STATE OF CONNECTICUT
CONNECTICUT SITING COUNCIL

IN RE: PROPOSED WIND REGULATIONS **May 29, 2012**

FAIRWINDCT, INC.'S, MICHAEL AND STELLA SOMERS' AND SUSAN WAGNER'S COMMENTS ON THE DRAFT REGULATIONS NOTICED BY THE SITING COUNCIL IN THE CONNECTICUT LAW JOURNAL ON MAY 1, 2012

In response to the invitation provided in the notice published by the Siting Council in the Connecticut Law Journal on May 1, 2012, FairwindCT, Inc., Michael and Stella Somers and Susan Wagner provide comment.

General Comments:

Human experience with industrial wind turbines has been ignored by the Siting Council in the preparation of its draft regulations. The Siting Council has chosen to facilitate the siting of wind turbines without an adequate margin of safety for the protection of human health and safety. Similarly, these draft regulations are not protective of wildlife and the few remaining rural resources of the state. Nor will they adequately protect the State's historic resources. The draft regulations are flexible to a fault. Industry, towns and citizens are not given adequate notice of any standards. The draft regulations are window dressing, designed merely to satisfy the literal requirement of Public Act 11-245, without actually satisfying its intent. These regulations should not be adopted as proposed.

Overall, the regulations show a disregard for the years of wind turbine experience gained in other countries and states. The Siting Council has decided to provide for few objective criteria, most of which may be then waived by the Siting Council. For example, regulations in experienced jurisdictions allow for setbacks to be unilaterally increased, but not decreased. Given that regulations in Connecticut need to be noticed with a right to a public comment period, once these regulations are adopted, the regulations should be followed without exception, unless the Siting Council undertakes the proper rule-changing procedures. The following language, substantially based on an ordinance of the City of Riverside, California,[1] is proposed as a way to remedy this problem:

> Setback reductions may be permitted if the Siting Council determines, based on the submissions of the applicant, the location of the proposed project, the existing and planned land uses, and the anticipated human visitation and use, that the potential safety hazards will be eliminated or substantially reduced. Whenever a setback reduction is proposed pursuant to this subsection, the setback reduction will be <u>included in all notices</u>, and, if granted, the commercial wind energy facility permit shall specifically state all required setbacks. In addition, the Siting Council will issue a written determination which cites all of the factors that support a setback reduction.

If the above language is added, and paired with the opportunity for the public to comment on the proposed setback reduction, then the waiver that is currently contained in each section might approach legality. Aside from that, the Siting Council should have no ability to waive regulatory requirements, aside from situations giving rise to state of emergencies and national defense concerns, neither of which are likely in relation to the siting of wind turbines.

COMMENTS REGARDING SPECIFIC SECTIONS:

- **R.C.S.A. § 16-50j-2a(12). Definitions.**

The Siting Council has expanded the definition of "fuel," in response to arguments raised by FairwindCT regarding the Siting Council's jurisdiction. Changing a statutory definition through a regulation-making procedure is an *ultra vires* action by the Siting Council. The Siting Council has no authority to expand the definition of "fuel" to expand its jurisdiction. This expansion seems to be an effort to seize jurisdiction over "any other resource yielding energy." Conceivably this means solar panels, hydroelectric dams, tidal and all other sources. Granted,

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[1] Cited in the Commercial Wind Energy Facility & Wind Access Model Ordinance prepared for the Town of Barton, Wisconsin (hereinafter, "Model Ordinance"). Attached as Exhibit 1. Available at docs.wind-watch.org/wind-energy-model-ord.doc.

statutory size restrictions may apply, but this expansion of jurisdiction should be up to the legislature, not the Siting Council. Further, the referenced statute limits the use of the definition of "fuel" to "sections 16a-17 to 16a-20, inclusive."[2] Therefore, the Siting Council should not adopt that definition from Chapter 296 which deals with unfair trade practices by merchants in the fuel business.

- **R.C.S.A. §16-50j-2a(19). Definitions.**

This definition of "modification" lacks clarity. The definition of "modification" in the proposed regulations states that a "significant change" is one that the Siting Council "deems significant." The Siting Council, the regulated community, towns and citizens would be better served by a definition that is objective and specific. A modification may be defined as: "any physical change or change in the method of operation that would result in an increase in the maximum capacity or output of any equipment above the capacity or output originally approved by the Council."

- **R.C.S.A. § 16-50j-18. Grant of Hearing.**

For purposes of clarity, and reducing litigation, the first sentence should read "A hearing must be held…" not "will" or "shall" be held, as the latter two words have not always been interpreted as introducing mandatory requirements.

- **R.C.S.A. § 16-50j-94(b). Visual Impact.**

The requirements for the Visual Impact Evaluation Report are not specific. The result of this is that they can be manipulated by applicants in a way that would greatly minimize the impact of taller structures.[3] For example, a wind turbine more than 600 feet high calls for a "study area radius" of 8 miles. One could interpret this to mean that there must be photographic

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[2] Conn. Gen. Stat. § 16a-17.

[3] This impact is dramatic. For an illustration, see photos of 1.5 MW GE wind turbines with 80 meter hub heights installed in Freedom, Maine, attached as Exhibit 2. Available at http://www.energymaine.com/brwind/index.html.

simulations done throughout the entire study area, but *this is not specified in the regulations.* The analysis must be more specifically described. Given the current description, an applicant could do one analysis 8 miles away and fulfill the regulatory requirements, which is unacceptable because it would completely ignore the more significant visual impact of the wind turbines on properties located at closer ranges.

Since these studies will be done by computer simulation, it is not a burden to insist that, for the largest wind turbines, applicants do simulations at radii of 1 mile, 2 miles, 3 miles, 4 miles, 5 miles, 6 miles, 7 miles, and 8 miles, choosing locations with the highest level population densities approximately 20 degrees from one another around the circumference of each circle. This would result in 144 photographs, and a much more accurate understanding of the visual impact the turbines would have on the 8-mile "study area" that the Siting Council has adopted.

A visual impact evaluation report should be specifically prepared for any site of natural or historic significance, such as a National Natural Landmark, Certified Historic District, or a site on or eligible to be on the National Register of Historic Places, if located within 10 miles of a proposed wind turbine.

Subsection (2) "State Historic Preservation Office Review" should not be in the section entitled "Visual Impact" as SHPO will consider more than just visual impact when determining whether a proposed wind turbine project will have a significant impact on a historic property. For example, a large increase in noise above ambient noise levels might be of concern to SHPO, despite the fact it is not covered at this time by the DEEP noise regulations.

While the regulation requires comments from SHPO be submitted, the regulations are silent regarding what the Council will do with those comments. In the past, the Council, an agency with no expertise in or jurisdiction over historic resources, has ignored the recommendations of SHPO, despite SHPO's professional understanding of the impact of such large structures on nearby historic properties. This regulation should be revised to require: (1) the submission to SHPO of a map that includes all Certified Historic Districts and all properties on, or eligible for inclusion on, the National Register of Historic Places within 10 miles of any proposed wind turbine; and (2) that any decision by SHPO that a project will have an adverse effect should be treated as final and not subject to additional review by the Council.

- **R.C.S.A. § 16-50j-94(c). Noise Evaluation Report.**

The requirements for the Noise Evaluation Report are largely unnecessary; noise is already subject to DEEP's noise regulations. The proposed regulations require, as they should, that calculations be done of projected maximum cumulative sound levels measured at the property lines. This is the only relevant noise measurement. The Siting Council also requires, however, that various sound levels be measured to the "nearest receptors" and that these "nearest receptor locations" be shown on a map. Not only are these "receptors" not defined, there is no statutory or regulatory authority for using any receptor locations that are not on the property lines. If additional measurements need to be taken to determine that neighboring homeowners are not putting themselves in danger when they waive setbacks, this can be done as a separate part of the application process.

As wind turbines age, more noise and vibration will result, due to blade mistuning, misalignment, imbalance, resonance, fastener looseness, and damages and defects in bearings and tower structure.[4] Diligent monitoring and maintenance are a key factor in minimizing these

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[4] The Acoustic Ecology Institute. Wind Farm Noise: 2009 in Review (hereinafter, "AEI Noise Report"), p. 30. Attached as Exhibit 3. Available at http://www.acousticecology.org/spotlight_windfarmnoise2009.html.

noise problems.[5] Therefore, all applicants and petitions should be required to include a wind turbine maintenance plan with their noise evaluation report.

Certain configurations of wind turbines are noisier than others. The noise evaluation report must have a discussion of turbine configurations and distances between turbines, a justification for the final selected configuration (including a discussion of turbulence and noise aspects of the configuration), and a discussion of the alternatives considered. Noise impacts on pasture animals and wild animals must be studied and discussed.

The report should contain a discussion and comparison with other wind turbine sites in the United States where noise has been a sleep disturbance to neighboring properties and an explanation as to why there will be no such problem with the proposed project.

- **R.C.S.A. § 16-50j-94(d). Ice Drop and Ice Throw Evaluation Report.**

There should be a requirement that applicants report the amount of time "icing conditions" can be expected during the year. Not only does this impact the likelihood of ice drop and ice throw, it also impacts the effectiveness of the turbines. This should be based on historic data recorded over the past five years. This estimate should not be entirely based on numbers taken from agencies such as the Department of Transportation, or any similar data on *road* icing, since ice can be expected to occur more frequently on blades close to 500 feet in the air than it does on the roads. This data can be used, but the height of the turbines must be taken into account as well.

The manufacturer's technical documentation relating to recommended ice drop and ice throw setbacks distances and installed ice monitoring devices and sensors should not be provided to the Council only "if available" – it must be publicly filed if it exists. It is inappropriate for an applicant or petitioner to refuse to provide this information, or for the Council to place it under

[5] *Id.*

seal. Turbines that lack manufacturer's technical documentation on ice drop and ice throw should not be installed in Connecticut.

The report should summarize ice drop and ice throw events known to the industry over the five years preceding the submission of the petition or the application, including distances involved, and damage to properties and injuries suffered. The applicant or petitioner should be required to explain why similar events will not occur at the proposed site, or if they will, what mitigation steps have been taken by the applicant or petitioner.

- **R.C.S.A. § 16-50j-94(e). Blade Drop and Blade Throw Evaluation Report.**

There should be a required monitoring plan outlining how the applicant intends to make regular inspections and maintain the condition of the blades.

The manufacturer's technical documentation relating to recommended blade drop and blade throw setbacks distances and installed blade monitoring devices and sensors should not be provided to the Council only "if available" – it must be publicly filed if it exists. If it does not exist, this should be reason to reject the application. It is inappropriate for an applicant or petitioner to refuse to provide this information, or for the Council to place it under seal.

The report should summarize blade drop and blade throw events known to the industry over the five years preceding the submission of the petition or the application, including distances involved, and damage to properties and injuries suffered. The applicant or petitioner should be required to explain why similar events will not occur at the proposed site, or if they will, what mitigation steps have been taken by the applicant or petitioner.

- **R.C.S.A. §16-50j-94(f) Shadow Flicker Evaluation Report.**

The Council proposal limits shadow flicker studies to a one-mile radius. This is unsatisfactory. BNE Energy, Inc., in hearings before the Siting Council, did shadow flicker analyses using a 2000-meter (1.24 miles) radius. According to testimony sponsored by BNE, existing software used by the wind turbine industry uses 2000 meters as the default setting, and will accommodate a greater distance if required by the operator.

Analysis should not be limited to each off-site occupied structure. The analysis should include all residential properties in their entirety (with a map showing the property lines), roads, road intersections, and school bus stops within 2 miles of the wind turbines.

The operator that performs the analysis should be identified by name, with a summary of the operator's education, experience and training in use of the software. Furthermore, in the event of a hearing, the operator should be required to be sworn as a witness and subject to examination.

- **R.C.S.A. § 16-50j-94(g). Natural Resource Impact Evaluation Report.**

More specific requirements for this analysis should be listed, such as: a map giving the locations of any vernal pools; a discussion of wetland *impacts* (not just the calculation of fill amounts); a raptor and bat takings analysis, the impacts on *off-site* wetlands within 1500 feet of the wind turbine parcel; and *on-site* (not nearby) wildlife studies including elevated acoustic monitoring. Performing a wintering raptor study and acquiring a raptor taking permit from United States Fish and Wildlife Service should also be required.

The requirement that the applicant do an analysis of compliance with DEEP "recommended standards and guidelines" is too vague and begs a one sentence response of: "We comply with all recommended standards and guidelines." DEEP has not yet developed standards and guidelines specific to wind turbines. The fact that these standards and guidelines do not exist does not mean that the applicant or petition is in compliance with DEEP's general mission of environmental protection. The requirements to be met should be specifically outlined, not just summarized as a reference to something that may not exist. This specificity would benefit the Siting Council, applicants and petitioners, and the general public.

- **R.C.S.A. §16-50j-94(h). Decommissioning Plan.**

This section should be expanded to include a Commissioning Plan and Host Town Impact Analysis. A bond for decommissioning should be required, along with an analysis of why the amount of the bond is sufficient. All state and town roads that need modification and redesign should be identified and discussed during the petition or certificate proceedings and not during the D&M Plan proceedings. Changes to electric infrastructure should be included in the analysis or provided in a separate report.

By deferring such discussions to the D&M Plan, the host town is deprived of an opportunity to cross-examine, provide testimony and otherwise help refine plans to make modifications to the town infrastructure. Those with the most at stake are denied a voice; this is unacceptable.

- **R.C.S.A. § 16-50j-95. Considerations for Decision.**

The Siting Council should follow DEEP procedure and include a clear list of what needs to be included in order for an application to be considered technically sufficient. For example, it should be made clear that on-site bat and bird studies must be *completed* before the application or petition is considered by the Siting Council. There is a need for language indicating that surveys and plans that are not complete cannot be relied on by the Siting Council to determine impacts on water quality, and therefore an application or petition that relies on such surveys and plans is not technically sufficient.

This section does not make the requirements for applications and petitions clear. For both, it states that decisions shall be rendered "in accordance with [General Statutes] Sections 16-50g, 16-50k, 16-50p and 16a-35k." Despite this, the Siting Council could (and probably would) argue that the criteria of General Statutes § 16-50p does not apply to petitions.[6] The criteria found in General Statutes § 16-50p should apply to decisions made on these specific kinds of petitions for declaratory rulings. In fact, if it does not apply, it is strange that for *both* application and petitions there are so many additional reports required (see the new proposed R.C.S.A. § 16-50j-94). Regardless of the Siting Council's intent, however, this section is confusing and it is in the best interests of everyone that will be involved with future proceedings that it be supplemented and clarified to make it absolutely clear what will be considered by the Siting Council in each proceeding.

General Statutes § 16a-35k should not apply to a petition proceeding at all, since petition proceedings are meant to focus on whether an application is necessary – therefore consideration of Connecticut's renewable energy policy should play no role here.

- **R.C.S.A. § 16-50j-95(a) Setback Distances.**

As a starting point, all setback distances recognized by the local planning and zoning ordinances should be honored, unless there is a finding by the Siting Council that there should be an increase in setback distances in the interest of public safety.

Generally, a setback of 1.1 times the wind turbine height from the property line is completely inadequate. To illustrate, the following are just a few examples of setbacks from towns and counties in California,[7] a state with more experience than Connecticut in siting wind turbines:

- 1000 feet from any residential area.[8]

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6 The new proposed R.C.S.A § 16-50j-93 states that petitions shall also include the "additional information" required under 16-50j-96. This is the section on the D&M Plan, so the reference is likely a typographical error, but it does nothing to improve the confusion over what must be included in a petition for a declaratory ruling. This erroneous reference to proposed R.C.S.A § 16-50j-96 can also be found in proposed R.C.S.A § 16-50j-92.

7 All ordinances compiled in the Model Ordinance.

8 Contra Costa County, California.

- 3 times wind turbine height from any building.[9]
- Greater of 3 times wind turbine height or 500 feet from the exterior project boundaries.[10]
- Greater of 4 times wind turbine height or 500 feet from the exterior project boundaries, if project site is adjacent to parcels of less than 40 acres.[11]
- 6 times wind turbine height from the interstate.[12]
- 3 times wind turbine height from railroads.[13]

The State of Wisconsin has invested much effort recently in determining appropriate setbacks for its growing population of wind turbines. The Biological Subcommittee of the Wisconsin Wind Power Siting Collaborative stated that a setback of 2 to 5 miles from sensitive environmental areas, such as the Beckley Bog, would be appropriate.[14]

It is also important to have setbacks between the turbines themselves, for both safety and energy efficiency. The Town of Holland, Wisconsin, has an ordinance that puts this "in-between turbine setback" at 2 times the total height of each turbine.[15] While limiting "wind turbine density" might appear to prevent wind developers from getting the most use out of the land they acquire, this is not actually the case – these limits are necessary in order to optimize site layout by decreasing the turbulence induced by the wakes of neighboring turbines.[16] As a general rule

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9 Riverside, California.
10 Contra Costa County, California.
11 Kern County, California.
12 Alameda County, California.
13 Riverside, California.
14 Model Ordinance, at p. 28.
15 The Town of Holland Wind Energy Conversion System (WECS) Ordinance (hereinafter, "Holland Ordinance"), at § VII.L. Attached as Exhibit 4. Available at http://www.windaction.org/documents/27297.
16 Langreder, Wiebke. "Siting of Wind Farms: Basic Aspects." Attached as Exhibit 5. Available at http://www.wwindea.org/technology/ch02/en/2_4_1.html.

the distance between wind turbines in prevailing wind direction should be a minimum of the equivalent of five rotor diameters.[17]

Terry Matilsky, Professor of Physics at Rutgers University, has determined that ice throw can reach a distance of 1750 feet for a wind turbine with a hub height of 300 feet (91 meters) and blades 100 feet (30 meters) long.[18] A setback of more than 1750 feet is necessary to protect nearby residents from ice throw for a relatively small wind turbine. Greater distances are required as size increases. Even longer setbacks are necessary to address other concerns, such as serious noise issues, outlined in greater detail below.

There is documented evidence of residents living as far as 2 miles away from wind turbines being negatively impacted by the noise that is generated by the wind turbines.[19] Adopting a setback of any distance will always alleviate some problems, but as there have been many reports of audibility as far out as several miles away from wind turbines,[20] a setback of 2 miles would therefore be significantly more appropriate than half a mile if the State is genuinely concerned for the health of its residents.

The manufacturer's recommended setback distances must be provided to the public, unless the manufacturer has made absolutely no recommendations of any kind, which is unlikely. If the manufacturer has no recommended setback, this fact should be disclosed. It is not appropriate to file this information under seal.

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17 *Id.*

18 Analysis of Ice and Rotor Throw From Wind Turbines. Attached as Exhibit 6. Available at: http://wind-watch.org/doc/?p=414.

19 Kamperman, George W. and Richard R. James. "Noise-Con 2008: Simple guidelines for siting wind turbines to prevent health risks," p. 4. Attached as Exhibit 7. Available at http://www.wind-watch.org/documents/simple-guidelines-for-siting-wind-turbines-to-prevent-health-risks.

20 AEI Noise Report, p. 4.

- **R.C.S.A. § 16-50j-95(b). Noise.**

This proposed regulation contradicts the State policy regarding noise.[21] Most wind turbines will be sited in rural, residential areas. The proposed regulations call for degrading the noise standards in those neighborhoods by allowing the wind turbine operators to evaluate their source of noise as a Class C industrial emitter, rather than requiring the wind turbine operator to meet the existing local standard.

The Siting Council has granted itself the power, upon a showing of "good cause," to waive the noise level requirements. In addition to the general illegality of such a waiver, explained above, the Siting Council does not have the power to waive the noise regulations. There is a procedure under R.C.S.A. § 22a-69-7.1 which allows the Commissioner of DEEP to grant a variance from the noise regulations. The Commissioner was granted that power by the General Assembly; it was not granted to the Siting Council.[22] If an applicant or petitioner seeks this waiver, it should seek it under the DEEP process; it should have no second opportunity before the Council. Neither the Administrative Procedure Act, nor the noise statute provides for a right of appeal of an adverse decision under General Statutes § 22a-69(b)(3) to the Siting Council.

The regulation should be revised to provide a 2-mile setback from residences and no operation during times of violation of the noise regulation standards. This should not be waivable by the Siting Council. Such a setback is required to adequately protect human health and safety. While it was once believed that half a mile is an adequate setback to protect human health, in recent years this assumption has been repeatedly questioned. For example, Dr. Robert McMurtry, a former dean of medicine at the University of Western Ontario, has estimated (based on his own

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21 *See* Conn. Gen. Stat. § 22a-67.
22 *See* Conn. Gen. Stat. § 22a-69(b)(3).

surveys and those done by other researchers) that 25 percent of people living within 1.5 miles of wind turbines experience disruptions in their daily lives, especially sleep disturbances, which often balloon into other health problems.[23] As aforementioned, there have been reports of noise issues from as far as several miles away.[24]

The World Health Organization has published guidelines for noise levels that are more protective of human health than the DEEP noise regulations.[25] The WHO has found that continuous night-time noise exposure, like that which results from wind turbines, must remain at or below 30 dB in order to prevent sleep disturbance.[26] This is especially important in an environment with a low background noise level.[27] Physiological effects that are induced by noise during sleep include increased blood pressure, increased heart rate, increased finger pulse amplitude, vasoconstriction, changes in respiration, cardiac arrhythmia, and an increase in body movements.[28]

An article in the March 2012 British Medical Journal found that a "large body of evidence now exists to suggest that wind turbines disturb sleep and impair health at distances and external noise levels that are permitted in most jurisdictions."[29] The article cited an American study where a significant relationship was found between sleep and health and distance from wind turbines, with "a sharp increase in effects between 1 km and 2 km [0.62 and 1.24 miles]."[30]

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[23] AEI Noise Report, p. 25.
[24] *Id.* at 4.
[25] World Health Organization Guidelines For Community Noise ("WHO Community Noise Guidelines"). Attached as Exhibit 8. Available at http://www.who.int/docstore/peh/noise/guidelines2.html.
[26] *Id.* at 46. See also World Health Organization Night Noise Guidelines for Europe, p. XVII ("WHO Night Noise Guidelines") (recommending a maximum of 40 dB, and noting that only below 30 dB are "no substantial biological effects are observed"). Attached as Exhibit 9. Available at www.euro.who.int/document/e92845.pdf.
[27] WHO Community Noise Guidelines, p. 46.
[28] *Id.* at 44.
[29] "Wind turbine noise seems to affect health adversely and an independent review of evidence is needed." *British Medical Journal*. March 10, 2012. Attached as Exhibit 10. Available at: http://betterplan.squarespace.com/todays-special/2012/3/10/31012-british-medical-journal-wind-turbine-noise.html.
[30] *Id.*

Exposure to night-time noise also induces secondary effects, including increased fatigue, depressed mood or well-being, and decreased performance.[31] Long-term effects on psychosocial well-being have also been related to noise exposure during the night.[32] Vermont has chosen a limit that is similar to the WHO recommendation – 30 dB in the bedroom.[33] Given the serious risk to human health and well-being, the Siting Council should also adopt the WHO guidelines.

In setting noise limits, amplitude modulation must also be taken into account. The pulsing, beating character of noise emissions from wind turbines results in greater annoyance from noise at lower dB levels than is seen in situations involving other noise emitters, such as aircraft and road traffic.[34] Essentially, this means that a noise limit of 40 dB that would be fine for passing cars on a highway could be far too high for wind turbines. Low-frequency sound, often reported as a feeling of vibration within the chest, also results in greater annoyance at lower dB levels and needs to be modeled when determining setbacks.[35] The Siting Council must consider amplitude modulation and low frequency sound, as others already have in drafting wind turbine regulations, in order to adequately protect the health of Connecticut's residents.

The effect of wind shear also calls for more conservative setbacks. Wind shear is a situation in which wind speed increases substantially with height.[36] In such a situation, researchers have found that while sound levels remain close to what traditional sound models suggest up to 300 meters, beyond that the wind shear creates conditions of noise greater than would be expected.[37] The regulatory limits are then exceeded at homes 400 meters away, when

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31 WHO Community Noise Guidelines, p. 46.
32 *Id.*
33 AEI Noise Report, p. 12.
34 *Id.* at 9-10.
35 *Id.* at 10.
36 *Id.* at 17.
37 *Id.*

they are not at 200 meters away.[38] In some cases, increases can occur at closer ranges as well.[39] These increases can be very significant; they have been recorded as high as 20 dB above the traditional sound models.[40]

The Siting Council should not be allowed to waive limits on noise simply because there are building restrictions on the property. Landowners have the right to use their entire property without being subjected to a nuisance, regardless of whether or not they can build on it. Furthermore, if the noise levels are measured at the property lines, as is required by DEEP regulations, the locations of residences on the property are irrelevant.

As a practical matter, it is in the interest of the state to have noise setbacks that will adequate protect its residents and not put DEEP in the position that Massachusetts' Department of Environmental Protection was recently put in, as a result of poor wind turbine siting in Falmouth. In May 2012, the Massachusetts' DEP shut down one of Falmouth's wind turbines and limited the other to only daytime operation after finding that both were in violation of Massachusetts' noise standards.[41] It is not in the best interests of Connecticut to invest time and money into wind turbine projects just to have them stand still; in this situation the now-silent turbines benefit no one and continue to negatively impact the environment. It would be far better and more prudent to simply develop adequate setbacks in the first place.

Based on the March 2012 article in the British Medical Journal that finds existing noise setbacks too small to protect human health, and widespread concerns related to the inadequacy of traditional noise setbacks given phenomena such as amplitude modulation and wind shear, the

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[38] *Id.*

[39] *Id.*

[40] *Id.*

[41] McGrory, Brian. "State moves to shut turbine over noise levels." *Boston Globe.* May 16, 2012. Attached as Exhibit 11. Available at http://www.boston.com/news/local/massachusetts/articles/2012/05/16/massachusetts_officials_recommend_falmouth_shut_down_turbines.

Siting Council must establish a noise setback of at least 2 miles to the nearest residence. This setback must be established in addition to the requirement of compliance with existing DEEP noise regulations at the property lines.

- **R.C.S.A. §16-50j-95(c). Shadow Flicker.**

According to the wind turbine industry, shadow flicker is entirely knowable and can be modeled by computer. The industry uses a software product called WindPro,™ which purports to predict shadow flicker by day to the minute. There is no reason that any off-site property should be impacted by this totally predictable nuisance.

The proposed regulation limits shadow flicker to not more than 30 total annual hours on any off-site occupied structure from <u>each</u> proposed wind turbine location. A wind turbine field of 10 wind turbines could result in 300 total hours per year on a given structure, without violating the regulation. This is unacceptable. Furthermore, there is no scientific or social justification for the 30 total annual hour rule.

Mitigation plans should include turning off the offending turbines during times of flicker. The argument made by wind turbine developers is that this "offense is not all that long on any day" – by this logic, the operator should turn off the offending wind turbine during this short period of time each day, and thereby not subject nearby residents and animals to this man-made, potentially hazardous, absolutely annoying, and completely avoidable, phenomenon.

According to ordinances of the Town of Holland, Wisconsin, shadow flicker has been witnessed at distances well over one mile.[42] Because of this, Holland's limits ensure that shadow flicker "*will not fall on or in any existing occupied structure or sensitive receptor.*"[43] Further, shadow flicker expected to fall on a roadway or a portion of a residential parcel is only

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[42] Holland Ordinance § II.c.7.
[43] *Id.* § VII.K.

acceptable under the following circumstances: (1) flicker will not exceed 10 hours per year; (2) flicker will fall more than 100 feet from an existing residence; (3) traffic volumes are less than 500 vehicles per day on the roadway; (4) flicker shall not fall into an intersection; (5) if flickers exceeds any of the aforementioned conditions, the wind turbine will be shut down until the flicker problem has been remedied.[44] This regulation is not as protective as a total moratorium on all shadow flicker, but it does much more to protect human health and safety than does the regulation proposed by the Siting Council.

No shadow flicker should be allowed to fall on roads during rush hour or school bus operations. The risk is simply too great.

As with noise limits, the Siting Council proposes to waive limits on shadow flicker if there are building restrictions on the property. Landowners have the right to use their entire property without being subjected to a nuisance. Shadow flicker should only be allowed on other properties when wind energy is needed in response to a declared state or national emergency or when energy is needed for a national defense emergency.

- **R.C.S.A. § 16-50j-96. Requirement for a Development and Management Plan.**

Until there have been a number of years of experience with wind turbine operations, there should be no use of a D&M Plan for siting wind turbines. The D&M Plan procedure allows for sleight-of-hand, as applicants and petitioners can submit more specific drawings, or change turbine locations, once those who are most impacted by the project can no longer cross-examine them or offer their own experts to rebut questionable reports. If the D&M Plan procedure is allowed, the Siting Council will make changes to the design without regard to the rights of citizens. This is a denial of procedural due process guaranteed by the procedures required by the UAPA. The right to cross-examination under General Statutes § 4-178(5) "exceed[s] the minimal

[44] *Id.*

procedural safeguards mandated by the due process clause." *Adamchek v. Board of Education*, 174 Conn. 366, 369 (1978).

If the D&M Plan is to be used, it should not be used as an excuse to not meet all of the requirements of technical sufficiency. It should *only* be used to make minor changes that do not impact water quality, wildlife, human health, historic resources, noise, shadow flicker and additional concerns outlined in these regulations, as corrected by these comments.

Finally, if the D&M plan is to be used, it should only be used for applications. General Statutes § 16-50p(a)(1) provides the Council with the express authority to grant applications subject to conditions, such as a D&M Plan, however, there is no such provision for petitions.[45] Therefore, adding a requirement for a D&M plan for all proposed wind turbines, regardless of whether the application or petition process is used, is yet another *ultra vires* action by the Siting Council. The Siting Council cannot give itself powers beyond that granted to them by the legislature. This proposed regulation should, at the very least, be changed to make it clear that it applies only to applications.

Sections That Should Be Added:

- **R.C.S.A. § 16-50j-94(b)(3). National Natural Landmark, State and Local Parks, Scenic Highway and Other Protected Lands Impacts Report.**

Connecticut has only eight National Natural Landmarks. The regulations do not discuss how the Siting Council should take those into consideration when considering the siting of wind turbines. Currently in Colebrook, Beckley Bog, a National Natural Landmark, is within a half mile of three wind turbines recently approved by the Council, and within a mile and a half of another three recently approved turbines. The Siting Council did not require the developer to

[45] Conn. Gen. Stat. §§ 16-50j(c), 16-50*l*(d), 16-50v(h).

undertake any study of the impacts of the wind turbines on this fragile ecosystem. The Siting Council gave Beckley Bog no consideration.

State and local parks, scenic highways and other protected lands (e.g., local land trusts and other privately conserved lands) should be included in the analysis. A survey area radius of at least 10 miles from any turbine should be used.

- **R.C.S.A. § 16-50j-94(i). Telecommunication Impact Analysis.**

A report on the impact on microwave and telecommunication infrastructure needs to be provided. Any telecommunication structures that may pass a signal through the proposed wind farm should be identified, mapped and discussed. Notice should be given to the telecommunications owner and operator and a copy of the Telecommunications Impact Analysis should be served on the owner and operator.

- **R.C.S.A. § 16-50j-94(j). Transmission Analysis.**

An assessment of the transmission infrastructure needed to deliver the estimated minimum and maximum wind production potential needs to be provided. The potential impact both on the grid and the host town should be determined. The location of the wires must be mapped. A discussion of the cumulative effect on the transmission system should be provided.

- **R.C.S.A § 16-50j-94(k). Site Optimization Report.**

A discussion of all impacts that can be expected from the project and why the proposed design is better than any of the alternatives, including an explanation of why the proposed design will have the least possible deleterious effect on natural resources (such as wetlands, wildlife, and protected lands), human health (such as noise, shadow flicker, and blade and ice throw and drop), and historic resources (such as properties on the National Register of Historic Places).

- **R.C.S.A. § 16-50j-94(*l*). Cumulative Effects Report.**

A discussion of the cumulative effects with of all existing, pending and proposed petitions or certificates for additional wind turbines should be provided. The report must contain a discussion of all the cumulative impacts of all of the topics listed above.

Comment On Other Siting Council Regulations That Will Now Require Revision:

- **R.C.S.A. § 16-50j-39a. Completeness review.**

Add text that the items in R.C.S.A. § 16-50j-94 must be complete before a favorable completeness review decision can be made for any wind turbine application or petition. The minimum required for a finding of completeness should not be "that listed in Section 16-50j-39," as this description is far too vague. The list in R.C.S.A. § 16-50j-39 essentially includes: the purpose, the statutory authority, the contact information, information required under UAPA and PUESA, information required by any State department or agency, information the "petition [*sic*] may consider relevant" and information the Council may request. This list gives the petitioner no real notice as to what is required for completeness, nor does it inform intervening parties of when they can object to a petition as not being complete. This regulation proposed in October of 2011 should be amended to reflect the addition of the wind turbine regulations; no application can be complete without all the items listed in R.C.S.A. § 16-50j-94.

Conclusion:

The wind regulations proposed by the Siting Council are a beginning and represent a much-needed first step for the State of Connecticut. However, these regulations are far from complete and the Siting Council's work is far from finished. At a minimum, the proposed regulations need to be revised in accordance with the comments above. Other concerned citizens are sure to have many worthwhile comments as well and, after reviewing those comments, FairwindCT, Inc., Stella and Michael Somers, and Susan Wagner look forward to the opportunity to offer supplemental feedback, either by written submission or orally at the public hearing.

Respectfully submitted,

FAIRWINDCT, INC., STELLA SOMERS, MICHAEL SOMERS, and SUSAN WAGNER,

By: [signature]

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EXHIBIT 1

COMMERCIAL WIND ENERGY FACILITY & WIND ACCESS MODEL ORDINANCE

Prepared for: Town of Barton,
Washington County, Wisconsin

Written by: Catharine M. Lawton
Sec'y – Plan Commission
Town of Barton

TABLE OF CONTENTS

1. **Safety Setbacks**

The objective of this section is to outline the types of Commercial Wind Energy Facility safety setbacks that are typically regulated and the typical setback distances that have been used in practice.

Adequate buffer zones (the distance from the edge of the development to the turbines) are important because they reduce noise and visual impacts, create safety zones, and generally lessen the likelihood of adverse impacts on (or from) neighboring properties.[46] *Because of safety concerns with blade throw, ice throw and structural failure, many permitting agencies have separated operating wind turbines from residences, public travel routes and other land uses by a safety buffer zone or setback. To reduce injury to workers, discussion of blade throw and ice throw may be included in worker trainer and safety programs. Project operators and the public should not be allowed in the field during windy and icing condition, or when a turbine is operating out of control.*[47]

Adequate setbacks are the principal means by which safety issues associated with Commercial Wind Energy Facilities are addressed. In particular, it is important to establish adequate setbacks from the following: a) Structures (e.g., residences, businesses); b) Property Lines; c) Public Roads and Highways; d) Railroads; e) Above Ground Transmission Lines greater than 12 kV; f) existing and/or planned residential and commercial development; and g) sensitive or high value environmental areas.

Typically, setbacks are expressed as a multiple of the height of what is commonly referred to as the Wind Energy Conversion System ("WECS"), as a multiple of rotor diameter, or a specified distance. For example:

> *"No Commercial Wind Energy Facility shall be located where the center of the tower is within a distance of {x} times the total Wind Energy Facility (Turbine) height from {the setback item—e.g., structure, property line, etc.}"*

- **Typical Setbacks from Zoning Districts and Structures:** Typical setbacks are stated as either from Zoning Districts and/or from structures, and are reflected in adopted zoning ordinances as follows:

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[46] NWCC's *Permitting of Wind Energy Facilities: A Handbook,* p. 28.
[47] NWCC's *Permitting of Wind Energy Facilities: A Handbook,* p. 50.

- Residential Lot Setback - 20 rotor diameters or 1,320 feet from all property lines of lots in a residential zone.[48] whichever is greater.[49]

- 3 times the total WECS height from residential or commercial zoning, but in no case less than 500 feet; and 3

- Non-Residential Lot Setback – 5 rotor diameters or the building setback required in the underlying zone or 100 feet times the total WECS height from a dwelling unit but in no case less than 500 feet.[50]

- A minimum of 1,000 feet from any existing off-site residences or residential areas; and All WECS buildings and structures shall be sited to minimize visual impact to residences within one mile.[51]

- Minimum of 4 times total WECS height or 1,000 feet whichever is greater, from any off-site residence on an adjacent parcel; Minimum of 1.5 times total WECS height from any on-site residence or accessory structure designed for human occupancy.[52]

- 1.25 times to 3 times total WECS height from any building.[53]

Other examples can be found in the NWCC's publication, *Permitting of Wind Energy Facilities: A Handbook.*

- **<u>Typical Setbacks from Property Lines:</u>** Typical setbacks from property lines as reflected in adopted zoning ordinances are as follows:

  - 1.25 times total WECS height from all property lines; and 3 times total WECS height from any building site upon

[48] State of Oregon – Model Wind Energy Conversion System Ordinance, Draft of 12/31/96, pp. 16 – 17.
[49] State of Oregon – Model Wind Energy Conversion System Ordinance, Draft of 12/31/96, pp. 16 – 17.
[50] Alameda County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[51] Contra Costa County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[52] Kern County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[53] Riverside, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.

which a windfarm had not been approved but in no case less than 300 feet.[54]

- 3 times total WECS height or 500 feet whichever is greater from exterior project boundaries.[55]

- 4 times total WECS height or 500 feet, whichever is greater, from exterior boundaries if project site is adjacent to parcels of less than 40 acres; and 1.5 times total WECS height from all exterior boundaries if project is adjacent to parcels of 40 acres or more (with an allowance for setback reduction).[56]

- 1.25 times to 3 times total WECS height from any lot line; If WECS is located in the W-E or W-1 zone, 3 times total WECS height from any lot line of any lot containing a dwelling.[57]

Other examples can be found in the NWCC's publication, *Permitting of Wind Energy Facilities: A Handbook.*

- **<u>Typical Setbacks from Public Roads and Highways:</u>** Typical setbacks from public roads and highways as reflected in adopted zoning ordinances are as follows:

  - 3 times total WECS height but in no case less than 500 feet; 6 times total WECS height from the traveled way of I-580 but in no case less than 500 feet.[58]

  - All WECS, buildings and structures shall be sited to minimize the visual impact on adjacent roadways, and County scenic routes.[59]

  - Minimum 1.5 times total WECS height.[60]

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[54] Alameda County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[55] Contra Costa County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[56] Kern County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[57] Riverside, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[58] Alameda County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[59] Contra Costa, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[60] Kern County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.

- 5 times total WECS height from the right-of-way line of any public road or highway.[61]

- 1.25 times to 3 times total WECS height measured from the public right-of-way; Scenic setbacks required from various state highways.[62]

Other examples can be found in the NWCC's publication, *Permitting of Wind Energy Facilities: A Handbook.*

- **Typical Setbacks from Railroads:** Typical setbacks from railroads as reflected in adopted zoning ordinances are as follows:

  - Minimum 1.5 times total WECS height.[63]
  - 1.25 times to 3 times total WECS height.[64]

- **Typical Setbacks from Above Ground Transmission Lines Greater than 12 kV:** Typical setbacks from above ground transmission lines greater than 12 kV as reflected in adopted zoning ordinances are as follows:

  - 1.25 times total WECS height.[65]

- **Typical Setbacks from Sensitive Environmental Areas:** The nature of the setback will depend on the particular sensitive environmental areas at issue. The PSCW and DNR have stated that where significant sensitive environmental areas are concerned, a reasonable setback or buffer may be:

  - 2 to 5 miles.[66]

- **Setback Reductions:**[67] Setback reductions may be permitted if the Planning *{Commission/Board}* and *{governing body}* determines based on the submissions of the applicant, the location of the proposed project and the existing and planned land uses, the anticipated human visitation and use that eliminates or substantially reduces the potential safety hazards. Whenever a setback reduction is proposed pursuant to this subsection, the

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[61] Monterey, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[62] Riverside, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[63] Kern County, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[64] Riverside, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[65] Riverside, California. From NWCC's *Permitting of Wind Energy Facilities: A Handbook,* Appendix B.
[66] Preliminary Maps Prepared by the Biological Subcommittee of the Wisconsin Wind Power Siting Collaborative.
[67] From City of Riverside, California Ordinance – Commercial WECS Permits.

setback reduction will be included in all notices, and, if granted, the commercial wind energy facility permit shall specifically state all required setbacks. In addition, the Planning {*Commission/Board*} and {*governing body*} will issue a written determination of cites all of the factors that support a setback reduction.

2. **Wind Access Setbacks**

The objective of this section is to outline the Commercial Wind Energy Facility wind access setbacks that are typically regulated to ensure that the interest of off-site landowners are adequately protected. In addition, this section sets out the typical wind access setback distances that have been used in practice.

It is well recognized that development of wind projects may affect other uses on or adjacent to a site, or in the surrounding region.[68] *In particular, in some states, including Wisconsin, wind energy developers are entitled to obtain "Wind Access Permits" (pursuant to Wis. Stat. 66.032) to ensure continued and unobstructed access to the wind such that wind velocity is not decreased and wind turbulence is not increased. Such permits may prohibit adjacent landowners from building structures and/or planting vegetation that would adversely impact the developer's access to the wind. As such, it is important to ensure that wind energy development does not adversely impact the property rights of adjacent, off-site landowners—Wind Access Setbacks accomplish this goal.*

- No Commercial Wind Energy Facility shall be located where the center of the tower is within a distance of five (5) rotor diameters from a lot line that is perpendicular, or within 45 degrees of perpendicular, to the dominant wind direction.[69]
- No Commercial Wind Energy Facility shall be located where the center of the tower is within a distance of 2.5 rotor diameters from a lot line that is parallel, or within 45 degrees of parallel, to the dominant wind direction.[70]
- Where the lot line abuts a public right of way or a railroad right of way, the setbacks specified above shall be measured from the centerline of such right of way.[71]
- Notwithstanding the provisions set forth in these section, such setbacks from lot lines do not apply if the application is

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[68] NWCC's *Permitting of Wind Energy Facilities: A Handbook*, p. 29.
[69] From City of Riverside, California Ordinance – Commercial WECS Permits.
[70] From City of Riverside, California Ordinance – Commercial WECS Permits.
[71] From City of Riverside, California Ordinance – Commercial WECS Permits.

EXHIBIT 2

Beaver Ridge Wind, LLC

BEAVER RIDGE WIND: is a 4.5 megawatt (MW), 3-turbine wind project located in Freedom, Maine. Beaver Ridg
formed by Maine residents Mark Isaacson, Richard Silkman and Andrew Price (MIRSAP) in 2004. In November 20(
up with Patriot Renewables, an affiliate of Jay Cashman, Inc, to complete the project. The Beaver Ridge Wind projec
producing clean renewable electricity in November 2008 as only the second operational wind farm in Maine and the
Central Maine Power's service territory. Our three General Electric 1.5 SLE turbines produce approximately 12,500,(
hours of emission-free electricity each year. This is enough to power about 2,000 residential homes. Together with P
Renewables we continue to own and operate the Beaver Ridge Wind Project.

TURBINE DETAILS: Each wind turbine consists of a 262-foot steel tower that is 15 feet wide at the base, narrowi
wide at the top. The generator sits on top of the tower and is powered by three 122-foot blades. The blades complete
and 20 revolutions per minute, depending on the wind speed. Each wind turbine (excluding the foundation) weighs al

BENEFITS: The BRW wind project brings a number of significant benefits to the local community, the State of Ma
United States. The benefits include: local tax relief; local construction and ongoing operations and maintenance jobs;
and water, and improved energy security and independence. The turbines also help to preserve active farm land from
We believe that Maine should produce more energy locally and sustainably through a diverse mix of renewable sour
reduce our heavy dependence on fossil fuels and will lower the price all Mainers pay for energy.

Project Documents

Frequently Asked Questions-Updated 8/9/10 PDF
Beaver Ridge Fact Sheet -Updated 8/9/10 PDF

Photos

*Click on the thumbnail to view full resolution picture

Beaver Ridge Wind

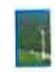
Beaver Ridge Wind Aerial_1-Sep 2008

Beaver Ridge Wind Aerial_2-Sep 2008

Beaver Ridge Wind Turbine-Aug 2008

Beaver Ridge Wind From N. Palermo Rd -Oct 2008

Beaver R Aerial_3



T1 Cranes Ready To Lift Aug 2008

T1 Rotor Ready To Lift Aug 2008

Tower Delivery at Sibley Intersection-Jul 2008

Freedom Anemometer Install- Nov 2004

Freedom A Install Comp

Click here to read our Principles Biographies & Qualifications


Tina Shute

EXHIBIT 3

THE acoustic ecology INSTITUTE
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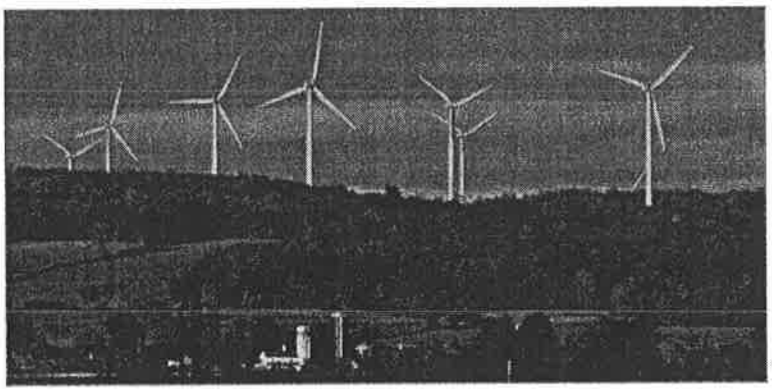
Wind Farm Noise: 2009 in Review

Research, public concerns, and industry trends



A Special Report from the Acoustic Ecology Institute, February 2010

45 Cougar Canyon   Santa Fe, NM   87508   USA
AcousticEcology.org   AEInews.org   505.466.1879   listen@acousticecology.org

Nature of the Noise Issues

Many people living near wind farms, in all parts of the country, report that noise from the 250- to 400-foot tall turbines is much more disruptive than they had been led to believe by project planners. Over the past couple of years, industry representative have been far less likely to claim that turbines will be inaudible, but there is still a tendency to assure residents that likely noise levels (generally 40-50dB) will be easy to live with. Many rural residents share the shock of one woman in Maine who discovered that, at night in rural areas, "40dB is loud!"[2]

How loud *are* current-generation wind turbines? Manufacturer specs for today's 300-400 foot, 1.5-2 megawatt wind turbines indicate that the sound power level of their noise emissions are generally 98-104dBA[3], roughly the same loudness as a chain saw or stereo at maximum volume[4] (though turbines obviously have a very different – and potentially less penetrating – type of sound). With this in mind, it makes a certain sense that industry sound models and public assurances would suggest that turbines should have negligible impacts beyond several hundred feet. However, we must remember that the noise source is not at ground level, quickly dissipated by trees and buildings; rather, it emanates from high above the ground, with a direct, unobstructed path to a very large surrounding area.

It's not hard to find reams of compelling first-hand accounts of wind farm noise online these days[5], so there's little need to present a long litany here. More useful, perhaps, would be a concise summary of the types of problems reported by people living within earshot of turbines.

First and foremost is sleep disruption. There is little question that noise levels more than 5 or 10dB over the still late-night ambient levels of 20-30dB can wake people. Some wind farm neighbors report many nights of getting only four or five hours sleep. Less appreciated is that low levels of noise also triggers non-waking arousal during sleep which disrupts normal sleep stages, leaving the sleeper less well-rested upon waking in the morning.[6] Many wind farm neighbors complain of headaches, irritability, trouble concentrating, and similar symptoms that are often rooted in lack of solid night-time rest.

For some people, turbine noise is also disruptive during the day. People report not being able to spend time in their gardens, or that their children play outside less. Metal workshop roofs can rattle in low-frequency sound waves, making it difficult to stay and work.

A smaller number of people report strange pressure in their ears or chest, or other physiological responses that can occur at any time of day or night when turbines are operating; these may be associated with particular wind or atmospheric conditions, or with a pre-existing physiological sensitivity or imbalance.

In the most extreme cases, families are forced to move from their homes to escape the effects of the ongoing noise disturbances. These are not necessarily people living extremely close to turbines; such unlivable situations have occurred from 1000 feet to over a half-mile from the closest turbines. Some wind farm developers have actually bought out neighbors that were especially impacted[7], though most are left to make the best they can with a piece of property that will be difficult, if not impossible[8], to sell. I have not seen any comprehensive listing of residents who had to move, but such reports are becoming more common in the US, Canada, and the UK, totaling perhaps three to six per year.

Finally, and hardest to address, are concerns about low-frequency noise. Here at AEI, we have yet to fully assess these issues, since there is enough clear information regarding audible noise to work with for now. Complicating assessment of likely impacts, low-frequency noise varies more than audible noise in both propagation patterns (which can be affected by geology as well as topography and air conditions) and in how sensitive different people are to both audible sound and sub-audible acoustic energy (infrasound). Certainly there are people whose homes seem to vibrate in some sort of resonance when nearby turbines are active; whether these are low-frequency effects, or a resonance within the structure from low-level audible noise, is sometimes hard to ascertain. It also appears that larger turbine blade diameters may be associated with highly amplitude-modulated infrasound; such impulses, even of sound well below hearing range, may be perceptible, either on the edges of audibility or as a physical sensation[9]. Much less clear is whether such low-frequency sound, at relatively low levels (compared to those experienced in, say, a factory or jet fighter), can itself cause health effects; suffice to say, there is much debate on this question, and <u>while the balance of evidence suggests that health impacts are unlikely to be widespread, it's premature to say – as the industry suggests – that the case is closed.</u>

Most of those who are sharing their stories do so not because of some underlying dislike of wind energy; indeed, many were supporters of local wind projects who simply believed the reassuring promises of wind companies. Rather, they hope that by sharing their nightmares of disrupted lives, they might be able to help others avoid a similar situation. <u>Over and over when listening to these folks, you hear the refrain, "if they'd only built them a little farther away."</u> Some suggest a half-mile would likely have worked for them, while others say there are some turbines out to closer to a mile that are troublesome. In stark contrast to industry assumptions that those complaining are simple NIMBYs, the fact is that most of those who are struggling with noise are more than willing to *see* turbines; they just don't want to hear them so often. While some people end up angry, and may speak from a place of distrust or spite (and after all, we all know that every town has its share of cranky naysayers who always feel put upon), many more simply want to help others understand that it's not always easy to adapt to the types of noises that wind turbines make. When other communities hear the same comforting assurances that they had heard, there is a desire to be sure that the whole picture is made clear.

(Note: Half-mile limits are sometimes proposed as a precautionary response to noise concerns, but there are definitely many people between a half and three-quarters of a mile who are affected, as well, including some of the more severe noise issues[10]. While adoption of half-mile setbacks would alleviate many of the worst problems, it is not enough to eliminate routine noise issues. Also, while acknowledging that occasional audibility at longer ranges cannot, in practice, be eliminated, it's worth noting that many cases of occasional audibility out to several miles have been reported, and some new questions are arising about over-water transmission from wind farms recently commissioned along the Great Lakes shoreline. Some reports and concerns about low-frequency sound transmission extend to up to two miles; though there is very little on-the-ground data to clarify how common or strong such long-range transmission is, independent acousticians in the US and New Zealand are currently investigating this question.)

See the later sections of this report on Noise Limits, Social Considerations, and Resolving the Science/Experience Paradox for more perspective on the concerns shared by many of those impacted by wind farm noise.

(especially from instances in which the models had been inaccurate), and the like. The models are used to place turbines in the landscape in a pattern designed to assure that houses will not be exposed to sound above the local limits -- but importantly, the siting is often finely tuned to just barely come in under the noise limit; therefore, any variation from the model's predictions can be problematic for neighbors (and especially so if the limits are set above likely true ambient levels, or are based on long-period averages).

Inevitably, any model will have its limitations. In many cases, sound models over-estimate the noise actually received in the field, thanks to more turbulence in the air and interference from the ground than the models assume (it is common for modelers to include some conservative assumptions to minimize the chance that they will underestimate impacts). On the flip side, there are clearly times when noise levels in the field exceed those predicted by sound models; these situations, if they occur with any regularity, can cause sleep disruption or other annoyance reactions that lead to community agitation.

Increasingly, acousticians are working to zero in on the specific wind conditions that are occurring during the times when neighbors are most bothered by turbine noise, so that they can adapt their turbine operations to reduce noise in this situation.[23] This is still a relatively new line of inquiry, and there are no clear summaries of these studies available; until comparisons can be made across several wind farms, such studies will be considered preliminary.

The most commonly noted situation in which turbine noise becomes problematic for neighbors is in a stable nighttime atmosphere. This means that there is a layer at ground level in which the wind is nearly still, with a layer of stronger wind above ground level yet below turbine height, with little turbulence between these layers; in these situations, the background ambient noise can be very low (20-30dB) at people's homes, while the turbines are operating and making noise. In some cases, the higher winds aloft may be carrying the turbine noise further than the models expect, thanks to the minimal turbulence. It is also not uncommon that the turbines can be operating at or under a noise limit of 40dB or 45dB (or even 36dB[24]), yet be much louder than the background, and so be especially irritating. In addition, there is some indication that the pulsing character of the noise can be more dramatic when wind speeds are lower at the bottom of the blade diameter than at the top, again not unlikely in these nighttime conditions.

The unusual nature of wind turbine noise

Amplitude Modulation

Many neighbors report the pulsing, beating character of the noise as being the key factor that makes it harder to ignore or get used to than other noises. This pulsing is known as "Amplitude Modulation" (AM): amplitude is the loudness, which is changing - modulating - over the course of each couple of seconds. When the AM is more than 5dB, the variability becomes clearly noticeable; it can be most troublesome when the quieter end of the pulse is not quite audible (for example, at relatively long distances).

Some recent field studies indicate that while the AM occurs of the course of 1 to 2 seconds between peaks (or troughs) of the noise level, the increase in noise occurs in only a tenth of a second or so, meaning that it is perceptually experienced as an impulse of sound, which is much more attention-grabbing than a gentle sinusoidal swaying of sound.

Several recent studies have presented models and measurements that continue to address outstanding questions about the directionality of AM. It appears that AM is most pronounced to the sides of turbines; this may be due to the motion of the blades or because noise coming off the trailing edge of the blades is directional. An interesting finding in one recent detailed recording study was that while the noise levels were lower to the side, the AM was only noticeable there[25]; this makes me wonder whether one reason that AM is troublesome is that it may occur in zones where the turbines are otherwise largely imperceptible.

Grab-bag of sounds

Another aspect of wind turbine noise that neighbors often mention is the many different sounds that are heard at different times: thumping, whistling, rumbling (the "train that never arrives" sound), as well as the pulses.

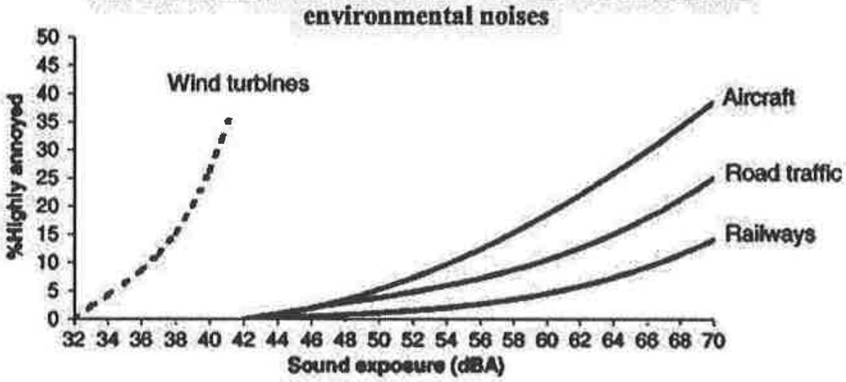
Low-frequency sound or physical/palpable "pressure waves"

Though it remains hard to quantify, many neighbors report various experiences of low-frequency sound or vibration around some wind farms. It's not clear if these are caused by particular geological situations, or by mechanical problems, or by the growing size of turbine blades. While we cannot make any concrete conclusions at this point, low frequency effects certainly bear ongoing consideration.

Perhaps related are some reports of what are experienced as "pressure waves" from turbines. In these reports, people speak about feeling the pressure waves in their chests, or that the waves rattle metal roofs. One compelling report from a hunter in Vermont notes that from "a half-mile to over 2 miles away, the sound is a low, dull, penetrating, throbbing series of never-ending pressure waves - hour after hour, day and night, sometimes for days on end, like Chinese water torture. While I was hunting there this year, I noticed that I didn't need a compass to orient myself in the deep, dark woods 2½ miles away so long as the turbines were throbbing.[26]"

All these qualities of the sound creates more annoyance at lower dB levels than other types of sounds
These unusual qualities of wind turbine noise likely explain another important research finding. Noise control experts have long used annoyance curves to predict what sound levels will trigger significant annoyance in nearby residents; these curves link rising sound levels to increasing proportions of the population reporting being annoyed. Several studies have now shown that annoyance curves for other noise sources are not applicable to wind turbine noise: around wind farms, equivalent levels of annoyance are triggered by much lower noise levels.

Figure 6: Annoyance associated with exposure to different environmental noises



This chart is copied from the 2009 report by the Minnesota Department of Health, entitled *Public Health Impacts of Wind Turbines*. It was originally published in Pederson and Waye, Perception and annoyance due to wind turbine noise—a dose-response relationship. J. Acous. Soc. Am. 116:3460. 2004.

Noise Limits: Useful benchmark, but the experience of sound is hard to quantify

All in all, as you can tell, noise limits and regulations are useful targets, and provide a way for communities to craft their own individual approach to shaping the soundscape experienced by residents. But, noise regulations remain a crude tool, and it's important that everyone involved realize that the experience of sound in the landscape can never be reduced to a particular decibel level.

For example, it's instructive to think a bit more deeply into some of the comparisons that are commonly used to describe likely wind farm noise levels. To reassure neighbors, wind companies often note that a 40-50db noise is similar to that made by a refrigerator, or light traffic on a road 50 feet to

100 feet away. This is true enough, as far as it goes. But consider: do you sleep next to your refrigerator? If you live in the country, would you readily adapt to steady light traffic on a road only 50 feet away? Add in the fact that turbine noise is often much more variable, pulsing, etc., than a refrigerator, and you begin to get a sense as to why simple dB levels are not really all that descriptive.

Even after a particular noise level is codified, it is likely that many communities will continue to find that wind farms are a new and hard-to-quantify element in the local soundscapes. As communities and acousticians continue to look more closely at the situations in which turbine noise has been particularly disruptive or has diverged most notably from the predictions of current noise modeling, we will have the opportunity to craft noise and operational regulations that better reflect the nature of this unique sound source.

Research results of note from 2009

Thanks to the increasing public, regulatory, industry, and scientific interest in the question of noise effects near wind farms, many fascinating new studies and overview reports were published over the past year. Here we briefly summarize many that anyone who is working on wind farm siting issues should know about; in many cases, we also provide a link to download the full paper, and to read AEI's more extensive online summaries of each paper. While AEI's online summaries are a useful way to learn more, we also encourage you to download any and all that pique your interest, in order to dig in more fully; AEI's web pages include links to the source papers, when available.

Note: Most of these studies are not formally peer-reviewed. While this is sometimes used as an attack on papers that are used by groups suggesting a need for more care in wind siting, the large government reports are also generally not peer-reviewed. In general, if a scientific journal is included in the citation below, then peer review can be assumed to have taken place. Presentations at conferences such as Wind Turbine Noise and Internoise are not peer reviewed; neither are reports issued by trade organizations or government agencies. This does not mean that the information presented in non-peer-reviewed papers is unworthy of consideration; rather it simply suggests that careful scrutiny of the data and interpretations are in order, since the author may not be forced to present the data with the same degree of caveats and references to other literature that would occur in peer-reviewed papers.

Effects on Neighbors (noise, annoyance, health, property values)

World Health Organization. Night Noise Guidelines for Europe.
Download: http://www.euro.who.int/eprise/main/WHO/Progs/NOH/Activities/20040721_1
AEI summary: http://aeinews.org/archives/429
This 184-page report offers a comprehensive overview of research into the various effects of noise on sleep quality and health (including the health effects of non-waking sleep arousal), and is recommended reading for anyone working with noise issues. The WHO now recommends a maximum year-round outside nighttime noise average of 40db to avoid sleep disturbance and its related health effects. The report notes that only below 30dB (outside annual night-time average) are "no significant biological effects observed," and that between 30 and 40dB, several effects are observed, with the chronically ill and children being more susceptible; however, "even in the worst cases the effects seem modest." Elsewhere, the report states more definitively, "There is no sufficient evidence that the biological effects observed at the level below 40 dB (night,outside) are harmful to health." At levels over 40dB, "Adverse health effects are observed," and "many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected." *Note: the annual average noise level used in WHO recommendations may be difficult to adapt to most wind farm noise regulations. Few localities or wind developers have the resources to measure noise year-round, and most regulations focus on shorter time periods. The State of Vermont, for example, has chosen a limit that is similar to the WHO recommendation (30dB inside the bedroom), but measured as a one-hour average.*

Minnesota Dept of Health. Public Health Impacts of Wind Turbines.
Download: http://energyfacilities.puc.state.mn.us/resource.html?Id=24519
AEI summary: http://aeinews.org/archives/456
This state agency report provides a good overview of our current understanding of wind farm noise propagation and impacts, with particular attention given to possible low frequency noise issues. The report makes no dramatic recommendations, though the data presented suggests that audible and low-frequency noise could affect neighbors within a half mile to mile. Among the key pieces of information contained in this report, gleaned from previous research studies:

- A reminder that the 2007 report on wind farms and human health from the National Academies of Science concluded that "noise produced by wind farms is generally not a major concern beyond a half mile" (i.e., under a half mile can be problematic).
- Some individuals have extraordinary sensitivity to low frequency sound, up to 25dB more sensitive than presumed (average) thresholds at some frequencies
- Some people can dismiss and ignore repetitive but low intensity noise, while for others, the signal will grow and become more apparent and unpleasant over time. These reactions may have little relationship to will or intent, and more to do with previous exposure history and

in early summer. The noise models being used by wind developers in Cape Vincent, NY, predict minimal impact on neighbors thanks to an average background ambient noise level of 45dB. This study found that on nights with little wind at ground level, actual ambient sound in this rural area is generally below 35dB, and in many areas, drops to 25dB or lower for much of the night. Also, and most importantly, the study used standard predictive measures (including wind differential at two near-ground heights, daytime solar radiation, and night time cloud cover) to estimate how often the winds at turbine hub height would be high enough to turn the turbines on, even as the wind at ground level remained low - the situation that often triggers the worst night time noise complaints near wind farms. The sobering result was that such nights, which create noise issues for neighbors far beyond those predicted by the simpler noise modeling used during permitting, could be a regular occurrence for most of the summer and fall. After taking noise measurements at a wind farm currently operating in a nearby town - which found levels similar to those predicted and allowed in current Cape Vincent planning - the author notes that the vast majority of Cape Vincent homes will be close enough to hear the turbines easily on these "worst case" nights, with a third of local households likely to experience objectionable noise levels.
For this paper, we highly recommend checking out AEI's much more detailed summary at the above link

Ovenden, Shaffer, Frenando. Impact of meteorological conditions on noise propagation from freeway corridors. J. Acous. Soc. Am. 126 (1), July 2009, 25-35.
This study combined field recordings and new acoustic modeling to describe the effects of wind shear and temperature differentials on the distance over which road noise exceeds regulatory limits. The essence of this study's results is that sound may bounce off a layer boundary that is caused by wind shear or temperature layers at 30-50 meters high (a wind shear is a situation in which wind speed increases substantially with height, especially when there is a relatively sharp boundary between low and higher wind speeds). In some conditions, the researchers here found that while sound levels remain close to what traditional sound models would suggest at ranges of 200-300 meters, noise levels can actually increase at ranges of 300 meters and beyond, creating conditions in which regulatory limits are exceeded at these greater distances. In some conditions, increases occur in chaotic patterns at closer ranges, as well. The difference between traditional sound models and the results here were as high as 15-20dB, and commonly occurred at 5-10dB. It is quite possible that the turbine sound that projects down into still air near the ground during wind shear conditions is subject to these same effects; this could partially account for unusually high noise levels reported by some neighbors at certain times.

Wind Turbine Noise 2009
http://www.windturbinenoise2009.org/
This third biannual international conference produced, as usual, a wealth of papers worth knowing about. Proceedings can be purchased on DVD from the website above. Among the many papers worth hunting down online or on the proceedings disc:

Sorensen, Neilson, Villadsen, Plovsing. Implementation of the Nord2000 model for wind turbines: new possibilities for calculating noise impact.
Email author: ts@emd.dk , pn@emd.dk , jv@emd.dk

> The model they introduce here is designed to address variable weather and atmospheric conditions throughout the year, as well as cumulative impacts from multiple turbines. It is claimed that this model can then predict how often, over the course of a year, a given noise level may be exceeded.

Dick Bowdler. Wind shear and its effect on noise assessment.
Email author: dick@dickbowdler.co.uk

> A great assessment of wind shear patterns over the course of nine months, at five wind farms in varying terrain, collecting data every ten minutes. This is a massive amount of data (30,000 data point in all), and illuminates wind shear patterns more clearly than perhaps ever before. Wind shear is a measure of how much higher (proportionately) wind is at hub height than at ground level. Of special note is that wind shear is dramatically higher at the lowest wind speeds, though there is some at all wind speeds. Also, as expected, there is much more shear

12% were annoyed; at 35-40dB (within most global regulatory limits), 85% heard them, while just under 20% were annoyed; and at 40-45dB (within common US regulatory limits), 95% heard them, while 45% were annoyed.

Dr. Robert McMurtry, a former dean of medicine at the University of Western Ontario, was quoted in a recent article in Macleans[39] that "When I first read about the side effects I thought that they didn't sound very convincing. But then I did my homework, and I became alarmed." Based on surveys he has done, and others in Europe, McMurtry estimates that 25 per cent of people living within 2.5 km (1.5 miles) of turbines experience disruptions in their daily lives, especially sleep disturbances, which often balloon into other health problems. He thinks that there are enough problems in wind farms worldwide to justify a serious epidemiological look at the industry. "You can assume that all these people are liars," says McMurtry. "But many of these folks will tell you that they welcome wind turbines. They just want someone to turn them off at night, or move them further back."

The third study that suggests that these trends may apply to more than just annoyance is the Department of Energy's property values study. This study, too, found no clear correlation with distance from or visibility of wind farms. The form of statistical analysis used to analyze the sales of 5000 homes sold within ten miles of wind farms has garnered some criticism[40], but I am not savvy enough with statistical techniques to know whether such criticism is warranted. However, a close look at the data reveals that there are some indications of a trend toward homes being sold at less than expected prices among the closest homes considered.

To assess whether nuisance factors affected home prices, the researchers compared sales within a mile of turbines to sales five miles or more from turbines. Their distance classifications included 0-3000 feet, 3000-5280 feet, 1-3 miles, 3-5 miles, and over 5 miles. While all zones beyond a mile showed virtually no differences in sales prices, both of the classes under a mile had modest 5% declines in value (interestingly, the decline was slightly more extreme between 3000 feet and a mile). However, there were not enough sales of homes this close (125 under a mile, compared to roughly 4000 at 1-5 miles, and 870 beyond 5 miles) to provide statistical significance; that is, the margin of error is greater than the 5% change found, which means that with a larger number of sales, the average change in value might move to zero (or, just as likely, to -10%). Despite the limitations of the small sample size, it is striking to look at the data charts presented in the paper, and to see that of all the wind farm-related factors that were being considered, *only* proximity nudged the values away from the baseline average. In the context of the rest of the findings, the change co-efficients for proximity (minus.05 and .06) actually jump out of the data.

When considered in consort with surveys that suggest that only a minority of those close to wind farms experience especially problematic noise conditions (and remembering that many wind farms have little in the way of noise issues at all), it seems reasonable to suggest that the average decline of 5% in home values may be concentrated in a smaller number of homes that lost considerable value. While this level of raw data is not available in the final report, the authors do recommend that more detailed study of the closest homes is a top priority for future research.

There have certainly been some instances of dramatic decreases in value, and even marketability, of homes near wind farms. In a few cases, wind developers have bought homes from people who could not live with the noise (and apparently could not easily sell on their own). Even one of the authors of the DOE study acknowledged[41] "It is possible that individual homes have been impacted, and frankly, I think it would be a bit silly to suggest otherwise. Human development impacts property values."

How to account for this pattern of a significant minority being dramatically affected?

A complex combination of factors probably contributes to this trend toward a significant minority of people being more affected. Among the possible contributing factors:

- Some may be project-specific, contributing to a cluster of higher annoyance at a given wind during quiet evenings when speeds at hub height are still moderate, but enough to trigger turbines into action.

- Finally, an interesting tidbit popped up in the past couple weeks. At a presentation at an Institute of Acoustics symposium on wind farm noise in Wales, Daryoush Allaei, a Minnesota-based noise control engineer stressed that as wind turbines age, more noise and vibration will result, due to blade mistuning, misalignment, imbalance, resonance, fastener looseness, and damages and defects in bearings and tower structure. He notes that maintenance is often put off for budgetary reasons, but that diligent monitoring and maintenance will be a key to minimizing noise problems around wind farms as they age.

EXHIBIT 4

ORDINANCE NUMBER 4-5-2010

THE TOWN OF HOLLAND WIND ENERGY CONVERSION SYSTEM (WECS) ORDINANCE

(1) No WECS greater than 110 feet in height shall be constructed, operated, or maintained in the Town of Holland without a license issued by the Town of Holland Town Board. Each application for a license to erect a WECS greater than 110 feet in height shall be reviewed on a case-by-case basis by the Town Plan Commission and the Town Board before issuing a license. The license fee for each WECS greater than 110 feet in height shall be calculated at the rate of $2,500.00 per wind turbine proposed in each WECS.

(2) No WECS of 110 feet or less in height, and less than 100 kilowatts shall be constructed, operated, or maintained in the Town of Holland without a conditional use permit issued by the Town of Holland Plan commission. Each application for a license to erect a WECS of 110 feet or less in height and less than 100 kilowatts, shall be reviewed on a case-by-case basis by the Town Plan Commission and the Town Board before issuing a conditional use permit. The conditional use permit fee for each WECS of 110 feet or less in height and less than 100 kilowatts shall be calculated at the rate of $100.00 per wind turbine proposed in each WECS.

(3) The Town of Holland has established standards for purposes of licensing and issuance of conditional use permits applicable to a WECS. These standards are to be used as guidelines for determining whether or not each proposed WECS satisfies reasonable conditions or restrictions, to the extent allowed by the state law, taking into account the health, safety, and general welfare of the public, prior to issuing such licenses or permits. Each applicant shall present arguments and information why the Standards, Guidelines and Rules should or should not apply for the purposes of health, safety, or general welfare of the Town and the immediate locality where the WECS is proposed to be erected.

(4) This ordinance repeals and replaces Article XXII Ordinance #2-2008 of the Town of Holland, Brown County, Wisconsin, Zoning Ordinance relating to regulations of large and small wind energy facilities.

(5) This ordinance shall take effect upon passage and posting or publication as provided by law.

This ordinance was passed and adopted by the Town of Holland on this ______ day of ________________, 2010.

TOWN OF HOLLAND

________________________________	__________________________
Town Chairman	Town Supervisor
________________________________	__________________________
Attest: Town Clerk	Town Supervisor

Published and posted this ______ day of __________________, 2010

TOWN OF HOLLAND

WIND ENERGY LICENSING STANDARDS, GUIDELINES AND RULES

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He also reported that his diary cows used to lay in the pasture along the fence line that now has a turbine in close proximity. The cows now stay close to the barn which is the farthest from the turbine. Wild turkey and white tail deer that previously inhabited the 40 acre wooded parcel his family had hunted for years are no longer there. The farmland owner has developed health issues since the turbines were erected that has affected his farming and recreational routines. He also described the affect it has had on his community. Neighbors and lifelong friends are no longer talking.

(c) Findings Regarding Setback Distances from Wind Turbines:

The Town of Holland concludes that a) the setbacks set forth in the State of Wisconsin 2007 Draft Model Wind Ordinance are not based on empirical evidence relating to health effects and do not adequately protect town residents from the impacts of large wind turbines; and b) a setback of 2,640 feet (1/2 mile) from large wind turbines to the nearest residence or occupied structure is necessary to protect the health and safety of Town of Holland residents, based on the following findings:

1. Minimum setbacks from occupied structures are necessary to mitigate noise impacts not predicted with sound models. Pre-construction sound models fail to accurately predict wind turbine noise impacts due to factors such as atmospheric conditions, temperature inversions, wind layers, geography and low frequency noise which travels further with less loss of intensity than higher frequency noise. In addition, at night when air stabilizes, wind turbine noise can travel further than expected and can be 5-15 db(A) louder than predicted. (See Kamperman & James; Acoustic Ecology Special Report: Wind Energy Noise Impacts 2008)

2. A dBC requirement is need to minimize adverse health effects from low frequency noise. A dBC requirement will likely result in setbacks between large wind turbines and nearby dwellings of 1 km (.62 miles) or greater for 1.5 to 3 MW wind turbines if wind turbines are located in rural areas where L90A background levels are 30 dBA or lower. (See Kamperman & James; WHO 1999; Bajdek Noise-Con 2007; Pedersen and Waye 1/11/2008)

3. Noise diminishes with distance. According to a sound propagation formula in the Wind Turbine Acoustic Noise White Paper by the University of Massachusetts Renewable Energy Research Lab, a SPL of 35 dBA is reached at approximately ½ mile from a wind turbine based on a sound power at 102 dBA at hub height as applied to a 1.5-3 MW wind turbine. Therefore, at a distance of less than a ½ mile, a wind turbine will create a SPL that exceeds safe levels. (See Rogers pg. 18 Figure 11; Burton 2001) While this model of sound propagation is descriptive of the noise generated by the machinery at the hub, the noise produced by the turbine blades is not accounted for in this model and has been found to travel further, which is verified by existing wind turbines. Therefore, this ordinance requires siting based on not only on set-backs, but also on sound studies.

Wind Turbine Sound Propagation at the example of 102 dBA sound power at hub

Distance in Feet	*dBA reduction -6 per doubling of distance*
1	102 dBA
2	96 dBA
4	90 dBA
8	84 dBA
16	78 dBA
32	72 dBA
64	66 dBA
128	60 dBA
256	54 dBA
512	48 dBA
1024	42 dBA
2048	36 dBA
4096	30 dBA
8192	24 dBA
16384	18 dBA
32768	12 dBA
65536	6 dBA
131072	0 dBA

4. The closer people live to wind turbines the more likely they will experience noise annoyance or develop adverse health effects from wind turbine noise. Further, the degree of difficulties resulting from the sound of wind turbines seems clearly related to the distance from the turbines, though the literature has studied a variety of turbine sizes in a variety of locations. A setback of 2640 feet from dwellings would eliminate most noise complaints. Research conducted by Christopher Bajdek showed that at approximately 0.8 km (1/2 mile) from wind turbines, 44% of the population would be considered highly annoyed from wind turbine noise. At a distance of approximately 1.62 km (1 mile) from wind turbines, the percent of highly annoyed people is expected to drop to 4%. George Kamperman and Richard James reviewed several studies to determine the impact of wind turbine noise on nearby residents. Their review showed that some residents living as far as 2 miles complained of sleep disturbance from wind turbine noise and many residents living 1000 feet from wind turbines experienced major sleep disruption and other health problems from nighttime wind turbine noise. G.P. Van den Berg studied a wind farm in northwestern Germany and discovered that residents living 500 m (1640 feet) from the wind turbines reacted strongly to turbine noise and residents up to 1900 m (1.18 miles) distance expressed annoyance. A survey conducted by Pedersen and Waye revealed that less than 10% of the respondents experienced sleep disturbance at distances of 1,984 feet to 3,325 feet and found that the sound from wind was of greater concern in rural environments because of the lower ambient noise. (Bajdek, Noise-Con 2007; Van den Berg 2004; Pedersen & Waye 2/27/08; Kamperman & James)

5. Eye-witnesses from the Town of Byron, Fond du Lac County, who testified at the public hearing held by the joint legislative committee in Madison, WI live 1,100 feet to ¾

mile from large wind turbines and they currently experience adverse health effects from wind turbine noise such as insomnia, headaches, nausea, and dizziness. (See Gerry Meyer's daily log)

6. Documents reviewed recommend wind turbines should be located between ½ mile to over 1 mile from dwellings. To avoid adverse noise impacts, the Western Australia Planning Commission Bulletin recommends that wind energy systems include sufficient buffers or setbacks to dwellings of 1 km (.62 mile). The National Wind Collaborating Committee stated that an appropriate setback distance may be up to ½ mile. The National Research Council stated noise produced by wind turbines generally is not a major concern for humans beyond ½ mile or so because various measures to reduce noise have been implemented in the design of modern turbines. The Wisconsin towns of Union, Woodville, Clay Banks, Magnolia, Wilton and Ridgeville among many others have adopted large wind turbine ordinances with setbacks of 1/2 mile from dwellings. Noise heard at distances exceeding 1 mile from neighboring townships prompted the Town of Forest in Fond Du Lac County to set their setback at 1 mile. The French National Academy of Medicine and UK Noise Association suggest a 1.5 km (approximately 1 mile) distance between large wind turbines and dwellings. Dr. Amanda Harry, Dr. Nina Pierpont, and Frey and Hadden recommend a setback greater than 1 mile. (See UK Noise Association 6/2006; French National academy of Medicine 3/14/2006; reports by Dr. Harry, Dr. Pierpont, Frey and Hadden; NWCC 1998, NRC report 5/2007)

7. Adverse health effects from wind turbine noise can be exacerbated by the rotating blades and shadows from the wind turbines. As wind turbine blades rotate in sunny conditions, they cast strobe-like shadows on the windows of nearby homes and buildings causing shadow flicker that cannot be avoided by occupants. Shadow flicker can cause some people to become dizzy, nauseated or lose their balance when they see the movement of the shadow. Shadow flicker from wind turbines at greater than 3 Hz poses a potential of inducing photosensitive seizures. Therefore, wind turbines should be sited such that shadows from wind turbine blades do not fall upon the windows of nearby dwellings or within 100 feet of dwellings for any considerable period. The Wind Energy Handbook recommends a setback of 10 rotor diameters to avoid shadow flicker on occupied structures, however, shadow flicker has been witnessed at distances well over one mile. (See Acoustic Ecology Institute special report 2008; Burton 2001; UK Noise Association 6/2006, Graham Harding 2008 and Dr. Nina Pierpont 3/2/2006 and 8/11/2006)

8. If placed too close to a road, the movement of the wind turbine blades and resulting shadow flicker can distract drivers and lead to accidents. (See NRC May 2007 report, pg. 263)

9. Wind turbines have been known to throw ice and debris from the turbine blades. According to Professor Terry Matilsky from the Department of Physics and Astronomy at Rutgers University, ice throws from large wind turbines can reach up to a distance of 1750 feet and blade throws can reach 2500 feet.

f. The owner/operator shall be responsible for compliance with all laws applicable to the generation, storage, clean up, transportation and disposal of hazardous wastes generated during any phase of the project's life.

J. Public Roads. Licensee shall, prior to the initiation of construction and use of haul roads, consult with the Town Board, County Highway Commissioner, the Wisconsin State Police and the County Sheriff's Office for load paths and restrictions on their respective roads or bridges. At Licensee's expense:

1. Licensee shall provide the Town Board, a preconstruction evaluation and identification of road surface materials stating the type and amount of surface cover, PASER ratings, and photographic or video documentation of predetermined designated traffic route, performed by a Wisconsin certified professional engineer mutually agreed upon by applicant and municipality.

2. Licensee shall contract with qualified contractors, approved by the town, to repair any damage to the haul roads due to transportation of equipment and Facility components ('Road Repair Obligations').

3. In the event a hazardous road condition exists that is not immediately corrected by Licensee, the Town board may order emergency road repairs be performed by qualified contractors. Licensee shall promptly reimburse the Town for reasonable emergency road repair costs.

4. Licensee shall assure funding of the Road Repair Obligations by a joint escrow account or surety bond of an amount to be determined by the Town Board prior to initiation of any construction.

5. Weather permitting, the final Road Repair Obligations shall be completed to the reasonable satisfaction of the Town Board as soon as weather conditions permit or within six (6) months after completion of construction of the Facility.

K. Shadow Flicker or Blade Glint. WECS shall be designed such that shadow flicker or blade glint will not fall on or in any existing occupied structure or sensitive receptor. Shadow flicker or blade glint expected to fall on a roadway or a portion of a residential parcel may be acceptable under the following circumstances:

1. The flicker or glint will not exceed 10 hours per year.

2. The flicker or glint will fall more than 100 feet from an existing residence.

3. The traffic volumes are less than 500 vehicles per day on the roadway.

4. The flicker or glint shall not fall onto an intersection.

5. If shadow flicker or blade glint exceeds any of the conditions listed in this section, the source WECU shall be shut down until the flicker or glint problem has been remedied.

L. Setbacks. Setbacks shall be measured from the outermost edge of the closest of the circular path of the wind turbine rotor blade. The Town board may increase the following minimum setbacks on a case-by-case basis, in order to protect public health and safety. Minimum setbacks shall be:

1. Property Line: 1.5 times its total height.

2. Public Roads and Highways: 1.5 times its total height.

3. Occupied Structures & Other Sensitive Receptors: 2640 feet (1/2 mile).

4. Wetlands and water bodies: 1320 feet from all sinkholes, wetlands, and navigable water ways.

5. Spacing and Density: Minimum setback distances between turbines shall be two (2) times the total height of each WECU.

M. Signage and Fencing. Licensee shall provide reasonable signage at the Facility, identifying the Premises as being part of the Facility and providing appropriate safety notices and warnings against trespassing. The no trespassing signs shall be posted around the entire premises at an appropriate distance for posting but no less than 2 conspicuous places for every 40 acre parcel within the Facility. Signs should be sized at a minimum to meet the provisions of Wis. Stat. 943.013(2).

1. No wind turbine, tower, building, or other structure associated with a wind energy system may be used to advertise or promote any product or service. No word or graphic representation, other than appropriate warning signs and owner or landowner identification, may be placed on a wind turbine, tower, building, or other structure associated with a wind energy system so as to be visible from any public road.

2. 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.

N. Electrical Standards. All wiring between Wind turbines and the Wind Energy Facility substation shall be underground. All neutral grounding connectors from commercial Wind Turbines shall be insulated from the earth and shall be sized to accommodate at least twice the peak load of the highest phase conductor, to absolutely prevent transient ground currents, in order to comply with the National Electric Safety Code and the IEEE Standard 519-1992, approved by the American National Standards Institute, as follows:

EXHIBIT 5

Siting of Wind Farms: Basic Aspects

When searching the internet for the definition of the word "layout" I came across following:

Layout in word processing and desktop publishing refers to the arrangement of text and graphics. The layout of a document can determine which points are emphasised and whether the document is aesthetically pleasing. While no computer program can substitute for a professional layout artist, a powerful desktop publishing tool can make it easier to lay out professional looking documents (source: www.webopedia.com)

In principle the same is valid for wind farm planning: The term layout in wind industry is used for choosing optimal locations for wind turbines. Tools like flow models help to identify the best positions, but cannot replace the engineer making the final decision by balancing interests.

So what is that engineering experience, what factors influence the decision?

Jessica Rautenstrauch, wind energy consultant from Anemos, Germany, at work.
© Paul Langrock (www.unendlich-viel-energie.de)

Wind resource

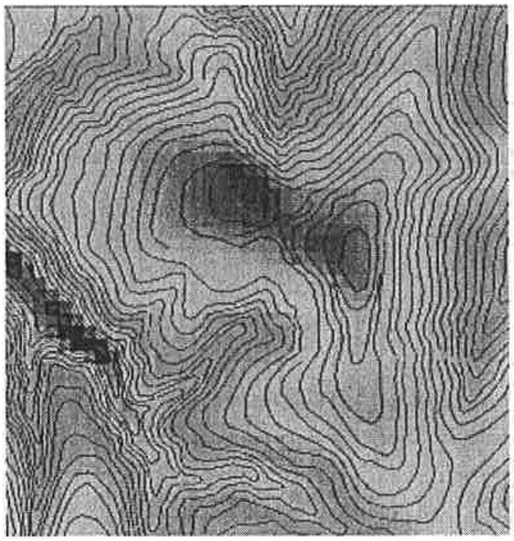
The wind resource is the most obvious factor to concentrate on when choosing a wind turbine location. We have a wide range of options to determine the wind resource of the site. The quality of the tools varies significantly and so does their price.

Common sense is a good starting point. Nature itself helps to guide us to suitable sites. Flagging of trees – permanent flagging and not the temporary bending in the wind – shows us the prevailing wind direction and is a good indicator for the strength of the wind.

However because of the uncertainty involved, using common sense as the only tool is of course insufficient. For any bankable estimate of the energy yield on-site wind speed measurements are required. The number of measurement masts required for a specific site depends next to the size of the project mainly on the complexity of the terrain. The measurement height should be minimum 2/3 of the expected future hub height. An increase in measurement height beyond this leads to a reduction of the uncertainty in the energy estimate. The measurement period must be one year or more to avoid any seasonal bias. Since the wind speed varies also inter-annually typically up to +/-12% a long-term correction is highly recommended.

The measured wind regime is extrapolated across the site to derive a resource map of the site using different flow models /4, 5/. A wind map like the one in Graph 1 can then be used to identify the windiest locations.

However additionally technical constraints should be taken into account when developing a layout /3/. A number of site specific wind load parameters can be extracted from the wind speed measurement. They are used to optimize the technical suitability of the chosen layout and the wind turbine type for the site specific wind regime.



Graph 1: Example Wind Resource Map. The colours denote the energy content of the wind, red high and blue low energy content.

Technical restrictions

Wind turbines are designed for specific conditions. During the construction and design phase assumptions are made about the wind climate that the wind turbines will be exposed to. In rough terms: For very complex sites with high wind speeds "heavy-duty" versions of wind turbines are available, which are sturdier but also more costly. Low wind speed sites in flat terrain do not put so high demands on the on the wind turbine structure, hence the construction can be more light-weight and hence cheaper. The different turbines have been classified by the IEC, class 1 being the highest wind speed class. The following table is a simplified summary of the IEC classification /1/.

IEC class	I	II	III	IV
V_{ave} (m/s) annual average wind speed at hub height	10	8.5	7.5	5
V_{ref} (m/s) 50-year maximum 10-minute wind speed	50	42.5	37.5	30

Table 1: IEC classes

But not only the wind speed but also other parameters play a role and have to be checked, when developing a layout for a specific turbine.

One of the most important parameters is the turbulence intensity. Turbulence intensity quantifies how much the wind varies typically within 10 minutes. Because the fatigue loads of a number of major components in a wind turbine are mainly caused by turbulence, the knowledge of how turbulent a site is of crucial importance.

We have to distinguish between two different sources of turbulence. Turbulence is generated by terrain features – which is referred to as ambient turbulence intensity - as well as by neighbouring wind turbines – which referred to as induced turbulence (Figure 1). Sources of ambient turbulence are for example forests, hills, cliffs or thermal effects. Thus ambient turbulence can be reduced by avoiding critical terrain features. But the wake-induced turbulence has far more impact than the ambient turbulence intensity /2/. Decreasing the spacing increases the turbulence induced by the wakes of neighbouring wind turbines meaning that there are limits to how close you can space the turbines. As a general rule the distance between wind turbines in prevailing wind direction should be a minimum of the equivalent of five rotor diameters. The spacing inside a row perpendicular to the main wind direction should be a minimum of three rotor diameters.

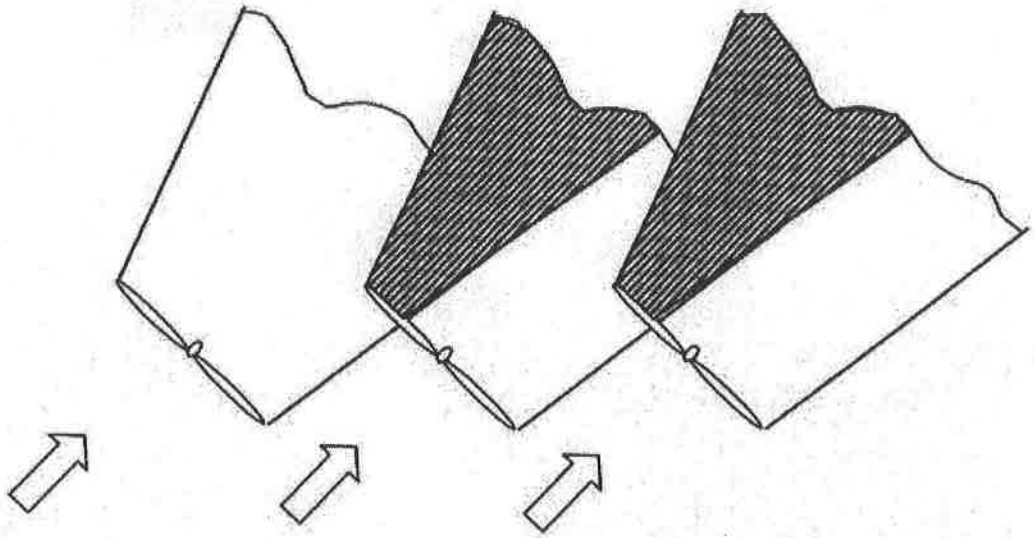


Figure 1: Shadowing in wind farm

If a layout is too close the resulting fatigue loads might be too high. In order to then ensure the lifetime of the main components wind sector management might have to be applied, meaning that some wind turbines might have to be switched off when they are operating in the wake of the neighbouring wind turbine.

Another parameter which has to be checked when developing a layout is the flow inclination, velocity tilt or in-flow angle. When wind turbines are to be placed on steep slopes or cliffs the wind might hit the rotor not perpendicular but at an angle. This angle is related to the terrain slope. With increasing height above ground level the effect of the terrain slope is normally reduced such that the terrain slope is only of indicative use to estimate the velocity tilt. A large in-flow angle will not only reduce the energy production but will also lead to an increased level of fatigue of some of the mayor components.

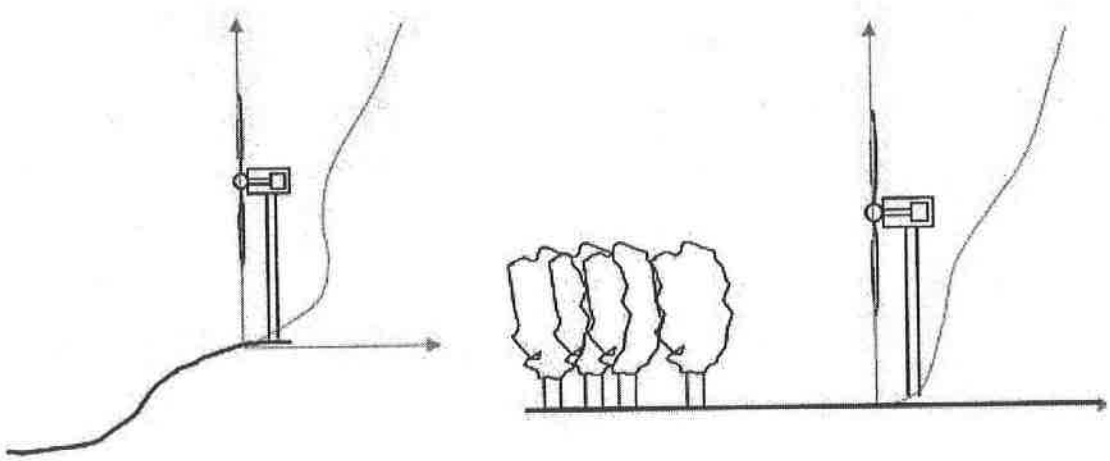


Figure 2: Distorted wind profile at steep slope (left) and behind a forest (right)

Furthermore a steep slope might cause a negative gradient across some parts of the rotor (Figure 2).

Normally the wind speed increases with increasing height. In flat terrain the wind speed increases logarithmically with height. In complex terrain the wind profile is not a simple increase and additionally a separation of the flow might occur, leading to heavily increased turbulence. The resulting wind speed gradients across the rotor lead to high fatigue loads particularly on the yaw system.

Obstacles like forest can have a similar effect on the wind profile and should be thus avoided.

Planning constraints

Next to the wind resource and technical considerations a good layout should also take planning constraints into account. The visual impact is course the most obvious. A layout that follows the shape of the terrain rather than straight rows of wind turbines appears to be less intrusive. Noise is another important parameter to take into account. Next to noise also the impact due to flicker at the nearest inhabited houses should be estimated. The accepted levels vary from country to country.

Electro-magnetic interference can cause problems. Hence placing wind turbines in a transmission corridor should be avoided.

Some areas on site might have to be excluded from development due to other factors related to fauna, flora and archaeology.

Jessica Rautenstrauch, wind energy consultant from Anemos, Germany, at work.
© Paul Langrock (www.unendlich-viel-energie.de)

Summary

A large number of parameters have to be taken into account when developing a layout. Some work can be done using tools, but in the end the balance between financial, technical and planning constraints can be best done by an experiences engineer.

Literature

/1/ IEC 61400-1, Ed.2 – Wind Turbine Generator Systems – Part 1: Safety Requirements, FDIS 998
/2/ S. Frandsen, St.; L. Thøgersen, L.;: Integrated Fatigue Loading for Wind Turbines in Wind Farms by Combining Ambient Turbulence and Wakes; Wind Engineering, Vol. 23 No. 6, 1999
/3/ K. Kaiser, W. Langreder: Site Specific Wind Parameter and their Effect on Mechanical Loads, Proceedings EWEC, Copenhagen, 2001
/4/ E.rik L. Petersen, N. G. Mortensen, L. Landberg, J. Højstrup and H. Frank: (, Wind Power Meteorology Part I: Climate and Turbulence, Wind Energy, 1, 25-45 (1998), Risø-I-1206, 1997
/5/ E. L. Petersen, N. G. Mortensen, L. Landberg, J. Højstrup and H. Frank: Wind Power Meteorology Part II: Siting and Models, Wind Energy, 1, 55-72 (1998)

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EXHIBIT 6

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This document has been prepared by Terry Matilsky, Professor of Physics at Rutgers University. For almost 40 years, he has been funded by NASA and other federal agencies to do data analysis from various scientific satellites; to examine what information tells us about a phenomena, and draw rational and solid, scientific conclusions from them.

In the course of his career, he has testified on several occasions as an expert witness concerning various laws of physics and their environmental effects, most recently in March, 2005, when he was requested to appear in front of the Vermont Public Service Board concerning matters of ice throw from Wind Turbines. His CV appears at the end of this paper as Appendix A.

As problems have developed from world-wide installations of large scale wind turbine generators, study has begun on many previously ignored environmental and health concerns. These studies have yielded much data that can be used to assess the impact of proposed installations, and thus assure that these installations be sited correctly, with due understanding of the potential negative effects that such installations will entail. They come primarily from universities, where there is less economic incentive to overlook potentially important phenomena.

Being able to calculate sound levels and probabilities of ice throw from physical models is a huge advantage over doing measurements, but a physical model is never the same as reality. If the model is incorrect, large discrepancies can exist between what is measured and what is predicted. This is the case with wind turbine sound, where very relevant atmospheric and climatic behavior has been 'overlooked'.

The following is a detailed appraisal of Ecogen's section **3.7 Noise impacts** and section **3.10.1 Ice Shedding**. For your convenience, I am presenting each comment that requires an answer with a sequential number and a bullet, to aid in your preparation of responses. For noise impacts, there are **28 POINTS** needing action, and for ice shedding there are **6 POINTS** needing action, for a total of **34 POINTS** requiring action.

ANALYSIS OF ICE AND ROTOR THROW FROM WIND TURBINES

PART I---basic kinematics

The calculation provided below demonstrates that:

ICE, DEBRIS OR ANYTHING BREAKING OFF THE WIND TURBINE BLADES (including the blades themselves) CAN IMPACT A POINT ALMOST 1700 FEET AWAY FROM THE BASE OF THE TURBINE… This is dependent on which model wind turbine you examine. Details follow using parameters from GE wind turbines that Ecogen is proposing.

WHAT WE KNOW:

RADIUS OF BLADE: OVER 100 FEET
ROTATIONAL SPEED: UP TO 1 REVOLUTION EVERY 3 SECONDS (OR ABOUT 20 REV/MIN)

PRELIMINARY RESULTS:

ROTOR TIP SPEED:

> IN ONE REVOLUTION, THE BLADE TIPS SWEEP OUT A CIRCLE WHOSE RADIUS IS OVER 100 FEET. THIS DISTANCE IS $2\pi R$ OR ABOUT 628 FEET. IF IT TAKES 3 SECONDS TO MOVE THIS DISTANCE, OUR SPEED IS 628/3 FEET PER SECOND. THIS IS ABOUT 210 FEET/SECOND OR 150 MPH.

When you do the mathematics in detail, you find that launching the fragment horizontally is NOT the worst case scenario for maximum horizontal range. (LAUNCHING FROM THE TOP OF THE TURBINE (horizontally) YIELDS A RANGE OF SLIGHTLY MORE THAN 1000 FEET.) Instead, this maximum distance occurs when debris is released with the blade at a 45 degree angle from the vertical.

Imagine the blade at 45 degrees from its vertical position. At this point, the projectile will be launched about 70 ft. from the horizontal position of the hub. (This is 100 times the cosine of 45 degrees). Also, it will be about 70 feet higher (vertically) than the hub.

(Again, we assume that the blades are 100 ft. in length). Thus, the vertical distance it has to fall is 300 feet (hub height) plus 70 feet (vertical distance that the piece of ice, or whatever, is from the hub).
Now, the range for this projectile is:

$R= v^2/g$

This is the range to come back down to the ORIGINAL vertical height. So after this distance, it is BACK at 370 feet off the ground.

R=(210 ft/sec x 210 ft/sec)/(32ft/sec/sec). or about 1400 ft.

Now, at this position, (neglecting air resistance), its vertical velocity is the same as when it was launched (except that it's now going DOWN instead of up). So, the vertical velocity is about 140 ft/sec. (210 x .7 or v cos 45)

The extra time it takes to fall to the ground from this height is:

$s= vt + 1/2\ g\ t^2$.

SO,
$370=140\ t + 16\ t^2$

Solving for t, we get about 2.5 seconds. In 2.5 seconds the increase in the range is:

v(horizontal) • t =140 x 2.5 ≈350 feet.

Thus, the TOTAL range of a projectile is: 1400 + 350 = 1750 feet. From this we subtract the 70 feet that the projectile was behind the hub when it was launched, and you end up with 1680 feet for the horizontal range from the base of the hub.

PART II---comments on inclusions of drag coefficients and risk assessment

1) Friction is NOT a fundamental force. What this means in practice is that any attempt to take into account air resistance in a description of ice throw can be fraught with model dependent errors. The drag coefficient usually quoted in wind developers' "papers" of 1.0 is totally inappropriate for the study. Variability in the Reynolds number is completely ignored. They assume a perfect ice cube of size = 4 inches. Then, they assume it always tumbles. But these are chunks of ice that are forming on propeller blades! Ice that forms on propeller blades tends to be shaped like propeller blades. And they can be QUITE aerodynamic (as are the blades). Any models employing ice cubes are at best, useless, and at worst, deceptive. Interestingly, when the chunks become larger, the Reynolds number increases, and viscosity becomes less important. What this

means is that the larger, more dangerous chunks will tend to travel further than small ones.

Moreover, the study of "harvested" ice that is subjected to wind tunnel testing is likewise demonstrably without merit. The procedure is to break off chucks of ice, make molds, and then subject them to wind tunnel tests. But real ice melts. It changes shape. It becomes smoother. The "studies" ignore this, instead adopting a drag coefficient = 1.0 This is close to the drag that a half a tennis ball (say) would present if it were thrown into the wind with the open "cup" catching the wind at all times! A rather silly assumption, and one that is totally inappropriate. Ice is NOT like this. While the developers tout their results as being representative (decidedly untrue), they ignore MacQueen's 1983 study that concluded that a maximum range of 800m (about 2500 feet) was quite possible. Indeed, even a range of 2 km. (over one mile) was conceivable. Developers discount this because he "assumed that the ice 'fragments' were actually large flat slabs weighing perhaps 80 kg." Actually, he was modeling BLADE throw, another issue that seems to be ignored despite the fact that within the past year there has been at least one documented instance of this; an entire rotor blade broke off from the hub. (Wethersfield, N. Y.) Incidentally, as near as I can tell, the MacQueen study is the ONLY peer reviewed analysis for throw possibilities. The rest are calculations done by wind company employees and/or consultants.

2) I never claim my calculation to be anything other than a maximum calculation of distance, beyond which you don't have to worry. I am not usually accused of being conservative in many ways, but when it comes to human life, I suppose I am. Why worry when you can just adopt my calculation and not be concerned at all with tragedy in the future? Moreover, any risk assessment data is useless, since the calculations are not assuming an appropriate model to begin with! I remember when de-icing airplane wings was said to be unnecessary, posing no risk to public safety, and only after tragedy struck is it now "de rigeur" to do it (and do it carefully and thoroughly). All other mumbo jumbo is exactly that unless they get the basic physics right.

3) If you are going to invoke air, and air resistance, it is the height of deception not to include the effects of lift. Frisbees fly far. Why? Because of air. If you throw a frisbee facing the direction of travel, it will travel only a few feet. The drag coefficient is probably of order unity in this situation. If you sling it in the direction of travel, it goes very far. And rime ice, of course, will likely be shed from the rotors in a similar aerodynamic fashion. The wind companies assume that the fragment will tumble; thin blades of ice may not (as a frisbee does not, when properly oriented).

4) Throughout these discussions, the wind developers have been groping for setback distances that they can live with. They started with 1.5 times the ground-tip distance: about 150m. As near as I can tell, this was just pulled out of a hat. (In physics, we call this a "toy model".) Then, the distance was increased to 200m. in several " papers." Now, in a recent " paper", 400m is quoted. They are getting closer to my original number!

What about data? If you refer to the Atlantic Wind Test Site memo of March 27, 2002, they state:
"Summary---Following the moderate wind icing event at AWTS on March 27, 2002, fragments of ice, large enough to cause injury, have been observed being thrown from the turbine blades. Concerns over dangers of flying ice are legitimate. In 15 m/s winds, ice was observed to travel approximately 200m." Instead of recognizing this, companies present a figure from an utterly useless and anecdotal "questionnaire" that purports to show that ice throw is "unlikely" more than 100 meters from the site. This figure is a completely misleading representation of "data" that has been bandied about for years by developers.

5) In the beginning, the claim was that the rotor sensors would stop the blades because of ice buildup. Now, even the papers put forward by the companies admit their error here. They state: "...rime ice formation appears to occur with remarkable symmetry on all turbine blades with the result that no imbalance occurs and the turbine continues to operate." Another failure of their initial assumptions and models.

In conclusion, there are some problems with wind turbines that have unavoidable consequences. Birds will die, bats will die. In these scenarios you NEED to adopt a risk analysis study. But here, YOU CAN ELIMINATE THE ENTIRE PROBLEM, if you just adopt a conservative value for your setbacks.

REFERENCE: J. F. MacQueen, et. al, IEE Proceedings, Vol. 130, Pt. A, No. 9, pp. 574-586 (1983).

EXHIBIT 7

Dearborn, Michigan

NOISE-CON 2008

2008 July 28-31

Simple guidelines for siting wind turbines to prevent health risks[1]

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Revision: 1.0

Industrial scale wind turbines are a familiar part of the landscape in Europe, U.K. and other parts of the world. In the U.S., however, similar industrial scale wind energy developments are just beginning operation. The presence of industrial wind projects will increase dramatically over the next few years given the push by the Federal and state governments to promote renewable energy sources through tax incentives and other forms of economic and political support. States and local governments in the U.S. are promoting what appear to be lenient rules for how industrial wind farms can be located in communities, which are predominantly rural and often very quiet. Studies already completed and currently in progress describe significant health effects associated with living in the vicinity of industrial grade wind turbines. This paper reviews sound studies conducted by consultants for governments, the wind turbine owner, or the local residents for a number of sites with known health or annoyance problems. The purpose is to determine if a set of simple guidelines using dBA and dBC sound levels can serve as the 'safe' siting guidelines. Findings of the review and recommendations for sound limits will be presented. A discussion of how the proposed limits would have affected the existing sites where people have demonstrated pathologies apparently related to wind turbine sound will also be presented.

Background

A relatively new source of community noise is spreading rapidly across the rural U.S. countryside. Industrial grade wind turbines, a common sight in many European countries, are now being promoted by Federal and state governments as the way to minimize coal powered electrical energy and its effects on global warming. But, the initial developments using the newer 1.5 to 3 MWatt wind turbines here in the U.S. has also led to numerous

---

complaints from residents who find themselves no longer in the quiet rural communities they were living in before the wind turbine developments went on-line. Questions have been raised about whether the current siting guidelines being used in the U.S. are sufficiently protective for the people living closest to the developments. Research being conducted into the health issues using data from established wind turbine developments is beginning to appear that supports the possibility there is a basis for the health concerns. Other research into the computer modeling and other methods used for determining the layout of the industrial wind turbine developments and the distances from residents in the adjacent communities are showing that the output of the models should not be considered accurate enough to be used as the sole basis for making the siting decisions.

The authors have reviewed a number of noise studies conducted in response to community complaints for wind energy systems sited in Europe, Canada, and the U.S. to determine if additional criteria are needed for establishing safe limits for industrial wind turbine sound immissions in rural communities. In several cases, the residents who filed the complaints have been included in studies by medical researchers who are investigating the potential health risks associated with living near industrial grade wind turbines 365 days a year. These studies were also reviewed by the authors to help in identifying what factors need to be considered in setting criteria for 'safe' sound limits at receiving properties. Due to concerns about medical privacy, details of these studies are not discussed in this paper. Current standards used in the U.S. and in most other parts of the world rely on not-to-exceed dBA sound levels, such as 50 dBA, or on not-to-exceed limits based on the pre-construction background sound level plus an adder (e.g. L_{90A} + 5 dBA).

Our review covered the community noise studies performed in response to complaints, research on health issues related to wind turbine noise, critiques of noise studies performed by consultants working for the wind developer, and research/technical papers on wind turbine sound immissions and related topics. The papers are listed in Tables 1-4.

Table 1-List of Studies Related to Complaints

Resource Systems Engineering, Sound Level Study – Ambient & Operations Sound Level Monitoring, Maine Department of Environmental Protection Order No. L-21635-26-A-N, June 2007
ESS Group, Inc., Draft Environmental Impact Statement For The Dutch Hill Wind Power Project – Town of Cohocton, NY, November 2006
David M. Hessler, Environmental Sound Survey and Noise Impact Assessment – Noble Wethersfield Wind park – Towns of Wethersfield and Eagle NY For: Noble Environmental Power, LLC January 2007
George Hessler, "Report Number 101006-1, Noise Assessment Jordanville Wind Power Project," October 2006
HGC Engineering, "Environmental Noise Assessment Pubnico Point Wind Farm, Nova Scotia, Natural Resources Canada Contract NRCAN-06-0046," August 23, 2006
John I. Walker, Sound Quality Monitoring, East Point, Prince Edward Island" by Jacques Whitford, Consultants for Prince Edward Island Energy Corporation, May 28, 2007

and sleep deprivation - how wind turbines inappropriately placed can act collectively and destroy rural quietitude," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
James D. Barnes, "A Variety of Wind Turbine Noise Regulations in the United States - 2007," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
M. Schwartz and D. Elliott, Wind Shear Characteristics at Central Plains Tall Towers, NREL 2006
IEC 61400 "Wind turbine generator systems, Part 11: Acoustic noise measurement techniques,".rev:2002

Discussion

After reviewing the materials in the tables; we have arrived at our current understanding of wind turbine noise and its impact on the host community and its residents. The review showed that some residents living as far as 3 km (two (2) miles) from a wind farm complain of sleep disturbance from the noise. Many residents living one-tenth this distance (300 m. or 1000 feet) from a wind farm are experiencing major sleep disruption and other serious medical problems from nighttime wind turbine noise. The peculiar acoustic characteristics of wind turbine noise immissions cause the sounds heard at the receiving properties to be more annoying and troublesome than the more familiar noise from traffic and industrial factories. Limits used for these other community noise sources do not appear to be appropriate for siting industrial wind turbines. The residents who are annoyed by wind turbine noise complain of the approximately one (1) second repetitive swoosh-boom-swoosh-boom sound of the turbine blades and "low frequency" noise. It is not apparent to these authors whether the complaints that refer to "low frequency" noise are about the audible low frequency part of the swoosh-boom sound, the one hertz amplitude modulation of the swoosh-boom sound, or some combination of both acoustic phenomena.

To assist in understanding the issues at hand, the authors developed the 'conceptual' graph for industrial wind turbine sound shown in Figure 1. This graph shows the data from one of the complaint sites plotted against the sound immission spectra for a modern 2.5 MWatt wind turbine; Young's threshold of perception for the 10% most sensitive population (ISO 0266); and a spectrum obtained for a rural community during a three hour, 20 minute test from 11:45 pm until 3:05 am on a windless June evening in near Ubly, Michigan a quiet rural community located in central Huron County. (Also called: Michigan's Thumb.) It is worth noting that this rural community demonstrates how quiet a rural community can be when located at a distance from industry, highways, and airport related noise emitters.

During our review we posed a number of questions to ourselves related to what we were learning. The questions (italics) and our answers are:

Do National or International or local community Noise Standards for siting wind turbines near dwellings address the low frequency portion of the wind turbine's sound immissions?[2] No! State and Local governments are in the process of establishing wind farm noise limits and/or

[2] Emissions refer to acoustic energy from the 'viewpoint' of the sound emitter, while immissions refer to acoustic energy from the viewpoint of the receiver.

EXHIBIT 8

GUIDELINES

FOR

COMMUNITY NOISE

Edited by

Birgitta Berglund
Thomas Lindvall
Dietrich H Schwela

This WHO document on the *Guidelines for Community Noise* is the outcome of the WHO- expert task force meeting held in London, United Kingdom, in April 1999. It bases on the document entitled "Community Noise" that was prepared for the World Health Organization and published in 1995 by the Stockholm University and Karolinska Institute.

World Health Organization, Geneva
Cluster of Sustainable Development and Healthy Environment (SDE)
Department of the Protection of the Human Environment (PHE)
Occupational and Environmental Health (OEH)

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messages (at school, listening to foreign languages, telephone conversation), it is recommended that the signal-to-noise ratio should be at least 15 dBA. Thus, with a speech level of 50 dBA, (at 1 m distance this level corresponds to a casual speech level of both women and men), the sound pressure level of interfering noise should not exceed 35 dBA. For vulnerable groups even lower background levels are needed. If it is not possible to meet the strictest criteria for vulnerable persons in sensitive situations (e.g. in classrooms), one should strive for as low background levels as possible.

3.4. Sleep Disturbance

Uninterrupted sleep is known to be a prerequisite for good physiological and mental functioning of healthy persons (Hobson 1989); sleep disturbance, on the other hand, is considered to be a major environmental noise effect. It is estimated that 80-90% of the reported cases of sleep disturbance in noisy environments are for reasons other than noise originating outdoors. For example, sanitary needs; indoor noises from other occupants; worries; illness; and climate (e.g. Reyner & Horne 1995). Our understanding of the impact of noise exposure on sleep stems mainly from experimental research in controlled environments. Field studies conducted with people in their normal living situations are scarce. Most of the more recent field research on sleep disturbance has been conducted for aircraft noise (Fidell et al. 1994 1995a,b 1998; Horne et al. 1994 1995; Maschke et al. 1995 1996; Ollerhead et al. 1992; Passchier-Vermeer 1999). Other field studies have examined the effects of road traffic and railway noise (Griefahn et al. 1996 1998).

The primary sleep disturbance effects are: difficulty in falling asleep (increased sleep latency time); awakenings; and alterations of sleep stages or depth, especially a reduction in the proportion of REM-sleep (REM = rapid eye movement) (Hobson 1989). Other primary physiological effects can also be induced by noise during sleep, including increased blood pressure; increased heart rate; increased finger pulse amplitude; vasoconstriction; changes in respiration; cardiac arrhythmia; and an increase in body movements (cf. Berglund & Lindvall 1995). For each of these physiological effects, both the noise threshold and the noise-response relationships may be different. Different noises may also have different information content and this also could affect physiological threshold and noise-response relationships (Edworthy 1998).

Exposure to night-time noise also induces secondary effects, or so-called after effects. These are effects that can be measured the day following the night-time exposure, while the individual is awake. The secondary effects include reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance (Öhrström 1993a; Passchier-Vermeer 1993; Carter 1996; Pearsons et al. 1995; Pearsons 1998).

Long-term effects on psychosocial well-being have also been related to noise exposure during the night (Öhrström 1991). Noise annoyance during the night-time increased the total noise annoyance expressed by people in the following 24 h. Various studies have also shown that people living in areas exposed to night-time noise have an increased use of sedatives or sleeping pills. Other frequently reported behavioural effects of night-time noise include closed bedroom windows and use of personal hearing protection. Sensitive groups include the elderly, shift workers, persons especially vulnerable to physical or mental disorders and other individuals with sleeping difficulties.

Questionnaire data indicate the importance of night-time noise on the perception of sleep quality. A recent Japanese investigation was conducted for 3 600 women (20–80 years old) living in eight roadside zones with different road traffic noise. The results showed that four measures of perceived sleep quality (difficulty in falling asleep; waking up during sleep; waking up too early; feelings of sleeplessness one or more days a week) correlated significantly with the average traffic volumes during night-time. An in-depth investigation of 19 insomnia cases and their matched controls (age,work) measured outdoor and indoor sound pressure levels during sleep (Kageyama et al. 1997). The study showed that road traffic noise in excess of 30 dB LAeq for nighttime induced sleep disturbance, consistent with the results of Öhrström (1993b).

Meta-analyses of field and laboratory studies have suggested that there is a relationship between the SEL for a single night-time noise event and the percentage of people awakened, or who showed sleep stage changes (e.g. Ollerhead et al. 1992; Passchier-Vermeer 1993; Finegold et al. 1994; Pearsons et al. 1995). All of these studies assumed that the number of awakenings per night for each SEL value is proportional to the number of night-time noise events. However, the results have been criticized for methodological reasons. For example, there were small groups of sleepers; too few original studies; and indoor exposure was estimated from outdoor sound pressure levels (NRC-CNRC 1994; Beersma & Altena 1995; Vallet 1998). The most important result of the meta-analyses is that there is a clear difference in the dose-response curves for laboratory and field studies, and that noise has a lower effect under real-life conditions (Pearsons et al. 1995; Pearsons 1998).

However, this result has been questioned, because the studies were not controlled for such things as the sound insulation of the buildings, and the number of bedrooms with closed windows. Also, only two indicators of sleep disturbance were considered (awakening and sleep stage changes). The meta-analyses thus neglected other important sleep disturbance effects (Öhrström 1993b; Carter et al. 1994a; Carter et al. 1994b; Carter 1996; Kuwano et al. 1998). For example, for road traffic noise, perceived sleep quality is related both to the time needed to fall asleep and the total sleep time (Öhrström & Björkman 1988). Individuals who are more sensitive to noise (as assessed by different questionnaires) report worse sleep quality both in field studies and in laboratory studies.

A further criticism of the meta-analyses is that laboratory experiments have shown that habituation to night-time noise events occurs, and that noise-induced awakening decreases with increasing number of sound exposures per night. This is in contrast to the assumption used in the meta-analyses, that the percentage of awakenings is linearly proportional to the number of night-time noise events. Studies have also shown that the frequency of noise-induced awakenings decreases for at least the first eight consecutive nights. So far, habituation has been shown for awakenings, but not for heart rate and after effects such as perceived sleep quality, mood and performance (Öhrström and Björkman 1988).

Other studies suggest that it is the difference in sound pressure levels between a noise event and background, rather than the absolute sound pressure level of the noise event, that determines the reaction probability. The time interval between two noise events also has an important influence of the probability of obtaining a response (Griefahn 1977; *cf.* Berglund & Lindvall 1995). Another possible factor is the person's age, with older persons having an increased probability of awakening. However, one field study showed that noise-induced awakenings are independent of age (Reyner & Horne 1995).

For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB LAmax more than 10–15 times per night (Vallet & Vernet 1991), and most studies show an increase in the percentage of awakenings at SEL values of 55–60 dBA (Passchier-Vermeer 1993; Finegold et al. 1994; Pearsons et al. 1995). For intermittent events that approximate aircraft noise, with an effective duration of 10–30 s, SEL values of 55–60 dBA correspond to a LAmax value of 45 dB. Ten to 15 of these events during an eight-hour night-time implies an LAeq,8h of 20–25 dB. This is 5–10 dB below the LAeq,8h of 30 dB for continuous night-time noise exposure, and shows that the intermittent character of noise has to be taken into account when setting night-time limits for noise exposure. For example, this can be achieved by considering the number of noise events and the difference between the maximum sound pressure level and the background level of these events.

Special attention should also be given to the following considerations:

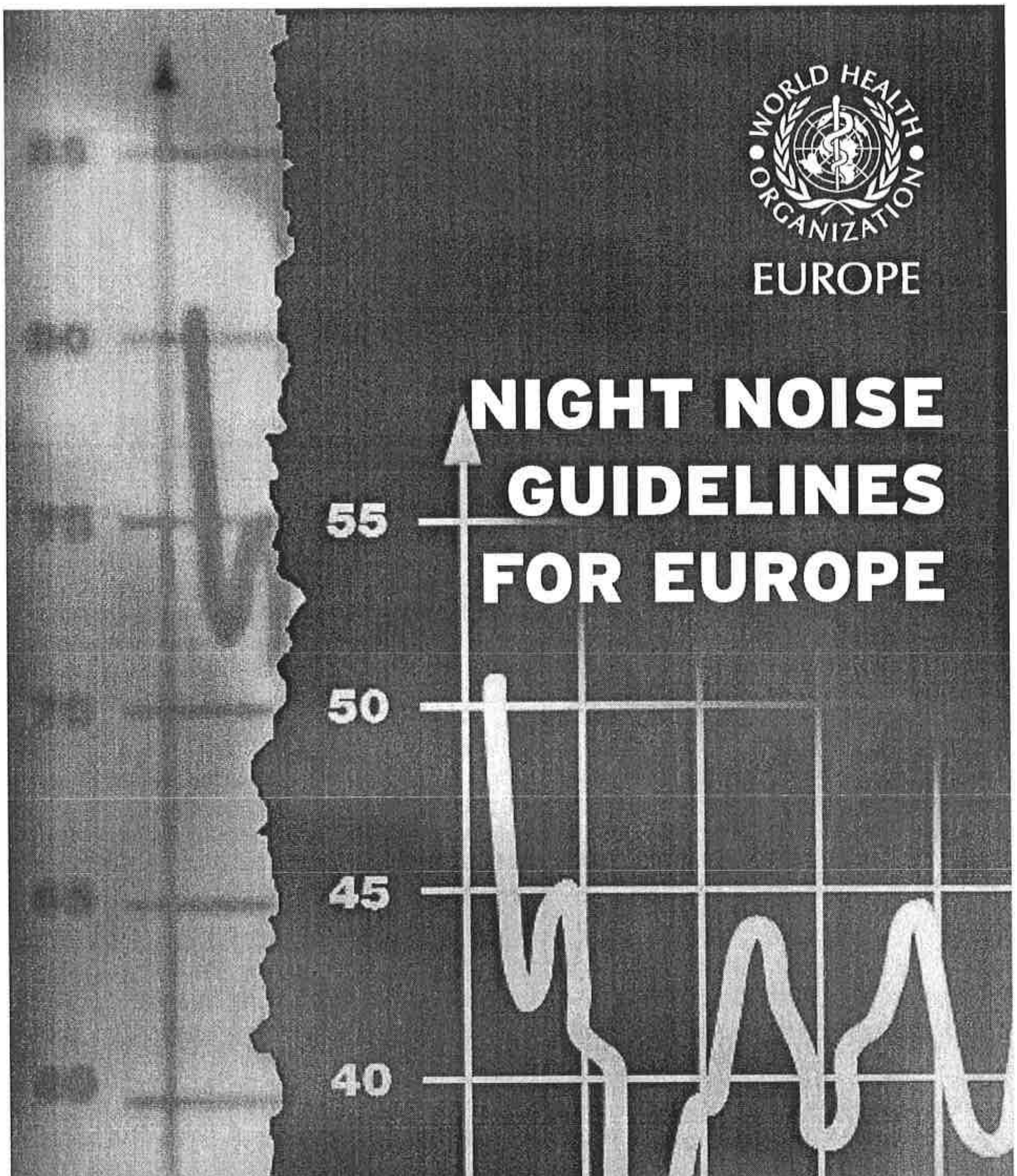
a. Noise sources in an environment with a low background noise level. For example, night-traffic in suburban residential areas.

b. Environments where a combination of noise and vibrations are produced. For example, railway noise, heavy duty vehicles.

c. Sources with low-frequency components. Disturbances may occur even though the sound pressure level during exposure is below 30 dBA.

If negative effects on sleep are to be avoided the equivalent sound pressure level should not exceed 30 dBA indoors for continuous noise. If the noise is not continuous, sleep disturbance correlates best with LAmax and effects have been observed at 45 dB or less. This is particularly true if the background level is low. Noise events exceeding 45 dBA should therefore be limited if possible. For sensitive people an even lower limit would be preferred. It should be noted that it should be possible to sleep with a bedroom window slightly open (a reduction from outside to inside of 15 dB). To prevent sleep disturbances, one should thus consider the equivalent sound pressure level and the number and level of sound events. Mitigation targeted to the first part of the night is believed to be effective for the ability to fall asleep.

EXHIBIT 9



NIGHT NOISE GUIDELINES FOR EUROPE

WORLD HEALTH ORGANIZATION
EUROPE

NIGHT NOISE GUIDELINES FOR EUROPE

Keywords

NOISE - ADVERSE EFFECTS - PREVENTION AND CONTROL

SLEEP DEPRIVATION - ETIOLOGY

SLEEP DISORDERS - PREVENTION AND CONTROL

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GUIDELINES

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Edited by Charlotte Hurtley, Layout by Dagmar Bengs

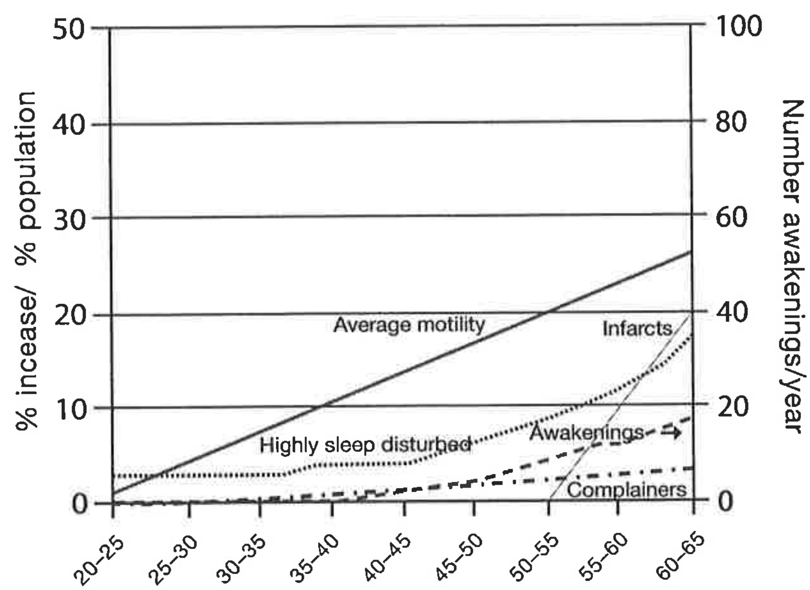

Fig. 4 Effects of aircraft noise at night*

**Average motility and infarcts are expressed in percent increase (compared to baseline number); the number of highly sleep disturbed people is expressed as a percent of the population; complainers are expressed as a % of the neighbourhood population; awakenings are expressed in number of additional awakenings per year.*

source dependent. Although L_{night} gives a good relation for most effects, there is a difference between sources for some. Train noise gives fewer awakenings, for instance. Once source is accounted for, the relations are reasonably accurate.

RECOMMENDATIONS FOR HEALTH PROTECTION

Based on the systematic review of evidence produced by epidemiological and experimental studies, the relationship between night noise exposure and health effects can be summarized as below. (Table 3)

Below the level of 30 dB $L_{night,outside}$, no effects on sleep are observed except for a slight increase in the frequency of body movements during sleep due to night noise. There is no sufficient evidence that the biological effects observed at the level below 40 dB $L_{night,outside}$ are harmful to health. However, adverse health effects are observed at the level above 40 dB $L_{night,outside}$, such as self-reported sleep disturbance, environmental insomnia, and increased use of somnifacient drugs and sedatives.

Therefore, 40 dB $L_{night,outside}$ is equivalent to the lowest observed adverse effect level (LOAEL) for night noise. Above 55 dB the cardiovascular effects become the major public health concern, which are likely to be less dependent on the nature of the noise. Closer examination of the precise impact will be necessary in the range between 30 dB and 55 dB as much will depend on the detailed circumstances of each case.

Table 3
Effects of different levels of night noise on the population's health

Average night noise level over a year $L_{night,outside}$	Health effects observed in the population
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

A number of instantaneous effects are connected to threshold levels expressed in L_{Amax}. The health relevance of these effects cannot be easily established. It can be safely assumed, however, that an increase in the number of such events over the baseline may constitute a subclinical adverse health effect by itself leading to significant clinical health outcomes.

Based on the exposure-effects relationship summarized in Table 3, the night noise guideline values are recommended for the protection of public health from night noise as below.

Table 4
Recommended night noise guidelines for Europe

Night noise guideline (NNG)	$L_{night,outside}$ = 40 dB
Interim target (IT)	$L_{night,outside}$ = 55 dB

[1] $L_{night,outside}$ is the night-time noise indicator (L_{night}) of Directive 2002/49/EC of 25 June 2002: the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year; in which: the night is eight hours (usually 23.00 – 07.00 local time), a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances, the incident sound is considered, the assessment point is the same as for L_{den}. See *Official Journal of the European Communities*, 18.7.2002, for more details.

For the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than 40 dB of $L_{night,outside}$ during the part of the night when most people are in bed. The LOAEL of night noise, 40 dB $L_{night,outside}$, can be considered a health-based limit value of the night noise guidelines (NNG) necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise.

An interim target (IT) of 55 dB $L_{night,outside}$ is recommended in the situations where the achievement of NNG is not feasible in the short run for various reasons. It should be emphasized that IT is not a health-based limit value by itself. Vulnerable groups cannot be protected at this level. Therefore, IT should be considered only as a feasibility-based intermediate target which can be temporarily considered by policy-makers for exceptional local situations.

RELATION WITH THE GUIDELINES FOR COMMUNITY NOISE (1999)

Impact of night-time exposure to noise and sleep disturbance is indeed covered in the 1999 guidelines, as below (WHO, 1999):

> "If negative effects on sleep are to be avoided the equivalent sound pressure level should not exceed 30 dBA indoors for continuous noise. If the noise is not continuous, sleep disturbance correlates best with L_{Amax} and effects have been observed at 45 dB or less. This is particularly true if the background level is low. Noise events exceeding 45 dBA should therefore be limited if possible. For sensitive people an even lower limit would be preferred. It should be noted that it should be possible to sleep with a bedroom window slightly open (a reduction from outside to inside of 15 dB). To prevent sleep disturbances, one should thus consider the equivalent sound pressure level and the number and level of sound events. Mitigation targeted to the first part of the night is believed to be effective for the ability to fall asleep."

The 1999 guidelines are based on studies carried out up to 1995 (and a few meta-analyses some years later). Important new studies (Passchier-Vermeer et al., 2002; Basner et al., 2004) have become available since then, together with new insights into normal and disturbed sleep. New information has made more precise assessment of exposure-effect relationship. The thresholds are now known to be lower than L_{Amax} of 45 dB for a number of effects. The last three sentences still stand: there are good reasons for people to sleep with their windows open, and to prevent sleep disturbances one should consider the equivalent sound pressure level and the number of sound events. The present guidelines allow responsible authorities and stakeholders to do this. Viewed in this way, the *night noise guidelines for Europe* are complementary to the 1999 guidelines. This means that the recommendations on government policy framework on noise management elaborated in the 1999 guidelines should be considered valid and relevant for the Member States to achieve the guideline values of this document.

EXHIBIT 10

3/10/12 British Medical Journal: Wind Turbine Noise

Saturday, March 10, 2012 at 01:28PM
The BPRC Research Nerd in Life in a wind farm, Noise, Wind farm, Wind farm health effects, health effects, sleep disturbance, wind energy, wind farm health effects, wind farm noise, wind farm sleep deprivation, wind turbine, wind turbine noise

Note: The British Medical Journal is an international peer reviewed journal of medicine.

Wind turbine noise seems to affect health adversely and an independent review of evidence is needed

SOURCE: British Medical Journal, **www.bmj.com**

March 8, 2012

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The evidence for adequate sleep as a prerequisite for human health, particularly child health, is overwhelming. Governments have recently paid much attention to the effects of environmental noise on sleep duration and quality, and to how to reduce such noise.**1** However, governments have also imposed noise from industrial wind turbines on large swathes of peaceful countryside.

The impact of road, rail, and aircraft noise on sleep and daytime functioning (sleepiness and cognitive function) is well established.**1** Shortly after wind turbines began to be erected close to housing, complaints emerged of adverse effects on health. Sleep disturbance was the main complaint.**2** Such reports have been dismissed as being subjective and anecdotal, but experts contend that the quantity, consistency, and ubiquity of the complaints constitute epidemiological evidence of a strong link between wind turbine noise, ill health, and disruption of sleep.**3**

The noise emitted by a typical onshore 2.5 MW wind turbine has two main components. A dynamo mounted on an 80 m tower is driven through a gear train by blades as long as 45 m, and this generates both gear train noise and aerodynamic noise as the blades pass through the air, causing vortices to be shed from the edges. Wind constantly changes its velocity and direction, which means that the inflowing airstream is rarely stable. In addition, wind velocity increases with height (wind shear), especially at night, and there may be inflow turbulence from nearby structures—in particular, other turbines. This results in an impulsive noise, which is variously described as "swishing" and "thumping," and which is much more annoying than other sources of environmental noise and is poorly masked by ambient noise.**4 5**

Permitted external noise levels and setback distances vary between countries. UK guidance, ETSU-R-97, published in 1997 and not reviewed since, permits a night time noise level of 42 dBA, or 5 dBA above ambient noise level, whichever is the greater. This means that turbines must be set back by a minimum distance of 350-500 m, depending on the terrain and the turbines, from human habitation.

The aerodynamic noise generated by wind turbines has a large low frequency and infrasound component that is attenuated less with distance than higher frequency noise. Current noise measurement techniques and metrics tend to obscure the contribution of impulsive low frequency noise and infrasound.**6** A laboratory study has shown that low frequency noise is considerably more annoying than higher frequency noise and is harmful to health—it can cause nausea, headaches, disturbed sleep, and cognitive and psychological impairment.**7** A cochlear mechanism has been proposed that outlines how infrasound, previously disregarded because it is below the auditory threshold, could affect humans and contribute to adverse effects.**8**

Sixteen per cent of surveyed respondents who lived where calculated outdoor turbine noise exposures exceeded 35 dB LAeq (LAeq, the constant sound level that, in a given time period, would convey the same sound energy as the actual time varying sound level, weighted to approximate the response of the human ear) reported disturbed sleep.**4** A questionnaire survey concluded that turbine noise was more annoying at night, and that interrupted sleep and difficulty in returning to sleep increased with calculated noise level.**9** Even at the lowest noise levels, 20% of respondents reported disturbed sleep at least one night a month. In a meta-analysis of three European datasets (n=1764),**10** sleep disturbance clearly increased with higher calculated noise levels in two of the three studies.

In a survey of people residing in the vicinity of two US wind farms, those living within 375-1400 m reported worse sleep and more daytime sleepiness, in addition to having lower summary scores on the mental component of the short form 36 health survey than those who lived 3-6.6 km from a turbine. Modelled dose-response curves of both sleep and health scores against distance from nearest turbine were significantly related after controlling for sex, age, and household clustering, with a sharp increase in effects between 1 km and 2 km.**11** A New Zealand survey showed lower health related quality of life, especially sleep disturbance, in people who lived less than 2 km from turbines.**12**

A large body of evidence now exists to suggest that wind turbines disturb sleep and impair health at distances and external noise levels that are permitted in most jurisdictions, including the United Kingdom. Sleep disturbance may be a particular problem in children,**1** and it may have important implications for public health. When seeking to generate renewable energy through wind, governments must ensure that the public will not suffer harm from additional ambient noise. Robust independent research into the health effects of existing wind farms is long overdue, as is an independent review of existing evidence and guidance on acceptable noise levels.

Notes

Cite this as: *BMJ* 2012;344:e1527

Footnotes

- Competing interests: Both authors have completed the ICMJE uniform disclosure form at **www.icmje.org/coi_disclosure.pdf** (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; CDH has given expert evidence on the effects of wind turbine noise on sleep and health at wind farm planning inquiries in the UK and Canada but has derived no personal benefit; he is a member of the board of the Society for Wind Vigilance; AE has written letters of objection on health grounds to wind farm planning applications in Ireland.

- Provenance and peer review: Not commissioned; externally peer reviewed.

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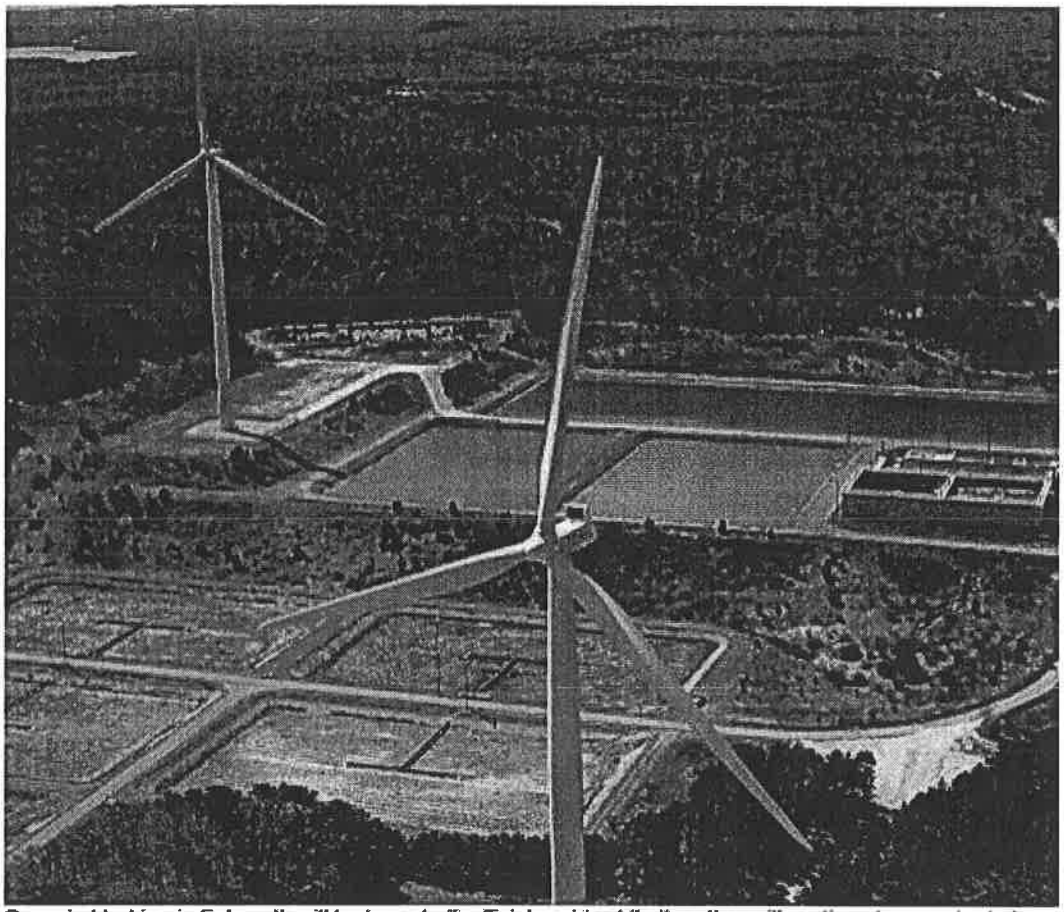
EXHIBIT 11

The Boston Globe

BRIAN MCGRORY

State moves to shut turbine over noise levels

Step may boost wind-power foes



One wind turbine in Falmouth will be turned off, officials said, while the other will continue to operate during the day. (David L. Ryan/Globe Staff)

By David Abel
Globe Staff / May 16, 2012

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