Primer for

Addressing Wind Turbine Noise

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Table of Contents

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. See Figure 1.

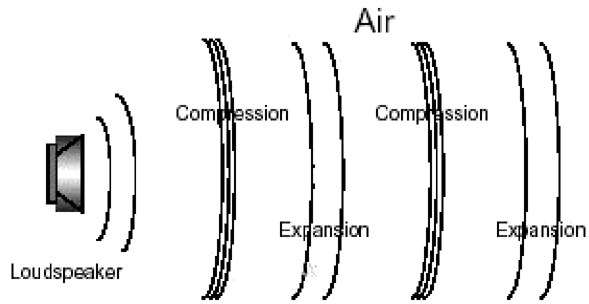


Figure 1. Sound

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 purposes. 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.) The ANSI, EPA, ISO and the World Health Organization's (WHO) recommendations for maximum noise exposure are based 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.

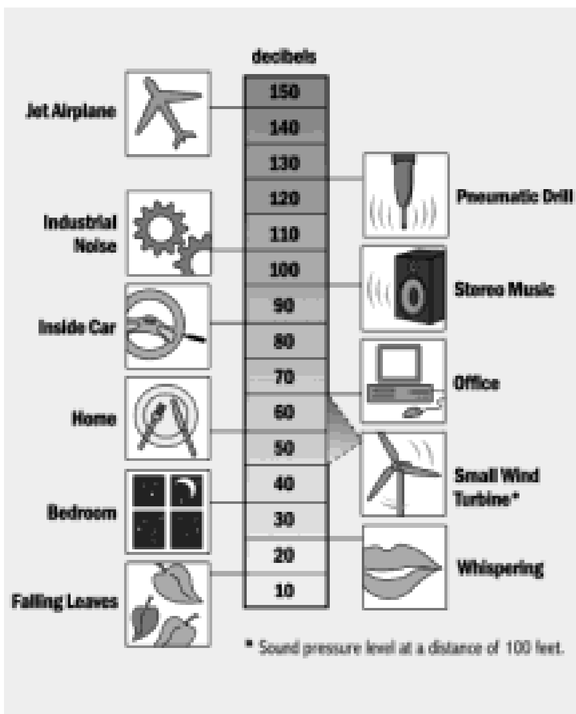
Table 1 lists some important frequency ranges for studying the impact of wind turbine noise.

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.



http://www.awea.org/faq/noisefaq.html

Figure 2. The Decibel Scale

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 the a 1-3 dB change in volume.
- A 3-5 dB is clearly noticeable.
- Most people subjectively perceive a 10 dB increase as twice as loud.

Peoples' perception of noise, however, does not correspond with this 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 map 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 1 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 and WHO[1] 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.

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

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, ie, 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 scales, visit:

http://www.acoustics-noise.com/dBA-B-C-D-U-G-U-AU-tables.shtml

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[2]

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)

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

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, turbine 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 is also related to other noises. One study in Wisconsin[3] reported that turbines was more noticeable and annoying at the cut-in 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

Exposure to extremely high noise levels can also cause headaches, irritability, fatigue, constricted arteries, and a weakened immune system[4]. 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 you remove the noise, 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

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

[4] 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

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 theses recommendations 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

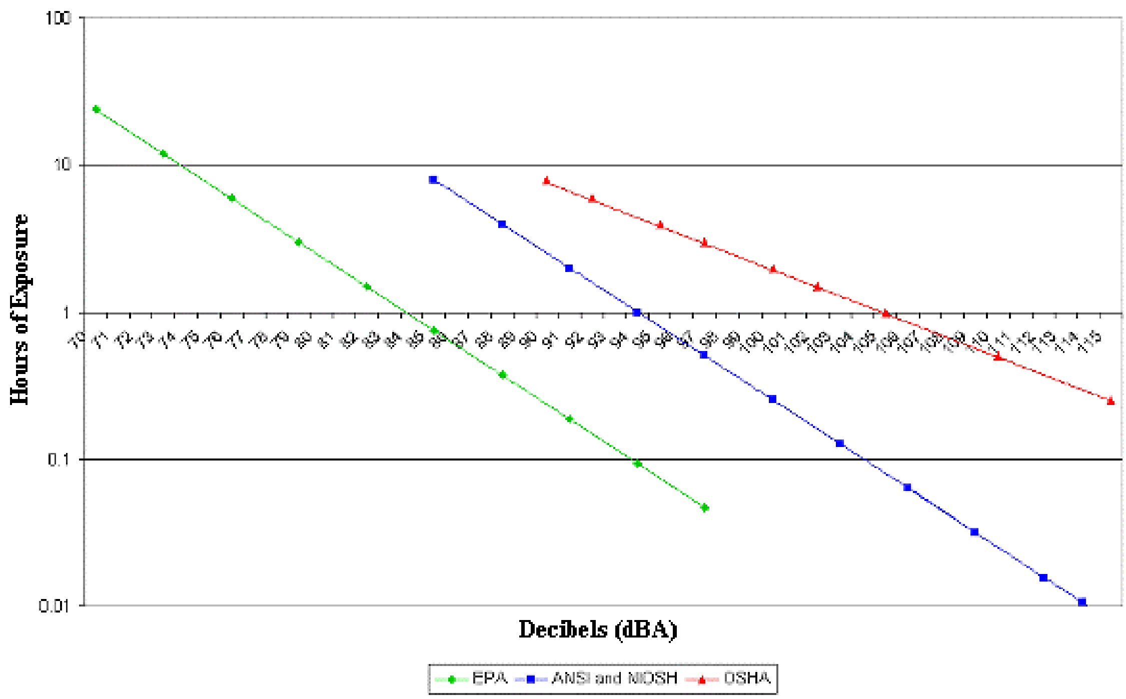

Figure 3. Comparison of Maximum Noise Exposure Standards

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.

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

- the total noise exposure (including daytime exposure)
- the peak noise volume
- if intermittent, 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[5] 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.

[5] 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

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.

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}.

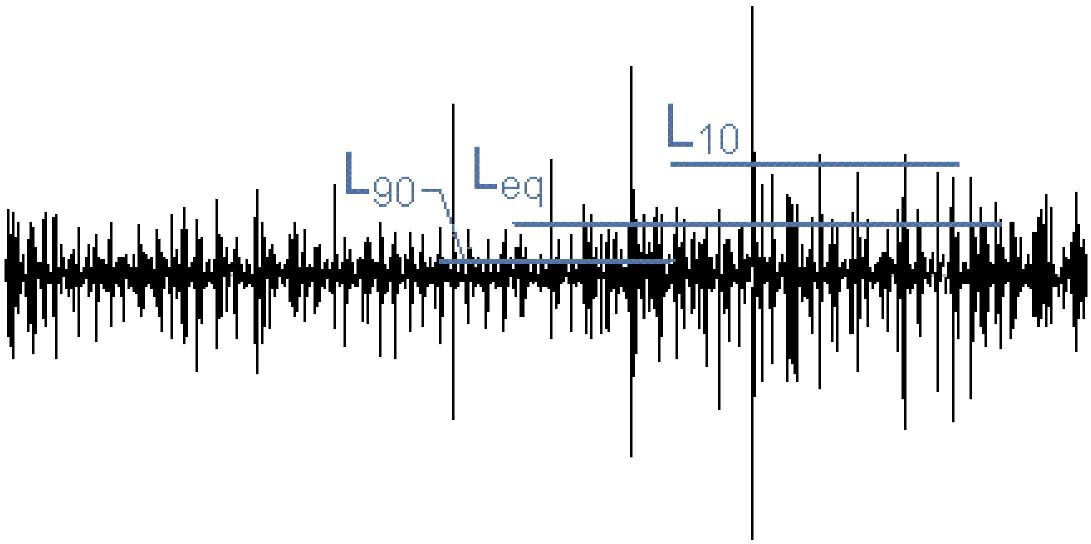

Figure 4. Statistical Noise Indicators

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[6] requires the operator of noise producing equipment to determine the L_{10} and L_{50} of a community prior to installing the equipment. 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[7] 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

[6] 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.)

[7] Unpublished correspondence.

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 four 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.

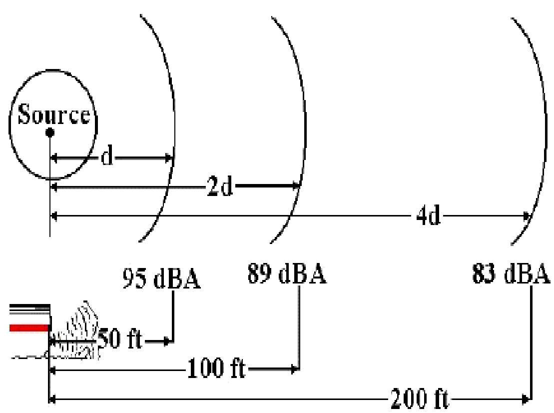

Figure 5. Attenuation by Distance

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.

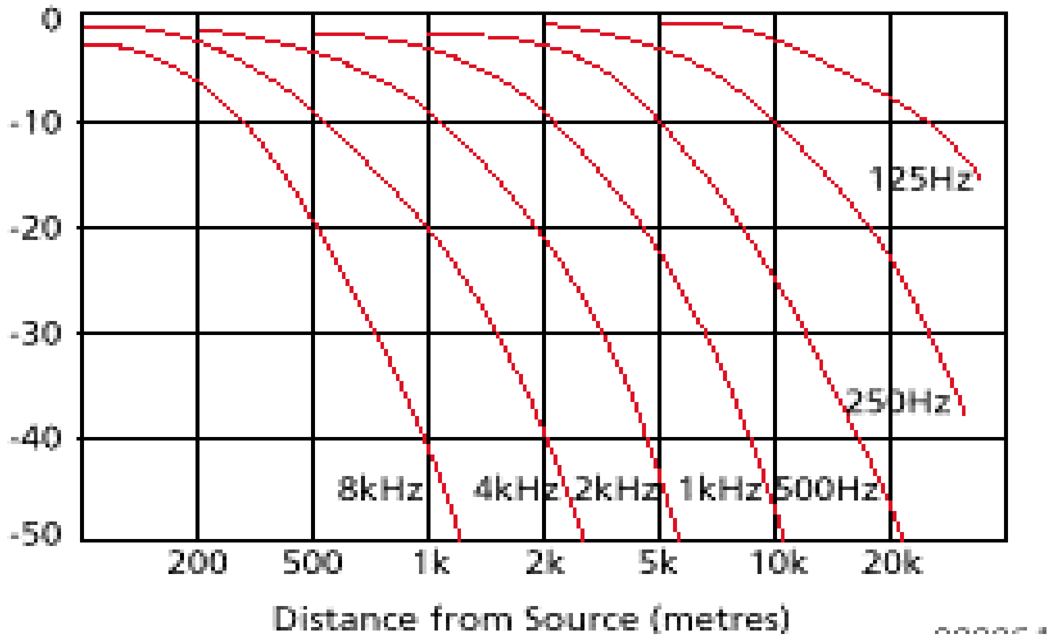

Figure 6. Frequency Attenuation

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. 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.

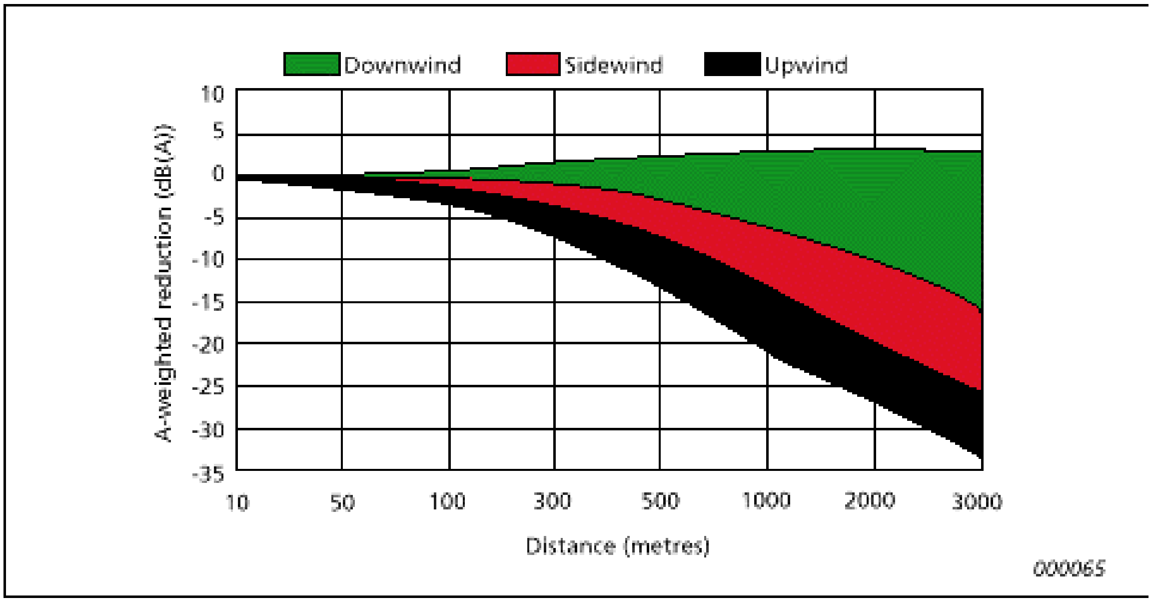

Figure 7. Wind Attenuation of Sound

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 octaves in the low frequency range.

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[8]. 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[9]. 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).

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

[9] 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 will complete a Master of Technical and Professional Communication from Lawrence Technological University (LTU) in December 2005. Mr Alberts is 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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