cityofnovi.org

CITY of NOVI CITY COUNCIL

Agenda Item C
May 3, 2010

SUBJECT: Approval of Zoning Ordinance Text Amendment 18.237, to amend Ordinance No. 97-18 as amended, the City of Novi Zoning Ordinance, at Article 25, General Provisions, Section 2508, Uses Not Otherwise Included Within a Specific Use District, in order to provide standards for siting wind energy turbines. **SECOND READING**

SUBMITTING DEPARTMENT: Community Development Department - Planning

CITY MANAGER APPROVAL:

BACKGROUND INFORMATION:

At the March 22, 2010 City Council meeting, Council approved the first reading of an ordinance addressing the siting of wind turbines. At that meeting, Council expressed some reservations about the standards of the ordinance and requested additional information. Following is a brief summary of changes made to the ordinance in response to Council's comments and additional information researched by staff. Please note this information was also provided in an off-week packet and staff has not received any further comments since that time.

Turbines in Residential Districts

The City Council noted a concern discussed by the Planning Commission: whether the proposed ordinance should allow wind turbines in residential districts. Staff received a mixed reaction from questionnaire respondents and citizens regarding whether or not wind turbines should be permitted in residential districts. The Planning Commission recommended approval of ordinance language that allowed turbines only on residential properties 25 acres or greater that are developed with institutional uses. This would allow schools, churches and civic uses, such as Tollgate Farms to install wind turbines.

For consideration of whether wind turbines should be permitted in additional residential areas, staff has attached information on wind turbines marketed toward residential areas. One wind turbine with the brand name Windspire is a vertical-axis, tower-mounted design intended for small-scale wind production. The standard height is 30 feet with optional pole extensions of 5, 10 and 20 feet. Due to the vertical axis design, the literature indicates that sound levels are only about 5 decibels above ambient noise levels, which is comparable to the ordinance provisions (see noise discussion, below). A fully installed Windspire turbine costs between $9,000 and $12,000 and has a typical payback period of less than ten years. There are both vertical axis and horizontal axis residential scale turbines. The Windspire is one example of the options available to homeowners.

Based on the comments of the Council, and additional information provided for wind turbines marketed toward residential properties, the attached ordinance has been revised to permit Small Structure-Mounted Wind Energy Turbines on residential properties up to a height of fifteen feet above the roof and to permit Small Tower-Mounted Wind Energy Turbines in all residential districts, provided that the height of the wind turbine is limited to the ordinance's residential maximum height standards of 35 feet.

Number of Turbines Permitted on a Parcel

City Council's concern about the proposed ordinance being overly restrictive regarding the number of turbines permitted on the parcel has been addressed in the revised ordinance by omitting the limitation on the number of turbines permitted on a parcel. One local wind turbine dealer indicated that it is not uncommon for customers to request more than one wind turbine be installed per parcel, or to request multiple "green" installations, such as a wind turbine and a solar panel. Staff notes the maximum number of wind turbines would be indirectly limited based on the applicant's ability to meet the required setbacks per the ordinance and also to conform to the manufacturer's standards regarding the siting of the particular turbine. For example, in the case of the aforementioned Windspire, the manufacturer recommends the turbine be setback a minimum of 30 to 100 feet (depending on the location of other objects on the property) for peak functioning.

Noise Concerns
Attached is a diagram comparing the noise emitted by a wind energy turbine to various noises typically heard in a suburban environment. The noise from a small wind energy turbine would be comparable to the noise level of a typical singe-family home. The draft ordinance language includes provisions requiring an applicant to submit data demonstrating the noise level on the property where the turbine is proposed. The noise emanating from the turbine cannot exceed the lowest noise level recorded between the hours of 9:00 p.m. and 9:00 a.m. on a residential property line, and the lowest noise level recorded plus 5 decibels on a non-residential property line. The manufacturer's specifications typically include information on the noise output of a turbine.

The proposed ordinance noise standards may be clarified by reviewing the attached "Primer of Addressing Wind Turbine Noise" by Daniel J. Alberts of Lawrence Technological University. The State of Oregon standards (found on page 17) similarly require that turbine operators determine the preexisting sound levels in the community. New wind turbine equipment must not raise the statistical noise levels by more than 10 decibels in any one hour above a certain threshold.

Other Local Ordinances
During the preparation of the draft wind turbine ordinance, staff reviewed a number of local ordinances. Attached is a chart summarizing the main points of each of the ordinances reviewed. Ottawa County's ordinance was used as the basis for Novi's draft ordinance.

Approval Process
Noting the City Council's concern to streamline the approval process of permitted wind turbines, staff has revised the ordinance as follows:

- Small Structure-Mounted Turbines (no more than 15 feet above the height of the roof) would be a principal permitted use requiring administrative approval in all zoning districts.
- Small Tower-Mounted Turbines up to 100 feet in height in non-residential districts, would be a principal permitted use requiring administrative approval.
- Small Tower-Mounted Turbines up to 35 feet in height in residential districts would now be a principal permitted use requiring administrative approval.
- Medium Tower-Mounted Wind Turbines up to 150 feet in height would remain as proposed: a special land use in the I-1, I-2 and OST districts subject to approval by the City Council, after review and recommendation by the Planning Commission.

Variances from any of the ordinance standards would be considered by the Zoning Board of Appeals.

Attached please find a revised draft ordinance and summary chart, information on the Windspire turbine for residential use, a chart summarizing other local ordinances, a noise comparison chart for wind turbines and other typical noise generators and a primer on wind turbine noise.

RECOMMENDED ACTION: Approval of Zoning Ordinance Text Amendment 18.237, to amend Ordinance No. 97-18 as amended, the City of Novi Zoning Ordinance, at Article 25, General Provisions, Section 2508, Uses Not Otherwise Included Within a Specific Use District, in order to provide standards for siting wind energy turbines. **SECOND READING**

	1	2	Y	N
Mayor Landry				
Mayor Pro-Tem Gatt				
Council Member Crawford				
Council Member Fischer				

	1	2	Y	N
Council Member Margolis				
Council Member Mutch				
Council Member Staudt				

COUNCIL MINUTES
FIRST READING

Excerpt

REGULAR MEETING OF THE COUNCIL OF THE CITY OF NOVI
MONDAY, MARCH 22, 2010 AT 7:00 P.M.
COUNCIL CHAMBERS – NOVI CIVIC CENTER – 45175 W. TEN MILE ROAD

ROLL CALL: Mayor Landry, Mayor Pro Tem Gatt, Council Members Crawford, Fischer, Margolis-absent/excused, Mutch, Staudt

7. **Consideration of Zoning Ordinance Text Amendment 18.237, to amend Ordinance No. 97-18 as amended, the City of Novi Zoning Ordinance, at Article 25, General Provisions, Section 2508, Uses Not Otherwise Included Within a Specific Use District, in order to provide standards for siting wind energy turbines. First Reading**

Mr. Pearson said this was something new and they were looking ahead and were trying to be ahead of the curve and this had positive recommendations.

Member Mutch felt it was overly restrictive in its application and not always in the right areas. He said in the Planning Commission minutes there was a lot of discussion and concern about allowing any kind of wind turbine in residential areas. He thought that no one would be looking forward to their neighbor having a 100 ft wind turbine in their backyard or even some of the smaller structures. He thought the blanket prohibition that didn't even consider lot size or adjacent land uses, in regard to some of the smaller turbines; he would question the application of that. Also, conversely, it was kind of a free for all on the Industrial Districts with pretty much letting everything go but the limitations in terms of the numbers of wind turbines permitted. He said the applications he had seen where companies were utilizing this were typically looking at doing three or four small turbines attached to a structure or near a structure and he thought they limited that. He stated he wanted to see more information from staff regarding other suburban communities that had wind turbines in their communities. Member Mutch noted that at a certain point, the ordinance was so restrictive he didn't see the point to it. He commented that Novi had fairly limited capacity for wind power from everything he had read, so he wasn't sure there would be any significant wind turbine activity. However, he didn't want to set up a situation where people had an expectation that they could do it, but then after they get to the ordinance requirements, it's nearly impossible to do. Member Mutch said he'd like more information from staff to see how they matched up to that actual application on some of the smaller wind turbines before the second reading.

CM-10-03-050 Moved by Gatt, seconded by Landry; MOTION CARRIED:
To approve Zoning Ordinance Text Amendment 18.237, to amend Ordinance No. 97-18 as amended, the City of Novi Zoning Ordinance, at Article 25, General Provisions, Section 2508, Uses Not Otherwise included within a Specific Use District, in order to provide standards for siting wind energy turbines. First Reading

DISCUSSION

Member Fischer said he would like more information on the noise because he was very concerned about the application in the residential area. He said he would prefer to be more cautious in that aspect to ensure they didn't get into a position where wind turbines were installed and they detracted from home values. Then, they would have to go back and try to right the wrong after the fact. He preferred to be more conservative in the residential area; other than that he could support the motion on the table.

Member Crawford agreed with the other members of Council. She said she was not able to open up the text to see what the amendment actually was. So, she didn't know what it said and didn't feel comfortable voting in approval without knowing what was in it. She said if they were assured that staff was going to look at it again and bring Council more information, she would feel better about it.

Member Staudt stated he shared Member Mutch's concerns about some of the restrictions but would approve the first reading because he was interested in thinking about this more and hearing the comments of Council. He said it was very similar to the next item they were going to discuss and he had the same concerns about both. He stated he was willing to let this move forward, and thought there would be a lot more discussion as they thought about the comments. Member Staudt asked what the process was in the past, if someone wanted to do some of these things. Mr. Pearson said he didn't know if they had one. He said there was an industrial user that was looking at doing some manufacturing and down the road looking at a demonstration and actual installation. He thought that was what kind of spurred some of this on regarding having regulations. Member Staudt said from an economic development standpoint, he didn't want to put rules in that would basically throw into the face of potential businesses that Novi had overly oppressive rules related to their stuff. He said it was one of those things where this was really new and there wasn't a lot of history with these types of ordinances, especially in this area. He said he would accept moving forward with a good discussion in the future.

Roll call vote on CM-10-03-050 **Yeas: Mutch, Staudt, Landry, Gatt, Fischer**
Nays: Crawford
Absent: Margolis

FYI
DEM

METRO DETROIT

POSTED APRIL 18, 2010

Home windmills spin debate

Cities are imposing restrictions, bans

BY BILL LAITNER
FREE PRESS STAFF WRITER

Comments (25) Recommend Print E-mail Letter to the editor Share

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Most talk on windmills in Michigan is about the giant ones going up on farms and offshore.

But small wind turbines designed for urban homes, small businesses and schools -- which cost $15,000 to $30,000 -- are generating debate in some Detroit suburbs.

Facing requests from homeowners, Royal Oak enacted a zoning ordinance last year to regulate home-based wind turbines, with Birmingham and Novi soon to do so.

"We've had some people very eager to see this come, and a small number want them on their houses" to feed electricity into their homes, Birmingham Planning Board chairman Robin Boyle said.

This week, the board voted 7-0 to ban wind turbines in residential areas, restricting them to commercial districts and to areas of mixed-use zoning where condos coexist with shops. The ban could get final approval April 26 by the City Commission.

Among the concerns? The injury risk of turbines spinning near people, the threat of towers being residential eyesores and the quality-of-life fear of flicker -- the distraction of sunlight flashing off moving blades, like a strobe light that belongs in a nightclub.

"If technology changes, we'll revisit this and see whether they can be more compatible with residential zoning," said Boyle, who is also chairman of urban studies and planning at Wayne State University.

Royal Oak's ordinance, passed last year, is less restrictive, allowing wind turbines at twice the maximum permitted height for homes -- about 60 feet -- and up to 100 feet in other zoning districts, city planner Doug Hedges said. No residents have applied for a permit, Hedges said.

Novi's new ordinance might get final approval in May, Community Relations Director Sheryl Walsh said.

"If this goes through, it does allow for wind turbines in residential areas," but the City Council likely will impose limits, Walsh said.

A single, $20,000 wind turbine could power a small home, "but you need an average wind all the time of at least 14 m.p.h.," which in Michigan puts ideal sites at high elevations or along lake shores, said Donna Napolitano, co-owner of Mechanical Energy Systems in Canton.

1 | 2 Next Page Single-page view

A new wind turbine like these, made in Manistee, is to have a ribbon cutting Tuesday at Birmingham Covington School. (WINDSPIRE ENERGY)

A version of this story appeared on page 10A of the Sunday, April 18, 2010, print edition of the Detroit Free Press.

RELATED INFORMATION

If you want to go

The Michigan Wind Energy Conference is to be Tuesday and Wednesday at Cobo Center in Detroit.

One talk Wednesday is for small-business owners; another that day is on a Detroit nonprofit using wind power. But most sessions are for planners of big projects.

Tickets are $149 for one day, $230 for both days, with discounts for students and those ordering in advance. Go to www.glrea.org or call 800-434-9788.

MORE METRO DETROIT HEADLINES

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- Michigan a draw for Ohio smokers
- Pointes in short recreation coordinator
- Eastern Michigan University freezes tuition
- Monroe Co. soldier wouldn't leave others

REVISED DRAFT ORDINANCE

STATE OF MICHIGAN

COUNTY OF OAKLAND

CITY OF NOVI

ORDINANCE NO. 09- 18 – 237

AN ORDINANCE TO AMEND ORDINANCE NO. 97-18, AS AMENDED, THE CITY OF NOVI ZONING ORDINANCE; IN ORDER TO PROVIDE FOR STANDARDS FOR SITING WIND ENERGY TURBINES.

Draft Ordinance 7/29/09

THE CITY OF NOVI ORDAINS:

Part I. That Ordinance No. 97-18, the City of Novi Zoning Ordinance, as amended, hereby amended to read as follows:

Sec. 2508. Uses Not Otherwise Included Within a Specific Use District

1. – 7. [Unchanged]

8. Wind Energy Turbines

a. Intent. The purpose of this Ordinance is to establish guidelines for siting Wind Energy Turbines (WETs). The goals are as follows:

1. To promote the safe, effective and efficient use of a WET in order to reduce the consumption of fossil fuels in producing electricity.
2. Preserve and protect public health, safety, welfare and quality of life by minimizing the potential adverse impacts of a WET.
3. To establish standards and procedures by which the siting, design, engineering, installation, operation and maintenance of a WET shall be governed.

b. Definitions. For purposes of this article, the following items shall be defined as stated:

1. Ambient Sound Level: The amount of background noise at a given location prior to the installation of a WET(s) which may include, but is not limited to, traffic, machinery, lawnmowers, human activity and the interaction of wind with the landscape. The ambient sound level is measured on the dB(A) weighted scale as defined by the American National Standards Institute.

2. Anemometer: Temporary wind speed indicator constructed for the purpose of analyzing the potential for utilizing a wind energy turbine at a given site. This

includes the tower, base plate, anchors, cables and hardware, wind direction vanes, booms to hold equipments, data logger, instrument wiring, and any telemetry devices that are used to monitor or transmit wind speed and wind flow characteristics over a period of time for either instantaneous wind information or to characterize the wind resource at a given location.

3. Decommissioning: The process of terminating operation and completely removing a WET(s) and all related buildings, structures, foundations, access roads and equipment.

4. Medium Wind Energy Turbine (MWET): Tower-mounted wind energy system that converts wind energy into electricity through the use of equipment which includes any base, blade, foundation, generator, nacelle, rotor, tower, transformer, vane, wire, inverter, batteries or other components used in this system. The MWET has a nameplate capacity that does not exceed two hundred fifty (250) kilowatts. The total height exceeds one hundred (100) feet and the total capacity exceeds thirty (30) kilowatts. The total height does not exceed one hundred fifty (150) feet.

5. Nacelle: Refers to the encasement which houses all of the generating components, gear box, drive tram and other equipment.

6. Net-metering: Special metering and billing agreement between utility companies and their customers, which facilitates the connection of renewable energy generating systems to the power grid.

7. Operator: Entity responsible for the day-to-day operation and maintenance of a WET.

8. Rotor Diameter: Cross-sectional dimension of the circle swept by the rotating blades of a WET.

9. Shadow Flicker: The moving shadow, created by the sun shining through the rotating blades of a WET. The amount of shadow flicker created by a WET is calculated by a computer model that takes into consideration turbine location, elevation, tree cover, location of all structures, wind activity and sunlight.

10. Small Tower-Mounted Wind Energy Turbine (STMWET): Tower-mounted wind energy system that converts wind energy into electricity through the use of equipment which includes any base, blade, foundation, generator, nacelle, rotor, tower, transformer, vane, wire, inverter, batteries or other components used in this system. The STMWET has a nameplate capacity that does not exceed thirty (30) kilowatts. The total height does not exceed one hundred (100) feet.

11. Small Structure-Mounted Wind Energy Turbine (SSMWET): Converts wind energy into electricity through the use of equipment which includes any base, blade, foundation, generator, nacelle, rotor, tower, transformer, vane, wire, inverter, batteries or other components used in this system. A SSMWET is attached to a structure's roof, walls or other elevated surface, including accessory structures such as but not limited to cellular phone towers. The SSMWET has a nameplate capacity that does not exceed ten (10) kilowatts. The total height does not exceed fifteen (15) feet as measured from the highest point of the roof, excluding chimneys, antennae and other similar protuberances.

12. Total height: The vertical distance measured from the ground level at the base of the tower to the uppermost vertical extension of any blade, or the maximum height reached by any part of the WET.

13. Tower: Freestanding monopole that supports a WET.

14. Wind Energy Turbine (WET): Any structure-mounted, small, medium or large wind energy conversion system that converts wind energy into electricity through the use of a Wind Generator and includes the nacelle, rotor, tower and pad transformer, if any.

c. Applicability. This ordinance applies to all WETs proposed to be constructed after the effective date of this ordinance. All WETs constructed prior to the effective date of this ordinance shall not be required to meet the requirements of this ordinance; however, any physical modification to an existing WET that materially alters the size, type, equipment or location shall require a permit under this ordinance.

d. Small Structure-Mounted Wind Energy Turbine and Small Tower-Mounted Wind Energy Turbine. Notwithstanding other provisions of this section of the ordinance, a Small Structure-Mounted Wind Energy Turbine (SSMWET) and Small Tower-Mounted Wind Energy Turbine (STMWET) shall be considered a principal permitted use in all zoning districts. ~~except that it shall not be permitted in RA (Residential Acreage), R-1, R-2, R-3, R-4 (One-Family Residential Districts), RT (Two-Family Residential District), RM-1 (Low Density, Low-Rise Multiple Family Residential District) and RM-2 (High Density, Mid-Rise Multiple Family Residential District) except for SSMWETs permitted as a Special Land Use in single family residential districts with developed institutional uses as provided for in Section 2508.8.d.1~~ A SSMWET and/or STMWET shall not be erected, constructed, installed or modified as provided in this ordinance unless administrative approval from the Planning Division and appropriate building permits have been issued to the owner(s) or operator(s). ~~A Small Tower-Mounted Wind Energy Turbine (STMWET) shall be considered a principal permitted use subject to special conditions in all Zoning Districts except that it shall not be permitted in RA (Residential Acreage), R-1, R-2, R-3, R-4 (One-Family Residential Districts), RT (Two-Family Residential District), RM-1 (Low~~

~~Density, Low-Rise Multiple Family Residential District) and RM-2 (High Density, Mid-Rise Multiple Family Residential District) except for STMWETs permitted as a Special Land Use in single-family residential districts with developed institutional uses as provided for in Section 2508.8.d.1 and that in the OST (Planned Office Service Technology), I-1 (Light Industrial), and I-2 (General Industrial) districts, a STMWET is a principal permitted use if the property is greater than 300 feet from any residential zoning district. A STMWET shall not be erected, constructed, installed or modified as provided in this ordinance unless City Council approval has been granted after a recommendation from the Planning Commission and appropriate building permits have been issued to the owner(s) or operator(s).~~ All SSMWETs and STMWETs are subject to the following minimum requirements:

~~1. A SSMWET and STMWET shall be considered a principal permitted use subject to special conditions on parcels 25 acres or larger where an institutional use exists as the primary use of the site in the following districts: RA (Residential Acreage) and R-1, R-2, R-3, R-4 (One-Family Residential Districts). A SSMWET and/or STMWET on a residentially zoned parcel shall not be erected, constructed, installed or modified as provided in this ordinance unless City Council approval has been granted after a recommendation from the Planning Commission and appropriate building permits have been issued to the owner(s) or operator(s). For purposes of this section, an institutional use is defined as an educational, religious or civic use.~~

~~2.~~1. Siting and Design Requirements

(a.) "Upwind" turbines shall be required for all horizontal WETs.

(b.) Visual Appearance

(i) A SSMWET or STMWET, including accessory buildings and related structures shall be a non-reflective, non-obtrusive color (e.g. white, gray, black). The appearance of the turbine, tower and any ancillary facility shall be maintained in working condition and free of rust and corrosion by the owner of the SSMWET or STMWET throughout the life of the SSMWET or STMWET.

(ii) A SSMWET or STMWET shall not be artificially lighted, except to the extent required by the FAA or other applicable authority, or otherwise necessary for the reasonable safety and security thereof.

(iii) A SSMWET or STMWET shall not be used for displaying any advertising (including flags, streamers or decorative items), except for reasonable identification of the turbine manufacture.

(c.) Ground clearance: The lowest extension of any blade or other exposed moving component of the SSMWET or STMWET shall be at least fifteen (15) feet above the ground (at the highest point of the natural grade within thirty (30) feet of the base of the tower) and, in addition, at least fifteen (15) feet above any outdoor surfaces intended for human use, such as balconies or roof gardens, that are located directly below the SSMWET or STMWET.

(d.) Noise: Noise emanating from the operation of a SSMWET(s) shall not exceed, at any time, the lowest ambient sound level that is present between the hours of 9:00 p.m. and 9:00 a.m. at any property line of a residential use parcel or from the property line of parks, schools, hospitals or churches. Noise emanating from the operation of a SSMWET or STMWET shall not exceed, at any time, the lowest ambient noise level plus 5 dBA that is present between the hours of 9:00 p.m. and 9:00 a.m. at any property line of a non-residential use parcel.

(e.) Vibration: Vibrations shall not be produced which are humanly perceptible beyond the property on which a SSMWET or STMWET is located.

(f.) Guy Wires: Guy wires shall not be permitted as part of the SSMWET or STMWET.

(g.) In addition to the Siting and Design Requirements listed previously, the SSMWET shall also be subject to the following:

(i.) Height: The height of the SSMWET shall not exceed 15 feet as measured from the highest point of the roof, excluding chimneys, antennae and other similar protuberances.

(ii.) Setback: The setback of the SSMWET shall be a minimum of fifteen (15) feet from the property line, public right-of-way, public easement or overhead utility lines if mounted directly on a roof or other elevated surface of a structure. If the SSMWET is affixed by extension to the side, roof or other elevated surface, then the setback from the property lines or public right-of-way shall be a minimum of fifteen (15) feet. The setback shall be measured from the furthest outward extension of all moving parts.

(iii.) Location: The SSMWET shall not be affixed to the side of a structure facing a road.

~~(iv.) Quantity: No more than two (2) SSMWETs shall be installed on any parcel of property.~~

(iv.) Separation: If more than one SSMWET is installed, a distance equal to the height of the highest SSMWET must be maintained between the base of each SSMWET.

(h.) In addition to the Siting and Design Requirements listed previously, the STMWET shall also be subject to the following:

(i.) Height: The total height of a STMWET in any nonresidential district shall not exceed one hundred (100) feet. The total height of a STMWET ~~on a parcel with an institutional use~~ in any residential district shall not exceed ~~sixty~~ thirty-five (~~60~~35) feet.

(ii.) Location: The STMWET shall only be located in the rear yard of a property that has an occupied building. In the case of a double-frontage lot, the STMWET may be located in an interior side yard.

(iii.) Occupied Building Setback: The setback from all occupied buildings on the applicant's parcel shall be a minimum of twenty (20) feet measured from the base of the tower.

(iv.) Other Setbacks: The setback shall be equal to the total height of the STMWET as measured from the base of the tower, from the property line, public right-of-way, public easement or overhead utility lines. This setback may be reduced if the applicant provides a registered engineer's certification that the WET is designed to collapse, fall, curl or bend within a distance or zone shorter than the height of the wind turbine.

~~(v.) Quantity: No more than one (1) STMWET shall be installed on any parcel of property.~~

(vi.) Electrical System: All electrical controls, control wiring, grounding wires, power lines and system components shall be placed underground within the boundary of each parcel at a depth designed to accommodate the existing land use to the maximum extent practicable. Wires necessary to connect the wind generator to the tower wiring are exempt from this requirement.

~~3.~~2. Application Requirements. The following information should be submitted with the proposed site plan.

(a.) Documented compliance with the noise requirements set forth in this ordinance. Said documentation shall require, at a minimum, data reflecting ambient sound measurements taken over a two (2) week period, which shall include the location on the property where the measurements were taken. The method of measuring ambient sound levels and the location on the property where the measurements will be taken shall be approved by the City prior to the collection of the data.

(b.) Documented compliance with applicable local, state and national regulations including but not limited to, all applicable safety, construction, environmental, electrical, communications and FAA requirements.

(c.) Proof of applicant's liability insurance.

(d.) Evidence that the utility company has been informed of the customer's intent to install an interconnected, customer-owned generator and that such connection has been approved. Off-grid systems shall be exempt from this requirement.

(e.) The STMWET application shall also include the following: A description of the methods that will be used to perform maintenance on the STMWET and the procedures for lowering or removing the STMWET in order to conduct maintenance.

4. Safety Requirements

(a.) If the SSMWET or STMWET is connected to a public utility system for net metering purposes, it shall meet the requirements for interconnection and operation as set forth in the public utility's then-current service regulations meeting federal, state and industry standards applicable to wind power generation facilities, and the connection shall be inspected by the appropriate public utility.

(b.) The SSMWET or STMWET shall be equipped with an automatic braking, governing or feathering system to prevent uncontrolled rotation, over-speeding and excessive pressure on the tower structure, rotor blades and other wind energy components unless the manufacturer certifies that a braking system is not necessary.

(c.) A clearly visible warning sign regarding voltage shall be placed at the base of the SSMWET or STMWET. The sign shall contain at least the following:

(i.) Warning high voltage
(ii.) Manufacturer's and owner(s)/operator(s) name(s)
(iii.) Emergency contact numbers (list more than one number)

(d.) The structural integrity of the SSMWET or STMWET shall conform to the design standards of the International Electrical Commission, specifically IEC 61400-1, "Wind Turbine Safety and Design" and or IEC 61400-23 "Blade Structural Testing," or any similar successor standards.

5. Signal Interference

(a.) The SSMWET or STMWET shall not interfere with communication systems such as, but not limited to, radio, telephone, television, satellite or emergency communication systems.

6. Decommissioning

(a.) The SSMWET or STMWET owner(s) or operator(s) shall complete decommissioning within six (6) months after the end of the useful life. Upon request of the owner(s) or assigns of the SSMWET of STMWET, and for a good cause, the City Council may grant a reasonable extension of time. The SSMWET or STMWET will presume to be at the end of its useful life if no electricity is generated for a continuous period of twelve (12) months. All decommissioning expenses are the responsibility of the owner(s) or operator(s).

(b.) If the SSMWET or STMWET owner(s) or operator(s) fails to complete decommissioning within the period prescribed above, the City Council may designate a contractor to complete decommissioning with the expense thereof to be charged to the violator and/or to become a lien against the premises. If the SSMWET or STMWET is not owned by the property owner, a bond must be provided to the City for the cost of decommissioning each SSMWET or STMWET.

(c.) In addition to the decommissioning requirements listed above, the STMWET shall also be subject to the following:

(i.) Decommissioning shall include the removal of each STMWET, buildings, electrical components and any other associated facilities. Any foundation shall be removed to a minimum depth of sixty (60) inches below grade, or to the level of the bedrock if less than sixty (60) inches below grade.

(ii.) The site and any disturbed earth shall be stabilized, graded and cleared of any debris by the owner(s) of the facility or its assigns. If the site is not to be used for agricultural practices following removal, the site shall be seeded to prevent soil erosion.

e. Medium Wind Energy Turbine. A Medium Wind Energy Turbine (MWET) shall be considered a principal permitted use subject to special conditions in the following districts: I-1 (Light Industrial), I-2 (General Industrial) and OST (Office Service Technology). A MWET shall not be erected, constructed, installed or modified as provided in this ordinance unless City Council approval has been granted after a recommendation from the Planning Commission and appropriate building permits have been issued to the owner(s) or operator(s). All MWETs are subject to the following minimum requirements:

1. Siting and Design Requirements

(a.) "Upwind" turbines shall be required for all horizontal WETs.

(b.) The design of a MWET shall conform to all applicable industry standards.

(c.) Visual Appearance

(i) Each MWET, including accessory buildings and related structures shall be mounted on a tubular tower and a non-reflective, non-obtrusive color (e.g. white, gray, black). The appearance of turbines, towers and buildings shall be maintained in working condition and free of rust and corrosion by the owner of the MWET throughout the life of the MWET.

(ii) Each MWET shall not be artificially lighted, except to the extent required by the FAA or other applicable authority, or otherwise necessary for the reasonable safety and security thereof.

(iii) A MWET shall not be used for displaying any advertising (including flags, streamers or decorative items), except for reasonable identification of the turbine manufacture.

(d.) Vibration: Each MWET shall not produce vibrations humanly perceptible beyond the property on which it is located.

(e.) Shadow Flicker: The MWET owner(s) and/or operator(s) shall conduct an analysis on potential shadow flicker at any occupied building with direct line-of-sight to the MWET. The analysis shall identify the locations of shadow flicker that may be caused by the project and the expected durations of the flicker at these locations from sun-rise to sun-set over the course of a year. The analysis shall identify situations where shadow flicker may affect the occupants of the buildings for more than 30 hours per year and describe measures that shall be taken to eliminate or mitigate the problems. Shadow flicker on a building shall not exceed thirty (30) hours per year.

(f.) Guy Wires: Guy wires shall not be permitted as part of the MWET.

(g.) Electrical System: All electrical controls, control wiring, grounding wires, power lines and all other electrical system components of the MWET shall be placed underground within the boundary of each parcel at a depth designed to accommodate the existing land use to the maximum extent practicable. Wires necessary to connect the wind generator to the tower wiring are exempt from this requirement.

(h.) Location: If an MWET is located on an agricultural, commercial, industrial or public property that has an occupied building it shall only be located in the rear yard. In the case of a double frontage lot, the MWET may be located in an interior side yard. The MWET shall only be located in a General Common Element in a Condominium Development.

(i.) Height: The total height of an MWET shall not exceed one hundred fifty (150) feet.

(j.) Ground Clearance: The lowest extension of any blade or other exposed moving component of a MWET shall be at least fifteen (15) feet above the ground (at the highest point of the grade level within fifty (50) feet of the base of the tower) and, in addition, at least fifteen (15) feet above any outdoor surfaces intended for human occupancy, such as balconies or roof gardens, that are located directly below the MWET.

(k.) Noise: Noise emanating from the operation of a MWET shall not exceed, at any time, the lowest ambient sound level that is present between the hours of 9:00 p.m. and 9:00 a.m. at any property line of a residential or agricultural use parcel or from the property line of parks, schools, hospitals and churches. Noise emanating from the operation of a MWET(s) shall not exceed, at any time, the lowest ambient noise level plus 5 dBA that is present between the hours of 9:00 p.m. and 9:00 a.m. at any property line of a non-residential or non-agricultural use parcel.

~~(l.) Quantity: No more than one (1) MWET shall be installed for every two and one-half (2.5) acres of land included in the parcel.~~

(~~m~~l.) Setback and Separation:

(i.) Occupied Building Setback: The setback from all occupied buildings on the applicant's parcel shall be a minimum of twenty (20) feet measured from the base of the Tower.

(ii.) Property Line Setbacks: With the exception of the locations of public roads (see below) and parcels with occupied buildings (see above), the internal property line setbacks shall be equal to the total height of the MWET as measured from the base of the tower. This setback may be reduced to a distance agreed upon as part of the special use permit if the applicant provides a registered engineer's certification that the WET is designed to collapse, fall, curl or bend within a distance or zone shorter than the height of the WET.

(iii.) Public Road Setbacks: Each MWET shall be set back from the nearest public road a distance equal to the total height of the MWET, determined at the nearest boundary of the underlying right-of-way for such public road.

(iv.) Communication and Electrical Lines: Each MWET shall be set back from the nearest above-ground public electric power line or telephone line a distance equal to the total height of the MWET, as measured from the base of the tower, determined from the existing power line or telephone line.

(v.) Tower Separation: MWET tower separation shall be based on industry standard and manufacturer recommendations.

2. Safety Requirements

(a.) If the MWET is connected to a public utility system for net metering purposes, it shall meet the requirements for interconnection and operation as set forth in the public utility's then-current service regulations meeting federal, state and industry standards applicable to wind power generation facilities, and the connection shall be inspected by the appropriate public utility.

(b.) The MWET shall be equipped with an automatic braking, governing or feathering system to prevent uncontrolled rotation, over-speeding and excessive pressure on the tower structure, rotor blades and other wind energy components unless the manufacturer certifies that a braking system is not necessary.

(c.) Security measures need to be in place to prevent unauthorized trespass and access. Each MWET shall not be climbable up to fifteen (15) feet above ground surfaces. All access doors to MWETs and electrical equipment shall be locked and/or fenced as appropriate, to prevent entry by non-authorized person(s).

(d.) All spent lubricants, cooling fluids and any other hazardous materials shall be properly and safely removed in a timely manner.

(e.) Each MWET shall have one sign, not to exceed two (2) square feet in area, posted at the base of the tower and on the security fence, if applicable. The sign shall contain at least the following:

(i.) Warning high voltage
(ii.) Manufacturer's and owner(s)/operator(s) name(s)
(iii.) Emergency contact numbers (list more than one number)

(f.) The structural integrity of the MWET shall conform to the design standards of the International Electrical Commission, specifically IEC 61400-1, "Wind Turbine Safety and Design," IEC 61400-22 "Wind Turbine Certification" and or IEC 61400-23 "Blade Structural Testing," or any similar successor standards.

3. Signal Interference

(a.) The MWET shall not interfere with communication systems such as, but not limited to, radio, telephone, television, satellite or emergency communication systems.

4. Decommissioning

(a.) The MWET owner(s) or operator(s) shall complete decommissioning within six (6) months after the end of the useful life. Upon request of the owner(s) or assigns of the MWET and for a good cause, the City Council may grant a reasonable extension of time. The MWET will presume to be at the end of its useful life if no electricity is generated for a continuous period of twelve (12) months. All decommissioning expenses are the responsibility of the owner(s) or operator(s).

(b.) Decommissioning shall include the removal of each MWET, buildings, electrical components and roads to a depth of sixty (60) inches, as well as any other associated facilities. Any foundation shall be removed to a minimum depth of sixty (60) inches below grade, or to the level of the bedrock if less than sixty (60) inches below grade. Following removal, the location of any remaining wind turbine foundation shall be identified on a map as such and recorded with the deed to the property with the County Register of Deeds.

(c.) All access roads to the MWET shall be removed, cleared and graded by the MWET owner(s), unless the property owner(s) requests in writing, a desire to maintain the access road. The City will not be assumed to take ownership of any access road unless through official action of the City Council.

(d.) The site and any disturbed earth shall be stabilized, graded and cleared of any debris by the owner(s) of the MWET or its assigns. If the site is not to be used for agricultural practices following removal, the site shall be seeded to prevent soil erosion.

(e.) If the MWET owner(s) or operator(s) fails to complete decommissioning within the period described above, the City may designate a contractor to complete the decommissioning with the expense thereof to be charged to the violator and/or to become a lien against the premises. If the MWET is not owned by the property owner, a bond must be provided to the City for the cost of decommissioning each MWET.

5. Application Requirements. The following information should be submitted with the proposed site plan.

(a.) Documented compliance with the noise and shadow flicker requirements set forth in this ordinance. Said documentation shall require, at a minimum, data reflecting ambient sound measurements taken over a two (2) week period, which shall include the location on the property where the measurements were taken. The method of measuring ambient sound levels and the location on the property where the measurements will be taken shall be approved by the City prior to the collection of the data.

(b.) Engineering data concerning construction of the MWET and its base or foundation, which may include, but is not limited to, soil boring data.

(c.) Anticipated construction schedule.

(d.) A copy of the maintenance and operation plan, including anticipated regular and unscheduled maintenance. Additionally, a description of the procedures that will be used for lowering or removing the MWET to conduct maintenance, if applicable.

(e.) Documented compliance with applicable local, state and national regulations including, but not limited to, all applicable safety, construction, environmental, electrical and communications. The MWET shall comply with Federal Aviation Administration (FAA) requirements, Michigan Airport Zoning Act, Michigan Tall Structures Act and any applicable airport overlay zone regulations.

(f.) Proof of applicant's liability insurance.

(g.) Evidence that the utility company has been informed of the customer's intent to install an interconnected, customer-owned generator and that such connection has been approved. Off-grid systems shall be exempt from this requirement.

(h.) A written description of the anticipated life of each MWET; the estimated cost of decommissioning; the method of ensuring that funds will be available for decommissioning and site restoration; and removal and restoration procedures and schedules that will be employed if the MWET(s) become inoperative or non-functional.

(i.) The applicant shall submit a decommissioning plan that will be carried out at the end of the MWET's useful life, and shall describe any agreement with the landowner(s) regarding equipment removal upon termination of the lease.

(j.) The proposed plan shall conform to the requirements of Section 2516 of the Zoning Ordinance: Site Plan Review (All Districts).

6. Certification and Compliance

(a.) The City must be notified of a change in ownership of a MWET or a change in ownership of the property on which the MWET is located.

f. Temporary Uses Related to Wind Energy Turbines. The following is permitted in all zoning districts as a temporary use, in compliance with the provisions contained herein, and the applicable WET regulations.

1. Anemometers

(a.) The construction, installation or modification of an anemometer tower shall require a building permit and shall conform to all applicable local, state and federal safety, construction, environmental, electrical, communications and FAA requirements.

(b.) An anemometer shall be subject to the minimum requirements for height, setback, separation, location, safety requirements and decommissioning that correspond to the size of the WET that is proposed to be constructed on the site.

(c.) An anemometer shall be permitted for no more than thirteen (13) months for a SSMWET, STMWET or MWET.

PART II.

Severability. Should any section, subdivision, clause, or phrase of this Ordinance b e declared by the courts to be invalid, the validity of the Ordinance as a whole, or in part, shall not be affected other than the part invalidated.

PART III.

Savings Clause. The amendment of the Novi Code of Ordinances set forth in this Ordinance does not affect or impair any act done, offense committed, or right accruing, accrued, or acquired or liability, penalty, forfeiture or punishment, pending or incurred prior to the amendment of the Novi Code of Ordinances set forth in this Ordinance.

PART IV.

Repealer. All other Ordinance or parts of Ordinance in conflict herewith are hereby repealed only to the extent necessary to give this Ordinance full force and effect.

PART V.

Effective Date: Publication. Public hearing having been held hereon pursuant to the provisions of Section 103 of Act 110 of the Public Acts of 2006, as amended, the provisions of this Ordinance shall be published within fifteen (15) days of its adoption by publication of a brief notice in a newspaper circulated in the City of Novi stating the date of enactment and effective date, a brief statement as to its regulatory effect and that a complete copy of the Ordinance is available for public purchase, use and inspection at the office of the City Clerk during the hours of 8:00 A.M. to 5:00 P.M., Local Time. The provisions of this Ordinance shall become effective seven (7) days after its publication.

MADE, PASSED, AND ADOPTED BY THE CITY COUNCIL OF THE CITY OF NOVI, OAKLAND COUNTY, MICHIGAN, ON THE ___ DAY OF _______, 2010.

____
DAVID LANDRY, MAYOR

____
MARYANNE CORNELIUS, CITY CLERK

Ayes:
Nayes:
Abstentions:
Absent:

REVISED DRAFT ORDINANCE
SUMMARY CHART

Summary Chart
of proposed ordinance regulations for
Three types of Wind Energy Turbines

	Residential Zoning Districts	OST District	Light Industrial District	General Industrial District	Other Non-Residential Zoning Districts
Structure Mounted (no more than 15 feet above roof)	Principal Permitted Use	Principal Permitted Use	Principal Permitted Use	Principal Permitted Use	Principal Permitted Use
Small Tower Mounted (100 feet maximum height)	Principal Permitted Use (Maximum permitted height of 35 feet)	Principal Permitted Use	Principal Permitted Use	Principal Permitted Use	Principal Permitted Use
Medium Tower Mounted (150 feet maximum height)	Not permitted	Principal Permitted Use Subject to Special Conditions	Principal Permitted Use Subject to Special Conditions	Principal Permitted Use Subject to Special Conditions	Not permitted

SUMMARY CHART
AREA ORDINANCES

Area Wind Ordinance Provisions

	City of Waterford	City of Port Huron	City of Troy	Staff Suggestions for City of Novi Proposed Ordinance
Approval Process	• Application submitted to and reviewed by the Building Official and Zoning Official. • Special Approval from the Planning Commission required for turbines larger than 60 feet.	• Administrative approval by the Planning Department.	• Approval of the City Council required (after a recommendation from Planning Commission).	• Administrative approval by the Planning Division for SSMWET and STMWET. • Special Land Use approval by the City Council for MWET.
Permitted Districts	• Turbines smaller than 60 feet permitted as accessory uses in all districts. • Turbines larger than 60 feet permitted with Special Approval in limited Office, Industrial and Commercial Districts. • Turbines larger than 120 feet permitted with Special Approval in General Industrial District.	• Wind turbine towers and roof-mounted turbines permitted in all zoning districts on parcels two acres or larger.	• Permitted in all districts.	• SSMWET and STMWET permitted in all districts. • MWET permitted in OST, I-1 and I-2 with Special Land Use approval.
Setbacks	• Subject to setback requirements of accessory structures.	• Equal to the height of the tower plus one-half the rotor blade diameter.	• No setback provisions.	• SSMWET – 15 feet. • STMWET – Equal to the height of the tower and 20 feet from occupied buildings. • MWET – Equal to the height of the tower and 20 feet from occupied buildings.
Height	• Small-Scale Wind Energy System (SWES) – Height does not exceed 60 feet. • Medium-Scale Wind Energy System (MWES) – Height is between 60 feet and 120 feet. • Large-Scale Wind Energy System (LWES) – Height exceeds 120 feet.	• Maximum height permitted equal to the permitted height of the zoning district. • Turbine towers up to a maximum height of 90 feet permitted in open areas in excess of two acres.	• Maximum height in residential districts of 50 feet. • Maximum height in non-residential districts of 75 feet.	• SSMWET – Height does not exceed 15 feet above the roof line. • STMWET – Height does not exceed 35 feet in residential districts and 100 feet in all non-residential districts. • MWET – Height does not exceed 150 feet.

WINDSPIRE INFORMATION

Key Features:

- Clean Renewable Energy
- Complete Wind Power System
- Sleek, Attractive Design
- Cost Effective
- Silent Operation
- Made in the USA from Recycled Materials
- Low Profile, only 30 Feet Tall (std version)
- Annual Energy ~ 2000+ kWh/yr (std version)
- Windspire for Extreme Winds also available
- Grid-Ready, Plug 'n Produce™
- Off-Grid Battery Charger Also Available
- Integrated Inverter
- High Efficiency Generator
- Hinged Monopole Makes Installation Simple
- Wireless Performance Monitor
- Very Low Maintenance
- Independently Tested
- IEEE & UL Certified

Mariah Power

www.mariahpower.com
5450 Louie Lane
Reno, NV 89511

775-657-4688

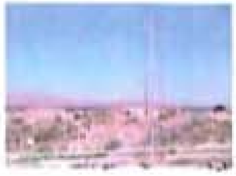
Printed on 100% Recycled Paper

Power to Inspire

Clean. Simple. Smart.

Clean Energy for You

Affordable, attractive and ultra quiet, the Windspire® wind turbine gives you the power to create clean energy [illegible]

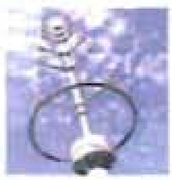


Power from Wind

The Windspire® wind turbine generates power when the wind blows [illegible]

Wind & Site Requirements

The Windspire® wind turbine was designed to operate [illegible]



Installation is Quick & Easy

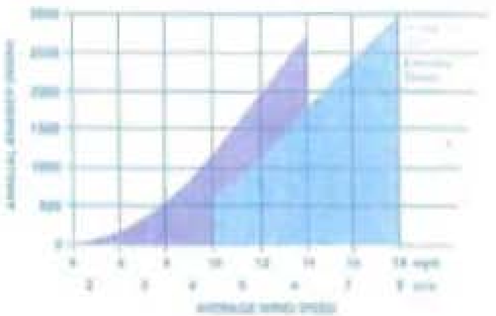
Simple to install and use, the Windspire® wind turbine comes as a complete system [illegible]

Be Smart & Save Money

The Windspire wind turbine is the lowest priced renewable energy appliance in the 1 kilowatt range. [illegible]

[illegible]

Windspire® Annual Energy Production



1 | The wind blows...

2 | The wind is caught by the Windspire® airfoils which spin the rotor around.
[illegible]

3 | The rotor turns a generator which produces electricity.
The heart of the Windspire® is the [illegible] generator. All components are designed to work together for maximum efficiency – a benefit of a truly integrated design.

4 | The on-grid inverter converts power output from the Windspire® into smooth alternating current (AC) for use with the electric grid. The off-grid version converts power output from the Windspire® into smooth direct current (DC) that is sent to a matching battery charger that charges a set of batteries

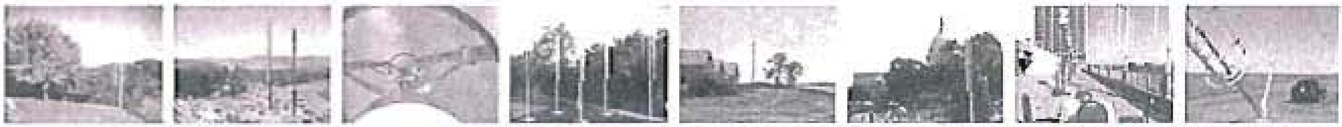
5 | The Windspire® supplies power to your home, shop or business.
Plug 'n Produce™.
You can get power from your Windspire® as soon as it is installed.

When the wind isn't blowing, [illegible]

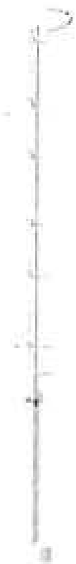
Safety controls prevent power surges, [illegible]

You can monitor electricity [illegible]

	STANDARD UNIT	[illegible]
[illegible]	2000 kWh* at 12 mph / 5.4 m/s avg. wind	2000 kWh* at 15 mph / 6.7 m/s avg. wind
[illegible]	1.2 kW at 25 mph / 11.2 m/s wind	1.1 kW at 30 mph / 13.4 m/s wind
[illegible]	30 ft / 9.1 m [illegible]	23 ft / 7.1 m [illegible]
[illegible]	6 dB above ambient [illegible]	6 dB above ambient [illegible]
[illegible]	624 lb / 283 kg	567 lb / 257 kg
[illegible]	8 mph / 3.6 m/s	8 mph / 3.6 m/s
[illegible]	100 mph / 47 m/s	145 mph / 75 m/s
[illegible]	Recyclable Aircraft Grade Extruded Aluminum	Recycled Aircraft Grade Extruded Aluminum
[illegible]	Recycled High-Grade Steel	Recycled High-Grade Steel
[illegible]	5 years	5 years



Frequently Asked Questions - and Answers!



General Windspire Questions

What Size is the Windspire?
It is 30 feet tall and four feet wide, designed to come in under the typical 35 ft height restrictions of local municipalities. Base pole extension kits of 5, 10, and 20 feet are also available to raise it higher.

How much "swept area" does the Windspire have?
The Windspire has 80 sq/ft of swept area.

How heavy is a Windspire?
A Windspire is about 650lbs.

What does "quiet" mean?
Because of the vertical axis design, sound levels are about 5 decibels above ambient, rendering it virtually inaudible.

Where are the Windspires Made?
Made in the USA. Windspires are manufactured in Manistee, Michigan at MasTech Manufacturing.

What is the Windspire made of?
The Windspire is made 85% of steel (main structure). The remaining 15% is extruded aircraft grade aluminum (airfoils) and a small percentage of electrical parts in the inverter and generator.

Aside from being a "Green" appliance, is the Windspire made of recycled materials?
Yes. The Windspire® is made of 69% recycled materials. This can be broken down as follows: Steel (85% of product) is 69% recycled, Aluminum (10% of product) is 90% recycled; Electronic components (5% of product) are 35% recycled.

How Does the Windspire Work?
The Windspire wind turbine operates with three sets of tall, narrow airfoils that catch the wind while spinning around a vertical axis. As the rotor turns, a generator conditions the energy into electricity. The inverter then converts the electricity to an alternating current(AC) that can be used for buildings and homes.

Is the Windspire a Grid-Tie or Off-Grid Product?
The Windspire that is currently available is grid-tie, which requires that the Windspire be tied into the local utility's grid. For safety reasons, the Windspire will not work if a connection cannot be made to the grid. Mariah Power has future plans for an off-grid version of the Windspire.

Are the fasteners for the Windspire metric or standard sizing?
The Windspire fasteners are all metric sizing.

Power And Energy

How Much Energy Will the Windspire Produce?
The 1.2kW Windspire will produce approximately 2000 kilowatt hours per year in 12 mile per hour average winds. This is approximately 1/3 to 1/6 of most homes in the US, about ½ the average European home, and several homes in developing countries.

What is the difference between Energy and Power?
At wind speeds greater than 8 mph, the Windspire will begin producing power, which is measured in Watts (W) or kilowatts (kW). Power output jumps up and down as quickly as the wind changes speed, so the industry measures output over time in kilowatt-hours (kWh) which is how many watts of power are produced over a full hour. Your electric company charges you for energy usage based on the rate/kWh. Over the course of a year, the 1.2kW Windspire will produce approximately 2000 kWh in 12 mph average winds to help offset the energy you require from your electric company. This is approximately a quarter of the energy usage of an average home.

What's the difference between a kW (kilowatt) and a kWh (kilowatt-hour)?
A kilowatt is an instantaneous measure of power. At any moment, the power that is produced by a small wind turbine is measured in watts or kilowatts (1000 watts). A kilowatt-hour is a measure of energy production: how much energy is produced over one hour. For example, if you turn on a 60W (.06 kW) light bulb for one hour, you draw .06 kWh. If you keep it on for a full year, you will use .06 kW x 8766 hours = 526 kWh. Of course, you should never do this!

Where Do Power Curves Come From?
True power curves come from lots of data taken at a real-world test facility. Data is matched with wind speeds taken from anemometers (wind measuring devices) placed at the hub height (center of rotor), and then "binned" to get lots of data for each wind speed. From the many data points, a line of best fit becomes the power curve. The standard for power curves is to use sea-level air density, so sometimes power curves are then corrected for air density differences. There are also power curves derived from calculations, wind tunnel tests, back of vehicle tests – however because these don't provide the true variability in wind speeds and quality, the results are often very unrealistic when compared with of real world installations.

What affects power output?
Power output is related to rotor size, air density, wind speed, and the efficiency of the wind turbine. The Windspire wind turbine has a comparable efficiency to most small propeller turbines.

At What Wind Speed does the Windspire Begin Producing Electricity?
We publish a cut-in speed of 4 m/s. However, the speed of cut-in is virtually irrelevant, because the amount of power produced at the bottom of the power curve is negligible. What is more important is how plump the power curve is, and the scale it reaches at higher wind speeds. This will contribute far more to the energy produced by a wind turbine.

What is the Peak Power Production of the Windspire?
Peak power is around 1.6 kW at a wind speed of 30 mph wind.

What Happens if my Windspire Produces More Power than I Use? For grid-tie units, your meter will literally spin backwards. For off-grid applications, the excess power will be dumped into heat. With the Smart Inverter incorporated into the Windspire, the firmware allows the rotor to slow down so as not to produce excess (waste) heat 7.

Why do you measure average energy output instead of daily or instantaneous?
Wind energy differs from solar because wind is much more variable than solar energy. If you think about it, when there is sun light, it is very consistent. The sun comes out at a set time of day and goes down at a set time. Wind fluctuates daily and seasonally so finding a daily output level is very difficult. Averages will help you evaluate your energy bill and give you a starting point when comparing different renewable energy systems.

Electricity and Electronics

How does the Windspire turn wind energy into electric power I can use in a home or building?
As the wind pushes the rotor around, the rotor turns a generator. The generator is basically a set of magnets that spin close to copper coils. The moving magnetic field from the magnets induces an electric current in the copper wire. This current then needs to be conditioned into an AC current by an inverter so that it is compatible with standard grid electricity. The generator and inverter are housed in the disc just below the rotor. The electricity then flows down a wire through the pole, and under the ground to connect with your home or building.

Is the Windspire a Grid-Tie or Off-Grid Product?
The currently available Windspire is grid-tie, which requires the unit to be tied to the local utility grid. In effect, the grid serves as the best, lowest cost battery there is. An off-grid version of the Windspire is in development and will be available soon.

Can I Sell Electricity Back to the Grid?
Many utilities offer net metering agreements that allow customers to receive credit for, or sell excess power back to the grid.

What is an Inverter?
An inverter is an electronic component that conditions the electricity for a specified type of output. For example, it needs to be consistent with 120V grid electricity in order to make it useful for grid-tie in North America. Our inverter consists of an electronic controller, and firmware - a computer program that is the brains behind the controller. The Firmware allows the inverter to be a lot smarter and adjust to changes in rotor speed and temperature, for example, than a simple electronic controller.

What if I want to use my own inverter for the Windspire? Can I do this?
No. The Windspire has been specially designed to operate the spinning speed, control energy output and integrates with the generator of the Windspire.

Does the Grid-Tie Windspire need to be connected to its own fuse?
Yes. It requires its own 20 amp fuse.

Can I link multiple Windspires together with the same electrical connection?
No. Due to National codes, each Windspire® must have its own grid connection.

How do I know if my Windspire is producing any electricity?
Mariah Power has developed their own software to wirelessly monitor the output of the Windspire. This software package is an additional package that can be purchased through your local dealer.

Economics

How Much does the Windspire Cost?
The Windspire is the most affordable renewable energy appliance in the 1 kilowatt range. The Windspire comes as a complete system that includes poles, rotor, generator, inverter, and wireless performance monitor, so there are no expensive extras to purchase. A 30% federal tax credit (available in the USA) and local rebates are available in some areas. The average payback is under 10 years.

* Are There Tax Credits Available?
The Federal Government provides a 30 percent tax credit for the total cost of the unit, including installation. Many state and local municipalities also offer rebates, as do local power companies.

To what extent will a Windspire power my home?
This is difficult to answer, because electricity use varies widely by home size, age, construction, climate, and the occupant's habits. Furthermore, the power you can expect depends entirely on your wind regime. The best place to start is with your

electricity bill and a wind map of your area. In a true generalization, a Windspire can power about 1/3 to 1/5 of the average US home, about ½ the average European home, and several homes in developing countries.

Safety and Environment

Is it Safe for Birds and Bats?

The Windspire airfoils move at a lower speed than most wind turbines and are more visible to flying birds. So far, we have had no reports of collisions - and we have had one report of a nest built under an active unit. You should also be aware that collisions with small wind turbines in general are very rare – overall they account for less than 0.003% of human-caused bird death - although the media has tended to hype them. To put it in perspective, cats, windows, and automobiles kill over a billion birds a year in the USA.

Is There a Brake for High Winds?

Yes, the rotor speed is limited by a brake that is applied if it runs at 405 rpm for more than 30 seconds, or immediately if it exceeds 420 rpm at any instant. Once applied, the brake will stay in effect for five minutes. The purpose of the brake is to preserve the structural integrity of the Windspire in extremely high stress situations. The brake does not bring the unit to a complete stop, but it brings it down to a slow rotation. If you are expecting a wind storm of prevailing winds over 105 mph, you should lower your Windspire to the ground for the storm.

Why is a dynamic brake applied to the generator? Wouldn't you want the Windspire to spin as fast as possible?

A dynamic brake is applied to the generator in high winds to reduce stress and maintain the structural integrity of the equipment so that you can enjoy a 20 year plus life span on the unit. Be wary of any wind generators that are sold without a braking system in place.

How is Overheating Prevented?

Internally there is a fan that cools the electronics. The inverter constantly monitors the temperature inside at 3 locations and if any of the sensors exceed safe operating limits the inverter will take action. If the wind in low to moderate, then the inverter will reduce the power output by applying the brake in an attempt to reduce the temperature. At high winds (RPM) or if it can't cool enough then it will shutdown for ½ hour to cool before restarting.

Siting

Are There Specific Requirements for Potential Customers?

A Windspire site requires land with unobstructed wind and adequate space for installation. The Windspire also needs at least class two winds - ideally class three (an average of 12 mph). You should also select the Windspire model that is appropriate for your electricity needs (grid-tie, vs off-grid, voltage in your country, etc.)

How much wind do I need for Windspire to make sense?

In general, an average of 12 mph (5.5 m/s) or more, although in some circumstances it may make sense in lower wind regimes. Doubling the wind speed gives you eight times as much power from the wind. Wind turbines get most of their power from the time of day when the wind is really blowing.

What if I want to reach higher wind speeds above 30 feet? Do you have extensions that I can purchase for my Windspire?

Yes. We offer extension poles in 5', 10' and 20' kits. Ask your local dealer about pricing and installation information.

How far apart do I need to place my Windspires from each other?

Depending on the direction of the prevailing wind, we have a chart for suggested minimum spacing.

Do I need a crane to install a Windspire?

No, a certified Windspire dealer will install your wind turbines. The Windspire is assembled horizontally on the ground and then raised via a hinge at the base plate of the unit. This makes raising and lowering the unit a simple task.

Can the Windspire Withstand Salt Air?

Coastal conditions are challenging. We currently take three measures to protect the steel structure from salt air. First, we etch the steel with phosphorous, second, we coat it in a zinc primer to protect the base metal, and third, we apply a top coat of industrial grade paint, the same kind as is used on steel bridges. If you are still worried about rust, we have a Marine Package available that replaces all fasteners with stainless steel and an enhanced rust proof coating. Ask your local dealer about the Marine Package.

How big of a foundation does a Windspire require?

For a typical installation, the Windspire requires a 6ft deep x 2ft wide hole to be dug and filled with 1 ½ yards of concrete. Special soil conditions may have different requirements. Your Windspire dealer will take care of pouring the foundation.

Testing and Certification

Are There Standards for Testing and Performance Ratings?

Basic electric standards such as UL and IEEE ratings are required for small wind turbines. The American Wind Energy Association (AWEA) recently created a set of standards and a certification process for small wind turbines. In the next 12-18 months the Windspire will be tested to these standards. Until the new standards are adopted, we recommend focusing your search on independently tested wind turbines with UL certified inverters.

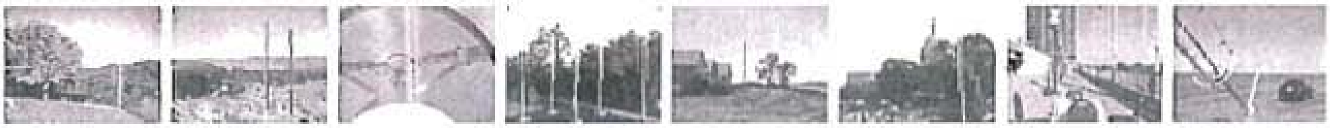
Is the Windspire Independently Tested and Certified?

The Windspire is independently tested at Windward Engineering in Spanish Fork, Utah. This testing allows customers to know what level of power production to expect from specific wind ranges. The Windspire received ETL certification in March of 2008 and has kept this certification up-to-date as we further improve electronic components. The ETL certification includes UL and IEEE testing for the US and Canada. The Windspire is also listed on the CEC's approved wind turbine list, a requirement for many rebates.

Comparing Wind Turbines from Different Manufacturers

What is "swept area" and why is it important when talking about wind turbines?
Swept area is a measurement used to evaluate how many square feet of wind a wind turbines' rotors can catch. The traditional equation for finding swept area of a HAWT (horizontal axis wind turbine - or propeller style) is by using the equation for the area of the circle [Pi x (r squared)], since propellers create a flat plane. Since a vertical axis turbine has a different configuration, the equation is dxh, where d is the diameter and h is the height of the airfoils. Since the Windspire® has a diameter of 4ft and the airfoil height is 20ft, our total swept area is 80 sq/ft.

Our patented generator creates energy with torque from the spinning rotors. The more torque our Windspire® can produce, the more electricity it will generate. The smaller the swept area, the less torque a wind turbine generator will be able to produce. This equates into less electricity generation. Pay special attention to wind turbine companies claiming large output with low swept area. The physics of some of these designs just don't add up.



Your Wind

The most important factor in producing energy from a wind turbine, any wind turbine, is the availability of wind. There are many perceptions of what "windy" means. Before you assume that your conditions are windy enough, you should find out what they actually are in terms of approximate average wind speeds (mph or m/s).

How much wind do you need?

In general, you want average wind speeds of around 12 mph (miles per hour), although in some places Windspire makes sense with lesser wind resources. For example, if you have high electricity rates, or substantial rebates or incentives available to you, it may make sense to place a Windspire in a zone with an average wind speed of only 10 mph. Note that "average wind speed" means the average 24 hours a day, 365 days a year, for an average year (and year-to-year averages can vary by a good deal).

How much wind do you have?

Great question. Here are some suggestions for how to find out:

1. Use visual references. This is cheap, but not very precise. On the other hand, people have a very good inherent ability to estimate many things. A couple of more common scales allow you to estimate wind speeds based on open water and land indicators (Beaufort Scale), and tree deformation (Griggs-Putnam Index). We have put together a useful guide to both scales for you to use.

   You should also take note of wind patterns - for example, is it generally windy at one time of day or another? Do the patterns change between seasons? In most places, the answers will be yes.

2. Use nearby data. Check out data from nearby weather stations. This can be used to determine wind conditions on a given day - a reality check. Some stations may provide average data too.

   One BIG caution is, don't rely on any data unless you have checked out the circumstances. Old or poorly calibrated anemometers (wind-measuring devices), poor siting, variable anemometer heights, damage, etc. can cause very erroneous measurements. Also, your local site may have anomolies of its own, so nearby data can only give you a general idea. Some sources for nearby data include:
   a. National Climatic Data Center. Search for local stations, and check for wind data. Not all stations have wind data.
   b. Weather Underground: A great source for information from people's personal weather stations across the country. Many include wind data.

3. Check wind maps. Short of collecting a year's worth of wind data using a sophisticated anemometer, wind maps can give you a good ballpark estimate of your average wind speed. The limitation is that wind maps have a broad resolution, whereas wind can vary greatly from one spot to another on the very same plot of land or within the broad radius of wind zones from maps. Wind varies based on the local geography (hill or valley) and obstructions (forest or open plains). It is important to find a location for your Windspire with unobstructed access to good wind.

4. Install an anemometer at your proposed site. An anemometer measures wind speeds, and higher end anemometers have a data logging capability. While simple handheld anemometers can be useful, you will get the most accuracy by installing a sophisticated anemometer on a pole to monitor wind over an extended periods of time. However, this is generally more costly than it is worth for a small wind installation (it can cost upwards of $3000 to just test your wind in this way). Some retailers and installation contractors can also offer more detailed wind site testing, and some states offer anemometer loan programs to help with wind power siting.

What about Wind Quality?

Other factors to consider are the direction of wind. If there is a prevailing direction, make sure you choose a location that is not block access to this wind with a building, tree or hill. Other considerations are the quality of the wind, including turbulence and gustiness. The Windspire handles gustiness well, since it does not have to re-align to changing wind directions and it can immediately capture the energy from changing wind speeds. It also handles turbulence relatively well, but extreme turbulence can be harsh on the equipment. Close to the ground winds are generally turbulent, but in some settings turbulence is amplified. If the wind needs to navigate an obstacle course before it reaches your turbine, the turbulence will be much higher than average.

Another frequent question is about wind tunnel effects in urban settings, or wind amplification over the edges of tall buildings.

These conditions do exist, but they have very narrow ranges. For sites in densely built environments or for commercial roof-top installations, we recommend conducting wind modeling to ensure optimal placement of the Windspire.

How far should Windspires be from buildings, trees, or each other?

The following are recommended minimum distances between a Windspire and an object. For the purpose of this table, position references are relative to the prevailing wind direction. For example, "in front" means that the object is blocking the prevailing wind; "behind" means the Windspire gets the benefit of the prevailing wind before it reaches the object. The reason there is still a minimal distance is because objects cause turbulence, even if behind the Windspire. Regardless of the distance recommendations, you should check that the wind speeds are still adequate in the exact spot where you plan to site the Windspire.

Obstacle	Position	Min. Distance
Buildings, trees, etc.	in front of Windspire beside Windspire behind Windspire	100 feet 50 feet 30 feet
Other Windspires	beside each other diagonally from each other 60 degrees behind 75 degrees behind directly behind each other	8 feet 11.2 feet 15.4 feet 26.5 feet 50 feet

For more information, see this guide

What are Wind Classes?

The US Department of Energy has divided winds into classes, as follows:

Classes of Wind Power Density at 10 m (33 ft) Above Ground

Wind Class	Mean Wind Speed (mph)	Mean Wind Speed (m/s)	Power Density (Watts/m^2)
1	9.8 or less	4.4 or less	100 or less
2	11.5	5.1	100-150
3	12.5	5.6	150-200
4	13.4	6.0	200-250
5	14.3	6.4	250-300
6	15.7	7.0	300-400
7	21.1 or more	9.4 or more	400-1000

Notes: These calculations are based on standard temperature and pressure, and mean wind speeds are the long-term average (the average taken over a full year, from data from many years). Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density.

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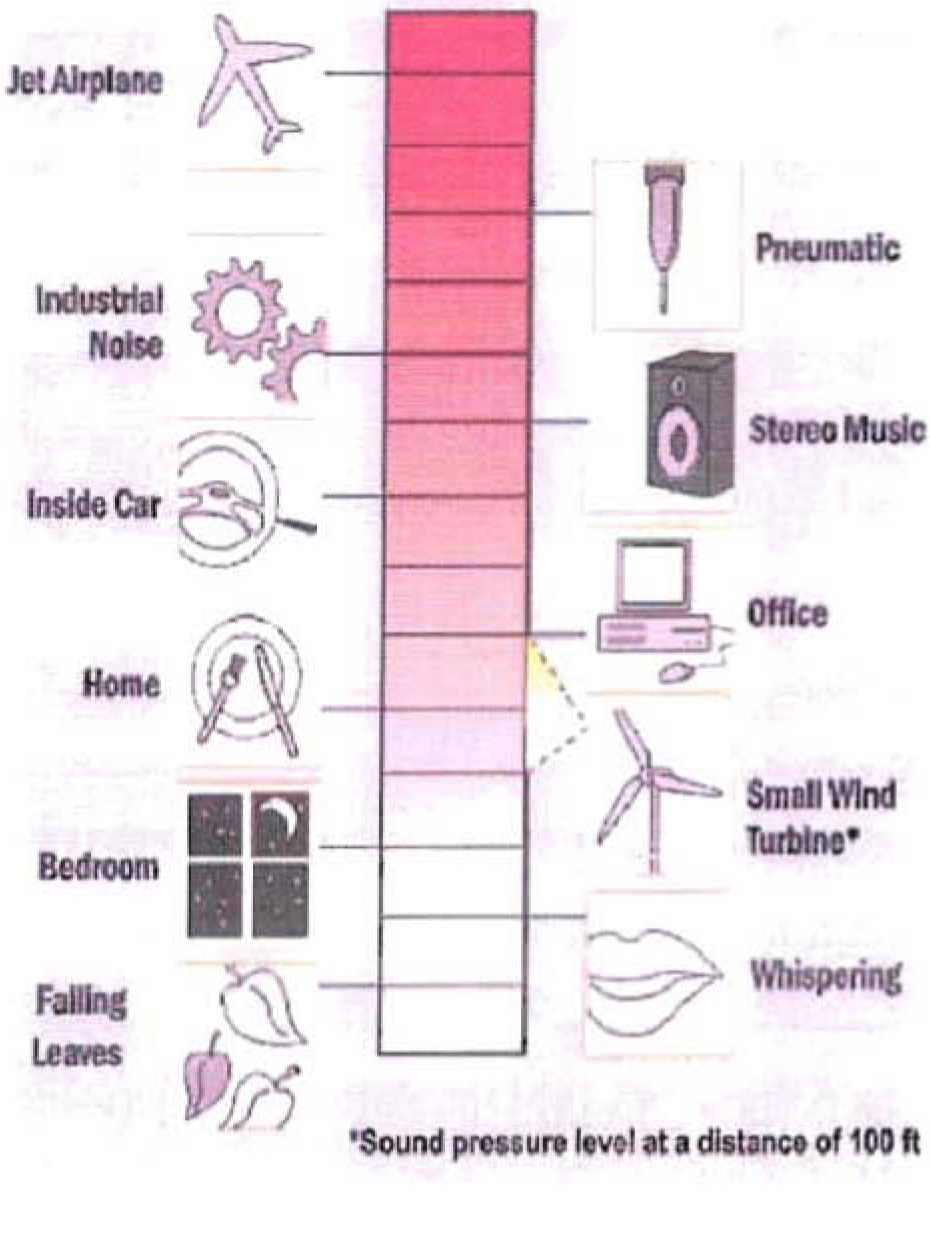
SOUND LEVEL COMPARISON

Sound Level Comparison of Common Noises and Wind Turbines



PRIMER FOR ADDRESSING WIND TURBINE NOISE

Primer for

Addressing Wind Turbine Noise

Revised Oct. 2006

by Daniel J. Alberts

LAWRENCE TECHNOLOGICAL UNIVERSITY

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Introduction

Michigan is proceeding to develop renewable energy policies. The Energy Office of Michigan, in their 2004 Annual Report to the Michigan Public Service Commission on Michigan's Renewable Energy Program, recommended that the State of Michigan adopt the following policies:

- Set a goal of installing 800 MW of wind power by the year 2010.
- Adopt statewide policies to encourage the development of wind energy in Michigan.
- Adopt a Renewable Portfolio Standard (RPS) that requires 1.0% of all energy sold within the state of Michigan be generated from renewable sources (including wind) by December 2006.
- Increase the RPS requirement by 0.5 % each year to reach a total of 10% by 2015.

Although the State of Michigan may encourage renewable energy development, local governments within the state will be responsible for zoning and permitting wind turbines. To develop zone and permit wind turbines, local governments will need to examine a variety of issues, including the impact of wind turbine noise on land use compatibility.

To help wind energy advocates and Michigan's policy makers better understand this issue, Michigan's Energy Office asked Lawrence Technological University to research the noise issue and present their findings to Michigan's Wind Working Group. The formal research documents are available at Lawrence Technological University's web site:

http://www.ltu.edu/engineering/mechanical/delphi_wind.asp

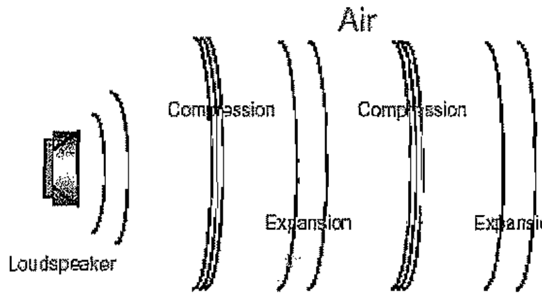
This paper consolidates the education material on noise concepts and assessment distributed through the two formal phases of the research with additional material on engineering standards for noise measurement. The author hopes this paper will help decision makers understand wind turbine noise well enough to develop beneficial permitting procedures and zoning ordinances, and permit wind energy development with minimal conflicts.

Noise Concepts and Definitions

The dictionary defines noise as unwanted sound. But to understand noise measurement and assessment, it is necessary to examine noise from an engineering perspective. This means defining several characteristics of sound, and redefining noise based on these definitions.

Sound is a defined as rapid fluctuations of air pressure which create a repeating cycle of compressed and expanding air.

Figure 1. Sound



Sound power is the energy converted into sound by the source. Sound power is not measured directly, it is calculated from measurements, and is used to estimate how far sound will travel and to predict the sound levels at various distances from the source. Several wind turbine manufacturers provide sound power with their turbine brochures. For example, Vestas' V80, 1.8 MW turbine emits between 98 and 109 dB(A) of sound power depending on configuration.

As sound energy travels through the air, it creates a sound wave that exerts pressure on receivers such as an ear drum or microphone. *Sound pressure* is typically measured in micropascals (μPa) and converted to a *sound pressure level* in decibels (dB) for reporting. The decibel scale is a logarithmic scale relative to the human threshold of hearing. Sound pressure level is used to determine loudness, noise exposure, and hazard assessment. (The next section covers sound pressure scales in more detail.) ANSI, the EPA, ISO, OSHA, and the WHO[1] all base their recommendations for maximum noise exposure on sound pressure levels.

As stated above, sound is a repeating cycle of compressed and expanding air. The *frequency* is the number of times per second, or Hertz (Hz), that this cycle repeats. An *octave* is a range where the lowest frequency is exactly half the highest frequency. A Concert A is 440 Hz, the next higher A is 880 Hz.

Sounds are often classified by the number of frequency components they contain. A *tone* is a sound that contains only one frequency. Musical notes are tones. Mechanical systems often emit noise that contains a noticeable tone. *Narrowband* sounds contain two or more frequency components, but the frequencies are very close to each other, within 1/3 of an octave. *Broadband* sounds contain multiple frequency components, and the frequencies span more than 1/3 of an octave. Cars, lawn equipment, jet engines and wind turbines all produce broadband noise.

[1] American National Standards Institute (ANSI), US Environmental Protection Agency (EPA), International Standards Institute (ISO), Occupational Safety and Health Administration (OSHA) and the World Health Organization (WHO)

Table 1 lists some important frequency ranges for studying the impact of wind turbine noise.

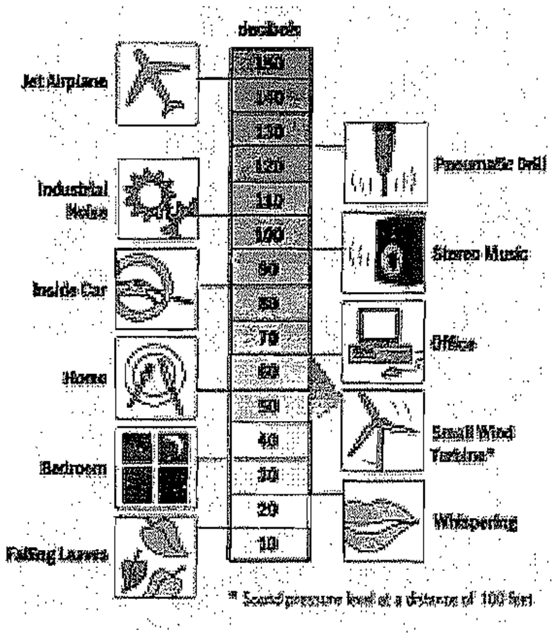
Table 1. Important Frequency Ranges

	Range
Normal Hearing	20 Hz – 20 kHz
Normal Speech	100 Hz – 3 kHz
Low Frequency	20 – 200 Hz
Infra Sound	< 16 Hz

Sound Pressure Level Scales

The human ear can detect and respond to sound pressures, from 20 μPa to over 200,000,000 μPa. (beyond 200,000,000 μPa the response becomes pain.) Engineers wanted a scale with a smaller range, so they mapped sound pressure on logarithmic scale which they defined as the decibel (dB). Zero decibels is the lowest pressure (20 μPa) that a person with normal hearing can detect. One hundred forty decibels is the pressure (20,000,000 μPa) that causes most people physical pain. Figure 2 shows how this scale relates to some common noise sources.

Figure 2. The Decibel Scale[2]



[2] Source: The American Wind Energy Association, http://www.awea.org/faq/noisefaq.html

Because decibels are a logarithmic scale, values do not add the same as they would for a linear scale. Doubling the sound power increases the sound pressure level by 3 dB. For example, two wind turbines each generating 110 dB of noise would produce a combined noise of 113 dB. However, doubling the sound pressure will increase the sound level by 6 dB.

A few additional things to remember about the decibel scale:

- Outside the laboratory most people cannot notice a volume change of less than 3 dB.
- A volume change of 3–5 dB is clearly noticeable.
- Most people subjectively perceive volume increase of 10 dB as twice as loud.

Peoples' perception of noise, however, do not always correspond with the dB scale. Sounds created with the same energy, but with different frequencies are not perceived to be equally loud. A lower frequency sound will seem quieter than a higher frequency sound of the same sound level. Noise control engineers wanted scales that reflected peoples' perception of noise. So they created 'weighting' scales.

In one sense, noise scales are like temperature scales. A thermometer measures the amount of heat in the air. The heat measurement is then compared to a reference scale such as Fahrenheit or Celsius. When we measure noise, we are actually measuring the amount of pressure that sound exerts on the receiver. We then compare that pressure to a decibel scale. However, the decibel scales are also adjusted by frequency. Engineers specify adjusted values by appending the scale name to the units, i.e., dB(A) or dB(C). Unadjusted values are reported as simply dB. Three of the scales, A, C, and G, have been identified as potentially relevant to addressing wind turbine noise.

The A scale is the most commonly used for community noise assessment and for specifying exposure limits. Designed to reflect the way people perceive sounds, the A scale divides the range of possible frequencies into octaves, and for each octave adjusts the decibel level so that a specified decibel level will seem to have the same loudness in each range. Table 2 shows how to adjust a sound pressure level for each frequency range to report a sound pressure level on the A, C, and G scales.

Table 2. Decibel Weighting Scales

Octave-center frequency (Hz)	Weighted response (dB)		
	A scale*	C scale*	G scale**
4			-16.0
8			-4.0
16			+7.7
31.5	-39.4	-3.0	-4.0
63	-26.2	-0.8	
125	-16.1	-0.2	
250	-8.6	0.	
500	-3.2	0.	
1,000	0.0	0.	
2,000	+1.2	-0.2	
4,000	-1.0	-0.7	

*From IEC 60651
**From ISO 7196

Many noise control texts state that the A scale is insufficient for determining the impact of noise or the level of annoyance when the frequency is below 100 Hz. Other texts state that the A scale is insufficient for any sound above 60 dB. These texts recommend the C scale which more closely resembles the actual sound pressure. However, the US Department of Labor based their noise exposure standards on the A scale. ANSI, the EPA, ISO, OSHA and WHO all provide their health impact data and their recommended noise exposure limits on the A scale; so it is likely the A scale will remain predominant.

As Table 2 shows, the difference between the A scale and the actual sound pressure varies significantly from one frequency range to another. So in order to ensure compliance with limits specified on the A scale, engineers specify non-adjusted limits for each range. Table 3 shows how Mundy Township in Michigan specified non-adjusted noise limits for each octave band to achieve the desired A scale limits.

Table 3. Octave Band Noise Limits

Frequency at center of octave band	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz
Non-adjusted dB level	72 dB	71 dB	65 dB	57 dB	51 dB	45 dB
Equivalent dB(A)	32.6 dB(A)	44.8 dB(A)	49 dB(A)	48.4 dB(A)	47.8 dB(A)	45 dB(A)

The G scale is used only for infrasound, i.e., sounds below 20 Hz. A few studies show that wind turbines do generate infrasound. However, the practicality and the importance of using the G scale for measuring this noise is still being debated.

For additional information on noise measurement, visit:

http://www.phys.unsw.edu.au/~jw/dB.html

http://www.dataphysics.com/support/library/downloads/articles/DP-Aweight.pdf

Wind Turbine Noise

Wind turbines generate two types of noise: aerodynamic and mechanical. A turbine's sound power is the combined power of both. Aerodynamic noise is generated by the blades passing through the air. The power of aerodynamic noise is related to the ratio of the blade tip speed to wind speed. Table 4 shows how the sound power of two small wind turbines vary with wind speed.

Table 4. Sound Power of Small Wind Turbines[3]

Make and Model	Turbine Size	Wind Speed (meters/second)	Estimated Sound Power
Southwest Windpower Whisper H400	900 W	5 m/s	83.8 dB(A)
		10 m/s	91 dB(A)
Bergey Excel BW03	10 kW	5 m/s	87.2 dB(A)
		7 m/s	96.1 dB(A)
		10 m/s	105.4 dB(A)

Depending on the turbine model and the wind speed, the aerodynamic noise may seem like buzzing, whooshing, pulsing, and even sizzling. Turbines with their blades downwind of the tower are known to cause a thumping sound as each blade passes the tower. Most noise radiates perpendicular to the blades' rotation. However, since turbines rotate to face the wind, they may radiate noise in different directions each day. The noise from two or more turbines may combine to create an oscillating or thumping "wa-wa" effect.

Wind turbines generate broadband noise containing frequency components from 20 – 3,600 Hz. The frequency composition varies with wind speed, blade pitch, and blade speed. Some turbines produce noise with a higher percentage of low frequency components at low wind speeds than at high wind speeds.

Utility scale turbines must generate electricity that is compatible with grid transmission. To meet this requirement, turbines are programmed to keep the blades rotating at as constant a speed as possible. To compensate for minor wind speed changes, they adjust the pitch of the blades into the wind. These adjustments change the sound power levels and frequency components of the noise. Table 5 lists the sound power for some common utility scale turbines.

Table 5. Sound Power of Utility Scale Wind Turbines

Make and Model	Turbine Size	Sound Power
Vestas V80	1.8 MW	98 – 109 dB(A)
Enercon E70	2 MW	102 dB(A)
Enercon E112	4.5 MW	107 dB(A)

A turbine's sound power represents the sound energy at the center of the blades, which propagates outward at the height of the hub. While writing this paper, I visited the Bowling Green Wind Farm Project, in Bowling Green, OH. At the base of 1.8 MW turbine, we measured the noise level at 58–60 dB(A). However, the turbines stand in a corn field, and depending on our position relative to the turbines, it was very difficult to distinguish the sound of the turbine from the rustling of the corn stalks.

Mechanical noise is generated by the turbine's internal gears. Utility scale turbines are usually insulated to prevent mechanical noise from proliferating outside the nacelle or tower. Small turbines are more likely to produce noticeable mechanical noise because of insufficient insulation. Mechanical noise may contain discernable tones which makes it particularly noticeable and irritating.

The amount of annoyance that wind turbine noise is likely to cause can be related to other ambient noises. One study in Wisconsin[4] reported that turbine noise was more noticeable and annoying at the cut-in wind speed of 4 m/s (9 mph) than at higher wind speeds. At this speed, the wind was strong enough to turn the blades, but not strong enough to create its own noise. At higher speeds, the noise from the wind itself masked the turbine noise. This could be of significance to Michigan communities where the average wind speeds very from 0 to 7 m/s (0–16.7 mph).

Health Impacts of Noise Exposure

Excessive exposure to noise has been shown to cause a several health problems. The most common impacts include:

- Hearing loss (temporary and permanent)
- Sleep disturbance

[3] Source: P. Migliore, J. van Dam and A. Huskey. Acoustic Tests Of Small Wind Turbines http://www.bergey.com/Technical/AIAA%202004-1185.pdf

[4] http://www.ecw.org/ecw/productdetail.jsp?productId=508&numPerPage=100&sortA

Exposure to extremely high noise levels can also cause headaches, irritability, fatigue, constricted arteries, and a weakened immune system[5]. However, there is no evidence that wind turbines generate the level of noise needed to create these problems.

Induced Hearing Loss

Noise exposure can induce two types of hearing loss: threshold shifts, which refers to the lowest volume a person can detect, and frequency loss, which means an inability to hear specific frequencies.

A person with normal hearing can detect any sound above 0 dB. Exposure to loud noises can temporarily desensitize nerve endings so that the lowest volume a person could hear might increase to 6 or 10 dB. With this shift, the person's entire perception of noise changes so that what was previously perceived as a normal volume seems too quiet to understand. If exposure is brief and the noise is removed, most people's hearing will return to normal. Long-term exposure, however, can cause permanent damage.

Hearing loss is related to the total sound energy to which a person is exposed. This is a combination of the decibel level and the duration of exposure. The Environmental Protection Agency (EPA), The American National Standards Institute (ANSI), and the US Occupational Safety and Health Administration (OSHA) have issued separate recommendations for maximum noise exposure to prevent hearing loss. Table 6 summarizes ANSI's recommendations.

Figure 3 shows how ANSI's recommendations compare to those of the EPA and OSHA.

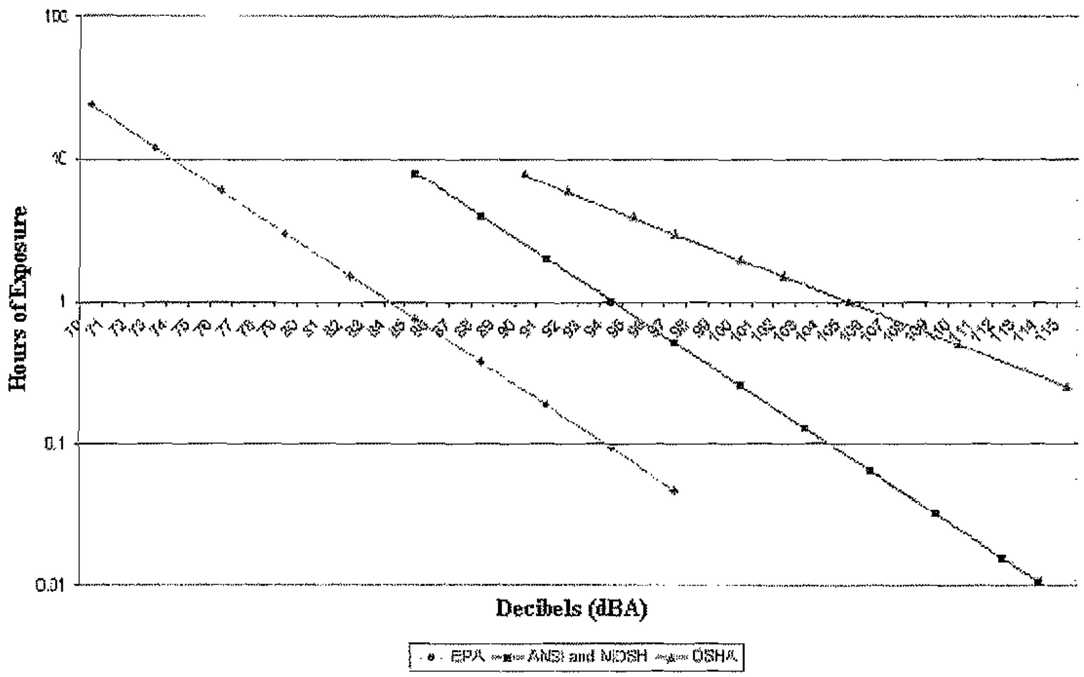
Table 6. ANSI Recommendations for Max Noise Exposure

Sound level dB(A)	Max exposure
90	8 hours
95	4 hours
100	2 hours
110	1/2 hour
115	1/4 hour

[5] Bragdon, Clifford. (19710Noise Pollution The Unquiet Crisis. (pg 69-71) University of Pennsylvania Press.

Stephens, Dafydd and Rood, Graham (1978) The Nonauditory Effects of Noise on Health (pg 285-312)in Handbook of Noise Assessment Edited by Daryl May Van Nostrand Reinhold Company New York

Figure 3. Comparison of Maximum Noise Exposure Standards[6]



Hearing loss can occur in specific frequencies. Elderly people tend to loose the ability to perceive higher frequencies before lower frequencies. Wind turbine noise, however, has not been linked to frequency loss.

Sleep Disturbance

The Institute of Environmental Medicine at Stockholm University prepared an extensive volume for the World Health Organization (WHO) on the impact of community noise on people's health. They report that noise exposure can affect sleep in several ways, including:

- increasing the time needed to fall asleep,
- altering the cycle of sleep stages, and
- decreasing the quality of REM sleep.

Over extended periods of time, any one of these problems could lead to more serious health issues.

[6]Source: http://www.nonoise.org/hearing/exposure/standardschart.htm

Sleep disturbances have been linked to three characteristics of noise exposure, including:

- the total noise exposure (including daytime exposure)
- the peak noise volume
- for intermittent noise, the number of volume peaks

The study reports that:

- Noise levels of 60 dB wakes 90% of people after they have fallen asleep.
- Noise levels of 55 dB affects REM cycles and increases time to fall asleep.
- Noise of 40-45 dB wakes 10% of people.

WHO recommends that ambient noise levels be below 35 dB for optimum sleeping conditions. These recommendations are significant because of a Dutch study[7] that showed noise from a 30 MW wind farm becomes more noticeable and annoying to nearby residents at night. This study noted that although the noise is always present, certain aspects of turbine noise, such as thumping and swishing, were not noticeable during the day, but became very noticeable at night. Residents as far as 1900 meters from the wind farm complained about the nighttime noise.

Intermittent peaks of 45 dB occurring more than 40 times per night, or peaks of 60 dB occurring more than 8 times per night will disturb most people's sleep. Intermittent starts and stops may be an issue for small, residential scale wind turbines (< 500 kW), and medium sized commercial turbines (500 kW – 1 MW) but are not likely to be an issue for utility scale turbines.

Many people (but not all) develop the ability to fall asleep regardless of the sound levels. Studies, however, show that this is only a partial adaptation. The presence of noise continues to negatively affect the sleep cycles and the quality of REM sleep.

Noise Assessment and Exposure Indicators

In many areas, noise levels change several times per day. So a noise that might seem loud at some times might be barely noticeable at other times. To account for these differences, many noise specifications use statistical limits. Table 7 lists some of the most commonly used indicators and their meanings.

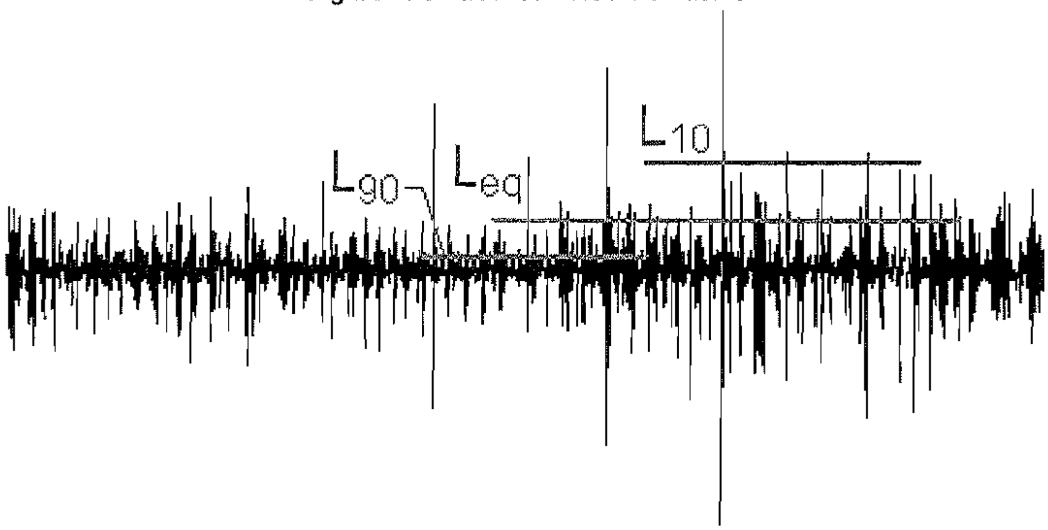
[7] G.P. van den Berg (2003) Effects of the wind profile at night on wind turbine sound. Journal of Sound and Vibration 277 (2004) 955–970

Table 7. Statistical Indicators

Indicator	Meaning
L_{max}	The maximum sound level measured.
L_{eq}	Equivalent continuous sound. An average sound energy for a given time
L_{10}	Sound level exceeded 10 percent of the time. Generally considered to be the sound level that will annoy most people.
L_{90}	Sound level exceeded 90 percent of the time. Generally considered to be a measure of ambient background noise.
L_{dn}	Day-night average sound level, or the average sound level for a 24-hour period

Figure 4 shows how sound levels vary over 1.5 minutes, and shows the relationship between L_{10}, Leq, and L_{90}.

Figure 4. Statistical Noise Indicators



With the exception of L_{max}, statistical indicators are not used to determine the effects of noise exposure on hearing or sleep. Community planners, however, often use these statistics to determine the existing noise levels and predict the impact or community responses of adding a new source of noise.

For example, the Oregon Noise Control Regulation[8] requires the operator of noise producing equipment to determine the L_{10} and L_{50} of a community prior to installing the equipment.

[8] http://www.energy.state.or.us/siting/noise.htm. (This web site also discusses some of the difficulty of measuring statistical noise levels for wind turbines.)

Operating the new equipment must not raise the statistical levels L_{10} or L_{50} by more than 10 dB in any one hour.

Kolano and Saha Engineers[9] especially recommend using statistical limits for regulating noise in hospital and school zones:

> For residential, community park, school, or hospital receiving zones the maximum wind turbine noise limit should be 10 dB greater than the preexisting statistical background sound level (L_{90}) of the community, or 3 dB less than the preexisting statistical high sound level of the community (L_{10}), whichever is lower. The preexisting L_{10} and L_{90} should be measured over a minimum of 3 continuous days that reasonably represents the community over the course of a year. For other zones, such as commercial, industrial and public rights of way the wind turbine noise limit should be 15 dB greater than the L_{90}, or equal to the L_{10}, whichever is less.

Sound Propagation and Attenuation

Propagation refers to how sound travels. Attenuation refers to how sound is reduced by various factors. Many factors contribute to how sound propagates and is attenuated, including air temperature, humidity, barriers, reflections, and ground surface materials. ISO 9613, "Predictive Modeling Standard," provides a standard method for predicting noise propagation and attenuation. This paper summarizes three of the most influential factors:

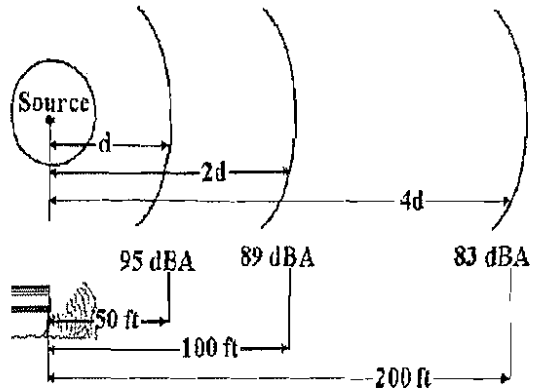
- distance
- wind direction
- building material absorption

Distance

As stated earlier, the decibel scale is logarithmic. Doubling the sound energy increases the sound pressure level by three decibels. But doubling the distance from a stationary source reduces the sound level by six decibels.

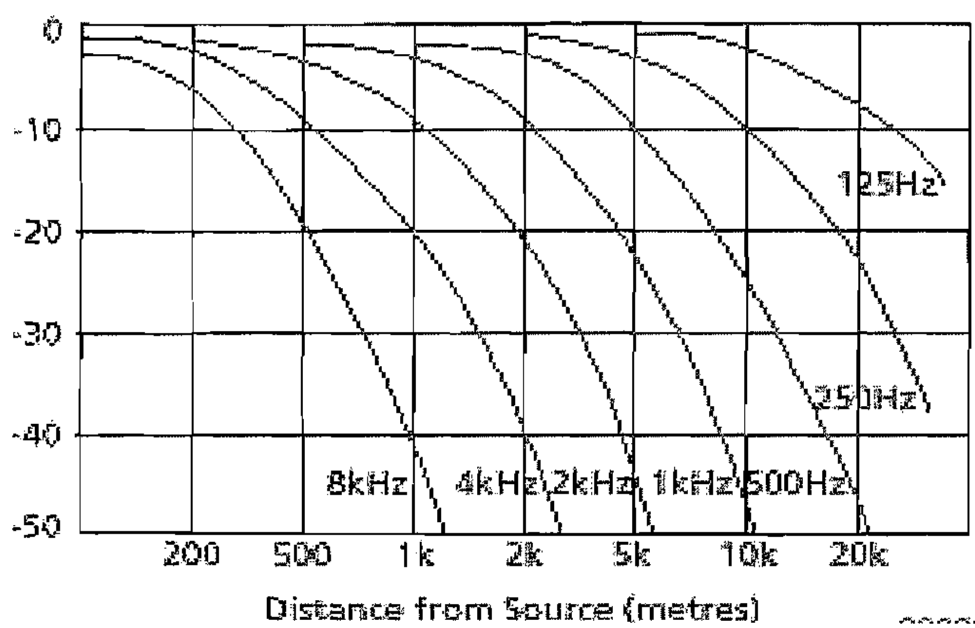
[9] Unpublished correspondence.

Figure 5. Attenuation by Distance[10]



Low frequencies travel further than high frequencies. An 8 kHz tonal sound will be attenuated (reduced in volume) about 40 dB per kilometer. By comparison, a 4 kHz tonal sound will be attenuated only about 20 dB per kilometer. For broadband noise, such as wind turbines produce, the low frequency components may travel further than the higher frequency components. Since low-frequency noise is particularly annoying to most people, it is important to specify limits for low frequency noise.

Figure 6. Frequency Attenuation[11]



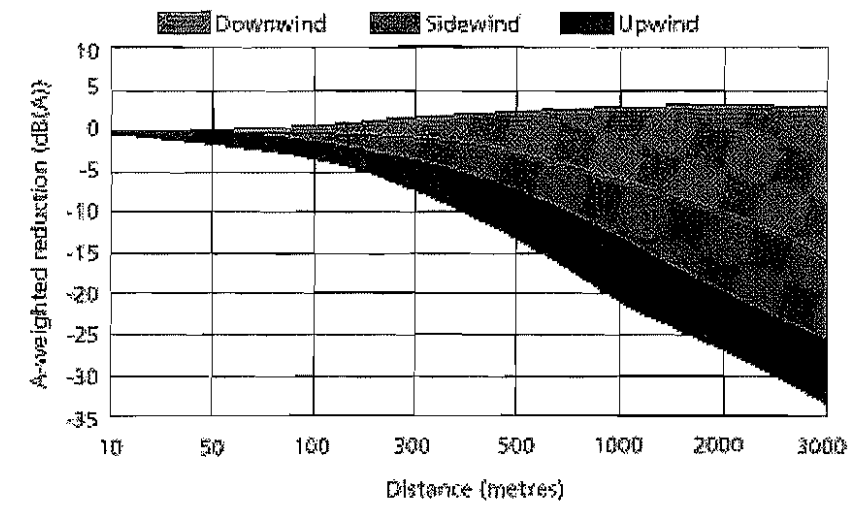
[10] Image source unknown.

[11] Source: Environmental Noise Booklet from Brüel & Kjær Sound & Vibration Measurement A/S. Retrieved from http://www.nonoise.org/library/envnoise/index.htm

Wind Direction

Wind direction also has an influence on sound propagation. Within 900 ft of a sound source, the wind direction does not seem to influence the sound. But after about 900 ft., the wind direction becomes a major factor in sound propagation. Downwind (meaning the wind is moving from the noise source towards the receiver) of the source, sound volume will increase for a time before decreasing. Upwind (the wind is moving from the receiver to the noise source), sound volumes decrease very quickly.

Figure 7. Wind Attenuation of Sound[12]



Building Materials

General home construction, with stud walls and windows in consideration, reduces noise differently for each frequency range. The EPA estimates that in cold climates, such as we have in Michigan, these types of homes attenuate 27 dB of noise. However, this estimate was based on traffic noise which consists of different frequency components than wind turbine noise.

Wind turbine noise, especially at lower wind and blade speeds, will contain more low frequency components than traffic noise. Light weight building home structures will not attenuate these frequencies components as well as higher frequency components. Table 8 lists the estimated attenuation for three octave bands in the low frequency range.

[12] Source: Environmental Noise Booklet from Brüel & Kjær Sound & Vibration Measurement A/S. Retrieved from http://www.nonoise.org/library/envnoise/index.htm

Table 8. Low Frequency Attenuation by Homes

Center of Octave Range	Estimated Attenuation
250 Hz	20 dB
125 Hz	10-15 dB
63 Hz	5-10 dB

Noise Ordinances

There are several methods to specifying noise limits:

- specifying a single all-encompassing maximum limit
- determining preexisting ambient noise levels and specifying that a new noise source may not increase the ambient noise by more than a particular amount
- setting a base limit, with adjustments for district types and time of day or night
- specifying maximum sound levels for each octave range

The American Wind Energy Association (AWEA) and the State of California recommend that noise from small turbines be limited to 60 dB(A) at the closest inhabited dwelling[13]. However, many people feel these simple limits are insufficient to protect people from noise's harmful effects, or even to address the annoyance level.

As mentioned before, the State of Oregon requires that turbine operators determine the preexisting L_{10} and L_{50} of a community. Operating the new equipment must not raise the statistical levels L_{10} or L_{50} by more than 10 dB in any one hour[14]. This method is adopted to address noise as a public nuisance, and takes into consideration the fact that each community will find different noise levels acceptable. However, many people consider it insufficient to account for low frequency noise or to protect people's sleep.

The International Standards Organization (ISO) recommends setting a base limit of 35– 40 dB(A) and adjusting the limit by district type and time of day. Table 9 lists the adjusted limits from a base of 35 dB(A).

[13] Permitting Small Wind Turbines: Learning from the California Experience http://www.energy.ca.gov/renewables/

[14] http://egov.oregon.gov/ENERGY/RENEW/Wind/docs/OAR340-035-0035.pdf

Table 9. ISO 1996-1971 Recommendations for Community Noise Limits

District Type	Daytime Limit	Evening Limit (7 -11 PM)	Night limit (11 PM – 7 AM)
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 most comprehensive method combines the district method with specific limits for frequency components in each octave range. The Charter Township of Mundy, MI's noise ordinance contains two tables; one specifying an overall limit, and one specifying octave band limits for each type of district. Table 10 shows an excerpt from Mundy's ordinance.

Table 10. Mundy Township Octave Band Noise Limits

		Frequency at center of octave band					Total Noise Limit
District Type		31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	
Residential	Day	72 dB	71 dB	65 dB	57 dB	51 dB	55 dB(A)
	Night	67 dB	66 dB	60 dB	52 dB	46 dB	50 dB(A)
Agricultural	Day	82 dB	81 dB	75 dB	67 dB	61 dB	65 dB(A)
	Night	72 dB	71 dB	65 dB	57 dB	51 dB	55 dB(A)

Note: The standard practice among noise control engineers is to specify limits for octave band components as unadjusted dB, and limits for total noise exposure as dB(A).

Engineering Standards

Several organizations have issued recommendations and standards related to noise measurement, assessment and control. Table 11 lists some of the applicable engineering standards.

Table 11. Noise Control Engineering Standard

Standard	Title
ASTM E1014-84	Standard Guide for Measurement of Outdoor A-Weighted Sound Level
ISO 9613	Predictive Modeling Standard
IEC 61400-11	Wind turbine generator systems –Part 11: Acoustic noise measurement techniques
ISO 1996-1971	Recommendations for Community Noise Limits
ANSI S1.4-1983	Specifications for Sound Level Meters
ANSI S12.18-1994	Procedures for Outdoor Measurement of Sound Pressure Levels

Referencing these standards in noise control ordinances will help clarify many aspects of community noise control that might otherwise be left open to interpretation.

Example Ordinance Language

Prior to installing the turbines, establish the existing ambient noise level according to ANSI S12.18-1994 with a sound meter that meets or exceeds ANSI S1.4-1983 specifications for a Type I sound meter.

Use the sound propagation model of ISO 9613 to micro site the turbines within a wind farm so that the turbines will not emit noise above the limits specified in Table 9 and Table 10 beyond the property line of the wind farm.

Conclusions

Community noise assessment and control is a land compatibility issue which must be carefully addressed. A few years ago, the city of Sterling Hts., MI permitted an outdoor concert venue adjacent to a residential neighborhood. The noise became a nuisance, neighbors filed law suits, and the city spent more than $31 million trying to settle the conflict.

With good preparation, however, similar conflicts with wind energy development can be avoided. This paper provides a foundation which should help decision makers develop beneficial permitting procedures and zoning ordinances, and permit wind energy development with minimal conflicts.

About the Author

Daniel J. Alberts is a senior member of the Society for Technical Communication. He holds a BS in Engineering from the University of Michigan and a Master of Science in Technical and Professional Communication from Lawrence Technological University (LTU). Mr Alberts was a founding member of LTU's Alternative Energy Student Group and served as the group's Vice President for the 2004-05 school year.

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SOUND PRESSURE LEVEL AND DISTANCE

This handout relates to the behaviour of sound waves in free field conditions, which means either outdoors away from reflecting surfaces or, if indoors, in an anechoic room.

Outdoors, it is very noticeable that sounds get quieter the farther away you are from the source.

As the ferry on the lake in the photo came closer to the photographer, the sound of its engines would have got louder; and this could have been confirmed by observing the readings on a sound level meter next to the camera.

Point sources

To be able to make any predictions of sound pressure levels at different distances from the source there has to be a theoretical model, inevitably based on mathematics. The commonest model for sound sources is the *point source* which assumes that the sound waves are radiating from a mathematical point - like ripples on the smooth surface of a pond after a small pebble is dropped into the centre.

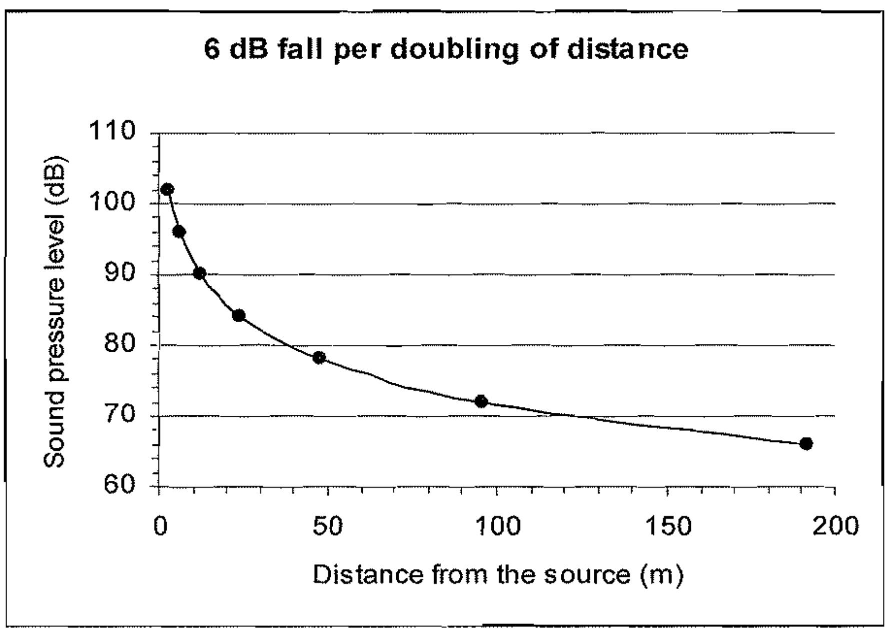
6 dB fall per doubling of distance

For a *point source*, the sound pressure level falls by 6 dB every time the distance between the source and the listener is doubled.

So, if a loudspeaker at an outdoor concert created a sound pressure level of 90 dB at a position 12 m away, we would expect the level to fall to 84 dB (which is 6 dB lower) at 24 m (double the distance) and we would expect it to rise to 96 dB (which is 6 dB higher) at 6 m (half the distance).

Complete the data in the table below and confirm the data points in the graph below.

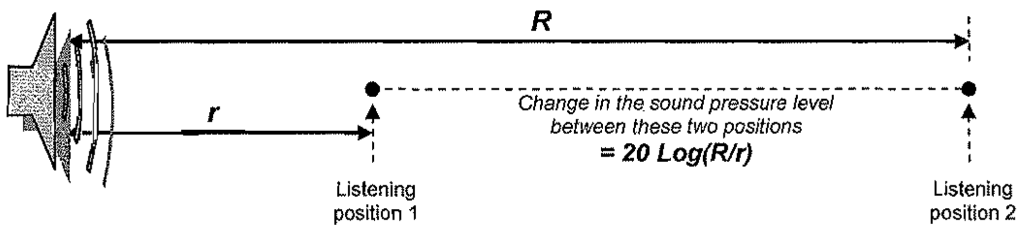
Distance away (m)	3	6	**12**	24	48	96	192
Sound pressure level (dB)		96	**90**	84			



Subtracting (or adding) 6 dB as we double (or halve) the distance between the source and the listener does not, however, allow us to predict the sound pressure level at any position we choose. In the example, on page 1, we might want to predict the sound pressure level 60 m from the loudspeaker.

Equation for the change in level with distance

The diagram shows a source of sound with two listening positions: the closer one is *r* metre away; the farther one is *R* metre away. (Big *R* for the Big distance; Small *r* for the Small distance.)



The change in the sound pressure level between the two positions is given by:

$$\textit{Change in the sound pressure level} = 20 \times \text{Log}\left(\frac{R}{r}\right)$$

In the example on page 1, $r = 12$ m and the sound pressure level there was 90 dB.

If we want to know what the sound pressure level will be 60 m away, at $R = 60$ m:

$$\textit{Change in the sound pressure level} = 20 \times \text{Log}\left(\frac{R}{r}\right)$$

$$= 20 \times \text{Log}\left(\frac{60}{12}\right) = 14.0\,\text{dB}$$

So, the sound pressure level 90 dB at 12 m will fall by 14.0 dB to give 76.0 dB (90 − 14.0) at 60 m. Check this result against the graph on page 1.

Work out what the sound pressure levels would be at: 30 m; and at 8 m. (82.0 dB and 93.5 dB).

Exercises

1. A loudspeaker produces a sound pressure level of 97 dB at a position 3 m in front of it. Calculate the sound pressure level that it would produce:
   (a) at a position 15 m in front of it; and
   (b) at a position 1 m in front of it.

2. (a) A singer stands 2 m away from a microphone and produces a sound pressure level of 88 dB at the microphone. What will the sound pressure level be at the microphone if the singer moves to a position 500 mm from the microphone?
   (b) If the recording level meter had indicated −10 dB with the singer in the first position, what will it indicate with the singer in the closer position?

1. (a) 83.0 dB; (b) 106.5 dB
2. (a) 100.0 dB sound pressure level, which is 12 dB higher than 88 dB;
   (b) + 2 dB VU level (because moving closer raised the level by 12 dB from − 10 dB to + 2 dB)