial surety allows a municipality to permit the construction of a wind energy conversion system without risking the cost of removing the structure, should the owner or developer fail to do so.

Of jurisdictions that require a surety, many require developers to put forward 150 percent of the cost of removal determined at the time of the granting of the special permit. The Massachusetts Green Communities Model Bylaw suggests 125 percent*. Some municipalities allow a conservative estimate of salvage value to be used as a portion of meeting the surety value.

A qualified engineer should determine the underlying cost of removal. No municipality surveyed for this project required that the engineer be independent. Sureties are used for both removal of the structure and rehabilitation of the site.

Decommissioning

Does not require surety, requires owner to remove structure

"Once a WECS is designated as abandoned, the owner shall be required to immediately dismantle the installation."

Town of Scituate Zoning Bylaw § 740.7. Scituate, MA

Requires 150% surety with increases built in

"Developer must put up 150% surety against removal of the structure at the time of granting the special permit. The surety must include Cost of Living increases at 10 and 15 years."

Town of Chester Wind Energy Conversion Facilities Bylaw § 5.7.8. Chester, MA

Requires surety with increases, does not specify amount

"Applicant, upon obtaining a special permit, shall deliver to the Board of Appeals a financial surety, in form and amounts reasonably acceptable to the Board of Appeals, to cover the cost of removal and disposal of the wind facility and the remediation of the landscape in accordance with this subsection. Such financial surety shall be renewed and updated as necessary throughout the life of the wind facility so as to continue to cover the removal, disposal and remediation costs."

Town of Williamstown, Massachusetts: Chapter 70, Zoning Bylaws § 70-7.2.7. Williamstown, MA

Allows salvage value to be factored into surety amount, and updated annually

22.4 An independent and certified Professional Engineer shall be retained to estimate the total cost of decommissioning without regard to salvage value of the equipment ("Decommissioning Costs"), and the cost of decommissioning including the salvage value of the equipment ("Net Decommissioning Costs"). Said estimates shall be submitted to the Town of Montville after the first year of operation and every other year thereafter.

22.5 The Owner/operator shall post and maintain decommissioning funds in an amount equal to Net Decommissioning Costs; provided that at no point shall decommissioning funds be less than one hundred percent (100%) of Decommissioning Costs. The decommissioning funds shall be posted and maintained with a bonding company or Federal or State-chartered lending institution chosen by the Owner/operator and Participating Landowners posting the financial security, provided that the bonding company or lending institution is authorized to conduct such business within the State and is approved by the Town of Montville. No work can begin on the WTG before the decommissioning bond is issued and approved.

Town of Montville Wind Turbine Generator Ordinance. Town of Montville, ME

* Green Communities Bylaw. Model As-of-Right Zoning Ordinance or Bylaw. §4.16.8.3. Boston, MA. March 2012.

Wildlife impacts

At a global and regional scale, the effect of wind energy on the environment is generally considered to be positive, given that it will displace mining activities, air pollution, greenhouse gas emissions, and other forms of environmental degradation associated with non-renewable energy production. However, wind energy development is not entirely environmentally benign as it may cause localized environmental impacts including direct collision impacts on birds and bats (Kuvlesky et al, 2007; NRC, 2007) and can fragment wildlife habitat.

For an in-depth explanation of the science of the environmental impact of wind turbines and potential mitigation, please refer to Appendix B.

Many regulations related to wildlife impacts are covered by state or federal regulations. However, some local regulations also address specific environmental issues; following are two examples, though the language in each is not ideal since it is ambiguous at times and thus could pose problems during the review process.

Wildlife impacts

Land clearing

"Land Clearing, Soil Erosion and Habitat Impacts – Clearing of natural vegetation shall be limited to that which is reasonably necessary for the construction, operation and maintenance of the Community-Scale Wind Facility and is otherwise prescribed by applicable law, regulations, and ordinances. Community-Scale Wind Facilities shall be designed to minimize land clearing and fragmentation of open space areas."

Town of Duxbury Community-Scaled Wind Facilities Bylaw § 616.6.3
Duxbury, MA

Land use, rare species

"Land Clearing/Open Space/Rare Species - Wind energy conversion facilities shall be designed to minimize land clearing and fragmentation of open space areas and shall avoid permanently protected open space when feasible. Wind turbines should be sited to make use of previously developed areas wherever possible. Wind energy conversion facilities shall also be located in a manner that does not have significant negative impacts on rare species in the vicinity (particularly avian species, bats, etc.)."

Town of Chester Wind Energy Conversion Facilities Bylaw § 5.7.4
Chester, MA

Land use, rare species

"Wind turbines shall be designed to minimize land clearing and fragmentation of open space areas and avoid permanently protected open space when feasible. Wind turbines should be sited to make use of previously developed areas wherever possible. Wind turbine facilities shall also be located in a manner that does not have significant negative impacts on rare species in the vicinity (particularly Avian species, bats, etc.) as may be applicable law."

Hanover Wind Energy Facilities Bylaw § 6.14.6
Hannover, MA

Resources

Following are resources* which will be of use to municipalities that are preparing bylaws for land-based wind energy developments. This list is not exhaustive, and focuses on Governmental, National and State resources only.

Detailed 'How to' guides on preparing bylaws

- MA DOER, (2012). Model As-of-Right Zoning Ordinance or Bylaw: Allowing Use of Wind Energy Facilities. Dept of Energy Resources (DOER), Massachusetts Executive Office of Environmental Affairs, Boston, MA.
- NH OEP (2008). Model Small Wind Energy Systems Ordinance. NH Office of Energy and Planning, Concord, NH.
- NYSERDA (2005). Wind Energy: Model Ordinance Options. NYS Energy Research & Development Authority, Albany, NY.
- St.Lawrence County Government (2007). Model Wind Energy Facility Local Law for St. Lawrence County Municipalities (Draft). St. Lawrence County Planning Office, St. Lawrence County Government, Canton, NY.
- Sussman, M. & James, J. (2011). Model Municipal Wind Siting Ordinance. Center for Climate Change Law at Columbia Law School, New York, NY.

U.S. Department of Energy National Laboratories

- National Renewable Energy Laboratory: National Wind Technology Center
- Sandia National Laboratories: Wind Energy

Government agencies involved in wind power activities.

- Bureau of Land Management: Wind Energy
- Federal Aviation Administration: Obstruction Evaluation / Airport Airspace Analysis
- Federal Energy Regulatory Commission: Integration of Renewables
- Fish and Wildlife Service: Wind Turbine Guidelines Advisory Committee
- Maine Department of Environmental Protection: Land Wind Power
- Massachusetts Gov. Official Website of the Executive Office of Energy and Environmental Affairs: Wind Energy
- National Oceanic and Atmospheric Administration: Earth System Research Laboratory
- New Hampshire Office of Energy and Planning: Resource Library: Small wind energy systems
- Renewable Energy Vermont: Technologies: Wind
- US Dept. of Energy, Energy Efficiency and Renewable Energy (EERE): Wind Program & Wind Powering America
- Vermont Public Services Department: Renewable Energy - Wind

National Wind Energy Associations and Organizations

- American Wind Energy Association
- American Wind Wildlife Institute
- Bats and Wind Energy Cooperative
- National Wind Coordinating Collaborative
- Union of Concerned Scientists: Citizens and Scientists for Environmental Solutions
- Utility Wind Integration Group

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* The electronic copy of this document includes active hyperlinks to each of these resources.

Glossary

The following list of terms has been compiled from a number of active bylaws, in addition to the U.S Fish and Wildlife Service's Land-Based Wind Energy Guidelines (USFWS 2012).

Aerodynamic sound: a noise that is caused by the flow of air over and past the blades of a WTG.

Ambient sound: Ambient sound encompasses all sound present in a given environment, being usually a composite of sounds from many sources near and far. It includes intermittent noise events, such as, from aircraft flying over, dogs barking, wind gusts, mobile farm or construction machinery, and the occasional vehicle traveling along a nearby road. The ambient also includes insect and other nearby sounds from birds and animals or people. The nearby and transient events are part of the ambient sound environment but are not to be considered part of the long-term background sound.

Anemometer: a device for measuring the speed and direction of the wind.

Anthropogenic: Resulting from the influence of human beings on nature.

Avian: Pertaining to or characteristic of birds.

Background sound (L90): refers to the sound level present at least 90% of the time. Background sounds are those heard during lulls in the ambient sound environment. That is, when transient sounds from flora, fauna, and wind are not present. Background sound levels vary during different times of the day and night. Because WTGs operate 24/7 the background sound levels of interest are those during the quieter periods which are often the evening and night. Sounds from the WTG of interest, near-by birds and animals or people must be excluded from the background sound test data. Nearby electrical noise from streetlights, transformers and cycling AC units and pumps etc., must also be excluded from the background sound test data.

Blade Passage Frequency (BPF): the frequency at which the blades of a turbine pass a particular point during each revolution (e.g. lowest point or highest point in rotation) in terms of events per second. A three bladed turbine rotating at 28 rpm would have a BPF of 1.4 Hz. [E.g. ((3 blades times 28rpm)/60 seconds per minute = 1.4 Hz BPF)]

Blade reflection: the intermittent reflection of the sun off the surface of the blades of a Wind Turbine.

Blade throw: Rotor blade fragments released from failed wind turbine blades.

Buffer zone: A zone surrounding a resource designed to protect the resource from adverse impact, and/or a zone surrounding an existing or proposed wind energy project for the purposes of data collection and/or impact estimation.

By right: A use permit that requires compliance with existing regulations but does not require special permission.

Carve-out: Essentially an 'exception to the rule' as defined by a specific bylaw.

Clear area: Area surrounding a wind turbine to be kept free of habitable structures.

Community-scale: Wind energy projects greater than 1 MW, but generally less than 20 MW, in name-plate capacity, that produce electricity for off-site use, often partially or totally owned by members of a local community or that have other demonstrated local benefits in terms of retail power costs, economic development, or grid issues.

Critical Electric Infrastructure (CEI): electric utility transmission and distribution infrastructure, including but not limited to substations, transmission towers, transmission and distribution poles, supporting structures, guy-wires, cables, lines and conductors operating at voltages of 13.8 kV and above and associated telecommunications infrastructure. CEI also includes all infrastructure defined by any federal regulatory agency or body as transmission facilities on which faults or disturbances can have a significant adverse impact outside of the local area, and transmission lines and associated equipment generally operated at

voltages of 100 kV or higher, and transmission facilities which are deemed critical for nuclear generating facilities.

Critical habitat: For listed species, consists of the specific areas designated by rule making pursuant to Section 4 of the Endangered Species Act and displayed in 50 CFR § 17.11 and 17.12.

Cut-in speed: The wind speed at which the generator is connected to the grid and producing electricity. It is important to note that turbine blades may rotate at full RPM in wind speeds below cut-in speed.

Decibel (dB): A dimensionless unit which denotes the ratio between two quantities that are proportional to power, energy or intensity. One of these quantities is a designated reference by which all other quantities of identical units are divided. The sound pressure level (Lp) in decibels is equal to 10 times the logarithm (to the base 10) of the ratio between the pressure squared divided by the reference pressure squared. The reference pressure used in acoustics is 20 MicroPascals.

Displacement: The loss of habitat as result of an animal's behavioral avoidance of otherwise suitable habitat. Displacement may be short-term, during the construction phase of a project, temporary as a result of habituation, or long-term, for the life of the project.

Distributed generation: Energy generation that is located at or near the end-user.

Distributed wind: Small and mid-sized turbines between 1 kilowatt and 1 megawatt that are installed and produce electricity at the point of use to off-set all or a portion of on-site energy consumption.

Emission: Sound energy that is emitted by a noise source (i.e. the WTG) is transmitted to a receiver (i.e. a dwelling) where it is immitted.

Fatality: An individual instance of death.

Fatality rate: The ratio of the number of individual deaths to some parameter of interest, such as megawatts of energy produced, the number of turbines in a wind project, the number of individuals exposed, etc., within a specified unit of time.

Feathering: Adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation.

Federal action agency: A department, bureau, agency or instrumentality of the United States which plans, constructs, operates or maintains a project, or which reviews, plans for or approves a permit, lease or license for projects, or manages federal lands.

Footprint: The geographic area occupied by the actual infrastructure of a project such as wind turbines, access roads, substation, overhead and underground electrical lines, and buildings, and land cleared to construct the project.

Frequency: The number of oscillations or cycles per unit of time. Acoustical frequency is usually expressed in units of Hertz (Hz) where one Hz is equal to one cycle per second.

Guy wire: Wires used to secure wind turbines or meteorological towers that are not self-supporting.

Habitat: The area which provides direct support for a given species, including adequate food, water, space, and cover necessary for survival.

Habitat fragmentation: Habitat fragmentation separates blocks of habitat for some species into segments, such that the individuals in the remaining habitat segments may suffer from effects such as decreased survival, reproduction, distribution, or use of the area.

Height, blade-tip: The height of a wind turbine measured from natural grade to the tip of the rotor blade at its highest point. This measure is also commonly referred to as the maximum tip height (MTH), or turbine height.

Height, tower: The height above grade of the fixed portion of the tower, measured to the top of the nacelle and excluding the wind generator.

Height, turbine: The height of a wind turbine measured from natural grade to the tip of the rotor blade at its highest point. This measure is also commonly referred to as the maximum tip height (MTH) or blade-tip height.

Hertz (Hz): Frequency of sound expressed by cycles per second.

Ice throw: accumulated ice buildup on the blades of a wind turbine that is, or can be, thrown during normal spinning or rotation.

Infill: Add an additional phase to the existing project, or build a new project adjacent to existing projects.

Infra-sound: sound with energy in the frequency range of 0-20 Hz is considered to be infra-sound. It is normally considered to not be audible for most people unless in relatively high amplitude. The most significant exterior noise induced dwelling vibration occurs in the frequency range between 5 Hz and 50 Hz.

Lattice design: A wind turbine support structure design characterized by horizontal or diagonal lattice of bars forming a tower rather than a single tubular support for the nacelle and rotor.

Listed species: Any species of fish, wildlife or plant that has been determined to be endangered or threatened under section 4 of the Endangered Species Act (50 CFR §402.02), or similarly designated by state law or rule.

Low Frequency Noise (LFN): refers to sounds with energy in the lower frequency range of 20 to 200 Hz. LFN is deemed to be excessive when the difference between a C-weighted sound level and an A-weighted sound level is greater than 20 decibels at any measurement point outside a residence or other occupied structure.

Mechanical noise: sound produced as a byproduct of the operation of the mechanical components of a WTG(s) such as the gearbox, generator and transformers.

Megawatt (MW): A measurement of electricity-generating capacity equivalent to 1,000 kilowatts (kW), or 1,000,000 watts.

Meteorological tower (MET tower): a meteorological tower used for the measurement of wind speed.

Migration: Regular movements of wildlife between their seasonal ranges necessary for completion of the species lifecycle.

Migration corridor: Migration routes and/or corridors are the relatively predictable pathways that a migratory species travel between seasonal ranges, usually breeding and wintering grounds.

Migration stopovers: Areas where congregations of wildlife assemble during migration. Such areas supply high densities of food or shelter.

Mitigation: (Specific to this context) Avoiding or minimizing significant adverse impacts, and when appropriate, compensating for unavoidable significant adverse impacts.

Mitigation Waiver: a legally enforceable, written agreement between the Applicant and a Nonparticipating

Landowner in which the landowner waives certain setback, noise or other protections afforded in the Ordinance.

Monitoring: 1) A process of project oversight such as checking to see if activities were conducted as agreed or required; 2) making measurements of uncontrolled events at one or more points in space or time with space and time being the only experimental variable or treatment; 3) making measurements and evaluations through time that are done for a specific purpose, such as to check status and/or trends or the progress towards a management objective.

Mortality rate: The numbers of birds or bats killed per turbine per year.

Nacelle: The frame and housing at the top of the tower that encloses the gearbox and generator and protects them from the weather.

Nameplate capacity: the electrical power rating of an individual wind turbine as certified by the manufacturer and normally expressed in watts, kilowatts (kW), or megawatts (MW).

Net metering: The difference between the electricity supplied to a customer over the electric distribution system and the electricity generated by the customer's small wind energy system that is fed back into the electric distribution system over a billing period.

Noise: any unwanted sound. Not all noise needs to be excessively loud to represent an annoyance or interference.

Passerine: Describes birds that are members of the Order Passeriformes, typically called "songbirds."

Plant communities of concern: Plant communities of concern are unique habitats that are critical for the persistence of highly specialized or unique species and communities of organisms. Often restricted in distribution or represented by a small number of examples, these communities are biological hotspots that significantly contribute to the biological richness and productivity of the entire region. Plant communities of concern often support rare or uncommon species assemblages, provide critical foraging, roosting, nesting, or hibernating habitat, or perform vital ecosystem functions. Includes any plant community with a Natural Heritage Database ranking of S1, S2, S3, G1, G2, or G3.

Power grid: The transmission system, managed by ISO New England, created to balance the supply and demand of electricity for consumers in New England.

Project transmission lines: Electrical lines built and owned by a project developer.

Raptor: As defined by the American Ornithological Union, a group of predatory birds including hawks, eagles, falcons, osprey, kites, owls, vultures and the California condor.

Rotor: The parts of a wind turbine that interact with wind to produce energy; the blades and hub of the wind turbine that rotate during turbine operation.

Rotor-swept area: The area of the circle or volume of the sphere swept by the turbine blades.

Rotor-swept zone: The altitude within a wind energy project which is bounded by the upper and lower limits of the rotor-swept area and the spatial extent of the project.

Sensitive receptor: Places or structures intended for human habitation, whether inhabited or not, public parks, state and federal wildlife areas, the manicured areas of recreational establishments designed for public use, including but not limited to golf courses, campgrounds and other nonagricultural state or federal licensed businesses. These areas are more likely to be sensitive to the exposure of the noise, shadow or flicker, etc. generated by a WTG or WTG Facilities. These areas include, but are not limited to: schools, daycare centers, elder care facilities, hospitals, places of seated assemblage, non-agricultural businesses and residences.

Setback: The base of the tower to the nearest property line.

Setback area: The entire land base that falls within a specified setback.

Shadow flicker: Alternating changes in light intensity caused by the movement of wind turbine blades casting shadows on the ground or a stationary object.

Sight line representation: A line depicted in profile extending from an observer's eye to the lowest point of a viewed tower.

Sign: Any word, letter, symbol, drawing, picture, design, device, article or object which advertises, calls attention to or indicates the location of any premises, person or activity; whatever its manner of composition or construction and however displayed.

Small Wind Energy Conversion System ("Small WECS"): A wind energy conversion system (WECS) consisting of a wind turbine, a tower, and associated control or conversion electronics, which has a rated capacity of not more than 100 kW and which will be used primarily for onsite consumption.

Sound: A fluctuation of air pressure which is propagated as a wave through air.

Sound power: The total sound energy radiated by a source per unit time. The unit of measurement is the watt.

Sound pressure: The instantaneous difference between the actual pressure produced by a sound wave and the average or barometric pressure at a given point in space.

Special permit: A special permit is a zoning instrument used primarily to review the location, site development, or conduct of certain land uses. These are uses that may have an impact on the area in which they are located, or are capable of creating special problems for bordering properties unless given special attention. A special permit may be granted at the discretion of the Special Permit Granting Authority (SPGA) and is not the automatic right of any applicant.

Special Permit Granting Authority (SPGA): Board designated by zoning ordinance or bylaw with the authority to issue special permits.

Species of concern: For a particular wind energy project, any species which: 1) is either, a) listed as an endangered, threatened or candidate species under the Endangered Species Act, subject to the Migratory Bird Treaty Act or Bald and Golden Eagle Protection Act; b) is designated by law, regulation, or other formal process for protection and/ or management by the relevant agency or other authority; or c) has been shown to be significantly adversely affected by wind energy development; and 2) is determined to be possibly affected by the project.

Species of habitat fragmentation concern: Species of concern for which a relevant federal, state, tribal, and/ or local agency has found that separation of their habitats into smaller blocks reduces connectivity such that the individuals in the remaining habitat segments may suffer from effects such as decreased survival, reproduction, distribution, or use of the area. Habitat fragmentation from a wind energy project may create significant barriers for such species.

String: A number of wind turbines oriented in close proximity to one another that are usually sited in a line, such as along a ridgeline.

Strobe: Light consisting of pulses that are high in intensity and short in duration.

Tonal sound or tonality: Tonal audibility. A sound for which the sound pressure is a simple sinusoidal function of the time, and characterized by its singleness of pitch. Tonal sound can be simple or complex.

Tower: The monopole, guyed monopole or lattice structure that supports a wind generator.

Tubular design: A type of wind turbine support structure for the nacelle and rotor that is cylindrical rather than lattice.

Tower Height: see Height, tower

Turbine height: see Height, turbine.

Utility-scale: Wind projects generally larger than 20 MW in nameplate generating capacity that sell electricity directly to utilities or into power markets on a wholesale basis.

Voltage (low and medium): Low voltages are generally below 600 volts, medium voltages are commonly on distribution electrical lines, typically between 600 volts and 110 kV, and voltages above 110 kV are considered high voltages.

Wildlife: Birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent.

Wildlife management plan: A document describing actions taken to identify resources that may be impacted by proposed development; measures to mitigate for any significant adverse impacts; any post-construction monitoring; and any other studies that may be carried out by the developer.

Wind energy conversion system (WECS): All equipment, machinery and structures utilized in connection with the conversion of wind to electricity. This includes, but is not limited to, all transmission, storage, collection and supply equipment, substations, transformers, site access, service roads and machinery associated with the use. A wind energy conversion facility may consist of one or more wind turbines.

Wind Monitoring or Meteorological ("test" or "met ") Towers: A temporary tower equipped with an anemometer, wind vane and other equipment to measure the wind resource (wind speed and direction), to determine how much electricity a wind energy facility can be expected to generate at a predetermined height above the ground.

Wind Overlay District (WOD): An area within a municipality where wind energy facilities shall be permitted subject to the review and permitting requirements of a wind turbine bylaw for that town; wind turbine development outside of said WOD would not be permitted.

Wind turbine: A machine for converting the kinetic energy in wind into mechanical energy, which is then converted to electricity.

Wind Turbine Flickering: The blinking effect while the rotor is in motion. Attention will be paid to siting the wind turbine(s) to reduce significant flickering.

Wind Turbine Generators (WTG): Equipment that converts and then transfers energy from the wind into usable forms of electrical energy and includes all related and supporting items including but not limited to all buildings, structures, electrical equipment, substations, transmission lines, access roads, parking lots, areas to be stripped or graded, and areas to be landscaped or screened.

Appendix A

The science of sound and noise

Additionally, people's perceptions of sound and reactions to noise are highly variable and subjective (BLM 2004, Rogers et al. 2004, Colby et al. 2009). Given this variability, it is difficult to generalize about the impacts of wind power noise.

To introduce fundamental concepts and terminology used in measurements of sound and noise, an overview of sound and noise is provided below. Questions related to wind turbine noise and its impacts are then addressed. The basics of sound and noise:

Sound is primarily characterized by its intensity, or its 'sound pressure level'. Sound pressure levels are measured in terms of decibels (dB), with 0 dB being the typical threshold of human hearing and 140 decibels being the typical threshold of pain. The decibel scale is based upon a logarithmic function, which means that a 10 dB increase in sound pressure level creates approximately a doubling in loudness (Alberts 2006, NMCPHC 2009).

Sound is also characterized by its frequency, which is measured in hertz (Hz). Although the normal human ear perceives sounds at frequencies ranging from about 20 Hz to 20,000 Hz, human perception of sound is less sensitive to very low and high frequencies, and is generally most sensitive to frequencies between 1,000 and 4,000 Hz. Sound below 200 Hz is considered to be 'low-frequency sound'; low frequency sound is present at low levels throughout the environment (e.g. sound from wind or water). Sound below 20 Hz is described as 'infrasound'; infrasound is generally not audible but it may cause vibration (Rogers et al. 2004, Alberts 2006, Leventhall 2006, NMCPHC 2009, CMOPH 2010).

Frequency influences our perception of sound; for this reason, various scales are used to calibrate sound pressure levels according to frequency. Environmental sounds are generally measured using an A-weighted scale, which accounts for the sensitivity of the human ear and de-emphasizes very high and low frequencies; A-weighted sound pressure levels are measured in units of dB(A) (Rogers et al. 2004, Alberts 2006). For comparison, the sound pressure level produced by rustling leaves is about 45 dB(A), the sound of normal conversation is about 60 dB(A), and the sound of a jet take-off is about 130 dB (A) (Reed College, 2010). Given that wind turbine sound is considered a form of environmental noise, it is generally measured according to the A-weighted scale and is discussed in terms of dB(A) (Rogers et al. 2004, Alberts 2006).

When discussing environmental noise such as wind turbine sound, is important to distinguish between two commonly used sound measurements: sound pressure and sound power.

- **Sound power** is the total acoustic power—or energy converted into sound—emitted by a source; this measurement may be used to estimate how far sound will travel and to predict sound levels at various distances from the source. Sound power is a property of the sound source and is not dependent upon distance.
- **Sound pressure** is the level of sound perceived by an observer. This is a property of the sound at a given observer distance from the source, and will decrease as the sound moves farther from the source.

Sound power and sound pressure measures cannot be compared (Rogers et al. 2004, Alberts 2006).

Perception of sound varies considerably from person to person based upon individual sensitivities. Perception of sound is also influenced the amount of ambient noise (i.e. noise from other sources) that is present; the same level of sound will generally appear to be louder when in a quiet setting than when in a setting with more background noise. For these reasons, responses to sound and noise differ greatly among people and places (Passchier-Vermeer and Passchier 2000, Colby et al. 2009).

Noise is typically measured by peak decibel level and state regulations will be usually be used as the default regulation level. Local regulations cannot place the decibel threshold below state regulations but they can implement a more stringent limit.

Wind turbines produce sound from mechanical as well as the sound of the rotating blades displacing air (typically referred to as a whooshing sound).

There are several options on where to measure the noise level. One of the most popular approaches is to measure the noise at the property boundaries. Local regulations can also set the noise level at the nearest building on abutting properties or at the nearest inhabited residence.

Appendix B

Wind power and the environment

At a global and regional scale, wind energy is generally considered to have a positive effect on the environment, given that it will displace mining activities, air pollution and greenhouse gas emissions associated with fossil fuel-based energy production. However, wind energy development may cause localized environmental impacts on birds, bats, and other wildlife (Drewitt and Langston 2006, NRC 2007, Ledec et al. 2011).

Research is ongoing into both the potential impacts of wind energy development on local ecology, and the ways to mitigate negative effects. Research to date indicates that developing wind power infrastructure can impact local environments, but the impacts will vary significantly depending on the wind farm design and location. For this reason, scientists generally agree that environmental effects should be taken into consideration during the siting and planning of wind farms (Drewitt and Langston 2006, Kuvlesky et al. 2007, NRC 2007, Drewitt and Langston 2008, Ledec et al. 2011).

Commonly expressed concerns and questions about the environmental impacts of wind power development on land are discussed below.

Habitat and terrestrial wildlife impacts

The impact of wind power development on habitat and terrestrial wildlife has, to date, attracted significantly less study than the effect on birds and bats. Experience with similar forms of development suggests, however, that the construction, maintenance and operation of wind power facilities will disturb habitat and, for this reason, may negatively impact wildlife (NRC 2007).

Scientists generally agree that the extent of the disturbance to habitat and surrounding wildlife caused by a wind power facility will depend upon a variety of factors, including the size of the wind power site and the type of ecosystem (Kuvlesky et al. 2007, NRC 2007). Although turbines themselves will cause some impact, it is the associated infrastructure—particularly roads and transmission lines—that will likely present a greater threat to habitat and terrestrial wildlife, especially where this infrastructure causes significant vegetation clearing, habitat fragmentation and soil disturbance (Kuvlesky et al. 2007, NRC 2007). Some analyses suggest that initial disturbance associated with construction will likely be far greater than long-term disturbance (Boone et al. 2005, NRC 2007). However, long-term effects are possible, such as loss of native species due to land clearing, displacement of wildlife due to noise, and vibrational intrusion (Drewitt and Langston 2006, Kuvlesky et al. 2007, Kikuchi 2008).

Birds

Studies indicate that the most common behavioral response of birds is to recognize wind turbines as obstacles and to fly around them. However, some birds do strike wind turbines and this, in turn, often results in bird fatalities (Drewitt and Langston 2006, Kuvlesky et al. 2007, Kikuchi 2008).

Documented rates of collision-related fatalities at onshore wind sites range anywhere from zero to 60 birds/turbine/year; however, the majority of studies estimate collision fatality rates of one or fewer birds/turbine/year (Winkelman 1992, Musters et al. 1996, Langston and Pullan 2003, Erickson et al. 2005, Drewitt and Langston 2006, Hotker et al. 2006, Kuvlesky et al. 2007). It has been suggested that these collisions estimates may be low due to sampling and observer biases (Erickson et al. 2005, NRC 2007, Drewitt and Langston 2008). When adjusted for such biases, estimates of bird fatalities at onshore wind sites typically range from fewer than 1 to 3 birds/turbine/year (Erickson et al. 2005, Drewitt and Langston 2008).

Birds may also collide with offshore wind turbines, although the limited research on bird interactions with offshore wind turbines has generally found high levels of wind turbine avoidance and few bird collisions (Kahlert et al. 2004, Desholm and Kahlert 2005, Energy et al. 2006). Given that there is currently little data on offshore wind turbine strike and mortality rates, it is not possible to draw general conclusions about bird collisions with offshore wind turbines (Wilson et al. 2010).

There are situations where the overall avian mortality associated with wind turbine collisions has caused significant concern. The most commonly cited instance is Altamont Pass Wind Resource Area (APWRA), a large, older wind farm in California. Early research conducted at APWRA estimated that, during the two years of study, up to 567 raptors may have died due to wind turbine collisions (Orloff and Flannery 1992, 1996, Erickson et al. 2005); a more recent analysis suggests that up to 2,710 birds—of which about 1,127 are raptors—are killed annually by APWRA's 5,400 wind turbines (Smallwood and Thelander 2008). High overall kills have also been noted at the Tarifa and Navarra wind farms in Spain (Langston and Pullan 2003). Given that some locations cause significant avian mortality, most scientists agree that wind power development sites must be carefully considered (Langston and Pullan 2003, Drewitt and Langston 2008, Kikuchi 2008, NWCC 2010).

It is important to note that many scientists and interest groups have expressed concern about the lack of peer-reviewed, long-term, standardized, and systematic assessments of avian collisions with wind turbines and suggest that, for this reason, there is still significant uncertainty regarding the potential impact of wind turbine collisions on bird populations (Langston and Pullan 2003, Kikuchi 2008). However, this same concern has been expressed about avian collisions with other man-made structures (e.g. communication towers, buildings, power lines, etc.) and is not isolated to collisions with wind turbines (Drewitt and Langston 2006, Hotker et al. 2006). In light of this, many studies suggest that more emphasis needs to be placed on peer reviewed, systematic, long-term studies of bird collisions with all human structures—including but not limited to wind turbines—in order to provide a more complete estimate of bird mortality due to collision and to improve understanding of how collisions impact bird populations at the local, regional, and global levels (Erickson et al. 2005, Drewitt and Langston 2006, Kikuchi 2008).

In addition to wind turbines, a variety of other human activities and anthropogenic causes are responsible for bird mortality, including cats, automobiles, pesticides and collisions with other man-made structures (Erickson et al. 2005). However, comparisons between different anthropogenic causes of bird fatalities should be approached with caution, given that: a) estimates of bird fatalities from both natural and human-related causes are highly uncertain, and b) different anthropogenic sources of bird mortality cannot be directly compared due to their significant variation in prevalence, geographic location, and other such factors (NRC 2007).

Estimates of bird fatalities due to different anthropogenic sources have been reported by Erickson et al. (2005) and the U.S. Fish and Wildlife Service (2002). These sources indicate that, annually in the U.S., collisions with buildings kill between 97 and 976 million birds; collisions with high-tension lines (e.g. power lines) kill anywhere between 130 million and 1 billion birds; collisions with communication towers kill between 4 and 50 million birds; cars kill up to 80 million birds; toxins and pesticides kill more than 72 million birds; and domestic cats kill hundreds of millions of songbirds and other species. These same studies report that, in 2003, collisions with wind turbines killed between 20,000 and 37,000 birds in the U.S. (see also NRC, 2007).

These numbers suggest that bird deaths due to wind turbine collisions are a small fraction of the total bird deaths due to human-related causes—less than 0.003 percent of anthropogenic bird kills in 2003 according to estimates from Erickson et al. (2005). However, wind turbine strike does impose additional risk to bird populations—particularly local bird communities—and it is likely that this risk will increase as wind power development expands (Drewitt and Langston 2006, NRC 2007, Drewitt and Langston 2008, Kikuchi 2008).

The type of birds that a given wind farm affects vary considerably with the topography of the site and the species dynamics in the area (Drewitt and Langston 2006, 2008). Studies indicate that passerines (songbirds), such as warblers and sparrows, generally compose the majority of turbine-related bird fatalities (Kuvlesky et al. 2007, NRC 2007); about 6 percent of turbine-strike bird fatalities in the U.S. are thought to be raptors, including red-tailed hawks, kestrels, and golden eagles (NRC 2007). While passerine and raptor collisions have attracted the most attention and study, other groups of birds, such as waterfowl and shorebirds, have also been known to collide with turbines (Kuvlesky et al. 2007).

The impacts of turbine collision fatalities on bird populations are complex, and added mortality may impose a greater risk to some types of birds than others. For example, while passerines compose the majority of turbine-related fatalities, they are also the most abundant bird group in the terrestrial ecosystem (NRC 2007). Given their abundance and relatively high reproduction levels, passerines are less likely to be impacted at a population level than are many other species (Kuvlesky et al. 2007, NWCC 2010). By contrast, although raptors compose only about 6 percent of turbine-related fatalities, they have longer life spans and lower reproductive rates than do passerines and, for this reason, are more likely to be impacted by additional mortalities caused by wind turbines (Kuvlesky et al. 2007, Newton 2007).

While some types of birds may be at greater risk than others, there does not appear to be conclusive evidence of large-scale impacts to any particular bird species due to wind turbine strike However, studies generally agree that wind turbines may impact local bird communities, and that the long-term effects of wind turbine collisions on bird populations remain highly uncertain (Drewitt and Langston 2006, Kuvlesky et al. 2007, Drewitt and Langston 2008).

Wind power development may indirectly impact bird populations through habitat change, disturbance, and resultant displacement. Studies generally agree that the construction and operation of wind power facilities does disturb habitat, and that this may adversely impact birds and other wildlife, and potentially lead to habitat loss of habitat. However, the scale and degree of this disturbance is uncertain, and its effects on bird life and habitat are contingent upon site- and species-specific factors, and are, therefore, highly variable (Langston and Pullan 2003, Drewitt and Langston 2006, NRC 2007).

Studies of onshore bird populations have recorded disturbance effects (i.e. reduction in bird use or absence of birds) up to 600m from wind turbines for certain species, such as whooper swans (Larsen and Clausen 2002), pink-footed geese (Larsen and Madsen 2000), and European white-fronted geese (Kruckenberg and Jaene 1999). Similarly, studies of offshore impacts have observed decreased concentrations of certain bird species, such as common eider and common scoter, within certain development sites (Langston and Pullan 2003, Drewitt and Langston 2008). However, studies of displacement and disturbance due to wind power facilities are often inconclusive due to lack of before- and after-development impact assessments, and there is currently little evidence regarding whether birds adjust to wind power development over long periods of time (Langston and Pullan 2003, Drewitt and Langston 2006).

Despite uncertainty about the scope and degree of disturbance and displacement caused by wind power facilities, it is widely recognized that habitat change caused by wind power development may potentially threaten certain bird populations (Langston and Pullan 2003, Drewitt and Langston 2006, Kikuchi 2008).

Bats

The impact of wind power development on bats attracted little attention until the early 2000s, when substantial bat fatalities were observed at wind power sites in Minnesota and West Virginia (Johnson et al. 2004, Kerns and Kerlinger 2004). Since then, increased monitoring efforts have documented bat fatalities at wind power facilities worldwide (Kunz et al. 2007, Arnett et al. 2008, NWCC 2010).

A considerable amount of research has recently been directed at understanding the interaction between bats and wind farms and finding ways to mitigate any negative impacts. It is generally agreed that wind farms do impact bats, although studies indicate that these impacts are both highly variable and site- and species-specific, and much remains uncertain about the extent of these impacts and the long-term implications for bat populations (Kunz et al. 2007, Arnett et al. 2008, Cryan and Barclay 2009, NWCC 2010).

Wind turbines can and do kill bats, and turbine-related bat fatalities have been documented at wind power facilities throughout the U.S. and the world (Kunz et al. 2007, Arnett et al. 2008). Direct collision with wind turbines is thought to be the primary source of bat fatalities due to wind power (Horn et al. 2008). However, recent work by Baerwald et al. (2008) suggests that bat fatalities may also be caused by 'barotrauma', a condition in which the internal organs of bats are damaged by dramatic changes in air pressure created in the near vicinity of rotating wind turbines (Baerwald et al. 2008).

Although the impact of wind power development on bats has generally attracted less attention than has the impact on birds, recent studies suggest that at many wind power sites, the turbine-related mortality rates for bats may be considerably higher than for birds (Kuvlesky et al. 2007, Arnett et al. 2008). Estimated fatality rates range from less than one bat/turbine/year at some sites to over 48 bats/turbine/year in others (Arnett et al. 2008), and it has been suggested that, annually, an average of 3.4 bats are killed per turbine in the U.S. (Johnson et al. 2004). Estimated bat fatalities from different studies cannot be directly compared due to differences in sampling protocols (Arnett et al. 2008); however, research generally indicates that the number of bat fatalities and the species affected varies considerably by region and wind power facility (Kunz et al. 2007, Arnett et al. 2008, NWCC 2010).

The effect of these mortalities on bat communities remains highly uncertain. Bats are long-lived and slow to reproduce, making bat populations susceptible to localized extinctions and vulnerable to negative impacts from added mortality factors (Kuvlesky et al. 2007, Arnett et al. 2008). For this reason, some scientists and conservation groups have expressed concern that bat populations may not be able to withstand the existing rate of turbine-related fatalities and/or increased fatalities due to added wind power facilities. However, significant uncertainty remains regarding the long-term impacts of wind power development on bat populations (Kunz et al. 2007, Arnett et al. 2008, NWCC 2010).

Wind turbines affect many different species of bats but three migratory tree-roosting species compose the majority of bat fatalities reported at wind facilities in North America: the hoary bat, the eastern red bat, and the silver-haired bat (Kunz et al. 2007, Arnett et al. 2008). Other species that have been affected include: the eastern pipestrelle, the little brown myotis, the big brown bat, the northern long-eared myotis, the Brazilian free-tailed bat, and the Seminole bat (Barclay et al. 2007, Cryan and Brown 2007, Kunz et al. 2007, NRC 2007, Arnett et al. 2008). None of the bat species known to be impacted by wind farms are currently classified as endangered or threatened (NWCC 2010).

Recent studies indicate that bat fatalities occur when wind turbine blades are in operation and that bats generally do not collide with stationary blades or wind turbine towers (Arnett et al. 2008, Horn et al. 2008). While it is not certain, it is believed that bats may collide with operational wind turbines as a result of inability to detect moving blades, failure to avoid blades due to insufficient reaction time, or difficulty escaping vortices created by wind turbine operation (Barclay et al. 2007, NRC 2007, Horn et al. 2008). It is also possible that bat mortality is caused by barotraumas, or fatal damage to their internal organs caused by dramatic changes in pressure in the near vicinity of operational wind turbines (Baerwald et al. 2008, Cryan and Barclay 2009). Bat fatalities appear to occur mostly during foraging and feeding rather than when bats are flying by or looking for a place to roost (Kunz et al. 2007, Horn et al. 2008).

Factors that have been identified as possibly influencing the risk of turbine-related mortality include:

- **Season and timing:** the majority of bat fatalities appear to occur within a few hours of sunset, and during mid-summer and early fall (the time of southward bat migration) (Kunz et al. 2007, Kuvlesky et al. 2007, Arnett et al. 2008, Cryan and Barclay 2009).
- **Height of wind turbines:** studies indicate that taller turbines cause more bat fatalities than do shorter turbines, a reasonable conclusion given that most bats fly at altitudes of between 100 and 500 meters (Barclay et al. 2007, Arnett et al. 2008);
- **Weather:** bat fatalities tend to be greater right before or after storms, possibly due to bats flying at lower altitudes as a result of low cloud ceilings, or sensory confusion due to unstable meteorological conditions (Kunz et al. 2007, Arnett et al. 2008); and
- **Wind speed:** some studies suggest that bat fatalities are highest on nights when wind turbines are operational but wind speeds are low (Arnett et al. 2008, Horn et al. 2008, Baerwald et al. 2009).

Most scientists agree that much remains unknown about bat populations and their behaviors, and that more standardized, long-term, and full-season research is needed to better understand how bats interact with wind turbines and the overall impacts of wind power facilities on bat communities (Kunz et al. 2007, Arnett et al. 2008, NWCC 2010).

Wind turbine-related fatality appears to be the dominant adverse impact of wind power development on bats (Kunz et al. 2007, Arnett et al. 2008, NWCC 2010). While concern has been expressed about negative impacts due to habitat loss or disturbance caused by the construction and operation of wind power facilities (see for example, Environmental 2008), significant effects to bats from causes other than direct fatalities do not appear to have been demonstrated.

Given that much remains unknown about bat populations and their migration, foraging, and roosting habits, it is difficult to be certain about how best to avoid and/or mitigate the negative impacts of wind power development. However, during the last decade, a variety of possible mitigation strategies have been identified and studied. Suggested mitigation strategies include:

- **Avoidance of ecologically sensitive areas:** it is suggested that, as with birds, high-risk areas—such as those with large abundances of bats or concentrations of threatened bat species—should be avoided (Arnett et al. 2008);
- **Curtailment of operation during high risk periods:** studies suggest that curtailment of wind turbine operation during high-risk periods—mainly nights with low winds when bats are more likely to be flying (Baerwald et al. 2009), especially during late summer and early fall—may significantly reduce the risk of bat injury or fatality (Kunz et al. 2007, Arnett et al. 2008, Baerwald et al. 2009);
- **Reduction of cut-in speed:** recent research indicates that increasing the minimum wind speed at which turbines begin operating—known as the 'cut in' speed—may reduce bat fatalities by up to 44-93 percent (Arnett et al. 2010). However, it is recognized that this mitigation strategy does incur 'marginal' power loss and increased costs for the wind development company in the form of staff time to set up and implement the mitigation practice (Arnett et al. 2010); and
- **Use acoustic devices to deter bats:** it has been suggested that acoustic devices may be used to deter bats from wind turbines (Spanjer 2006, Arnett et al. 2013). Though being explored as a possible mitigation strategy, no such device is currently available for widespread use at wind farms (Arnett et al. 2013).

References in appendices

Alberts, D. 2006. Primer for Addressing Wind Turbine Noise. Lawrence Technology University, MI: 19 pp.

Arnett, E., W. Brown, W. Erickson, J. Fiedler, B. Hamilton, H. Travis, A. Jain, G. Johnson, J. Kerns, R. Koford, C. Nicholson, T. O'Connel, M. Piorkowski, and R. Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. Journal of Wildlife Management, 72: 61-78.

Arnett, E. B., C. D. Hein, M. R. Schirmacher, M. M. P. Huso, and J. M. Szewczak. 2013. Evaluating the effectiveness of an ultrasonic acoustic deterrent for reducing bat fatalities at wind turbines. PLoS ONE 8:1-11.

Arnett, E. B., M. M. P. Huso, J. P. Hayes, and M. Schirmacher. 2010. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International, Austin, Texas, USA: 57 pp.

Baerwald, E., G. D'Amours, B. Klug, and R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology, 18: R695-R696.

Baerwald, E., J. Edworthy, M. Holder, and R. Barclay. 2009. A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities. Journal of Wildlife Management, 73: 1077-1081.

Barclay, R., E. Baerwald, and J. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Canadian Journal of Zoology, 85: 381-387.

BLM. 2004. Draft Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States. U.S. Department of the Interior, Bureau of Land Management, FES 05-11 Vol 1: 398 pp.

Boone, D., J. Dunscomb, R. Webb, and C. Wulf. 2005. A Landscape Classification System: Addressing Environmental Issues Associated with Utility-Scale Wind Energy Development in Virginia. Prepared by the Virginia Wind Energy Collaborative Environmental Working Group, April 21, 2005. 70 pp.

CMOPH. 2010. The potential health impacts of wind turbines. Ontario Ministry of Health and Long-term care: Chief Medical Officer of Public Health (CMOPH). 14 pp.

Colby, D., R. Dobie, G. Levanthall, D. Lipscomb, R. McCunney, M. Seilo, and B. Sondergaard. 2009. Wind Turbine Sound and Health Effects: An Expert Panel Review, A report prepared for the American Wind Energy Association and the Canadian Wind Energy Association, December 2009: 85 pp.

Cryan, P. and R. Barclay. 2009. Causes of Bat Fatalities at Wind Turbines: Hypotheses and Predictions. Journal of Mammalogy, 90: 1330-1340.

Cryan, P. and A. Brown. 2007. Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. Biological Conservation, 139: 1-11.

Desholm, M. and J. Kahlert. 2005. Avian collision risk at an offshore wind farm. Biological Letters 1:296-298.

Drewitt, A. and R. Langston. 2006. Assessing the impacts of wind farms on birds. Ibis, 148: 29-42.

Drewitt, A. and R. Langston. 2008. Collision effects of wind-power generators and other obstacles on birds. Annals of the New York Academy of Sciences, 1134: 233-266.

DONG Energy, Vattenfall, The Danish Energy Authority and The Danish Forest and Nature Agency. 2006. Danish Offshore Wind: Key Environmental Issues: 1138 pp.

AMEC Earth & Environmental, 2008. Environmental Impact Assessment City of Summerside Wind Farm: Final Report Submitted to the City of Summerside Fredericton, Report No. TE51100. New Brunswick. 170 pp.

Erickson, W., G. Johnson, and D. Young. 2005. A Summary and Comparison of Bird Mortality from Anthropogenic Causes with an Emphasis on Collisions. In, C. Ralph and D. Terrell (Eds.) Bird conservation implementation and integration in the Americas: Proceedings of the Third International Partners in Flight Conservation, Albany, CA: USDA. Report # TE51100: 170 pp.

Horn, J., E. Arnett, and T. Kunz. 2008. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management, 72: 123-132.

Hotker, H., K. Thomsen, and H. Jeromin. 2006. Impacts on biodiversity of exploitation of renewable energy sources: the example of birds and bats– facts, gaps in knowledge, demands for further research, and ornithological guidelines for the development of renewable energy exploitation. Michael-Otto-Institut, NABU, Bergenhusen. 65 pp.

Johnson, G., M. Perlik, W. Erickson, and M. Strickland. 2004. Bat activity, composition and collision mortality at a large wind plant in Minnesota. Wildlife Society Bulletin, 32: 1278-1288.

Kahlert, J., I. Petersen, A. Fox, M. Desholm, and I. Clausager. 2004. Investigations of birds during construction and operation of Nysted Offshore Wind Farm at Rødsand. National Environmental Research Institute, Kalø, Denmark, Annual Status Report 2003. 84 pp.

Kerns, J. and P. Kerlinger. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia. Annual report for 2003, Curry and Kerlinger, LLC, McLean, Virginia, USA. 39 pp.

Kikuchi, R. 2008. Adverse impacts of wind power generation on collision behaviour of birds and anti-predator behaviour of squirrels. Journal for Nature Conservation, 16: 44-55.

Kruckenberg, H. and J. Jaene. 1999. Zum Einfluss eines Windparks auf die Verteilung weidender Bläßgänse im Rheiderland (Landkreis Leer, Niedersachsen). Natur Landsch, 74: 420-427.

Kunz, T., E. Arnett, W. Erickson, A. Hoar, G. Johnson, R. Larkin, M. Strickland, R. Thresher, and M. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment, 5: 315-324.

Kuvlesky, W. J., L. Brennan, M. Morrison, K. Boydston, B. Ballard, and F. Bryant. 2007. Wind energy development and wildlife conservation: challenges and opportunities. Journal of Wildlife Management, 71: 2487-2498.

Langston, R. and J. Pullan. 2003. Windfarms and Birds: An analysis of the effects of windfarms on birds, and guidance on environmental assessment criteria and site selection issues. By BirdLife International to the Council of Europe, Bern Convention on the Conservation of European Wildlife and Natural Habitats. RSPB/ BirdLife in the UK. Report T-PVS/Inf, 2003: 12.

Larsen, J. and P. Clausen. 2002. Potential wind park impacts on whooper swans in winter: the risk of collision. Waterbirds, 25: 327-330.

Larsen, J. and J. Madsen. 2000. Effects of wind turbines and other physical elements on field utilization by pink footed geese (*Anser brachyrynchus*): A landscape perspective. Landscape Ecology, 15: 755-764.

Leventhall, G. 2006. Infrasound from wind turbines – fact, fiction or deception. Canadian Acoustics, 34: 29-36.

Musters, C., M. Noordervliet, and W. ter Keurs. 1996. Bird casualties caused by a wind energy project in an estuary. Bird Study, 43: 124-126.

Newton, I. 2007. Weather-related mass-mortality events in migrants. Ibis, 149: 453-467.

Nicholls, B. and P. Racey. 2007. Bats avoid radar installations: could electromagnetic fields deter bats from

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colliding with wind turbines? PLoS ONE, 3: e297.

NMCPHC. 2009. Physics of Sound. Powerpoint presentation by the Navy and Marine Corps Public Health Center (NMCPHC).

NRC, 2007. Environmental Impacts of Wind-Energy Projects. The National Research Council of the National Academies (NRC), National Academies Press, Washington, D.C. 376 pp.

NWCC, 2010. Wind turbine interactions with birds, bats, and their habitats: A summary of research results and priority questions. National Wind Coordinating Collaborative (NWCC). 8 pp.

Orloff, S. and A. Flannery. 1992. Wind turbine effects on avian activity, habitat use and mortality in Altamont Pass and Solano County wind resource areas. Final Report to the California Energy Commission. BioSystems Analysis, Inc. 199 pp.

Orloff, S. and A. Flannery. 1996. A Continued Examination of Avian Mortality in the Altamont Pass Wind Resource Area: Final Report to the California Energy Commission. BioSystems Analysis, Inc, Tiburon, CA. 52 pp.

Passchier-Vermeer, W. and W. F. Passchier. 2000. Noise exposure and public health. Environmental Health Perspectives, 108: 123-131.

Rogers, A. L., J. L. Manwell, and S. Wright. 2004. Wind turbine acoustic noise: a white paper. Renewable Energy Research Laboratory, Center for Energy Efficiency and Renewable Energy, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, Amherst, MA. 26 pp.

Smallwood, K. and C. Thelander. 2008. Bird mortality in the Altamont Pass wind resource area, California. Journal of Wildlife Management, 72: 215-223.

Spanjer, G. 2006. Responses of the big brown bat, *Eptesicus fuscus*, to a proposed acoustic deterrent device in a lab setting. In A report submitted to the Bats and Wind Energy Cooperative and the Maryland Department of Natural Resources. Bat Conservation International, Austin, TX. 12 pp.

USFWS, 2002. Migratory bird mortality: Many human-caused threats afflict our bird populations. U.S Fish and Wildlife Service (USFWS), Division of Migratory Bird Management, Arlington, VA. 2 pp.

USFWS, 2012. U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines. U.S. Fish and Wildlife Service (USFWS), March 23, 2012: 82 pp.

Wilson, J., M. Elliott, N. Cutts, L. Mander, V. Mendão, R. Perez-Dominguez, and A. Phelps. 2010. Coastal and Offshore Wind Energy Generation: Is It Environmentally Benign? Energies, 3: 1383-1422.

Winkelman, J. 1992. The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds Vol. 1: Collision Victims [in Dutch with English summary]. DLO-Instituut voor Cos- en Natuuronderzoek, RIN-report 92/2: 69-71.