

## EXAMPLES OF NOISE STANDARDS AND WIND TURBINE NOISE REGULATIONS

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### *International Standards and regulatory standards*

With little consideration of low frequency noise standards, which vary from country to country, the inadequacy of Michigan's wind turbine noise standard becomes apparent when reviewing general noise level standards for community noise and wind turbine noise that have been adopted around the world. Compare these standards with those specified in the Michigan Wind Guidelines: 55dB(A) (or, if ambient noise is greater than 55dB(A), ambient level plus 5 dB(A)). Michigan Standards also exceed regulatory limits set in Denmark, the Netherlands, Germany and New Zealand, which have not been included here.

### **ISO 1996-1971 Recommendations for Community Noise Limits**

<b>District Type</b>	<b>Daytime Limit</b>	<b>Evening Limit (7 -11 PM)</b>	<b>Night limit (11 PM – 7 AM)</b>
Rural	35 dB(A)	30 dB(A)	25 dB(A)
Suburban	40 dB(A)	35 dB(A)	30 dB(A)
Urban residential	45 dB(A)	40 dB(A)	35 dB(A)
Urban Mixed	50 dB(A)	45 dB(A)	40 dB(A)

**The World Health Organization has issued guidelines for community noise.**

<b>Environment</b>	<b>Critical health effect</b>	<b>Sound level dB(A)*</b>	<b>Time hours</b>
Outdoor living areas	Annoyance	50 - 55	16
Indoor dwellings	Speech intelligibility	35	16
Bedrooms	Sleep disturbance	30	8
School classrooms	Disturbance of communication	35	During class
Industrial, commercial and traffic areas	Hearing impairment	70	24
Music through earphones	Hearing impairment	85	1
Ceremonies and entertainment	Hearing impairment	100	4

Critical effects such as annoyance, speech intelligibility and sleep disturbance suggest that appropriate regulatory sound levels are 35 dB(A) for daytime and 30 dB(A) at night inside residences with windows open.

**U.K. standards** require that wind farm noise should be limited to 5 dB(A) above background for both day- and night-time except in low noise environments where the

day-time limit should be limited to an absolute level within the range of 35-40 dB(A). Pure tone penalties are from 2-5 dB(A).

**France** limits noise to 5dB(A) above background noise during the day and 3dB(A) above background noise at night.

**South Australia EPA noise guidelines for wind turbines** require the predicted A scale equivalent noise level that cannot be exceeded for more than 10% of the time (i.e.  $L_{Aeq,10}$ ) to be 35 dB(A) or the background noise exceeded 90% of the time (i.e.  $L_{A90,10}$ ) plus 5 dB(A).

**Danish guidelines for low frequency noise** are summarized in the following table:

For low frequency noise, the "A" weighted level of the noise in the frequency range 10 – 160 Hz is considered, the symbol used is  $L_{pA,LF}$ . The recommended limits are 5 – 15 dB lower than the ordinary noise limits, and the lowest recommended limit,  $L_{pA,LF} = 20$  dB, has a close connection with the infrasound limit,  $L_{pG} = 85$  dB....

	Infrasound, $L_{pG}$	Low frequency noise, $L_{pA,LF}$	Usual noise limit, $L_{pA}$
Dwelling, evening & night	85 dB	20 dB	30 dB / 25 dB
Dwelling, day	85 dB	25 dB	30 dB (day & evening)
Classroom, office etc.	85 dB	30 dB	40 dB
Other rooms in enterprises	90 dB	35 dB	50 dB

**South Australia Environmental Protection Authority guidelines states:**

The impact of a given noise is also closely linked to the amount it exceeds the background noise. For example, the same noise in a quiet rural area will generally have a greater adverse impact than in a busy urban area because of the masking effect of high ambient noise environments. If the noise generated does not exceed the background noise by more than 5 dB(A) the impact will be marginal and acceptable.

A unique characteristic of wind farms is that the noise level from each wind turbine generator (WTG) increases as the wind speed at the site increases. As an offset, the background noise also generally increases under these conditions and can mask the WTG noise.

Comparison with a base noise level alone will therefore not be sufficient to indicate the potential impact of a wind farm: a farm could comply with this base level at lower wind speeds but exceed it when the wind speed rises.

Most international and interstate jurisdictions (see examples below) set a base noise level for low wind speeds and also ensure that the wind farm noise does not exceed the background noise by more than 5 dB(A) as the wind speed increases....

The general approach for new development applies a night time level of 35 dB(A) to significant development in a rural location. To prevent adverse impacts from the increased noise of WTGs (wind turbine generators) under high wind conditions, the increasing noise level must also be compared to the corresponding background noise at the relevant receiver.

Noise criteria-new wind farm development

The predicted equivalent noise level ( $L_{Aeq,10}$ ), adjusted for tonality in accordance with these guidelines, should not exceed:

- 35 dB(A), or
- the background noise ( $L_{A90,10}$ ) by more than 5 dB(A)

whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power of the WTG. The background noise should be as determined by the data collection and regression analysis procedure recommended under these guidelines.

*MI guidelines and sampling of wind turbine noise zoning ordinance regulations and application requirements:*

### **Michigan Siting Guidelines for Wind Energy Systems**

2. Sound Pressure Level: On Site Use wind energy systems shall not exceed 55 dB(A) at the property line closest to the wind energy system. Exceptions for neighboring property are allowed with the written consent of those property owners. This sound pressure level may be exceeded during short-term events such as utility outages and/or severe wind storms. If the ambient sound pressure level exceeds 55 dB(A), the standard shall be ambient dB(A) plus 5 dB(A).

Commentary: Normal conversation is in the range of 50-65 dB(A). There is more commentary under the Utility Grid section of this document.

Application requirements:

6. Sound Pressure Level: Copy of the modeling and analysis report.

**Eveline Township, MI**

7. Maximum Noise Levels. Any proposed wind turbine generator shall produce sound levels that are no more than fifty (50) decibels as measured on the dB(A) scale at the property lines of the site in question. A noise report shall be submitted with any application for an anemometer tower or wind turbine generator tower. A noise report shall be prepared by a qualified professional and shall include the following, at a minimum,

a. A description and map of the project's noise producing features, including the range of noise levels expected, and the basis of the expectation.

b. A description and map of the noise sensitive environment, including any sensitive noise receptors, i.e. residences, hospitals, libraries, schools, places of worship, parks, areas with outdoor workers and other facilities where quiet is important or where noise could be a nuisance within two (2) miles of the proposed facility.

c. A survey and report prepared by a qualified engineer that analyzes the pre-existing ambient noise (including seasonal variation) and the affected sensitive receptors located within two (2) miles of the proposed project site. Potential sensitive receptors at relatively less windy or quieter locations than the project shall be emphasized and any problem areas identified;

d. A description and map of the cumulative noise impacts any problem areas identified

e. A description of the project's proposed noise control features and specific measures proposed to mitigate noise impacts for sensitive receptors as identified above to a level of insignificance.

8. Maximum Vibrations. Any proposed wind turbine generator shall not produce vibrations humanly perceptible beyond the property on which it is located.

**Huron County, MI**

E. Noise

1) Audible noise or the sound pressure level from the operation of the Wind Energy Facility shall not exceed fifty (50) dBA, or the ambient sound pressure level plus five (5) dBA, whichever is greater, for more than ten percent (10%) of any hour, measured at any residence, school, hospital, church or public library existing on the date of approval of any Wind Energy Facility Site Permit. The applicant shall be able to provide sound pressure level measurements from a reasonable number of sampled locations at the

perimeter and in the interior of the Wind Energy Facility to demonstrate compliance with this standard.

2) In the event audible noise from the operation of the Wind Energy Facility contains a steady pure tone, the standards for audible noise set forth in subparagraph a) of this subsection shall be reduced by five (5) dBA. A pure tone is defined to exist if the one-third (1/3) octave band sound pressure level in the band, including the tone, exceeds the arithmetic average of the sound pressure levels of the two (2) contiguous one-third (1/3) octave bands by five (5) dBA for center frequencies of five hundred (500) Hz and above, by eight (8) dBA for center frequencies between one hundred and sixty (160) Hz and four hundred (400) Hz, or by fifteen (15) dBA for center frequencies less than or equal to one hundred and twenty-five (125) Hz.

3) The ambient noise level shall be expressed in terms of the highest whole number sound pressure level in dBA, which is exceeded for more than five (5) minutes per hour. Ambient noise levels shall be measured at a building's exterior of potentially affected existing residences, schools, hospitals, churches and public libraries. Ambient noise level measurement techniques shall employ all practical means of reducing the effect of wind-generated noise at the microphone. Ambient noise level measurements may be performed when wind velocities at the proposed project site are sufficient to allow wind turbine operations, provided that the wind velocity does not exceed thirty (30) mph at the ambient noise measurement location.

4) Any noise level falling between two whole decibels shall be the lower of the two.

5) In the event the noise levels resulting from the Wind Energy Facility exceed the criteria listed above, a waiver to said levels may be approved provided that the following has been accomplished:

a. Written consent from the affected property owner(s) has been obtained stating that they are aware of the Wind Energy Facility and the noise limitations imposed by this Article, and that consent is granted to allow noise levels to exceed the maximum limits otherwise allowed; and

b. If the applicant wishes the waiver to apply to succeeding owners of the property, a permanent noise impact easement must be recorded in the Huron County Register of Deeds office which describes the benefited and burdened properties and which advises all subsequent owners of the burdened property that noise levels in excess of those otherwise permitted by the ordinance may exist on or at the burdened property.

### **Leelanau Township, MI**

E. Maximum Noise Levels. Any proposed wind turbine generator shall produce sound levels that are no more than 50 decibels as measured on the dB(A) scale at the property lines of the site in question. A noise report shall be submitted with any application for an anemometer tower or wind turbine generator tower. A noise report shall be prepared by a

qualified professional and shall include the following, at a minimum,

1. A description and map of the project's noise producing features, including the range of noise levels expected, and the basis of the expectation;
2. A survey and report prepared by a qualified engineer that analyzes the pre-existing ambient noise (including seasonal variation) and the potentially affected residences, schools, public buildings or other noise sensitive land uses located within 2 miles of the proposed project site.
3. A description and map of the cumulative noise impacts and any problem areas identified.
4. A description of the project's proposed noise control features and specific measures proposed to mitigate noise impacts for sensitive land uses.

F. Maximum Vibrations. Any proposed wind turbine generator shall not produce vibrations humanly perceptible beyond the property on which it is located.

### **Montague Township, MI**

K. Noise Emissions: The noise level measured at the property lines shall not exceed forty-five (45) decibels. In addition there shall be no obnoxious noise, even if an intermittent nature such as that characterized by either high or low frequency, even though it is less than forty-five (45) decibels. The Planning Commission reserves the right to retain the forty-five (45) decibel limitation or to waive or change the noise requirements for those properties that have been granted an exception to the twelve-hundred (1200) foot setback from the property line requirement.

- i. A description and map of the project's noise producing features, including the range and type of noise levels expected, the amount and distance of low frequency noise impact and the basis for these calculations.
- ii. A description and map of the noise sensitive environment, including any sensitive noise receptors, for example, residences, libraries, schools, places of worship, parks, and other facilities where noise could be a nuisance within one (1) mile of the proposed facility.
- iii. A survey and report prepared by a qualified engineer approved by the Planning Commission that analyzes the pre-existing ambient noise (including seasonal variation) and the affected sensitive receptors at relatively less windy or quieter location than the project should be emphasized and any problem areas identified.
- iv. The report to the Planning Commission will address the four types of noise that can be generated by the wind turbine operations: tonal, broadband, low frequency and impulsive. In addition, the report will describe any negative impacts (within a two-mile radius) that the proposed turbine(s) will have on the general health and well being of residents.

v. A description of the projects proposed noise control features and specific measures proposed to mitigate noise impacts for sensitive receptors as identified above to a level of insignificance.

## **Otsego County, MI**

### 18.48.3 Standards for WTG and Anemometer Tower Approval.

c. Noise permitted from WTGs is governed by the original ambient baseline noise study performed in accordance with Section 18.47.2(f) for the first WTG on the subject property and original fixed noise pressure limits above baseline for both day and night operations.

d. Broadband noise from any WTG shall be limited to no more than 10 decibels above the original ambient baseline sound level (or that level which is exceeded 90% of the time) beyond the property line, considering both daytime and night measurements as reported in the engineer's sound propagation model required in section 18.2(f). The day and night requirements will be different. The harmonic mean of the night measurements will set the baseline for night noise limits and the harmonic mean of the daytime measurements will set the baseline for daytime limits. Pure tones, defined as an octave band (at any frequency), are limited to no more than 3 decibels above the adjacent higher and lower octave bands.

#### *Application Requirements:*

f. Analysis, measurements and projections of WTG noise propagation shall conform to International Electromechanical Commission (IEC) Standard 61400-11 Part 11, as that standard may be amended or updated from time to time. Acoustic Noise Measurement Techniques shall include: optional noise directivity requirements (see below), infrasound (low frequency) projections, low frequency noise (between 20 and 100 Hz) measurement and analysis and impulsivity measurement (noise pressure of potential "thumping" sounds). Analysis shall include but is not limited to:

1. A survey of the existing ambient background noise levels. Analysis shall include day time measurements and also at least two ambient noise measurements between 9:00 PM and 11:59PM and two between 1:00 AM and 5:00AM.

2. A prediction of the WTG noise levels at the property border. This can be made with manufacturer's data or data from a private testing agency for proposed WTGs or by direct measurement for WTGs in place, so long as measurements are conducted according to IEC and 61400-11 part 11 as that standard may be amended or updated from time to time. Including infrasound and low frequency noise between 20 and 100 Hz, modeling must identify likely pure tone sources.

3. Identification and support for a model for sound propagation. The model may be hemispherical or spherical but particular attention must be paid to the noise propagation downwind of the proposed installation site and the propagation of sound at differing atmospheric densities.

4. A comparison of calculated wind sound pressure levels with and without the WTG or proposed WTGs. This confirms the baseline for permitted sound levels once the WTGs are operating.

This application requirement shall not apply to an anemometer tower.

### **White River and Chester Township, MI**

(10) Noise Emissions: Noise emissions from the operation of a WECS and Testing Facilities shall not exceed forty-five (45) decibels on the DBA scale as measured at the nearest property line or road.

a. A baseline noise emission study of the proposed site and impact upon all areas within one (1) mile of the proposed WECS location must be done (at the applicant's cost) prior to any placement of a WECS and submitted to the Township. The applicant must also provide estimated noise levels to property lines at the time of a Special Use application.

### **Shawano County, WI**

#### 5.5 Noise and Vibration

5.5.1 Noise Regulations Compliance: A WECS shall be considered in violation of the CUP unless the applicant demonstrates that the project complies with all noise level limits. Noise levels in excess of the limits 14 of 20 established in this ordinance shall be grounds for the Zoning Enforcement Officer or his/her designee to order immediate shut down of all non-compliant WECUs.

5.5.2 Post construction noise and vibration measurements: Within twelve months of the date when the project is fully operational, and within two weeks of the anniversary date of the pre-construction background noise measurements, repeat the existing sound and vibration environment measurements taken before the project approval. Post-construction sound level measurements shall be taken both with all WECUs running and with all WECUs off. Report post-construction measurements to the Shawano County Planning and Development Department (available for public review) using the same format as used for the pre-construction sound and vibration studies.

5.5.3 Noise Setbacks: The Shawano County Planning, Development, and Zoning Committee may impose a noise setback that exceeds the other setbacks set out in this ordinance if it deems that such greater setbacks are necessary to protect the public health, safety, and welfare of the community.

5.5.4 Noise Standard: The noise due to WECU operations shall not be greater than 5 dBA above the established background noise level for more than five 5 minutes out of any one hour time period as measured per Appendix A.

5.5.5 Low Frequency Noise or Infrasound Noise: No low frequency noise or infrasound noise from wind turbine operations shall be created which causes the noise level both within the project boundary and a one-mile radius beyond the project boundary to exceed the following limits:

1/3 Octave Band Center Frequency (Hz)	Sound Pressure Level (dB)
2 to 1	70 (each band)
16	68
20	68
25	67
31.5	65
40	62
50	60
63	57
80	55
100	52
125	50
250	47
500	45
1000	42
2000	40
4000	37
8000	35

5.5.6 Pure Tone Penalty: In the event audible noise due to wind turbine operations contains a steady pure tone, such as a whine, screech, or hum, the standards for Audible Noise shall be reduced by five (5) dB(A). A pure tone is defined to exist when: the one-third octave band sound pressure level in the band, including the tone, exceeds the arithmetic average of the sound pressure levels on the two (2) contiguous one-third octave bands by five (5) dB(A) for center frequencies of 500 Hz and above, and eight (8) dB(A) for center frequencies between 160 and 400 Hz, and by fifteen (15) dB(A) for center frequencies less than or equal to 125 Hz.

5.5.7 Repetitive, Impulsive Sound Penalty: In the event the audible noise due to wind turbine operations contains repetitive impulsive sounds, the standards for Audible Noise shall be reduced by five (5) dB(A).

5.5.8 Pure Tone and Repetitive, Impulsive Tone Penalty: In the event the audible noise due to wind turbine operations contains both a pure tone and repetitive impulsive sounds, the standards for Audible Noise shall be reduced by a total of five (5) dB(A).

5.5.9 Operations-Low Frequency Noise: A WECU that emits impulsive sound below 20 Hz that adversely affects the habitability or use of any existing dwelling unit, hospital, school, library, nursing home, or other sensitive noise receptor shall be deemed unsafe and must be shut down immediately.

5.5.10 Noise Complaint and Investigation Process: See Appendix B.

*Application requirements:*

3.2.15 Noise Report: A noise report that shall at a minimum include the following and be prepared by an acoustic engineer:

3.2.15.1 A sound and vibration assessment as identified in Appendix A.

3.2.15.2 A description of the project's proposed noise control features, including specific measures proposed to protect workers, and specific measures proposed to mitigate noise impacts for sensitive receptors to a level of insignificance.

3.2.15.3 A report that outlines issues and considerations for individuals that use hearing aids.

(The Shawano Appendix A is included as a separate document.)