Terrestrial Wind Turbine Siting Report

Date: January 13, 2009

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I. Executive Summary

This report is based on an interest in public-private establishment of land based wind turbines on State owned land. Assumptions were made on likely scale of equipment. The number of turbines was limited by the understanding of National Grid transmission capacity within the region. An internet search was conducted to evaluate siting setback criteria for commercial sized wind turbines. Information was gathered from international, state and county governments. A Rhode Island specific public safety criterion was also added. Noise was an issue that was raised in the research for siting of wind turbines. Table 3 is a summary of the recommended wind turbine siting criteria for an assumed scale turbine.

II. Siting Criteria

A. Setback Distances

The criteria jurisdictions used to site wind turbines from roads, property lines and structures were researched. Attachment A is the summary of this work. The siting criteria was varied and depended on the state and municipality. New England state requirements were investigated along with the states that have permitted the most wind turbines in the US, i.e., Texas and California. It was interesting to note that Texas did not have criteria that set out minimum siting distances to property lines and structures. Many of their wind power proposals are in their Panhandle, which is not densely settled and has a lot of existing oil derricks. Texas is expanding transmission line access in this area to about $3-5B. This expenditure will ensure that power from the expected growth of wind turbine generated electricity in this area will be able to be transported to other areas in their grid that need power. The majority of the siting criteria came from rural counties in the Midwest. In most instances their approach was a simple requirement of the turbines being placed away from structures, roads and property lines calculated on a factor based on the size of the wind turbine.

[1]"In California, wind turbine setbacks vary by county. The counties typically base the setback on the maximum of a fixed distance or a multiple of the overall turbine height. A common setback is three times the overall turbine height from a property line. There is no evidence that setbacks were based on formal analysis of the rotor fragment hazard.

The most comprehensive study of wind turbine rotor failures places the risk of failure at approximately 1 in1000 turbines per year. The maximum range of a rotor fragment is highly dependent on the release velocity that is related to the blade tip speed. Tip speed tends to remain constant with turbine size; therefore, the maximum range will tend to remain constant with turbine size. In the analysis of rotor fragment trajectories, the most comprehensive models yielded results that showed the shortcomings of simpler methods. Overall, the literature shows the possibility of setbacks for larger turbines may be based on a fixed distance and not the overall height.

California was developing analytical data that would determine minimum setbacks. At this time, the work has not been completed and they do not have science-based standards. The state recommends that a comprehensive model of the rotor fragment hazard be developed based on the results of the literature review. This tool would then be used with a variety of turbine sizes with the objective to develop risk based setback standards."

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[1] **PERMITTING SETBACK REQUIREMENTS FOR WIND TURBINES IN CALIFORNIA**
Prepared For: California Energy Commission - Public Interest Energy Research Program
Prepared By: California Wind Energy Collaborative November 2006

Until a scientific risk based standard is developed, DEM should consider a siting-criteria for placement of a wind turbine near property lines, permanent residential structures, roads and trails that would be 1.5 times the hub height plus the rotor radius. This is the distance recommended in Massachusetts and a number of other states. This would provide for an adequate margin of safety factor in the event of a structure failure.

[2]European Experience –
Dutch NOVEM Report

The Netherlands Agency for Energy and the Environment (NOVEM) wrote a handbook on wind turbine siting due to the risk posed by wind turbines. The overall report is summarized in English by Braam and Rademakers (2004) from the Energy Research Centre of the Netherlands, ECN, and the report was published in Dutch in 2005 (Braam, van Mulekom et al. 2005).

The appendix from the handbook reviews data from two large databases of wind turbines in Denmark and Germany. The database covers turbine operation from the 1980s until 2001. The authors analyzed the data and recommended values of risk for the following failure events:

- Failure at nominal operating rpm 4.2×10^{-4}
- Failure at mechanical breaking (~1.25 time nominal rpm) 4.2×10^{-4}
- Failure at mechanical breaking (~2.0 time nominal rpm) 5.0×10^{-6}

The authors compared these results to earlier values developed by European agencies in the earlier 1990s, with the overall blade failure rate declining three times. It is expected that with the maturity of the industry blade failures will continue to decrease. Documented blade failures and distances were also reported in the handbook. The maximum distance reported for an entire blade was 150 m, for a blade fragment the maximum distance reported was 500 m."

It should be noted the technology of wind turbines has changed. Towers are being built taller and the rotational speeds of the rotors have slowed considerable and rotors are lighter. This would mean the support structures are subjected to lower dynamic stresses. The failure rates of the older technology machine may not apply to the newer structures.

B. Noise Criteria

In the U.S., although no applicable federal noise regulations exist, the U.S. Environmental Protection Agency (EPA) has established noise guidelines. According to the EPA website, it "identifies a 24-hour exposure level of 70 decibels as the level of environmental noise which will prevent any measurable hearing loss over a lifetime. Likewise, levels of 55 decibels outdoors and 45 decibels indoors are identified as preventing activity interference and annoyance. These levels of noise are considered those which will permit spoken conversation and other activities such as sleeping, working and recreation, which are part of the daily human condition.

The levels are not single event, or "peak" levels. Instead, they represent averages of acoustic energy over periods of time such as 8 hours or 24 hours, and over long periods of time such as years. For example, occasional higher noise levels would be consistent with a 24-hour energy average of 70 decibels, so long as a sufficient amount of relative quiet is experienced for the remaining period of time.

[2] Ibid, Appendix A

Noise levels for various areas are identified according to the use of the area. Levels of 45 decibels are associated with indoor residential areas, hospitals and schools, whereas 55 decibels is identified for certain outdoor areas where human activity takes place. The level of 70 decibels is identified for all areas in order to prevent hearing loss."

At the present time, there are no common international noise standards or regulations for sound pressure levels. In most countries, however, noise regulations define upper bounds for the noise to which people may be exposed. These limits depend on the country and may be different for daytime and nighttime.

For example, in Europe, as shown in Table 1, fixed noise limits have been the standard.

Table 1
European Community Standards for Exposure to Acceptable Sound Pressure Levels

Country	Commercial	Mixed	Residential	Rural
Denmark			40	45
Germany				
(day)	65	60	55	50
(night)	50	45	40	35
Netherlands				
(day)		50	45	40
(night)		40	35	30

Most states do not have noise regulations, but many local governments have enacted noise ordinances to manage community noise levels.

Noise will be a major issue in siting wind turbines. States have taken two approaches. The first is to develop noise requirements that must be met by the turbines. Massachusetts developed a model zoning ordinance or by-law that allows construction of wind facilities by special permit. (Attachment B – Section 6.3). This model ordinance is based on the Massachusetts Department of Environmental Protection (DEP) regulation of noise emissions as a form of air pollution under 310 CMR 7.00, "Air Pollution Control". The Massachusetts noise regulation sets two specific limits. The first require the source not to increases the broadband sound level by more than 10 dB(A) above ambient. Broadband noise is a sound whose sound pressure level distribution over the frequency spectrum has no dominant peaks, varying smoothly with frequency. Broadband sound is often caused by the interaction of wind turbine blades with atmospheric turbulence, and also described as a characteristic "swishing" or "whooshing" sound. The second requirement limits the production of a "pure tone" condition that increases sound pressure levels by 3 decibels or more. Tonal sound is defined as sound at discrete frequencies. It is caused by components such as meshing gears, non-aerodynamic instabilities interacting with a rotor blade surface, or unstable flows over holes or slits or a blunt trailing edge.

Setting hard and fast noise standards may not prevent noise complaints. Wind turbine noises are not constant and change with the variation of wind speed. This variation of wind speed will also change the background noise levels, i. e., the higher the wind speed, the higher the background noise level. If tonal noises are present, higher levels of broadband background noise are needed to effectively mask the tone(s). In this respect, it is common for community noise standards to incorporate a penalty for pure tones, typically 5 dB(A). Therefore, if a wind turbine meets a sound pressure level

standard of 45 dB(A), but produces a strong whistling, 5 dB(A) are subtracted from the standard. This forces the wind turbine to meet a standard of 40 dB(A).

Setting noise standards through regulation may not take into account site conditions such as vegetation, which acts as a noise suppressor and background noise such as traffic, wind noises and if at an ocean setting, the sound of the waves on the beach. In the second approach, states/ counties have required a site-specific noise study to be conducted in the vicinity of the installation of a wind turbine. The noise study would allow for actual measurements of background noise levels and would also take into account impacts of vegetation. The noise study would account for local conditions and would determine if the wind turbines could meet noise standards prior to construction of the turbines.

C. Icing

The Finnish Meteorological Institute [3]assessed the safety risks from wind turbine icing. There is a need to develop safe distances to protect the public from discharges from ice build-up from a turbine. It should be noted that theoretical calculations can generate safety distances, but wind turbines do not act in a perfect world of no friction and do react to the laws of aerodynamics. Wind turbine blades operate in a similar manner as an airplane wing foil. It is the principle of "lift" that provides the power that turns the turbine blades. Turbine blades will slow down as ice adheres to the rotor blades because the lift characteristics are changed. According to the Finnish study, "a risk assessment methodology which has been used to demonstrate that the risk of being struck by ice thrown from a turbine is diminishingly small at distances greater than approximately 250 meters from the turbine in a climate where moderate icing occurs."

D. Public Safety

There were no specific public-safety siting criteria noted in the other state's siting criteria. One could argue all of the other siting distances would constitute public-safety criteria. In the case of Rhode Island, all sites being investigated are located on DEM controlled property. In many instances, the locations are at public beaches or at areas where public recreation activities take place. Criteria should be set that would protect the public from unforeseen mechanical or maintenance problems. A suggested criteria could be 1½ times the height of the turbine and it be applied to all trails, blue ways and other areas where the public could be injured by a mechanical mishap.

E. Avian and Bat Consideration –

The Division of Fish and Wildlife analyzed the possible impacts of wind turbine on avian resources. In their analysis, they suggested consideration for a 100-200 yard buffer along the coast. Young passerines often get blow off course, especially during fog events and head for shore at daylight. They are often exhausted and stop at the first available cover near the dunes. The Division also indicated DEM should avoid siting a wind turbine on East Matunuck Beach due to the piping plover issue.

F. Siting Criteria Summary

Table 2 sums the information collected on state and local siting criteria, international and state noise criteria, and icing. The table represents the minimum and maximum distances that states and localities have established for siting wind turbines.

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[3] Assessment Of Safety Risks Arising From Wind Turbine Icing, A report undertaken as part of a project entitled "Wind Energy in Cold Climates", Colin Morgan, Ervin Bossanyi, Mr. Henry Seifert, April 2, 1998

The impacts of a noise standard are unknown. If we were to adopt the most stringent noise standard in a residential area, it would result in the Dutch requirement that ambient noise levels in residential areas not exceed 35 DB in the evening. This standard is significantly lower than the lowest US requirement of 50 DB in a residential area. It recommendation that if DEM were to be involved with the siting and regulation of wind turbines, the agency should make siting contingent on the developer demonstrating the project can meet the 35 DB (in the evening) noise levels in a residential area.

Table 2

Summary of US Siting Criteria of Wind Turbines

Criteria	Minimum Distance or Noise Std. / (Jurisdiction)	Maximum Distance or Noise Std. / (Jurisdiction)
Distance from Property Line	50 feet / (NYS Energy R&D Authority)	810 ft / (Calumet County). WI) 1260 ft / (MN Wind Farm Setback)
Distance from Nearest Structure	1.1 times height of the tip of the turbine blade (~ 450 feet) / (PA Municipality Planning code Model Ordinance)	1500 feet / (Geary County KS and NYS Energy R&D Authority)
Distance from Roads	250 feet / (MN PUC)	Door County. WI 1000 ft or 3 X Wind turbine height* (1215 ft)
Icing		250 M ~ 820 feet
Public Safety		1 ½ times the total height of a turbine. (607.5 ft.)
Noise Standard Based Distance from Property Line	50 DBA / 45 DBA Pure Tone (Wisconsin Model Ordinance)	65 DB / (Riley KS)
Noise Standard Based Distance from Nearest Structure	50 DB / (NYS Energy R&D Authority, MN PUC) 10 DB above ambient / Door County WI)	55 DB/ (PA Municipality Planning code Model Ordinance)
Distance from shoreline (RI recommendation for avian concerns.)	300 feet	600 feet

- A 1.5 MW GE Turbine has a 77-meter diameter rotor plus a 61 to 85 meter hub height. (Maximum height (77/2 + 85 m equals 123.5m or ~ 405 ft.)

G. Rhode Island Recommended Wind Turbine Siting Criteria

The above section provides a summary of the current research done on siting industrial wind turbines. One of the major issues raised in the research is that the technology of wind turbines has changed considerably in the last five years and appears to continue to be dynamic today. Older turbines were generally smaller units that had high rotor speed and rotor blades were heavier that today's composite rotors. There is some work on risks associated with the older units, but there is not a lot of information on turbine failure on the newer units. One of the biggest concerns with location of wind turbines is proper safety distances from residential units, roads and human access. In Rhode Island, the state should require performance standards for the installation of wind turbines on state properties. One of the major issues that needs to be considered is the setting of adequate buffering in the event of catastrophic failure caused by a turbine operating beyond design speed.

According to the National Renewable Energy Laboratory "Modern wind turbines rely on three independently controlled pitch systems. Any one [of those systems] can save the machine from a [runaway] like that. They have their own battery supply systems, fault detection system and internal diagnostics. The master controller monitors all the subordinate control systems (back brake, lubrication system, yaw drive, anemometers, power system, as well as the pitch system). If any one of the sensors behaves abnormally it creates a fault and the machine shuts down." These systems should be required of any turbines that are located on state property.

Rhode Island should also require developers to meet American Wind Energy Association (AWEA) and the European International Electrotechnical Commission (IEC) wind turbine design standards to minimize the risk of wind turbine failure.

Based on the research available and the suggestions that wind turbines meet US and European standards, the following setback standards are recommended:

Table 3
Summary of Proposed Rhode Island Siting Criteria of Wind Turbines

Criteria	Minimum Distance or Noise Std. / (Jurisdiction)
Distance from Property Line	1.5 times the hub height plus the rotor radius
Distance from Nearest Structure	1.5 times the hub height plus the rotor radius
Distance from Roads	1.5 times the hub height plus the rotor radius
Icing	820 feet
Public Safety	1.5 times the hub height plus the rotor radius
Noise Standard Based Distance from Nearest Structure	Developers of a wind turbine project must demonstrate the ability of the project to meet 35DBA in the evening, 45 DBA in the daytime for residential areas and can not increase background tonal sound by 3 DB.
Distance from shoreline (RI recommendation for avian concerns.)	300 feet

H. Operational Considerations

The operation of wind turbines, in certain conditions, would require the imposition of some operational restrictions. The restrictions would be based on the model, size and operational characteristics of the wind turbine which might logically vary by site and risk analysis. A potential vendor would need to address conditions when the wind turbines could be safely operated. The operator would need to specify steps that need to be taken to reduce public risk especially under high wind and icing conditions. The whole issue of risk would need to be addressed in a comprehensive manner since the wind turbines may be collocated with Rhode Island active or passive recreational facilities like camps, beaches and trails.

Attachment A – State and County Setback Distances

Jurisdiction	Wind Turbine - Distance from Property	Wind Turbine -Distance from Nearest Structure	Noise Standard- Distance from property line	Noise Standard- Distance from Nearest Structure	Distance from Roads	Date of Enactment	Variances Allowed
California Energy Commission	The setback literature reviewed in this report does not provide an analytical rationale for determining wind turbine setbacks					November 2006	
Connecticut (Does not have wind specific siting requirements. All major energy projects go through a similar siting process.							
Illinois - Pike County Zoning Board	There is also a minimum setback of 1.1 T from the nearest property line. (T = the height of the tower plus the length of one blade)	The ordinance specifies a "setback" of three times the turbine height (the height of the tower plus the length of one blade), referred to as "3 T," from homes. However, turbines sited on a landowner's property may be as close as 1.1 T if the landowner consents.				5/24/2004	
Kansas							
a. Butler County	No turbines shall be located closer than 500 feet or the total height of the turbine plus 50 feet, whichever is greater, from property lines of any property not included in the Conditional Use Permit.	No turbine shall be located closer than 1000 feet from a residential structure. Turbines shall be located no closer than the total height of the turbine plus 50 feet from a common agricultural/residential accessory structure.			No turbines shall be located closer than 500 feet or the total height of the turbine plus 50 feet, whichever is greater, from public roads.		
b. Geary County		Individual wind turbines shall be set back from residential structures a minimum of 1500 feet.	• The noise level measured at the property line of the project	Commercial wind energy conversion systems should be located in			

			property shall not exceed 55 decibels at any time (“A” or “C” weighted). At the nearest existing residence or residence where a permit has been issued prior to the time an application has been filed pursuant to these regulations, the following shall be the standard: 26dB – IEC 61-4400 or actual measured at nearest residence – noise baseline + 10.	areas where there are adequate setbacks from residential areas and rural homes so that noise from the turbines is not an intrusion.			
c. Riley County	Individual wind turbines shall be set back from all property lines coincident with or outside of the project boundary a distance equal to one and one-half times the turbine height		The noise level caused by the operation of the project, measured at five feet above ground level at the property line coincident with or outside the project boundary, shall not exceed 65 decibels (A weighted) and shall not exceed 50 decibels (C-weighted) if it is determined that a pure tone noise is generated by the project.				

d. Wabaunsee County (5)	a setback from the nearest property line a distance equal to twice the height of the system,				setback from the nearest public road right-of-way a distance equal to the height of the system, including the rotor blades, plus an additional 50 feet.		
Massachusetts - Division of Energy Resources – Model Ordinance	Wind turbines shall be set back 100 feet from the nearest property line and private or public way.	Wind turbines shall be set back a distance equal to 1.5 times the overall blade tip height of the wind turbine from the nearest existing residential or commercial structure	See Noise Standard- Distance from Nearest Structure	The wind facility shall conform with DEP's, Noise Regulations (310 CMR 7.10). Facility can not: **(a)** Increases the broadband sound level by more than 10 dB(A) above ambient, or **(b)** Produces a "pure tone" condition that exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more. These criteria are measured both at the property line and at the nearest inhabited residence. An analysis prepared by a qualified engineer shall be presented to demonstrate compliance with these noise standards.		Unknown	The special permit granting authority may reduce the minimum setback distance as appropriate based on site-specific considerations, if the project satisfies all other criteria for the granting of a special permit under the provisions of this section.

Michigan Energy Office, Dept. of Labor and Economic Growth (3)	The distance between a Utility Grid wind energy system and the property lines of adjacent non-leased properties including public rights of way shall be at least the height of the wind turbine tower including the top of the blade in its vertical position. Where property is leased on both sides of a public right of way, a wind energy system may be placed no closer than one rotor radius from the closest edge of the right of way. The distance between an On Site Use wind energy system and the owner's property lines shall be at least 1 ½ times the height of the wind energy system tower including the top of the blade in its vertical position.		The sound pressure level generated by a Utility Grid wind energy system shall not exceed 55 dB(A) measured at the property lines between leased and non-leased property. This sound pressure level shall not be exceeded for more than 3 minutes in any hour of the day. If the ambient sound pressure level exceeds 55 dB(A), the standard shall be ambient dB(A) plus 5 dB(A).				
Minnesota (MN) Public Utilities Commission (1)	Current setbacks are three rotor diameters on the secondary wind axis and five rotor diameters on the predominant axis. This same applies to public lands.	At least 500 ft and sufficient distance to meet state noise standard.		Project must meet MN Noise Standards NAC 1, L50 50 dBA during overnight hours at all residential receivers (homes). Setback distance is calculated based on site layout and turbine for each residential receiver.	A minimum of 250-foot turbine setback from the edge of public road rights-of-ways. Setbacks should be developed and applied to state trails on a case-by-case basis	January 11, 2008	

New York State Energy Research & Development Authority Model Ordinance	Variable distances from 50 feet to 1.5 times the sum of proposed structure height plus the rotor radius.	Variable distances from 1.5 times the sum of proposed structure height to 1500 feet.	Noise shall not exceed 55 dBA, measured at the site property line.	Audible noise shall not exceed fifty (50) dBA for any period of time, when measured at any residence, school, hospital, church or public library existing on the date of approval of the wind energy facility.	No less than 1.5 times the sum of proposed structure height plus the rotor radius.	Unknown	
North Carolina - Currituck County, NC	1.5 times wind turbine height	2.5 times wind turbine height			1.5 – 2.5 times wind turbine height		
Pennsylvania Municipalities Planning Code (MPC) Model Ordinance (2)	All wind turbines shall be set back from the nearest property line a distance of not less than the greater of the maximum setback requirements for that zoning classification where the turbine is located* or 1.1 times the turbine height, whichever is greater.	Set back from the nearest occupied building should not be less than the greater of the maximum setback requirements for that zoning classification where the turbine is located* or 1.1 times the turbine height, whichever is greater. For non non-participating landowner's property, a set back distance of not less than five (5) times the hub height should be established.		Audible sound from a wind energy facility shall not exceed fifty (55) dBA, as measured at the exterior of any occupied building on a non-participating landowner's property.	All wind turbines shall be set back from the nearest public road a distance of not less than 1.1 times the turbine height, as measured from the right-of-way line of the nearest public road to the center of the wind turbine base.	4/24/06	Yes, if literal enforcement will exact undue hardship because of peculiar conditions pertaining to the land in question and provided that such waiver will not be contrary to the public interest.
Vermont -	For petitions involving wind-generating facilities, notice must be provided all towns wholly or partially within a radius of a **minimum of ten miles** of each proposed turbine. (2) The petitioner must include an assessment of the impact on all towns within this **ten-mile** radius. (3) The petition must include a view-shed						

	analysis that includes an analysis of aesthetic impacts for a ten-mile radius from the proposed project site.						
Vermont ANR- Large-Scale Renewable Energy Projects are not presently an allowable use of ANR lands. In the event a future statewide assessment shows that the best site(s) for such projects are on ANR lands, then the Agency may consider revising this policy and to allow for consideration of individual projects through the pertinent long range management planning process.							
Wisconsin – Model Wind Ordinance	Each Wind Turbine shall be set back from the nearest property line a distance no less than 1.1 times its Total Height, unless appropriate easements are secured from adjacent property owners, or other acceptable mitigation is approved by the Committee.	Each wind turbine shall be set back from the nearest residence, school, hospital, church or public library, a distance no less than the greater of (a) two (2) times its total height or (b) one thousand (1,000) feet	Audible sound shall not exceed fifty dBA for any period of time when measured at the property line of any residence, school, hospital, church or public library. A pure tone, such as a whine, screech, or hum, audible sound due to		Each wind turbine shall be set back from the nearest public road a distance no less than 1.1 times its total height, determined at the nearest boundary of the underlying right-of-way for such public road.		If the event audible sound exceed the audible sound standards, a waiver may be granted if: a. Written consent from the affected property owners has been obtained stating that they are aware of the audible sound standards, and that consent is granted

			wind energy facility operations shall not exceed forty-five (45) dBA				to allow sound levels to exceed the audible sound standards; and b. If the applicant wishes the waiver to apply to succeeding owners of the property, he can record permanent a sound impact easement which describes the benefited and burdened properties.
a. Calumet County WI	1800 feet			Turbine noise shall not exceed 5dB over the current background sound levels during the quietest part of the day (night). Excessive low-frequency noise at any nearby residence will require shut-down of the offending turbine			
b. Door County WI	1.1 times the total height of a wind turbine	Not less than twice the total height of the turbine or 1,000 feet or whichever is greater from an inhabited structure.		50 decibels near any residential or related areas. If an audible sound can be heard in the area, the limit is 45 decibels.	1,000 feet or three times the total height of a turbine, whichever is greater.		

Renewable Energy Research Laboratory, UMass, Amherst Wind Turbine Acoustic Noise White Paper (6)	The setback distance from property lines is determined by local building codes, and typically takes the height of the structure into consideration, e.g. 1.5 times the turbine height.		If a wind turbine is proposed within a distance equivalent to three times the blade-tip height of residences or other noise-sensitive receptors, a noise study should be performed and publicized.			January 2006	
Nina Pierpont, MD, PhD – Wind Turbine Syndrome (Testimony in NY hearing 3/7/06)		8000 ft					

(1) Wind turbines cannot be place in wetlands.
(2) The Facility Owner and Operator shall make reasonable efforts to minimize shadow flicker to any Occupied Building on a Non-participating Landowner's property.
(3) The applicant shall conduct an analysis on potential shadow flicker at occupied structures. The analysis shall identify the locations of shadow flicker that may be caused by the project and the expected durations of the flicker at these locations from sunrise to sunset over the course of a year. The analysis shall identify problem areas where shadow flicker may affect the occupants of the structures and describe measures that shall be taken to eliminate or mitigate the problems.
(4) Shadow flicker is not explicitly regulated. When a maximum number of hours of allowed shadow flicker per year is imposed for a neighbor's property (such as 30 hours/year for one wind-energy project in Germany), this number refers to those hours when the property is actually used by the people there and when they are awake. Denmark has no legislation regarding shadow flicker, but it is generally recommended that there be no more than 10 hours per year when flicker is experienced.
(5) All tower structures shall be located such that the maximum potential distance of ice throw from any individual structure shall be on the land owned by the leasers on which the structure is located. Specific documentation shall be provided to quantify the basis of the distance assumed and shall be included with the application materials. Ice throw shall not be allowed onto public roads or adjoining property.
(6) For public safety, ridgeline winter trails may need to be moved away from the base of the tower to a distance of 2-4 times the blade-tip height, depending on the site.

Attachment B – Massachusetts Model Amendment to a Zoning Ordinance

Model Amendment to a Zoning Ordinance or By-law: Allowing Wind Facilities by Special Permit

Prepared by:
Massachusetts Division of Energy Resources
Massachusetts Executive Office of Environmental Affairs

1.0 Purpose

The purpose of this by-law is to provide by special permit for the construction and operation of wind facilities and to provide standards for the placement, design, construction, monitoring, modification and removal of wind facilities that address public safety, minimize impacts on scenic, natural and historic resources of the city or town and provide adequate financial assurance for decommissioning.

1.1 Applicability

This section applies to all utility-scale and on-site wind facilities proposed to be constructed after the effective date of this section. It does not apply to single stand-alone turbines under 60 kilowatts of rated nameplate capacity.

Any physical modifications to existing wind facilities that materially alters the type or increases the size of such facilities or other equipment shall require a special permit.

2.0 Definitions

Utility-Scale Wind Facility: A commercial wind facility, where the primary use of the facility is electrical generation to be sold to the wholesale electricity markets.

On-Site Wind Facility: A wind project, which is located at a commercial, industrial, agricultural, institutional, or public facility that will consume more than 50% of the electricity generated by the project on-site.
Height: The height of a wind turbine measured from natural grade to the tip of the rotor blade at its highest point, or blade-tip height.
Rated Nameplate Capacity: The maximum rated output of electric power production equipment. This output is typically specified by the manufacturer with a "nameplate" on the equipment.
Special Permit Granting Authority: The special permit granting authority shall be the board of selectmen, city council, board of appeals, planning board, or zoning administrator as designated by zoning ordinance or by-law for the issuance of special permits, or by this section for the issuance of special permits to construct and operate wind facilities.
Substantial Evidence: Such evidence as a reasonable mind might accept as adequate to support a conclusion.
Wind Facility: All equipment, machinery and structures utilized in connection with the conversion of wind to electricity. This includes, but is not limited to, transmission, storage, collection and supply equipment, substations, transformers, service and access roads, and one or more wind turbines.
Wind Monitoring or Meteorological Tower: A temporary tower equipped with devices to measure wind speeds and direction, used to determine how much wind power a site can be expected to generate.
Wind turbine: A device that converts kinetic wind energy into rotational energy that drives an electrical generator. A wind turbine typically consists of a tower, nacelle body, and a rotor with two or more blades.

3.0 General Requirements

3.1 Special Permit Granting Authority No wind facility over 60 kilowatts of rated nameplate capacity shall be erected, constructed, installed or modified as provided in this section without first obtaining a permit from the special permit granting authority. The construction of a wind facility shall be permitted in any zoning district subject to the issuance of a Special Permit and provided that the use complies with all requirements set forth in sections 3, 4, 5 and 6. All such wind energy facilities shall be constructed and operated in a manner that minimizes any adverse visual, safety, and environmental impacts. No special permit shall be granted unless the special permit granting authority finds in writing that:

(a) the specific site is an appropriate location for such use;

(b) the use is not expected to adversely affect the neighborhood;

(c) there is not expected to be any serious hazard to pedestrians or vehicles from the use;

(d) no nuisance is expected to be created by the use; and
(e) adequate and appropriate facilities will be provided for the proper operation of the use.

Such permits may also impose reasonable conditions, safeguards and limitations on time and use and may require the applicant to implement all reasonable measures to mitigate unforeseen adverse impacts of the wind facility, should they occur.
Wind monitoring or meteorological towers shall be permitted in all zoning districts subject to issuance of a building permit for a temporary structure and subject to reasonable regulations concerning the bulk and height of structures and determining yard-size, lot area, setbacks, open space, parking, and building coverage requirements

3.2 Compliance with Laws, Ordinances and Regulations

The construction and operation of all such proposed wind facilities shall be consistent with all applicable local, state and federal requirements, including but not limited to all applicable safety, construction, environmental, electrical, communications and aviation requirements.

3.3 Proof of Liability Insurance

The applicant shall be required to provide evidence of liability insurance in an amount and for a duration sufficient to cover loss or damage to persons and structures occasioned by the failure of the facility.

3.4 Site Control

At the time of its application for a special permit, the applicant shall submit documentation of actual or prospective control of the project site sufficient to allow for installation and use of the proposed facility. Documentation shall also include proof of control over setback areas and access roads, if required. Control shall mean the legal authority to prevent the use or construction of any structure for human habitation within the setback areas.

4.0 General Siting Standards

4.1 Height 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 special permit under the provisions of this section.

4.2 Setbacks

Wind turbines shall be set back a distance equal to 1.5 times the overall blade tip height of the wind turbine from the nearest existing residential or commercial structure and 100 feet from the nearest property line and private or public way.

4.2.1 Setback Waiver

The special permit granting authority may reduce the minimum setback distance as appropriate based on site-specific considerations, if the project satisfies all other criteria for the granting of a special permit under the provisions of this section.

5.0 Design Standards

5.1 Color and Finish

The special permit granting authority shall have discretion over the turbine color, although a neutral, non-reflective exterior color designed to blend with the surrounding environment is encouraged.

5.2 Lighting and Signage

5.2.1 Lighting

Wind turbines shall be lighted only if required by the Federal Aviation Administration. Lighting of other parts of the wind facility, such as appurtenant structures, shall be limited to that required for safety and operational purposes, and shall be reasonably shielded from abutting properties.

5.2.2 Signage

Signs on the wind facility shall comply with the requirements of the town's sign regulations, and shall be limited to:

(a) Those necessary to identify the owner, provide a 24-hour emergency contact phone number, and warn of any danger.

(b) Educational signs providing information about the facility and the benefits of renewable energy.

5.2.3 Advertising

Wind turbines shall not be used for displaying any advertising except for reasonable identification of the manufacturer or operator of the wind energy facility.

5.2.4 Utility Connections

Reasonable efforts shall be made to locate utility connections from the wind facility underground, depending on appropriate soil conditions, shape, and topography of the site and any requirements of the utility provider. Electrical transformers for utility interconnections may be above ground if required by the utility provider.

5.3 Appurtenant Structures

All appurtenant structures to such wind facilities shall be subject to reasonable regulations concerning the bulk and height of structures and determining yard sizes, lot area, setbacks, open space, parking and building coverage requirements. All such appurtenant structures, including but not limited to, equipment shelters, storage facilities, transformers, and substations, shall be architecturally compatible with each other and shall be contained within the turbine tower whenever technically and economically feasible. Structures shall only be used for housing of equipment for this particular site. Whenever reasonable, structures should be shaded from view by vegetation and/or located in an underground vault and joined or clustered to avoid adverse visual impacts.

5.4 Support Towers

Monopole towers are the preferred type of support for the Wind Facilities.

6.0 Safety, Aesthetic and Environmental Standards

6.1 Emergency Services The applicant shall provide a copy of the project summary and site plan to the local emergency services entity, as designated by the special permit granting authority. Upon request the applicant shall cooperate with local emergency services in developing an emergency response plan.

6.1.1 Unauthorized Access

Wind turbines or other structures part of a wind facility shall be designed to prevent unauthorized access.

6.2 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.

6.3 Noise

The wind facility and associated equipment shall conform with the provisions of the Department of Environmental Protection's, Division of Air Quality Noise Regulations (310 CMR 7.10), unless the Department and the Special Permit Granting Authority agree that those provisions shall not be applicable. A source of sound will be considered to be violating these regulations if the source:

(a) Increases the broadband sound level by more than 10 dB(A) above ambient, or

(b) Produces a "pure tone" condition – when an octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more. These criteria are measured both at the property line and at the nearest inhabited residence. Ambient is defined as the background A-weighted sound level that is exceeded 90% of the time measured during equipment hours. The ambient may also be established by other means with consent from DEP. An analysis prepared by a qualified engineer shall be presented to demonstrate compliance with these noise standards. The special permit granting authority, in consultation with the Department, shall determine whether such violations shall be measured at the property line or at the nearest inhabited residence.

6.4 Land Clearing, Soil Erosion and Habitat Impacts

Clearing of natural vegetation shall be limited to that which is necessary for the construction, operation and maintenance of the wind facility and is otherwise prescribed by applicable laws, regulations, and ordinances.

7.0 Monitoring and Maintenance

7.1 Facility Conditions The applicant shall maintain the wind facility in good condition. Maintenance shall include, but not be limited to, painting, structural repairs, and integrity of security measures. Site access shall be maintained to a level acceptable to the local Fire Chief and Emergency Medical Services. The project owner shall be responsible for the cost of maintaining the wind facility and any access road, unless accepted as a public way, and the cost of repairing any damage occurring as a result of operation and construction.

7.2 Modifications
All material modifications to a wind facility made after issuance of the special permit shall require approval by the special permit granting authority as provided in this section.

8.0 Abandonment or Decommissioning

8.1 Removal Requirements Any wind facility which has reached the end of its useful life or has been abandoned shall be removed. When the wind facility is scheduled to be decommissioned, the applicant shall notify the town by certified mail of the proposed date of discontinued operations and plans for removal. The owner/operator shall physically remove the wind facility no more than 150 days after the date of discontinued operations. At the time of removal, the wind facility site shall be restored to the state it was in before the facility was constructed or any other legally authorized use. More specifically, decommissioning shall consist of:

- **(a)** Physical removal of all wind turbines, structures, equipment, security barriers and transmission lines from the site.
- **(b)** Disposal of all solid and hazardous waste in accordance with local and state waste disposal regulations.
- **(c)** Stabilization or re-vegetation of the site as necessary to minimize erosion. The special permit granting authority may allow the owner to leave landscaping or designated below-grade foundations in order to minimize erosion and disruption to vegetation.

8.2 Abandonment
Absent notice of a proposed date of decommissioning, the facility shall be considered abandoned when the facility fails to operate for more than one year without the written consent of the special permit granting authority. The special permit granting authority shall determine in its decision what proportion of the facility is inoperable for the facility to be considered abandoned. If the applicant fails to remove the wind facility in accordance with the requirements of this section within 150 days of abandonment or the proposed date of decommissioning, the town shall have the authority to enter the property and physically remove the facility.

8.3 Financial Surety
The special permit granting authority may require the applicant for utility scale wind facilities to provide a form of surety, either through escrow account, bond or otherwise, to cover the cost of removal in the event the town must remove the facility, of an amount and form determined to be reasonable by the special permit granting authority, but in no event to exceed more than 125 percent of the cost of removal and compliance with the additional requirements set forth herein, as determined by the applicant. Such surety will not be required for municipally or state-owned facilities. The applicant shall submit a fully inclusive estimate of the costs associated with removal, prepared by a qualified engineer. The amount shall include a mechanism for Cost of Living Adjustment.

9.0 Term of Special Permit

A special permit issued for a wind facility shall be valid for 25 years, unless extended or renewed. The time period may be extended or the permit renewed by the special permit granting authority upon satisfactory operation of the facility. Request for renewal must be submitted at least 180 days prior to expiration of the special permit. Submitting a renewal request shall allow for continued operation of the facility until the special permit granting authority acts. At the end of that period (including extensions and renewals), the wind facility shall be removed as required by this section.

The applicant or facility owner shall maintain a phone number and identify a responsible person for the public to contact with inquiries and complaints throughout the life of the project.

10.0 Application Process & Requirements

10.1 Application Procedures

10.1.1 General
The application for a wind facility shall be filed in accordance with the rules and regulations of the special permit granting authority concerning special permits.

10.1.2 Application
Each application for a special permit shall be filed by the applicant with the city or town clerk pursuant to section 9 of chapter 40A of the Massachusetts General Laws.

10.2 Required Documents

10.2.1 General
The applicant shall provide the special permit granting authority with ___ copies of the application. All plans and maps shall be prepared, stamped and signed by a professional engineer licensed to practice in Massachusetts. Included in the application shall be:

10.2.2 - Name, address, phone number and signature of the applicant, as well as all co- applicants or property owners, if any.

10.2.3 - The name, contact information and signature of any agents representing the applicant.

10.2.4 - Documentation of the legal right to use the wind facility site, including the requirements set forth in 10.3.2(a) of this section

10.3 Siting and Design
The applicant shall provide the special permit granting authority with a description of the property which shall include:

10.3.1 Location Map *(Modify for On-Site Wind Facilities)*
Copy of a portion of the most recent USGS Quadrangle Map, at a scale of 1:25,000, showing the proposed facility site, including turbine sites, and the area within at least two miles from the facility. Zoning district designation for the subject parcel should be included; however a copy of a zoning map with the parcel identified is suitable.

10.3.2 Site Plan

A one inch equals 200 feet plan of the proposed wind facility site, with contour intervals of no more than 10 feet, showing the following:

(a) Property lines for the site parcel and adjacent parcels within 300 feet.

(b) Outline of all existing buildings, including purpose (e.g. residence, garage, etc.) on site parcel and all adjacent parcels within 500 feet. Include distances from the wind facility to each building shown.

(c) Location of all roads, public and private on the site parcel and adjacent parcels within 300 feet, and proposed roads or driveways, either temporary or permanent.

(d) Existing areas of tree cover, including average height of trees, on the site parcel and adjacent parcels within 300 feet.

(e) Proposed location and design of wind facility, including all turbines, ground equipment, appurtenant structures, transmission infrastructure, access, fencing, exterior lighting, etc.

(f) Location of viewpoints referenced below in 10.3.3 of this section.

10.3.3 Visualizations *(Modify for On-Site Wind Facilities)*

The special permit granting authority shall select between three and six sight lines, including from the nearest building with a view of the wind facility, for pre- and post-construction view representations. Sites for the view representations shall be selected from populated areas or public ways within a 2-mile radius of the wind facility. View representations shall have the following characteristics:

(a) View representations shall be in color and shall include actual pre-construction photographs and accurate post-construction simulations of the height and breadth of the wind facility (e.g. superimpositions of the wind facility onto photographs of existing views).

(b) All view representations will include existing, or proposed, buildings or tree coverage.

(c) Include description of the technical procedures followed in producing the visualization (distances, angles, lens, etc.).

10.4 Landscape Plan (***Utility-Scale Wind Facilities Only)***

A plan indicating all proposed changes to the landscape of the site, including temporary or permanent roads or driveways, grading, vegetation clearing and planting, exterior lighting, other than FAA lights, screening vegetation or structures. Lighting shall be designed to minimize glare on abutting properties and except as required by the FAA be directed downward with full cut-off fixtures to reduce light pollution.

10.5 Operation & Maintenance Plan

The applicant shall submit a plan for maintenance of access roads and storm water controls, as well as general procedures for operational maintenance of the wind facility.

10.6 Compliance Documents

If required under previous sections of this by-law, the applicant will provide with the application:

(a) a description of financial surety that satisfies 8.3 of this section,

(b) proof of liability insurance that satisfies Section 3.3 of this section,

(c) certification of height approval from the FAA,

(d) a statement that satisfies Section 6.3, listing existing and maximum projected noise levels from the wind facility.

10.7 Independent Consultants – (*Utility-Scale Wind Facilities Only)*

Upon submission of an application for a special permit, the special permit granting authority will be authorized to hire outside consultants, pursuant to section 53G of chapter 44 of the Massachusetts General Laws. As necessary, the applicant may be required to pay not more than 50% of the consultant's costs.

Attachment C - National Park Service Conversion Policy

§ 59.3 Conversion requirements.

(a) *Background and legal requirements.*

Section 6(f)(3) of the L&WCF Act is the cornerstone of Federal compliance efforts to ensure that the Federal investments in L&WCF assistance are being maintained in public outdoor recreation use. This section of the Act assures that once an area has been funded with L&WCF assistance, it is continually maintained in public recreation use unless NPS approves substitution property of reasonably equivalent usefulness and location and of at least equal fair market value.

(b) *Prerequisites for conversion approval.*

Requests from the project sponsor for permission to convert L&WCF assisted properties in whole or in part to other than public outdoor recreation uses must be submitted by the State Liaison Officer to the appropriate NPS Regional Director in writing. NPS will consider conversion requests if the following prerequisites have been met:

(1) All practical alternatives to the proposed conversion have been evaluated.

(2) The fair market value of the property to be converted has been established and the property proposed for substitution is of at least equal fair market value as established by an approved appraisal (prepared in accordance with uniform Federal appraisal standards) excluding the value of structures or facilities that will not serve a recreation purpose.

(3) The property proposed for replacement is of reasonably equivalent usefulness and location as that being converted. Dependent upon the situation and at the discretion of the Regional Director, the replacement property need not provide identical recreation experiences or be located at the same site, provided it is in a reasonably equivalent location. Generally, the replacement property should be administered by the same political jurisdiction as the converted property. NPS will consider State requests to change the project sponsor when it is determined that a different political jurisdiction can better carry out the objectives of the original project agreement. Equivalent usefulness and location will be determined based on the following criteria:

(i) Property to be converted must be evaluated in order to determine what recreation needs are being fulfilled by the facilities which exist and the types of outdoor recreation resources and opportunities available. The property being proposed for substitution must then be evaluated in a similar manner to determine if it will meet recreation needs which are at least like in magnitude and impact to the user community as the converted site. This criterion is applicable in the consideration of all conversion requests with the exception of those where wetlands are proposed as replacement property. Wetland areas and interests therein which have been identified in the wetlands provisions of the Statewide Comprehensive Outdoor Recreation Plan shall be considered to be of reasonably equivalent usefulness with the property proposed for conversion regardless of the nature of the property proposed for conversion.

(ii) Replacement property need not necessarily be directly adjacent to or close by the converted site. This policy provides the administrative flexibility to determine location recognizing that the property should meet existing public outdoor recreation needs. While generally this will involve the selection of a site serving the same community(ies) or area as the converted site, there may be exceptions. For example, if property being converted is in an area undergoing major demographic change and the area has no existing or anticipated future need for outdoor recreation, then the project sponsor should seek to locate the substitute area in another location within the jurisdiction.

Should a local project sponsor be unable to replace converted property, the State would be responsible, as the primary recipient of Federal assistance, for assuring compliance with these regulations and the substitution of replacement property.

(iii) The acquisition of one parcel of land may be used in satisfaction of several approved conversions.

(4) The property proposed for substitution meets the eligibility requirements for L&WCF assisted acquisition. The replacement property must constitute or be part of a viable recreation area. Unless *each* of the following additional conditions is met, land currently in public ownership, including that which is owned by another public agency, may not be used as replacement land for land acquired as part of an L&WCF project:
(i) The land was not acquired by the sponsor or selling agency for recreation.
(ii) The land has not been dedicated or managed for recreational purposes while in public ownership.
(iii) No Federal assistance was provided in the original acquisition unless the assistance was provided under a program expressly authorized to match or supplement L&WCF assistance.
(iv) Where the project sponsor acquires the land from another public agency, the selling agency must be required by law to receive payment for the land so acquired. In the case of development projects for which the State match was not derived from the cost of the purchase or value of a donation of the land to be converted, but from the value of the development itself, public land which has not been dedicated or managed for recreation/conservation use may be used as replacement land even if this land is transferred from one public agency to another without cost.
(5) In the case of assisted sites which are partially rather than wholly converted, the impact of the converted portion on the remainder shall be considered. If such a conversion is approved, the unconverted area must remain recreationally viable or be replaced as well.
(6) All necessary coordination with other Federal agencies has been satisfactorily accomplished including, for example, compliance with section 4(f) of the Department of Transportation Act of 1966.
(7) The guidelines for environmental evaluation have been satisfactorily completed and considered by NPS during its review of the proposed 6(f)(3) action. In cases where the proposed conversion arises from another Federal action, final review of the State's proposal shall not occur until the NPS Regional office is assured that all environmental review requirements related to that other action have been met.
(8) State intergovernmental clearinghouse review procedures have been adhered to if the proposed conversion and substitution constitute significant changes to the original Land and Water Conservation Fund project.
(9) The proposed conversion and substitution are in accord with the Statewide Comprehensive Outdoor Recreation Plan (SCORP) and/or equivalent recreation plans.
(c) *Amendments for conversion.* All conversions require amendments to the original project agreements. Therefore, amendment requests should be submitted concurrently with conversion requests or at such time as all details of the conversion have been worked out with NPS. Section 6(f)(3) project boundary maps shall be submitted with the amendment request to identify the changes to the original area caused by the proposed conversion and to establish a new project area pursuant to the substitution. Once the conversion has been approved, replacement property should be immediately acquired. Exceptions to this rule would occur only when it is not possible for replacement property to be identified prior to the State's request for a conversion. In such cases, an express commitment to satisfy section 6(f)(3) substitution requirements within a specified period, normally not to exceed one year following conversion approval, must be received from the State. This commitment will be in the form of an amendment to the grant agreement.
(d) *Obsolete facilities.* Recipients are not required to continue operation of a particular facility beyond its useful life. However, when a facility is declared obsolete, the site must nonetheless be maintained for public outdoor recreation following discontinuance of the assisted facility. Failure to so maintain is considered to be a conversion. Requests regarding changes from a L&WCF funded facility to another otherwise eligible facility at the same site that significantly contravene the original plans for the area must be made in writing to the Regional Director. NPS approval must be

obtained prior to the occurrence of the change. NPS approval is not necessarily required, however, for each and every facility use change. Rather, a project area should be viewed in the context of overall use and should be monitored in this context. A change from a baseball field to a football field, for example, would not require NPS approval. A change from a swimming pool with substantial recreational development to a less intense area of limited development such as a passive park, or vice versa, would, however, require NPS review and approval. To assure that facility changes do not significantly contravene the original project agreement, NPS shall be notified by the State of *all* proposed changes in advance of their occurrence. A primary NPS consideration in the review of requests for changes in use will be the consistency of the proposal with the Statewide Comprehensive Outdoor Recreation Plan and/or equivalent recreation plans. Changes to other than public outdoor recreation use require NPS approval and the substitution of replacement land in accordance with section 6(f)(3) of the L&WCF Act and paragraphs (a) through (c) of this section.

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