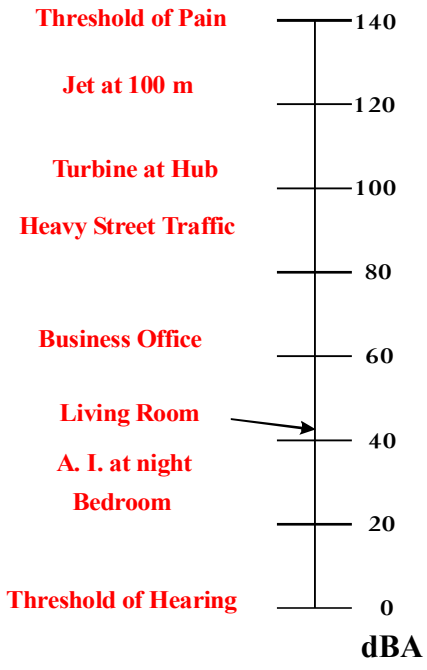
WIND TURBINE NOISE - John Harrison – 22nd August 2007

Noise is the major source of complaint with wind turbines. There are noise regulations but clearly they are inadequate. A receptor, you and me, should not have to hear a turbine above the background.

First, a few words about sound. Sound is a pressure wave in the air. Sound is perceived by the ear and brain. The ear is a remarkable organ. The ear operates from the threshold of hearing to the threshold of pain. The ratio of the pressures at the ear between these limits is 1 to 10 million.

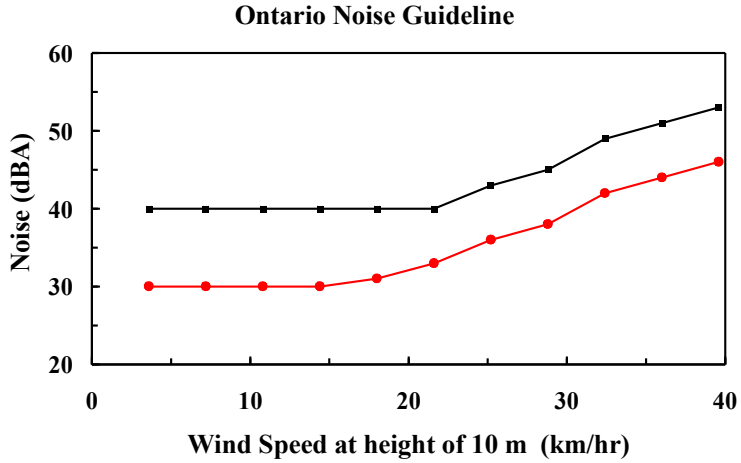
The ear is also sensitive to the pitch or frequency of the sound pressure wave. The range is from about 50 Hz (cycles per second) to about 10,000 Hz. For reference, middle C is 512 Hz.

Engineers base the measurement of sound on the behaviour of the ear. The scale is called the decibel, A weighted, scale or dBA. With this scale, the threshold of hearing is 0 dBA and the threshold of pain is 140 dBA. Some typical sound levels are shown on the diagram.



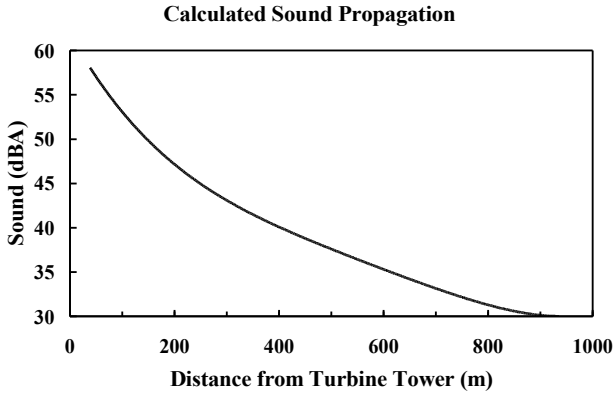
The Ontario Environmental Protection Act is supposed to protect us from a variety of intrusions upon our environment. Included are:
(a) Impairment of the quality of our natural environment;
(b) Harm or material discomfort;

(c) Adverse effects on our health;
(d) Loss of enjoyment of the normal use of our property.
As part of the act there are noise guidelines for wind turbines. For a rural area, these are summarized in the diagram.



The diagram shows noise in dBA units as a function of wind speed in km/hr. The red line is a typical background noise level, about 30 dBA, rising slowly for wind speeds above 20 km/hr. The black line is the upper allowable turbine noise. Two things to note: The turbine noise is a calculated 1-hour average; Ontario is generous to the wind industry in allowing a 10 dBA intrusion above background.

The noise at the hub of modern turbines is in the range 100 – 105 dBA. This noise spreads and is mildly absorbed by the atmosphere and ground cover. There is an internationally accepted method for calculating the noise at a receptor as a function of distance from the turbine.



Such a calculation is shown in my diagram. This shows the 1-hour average noise in dBA units as a function of distance from the tower. This example

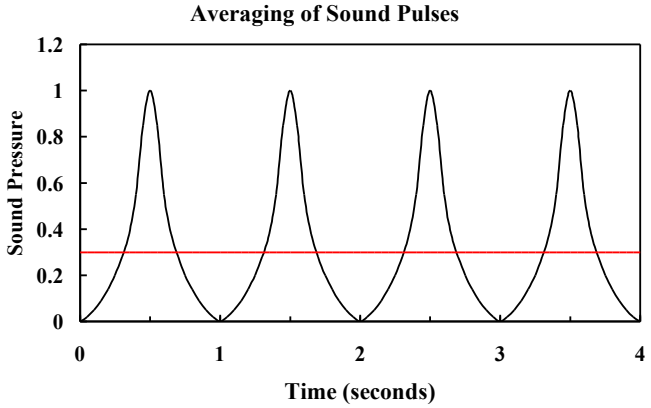
shows that the noise is down to 40 dBA at 400 – 500m from the turbine. This is the basis for many of the setback bylaws across Ontario.

There is a major problem. People living close to these turbines, across Canada and elsewhere suffer torment and health problems. For example, a survey of 223 people was conducted in Wisconsin 2 years after construction of a wind plant. The table shows the fraction of households that found noise to be a problem in their homes. There are many such reports.

Distance from turbines (m)	250-400	400-800	800-1500
Noise is a household problem	44%	52%	32%

I have been thinking about this problem since I attended the Kincardine OMB hearings in May of this year. I believe that there are four answers to the problem that I can talk about and one that I am still working on.

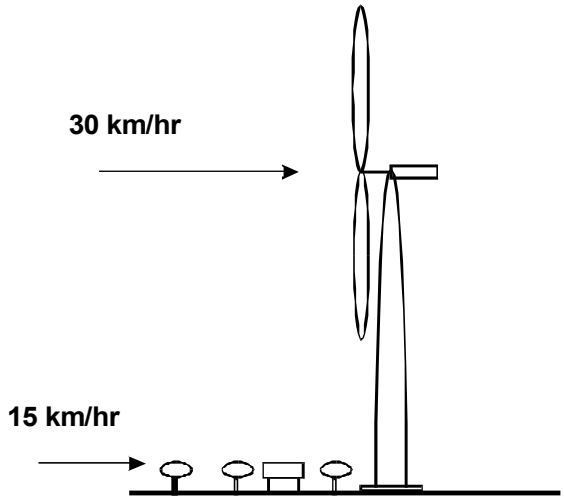
Cyclic Noise For those who have not stood within 500m of an active turbine, I have a recording. What one hears is "shwoosh – shwoosh – shwoosh". It is a tormenting repetitive sound. Ontario and the wind industry use one-hour averaging, so washing out these peaks.



The diagram shows a tutorial example of sound pressure as a function of time. The black line is the repetitive sound. The red is the average. The difference between the peaks and the average is about 10 dBA.

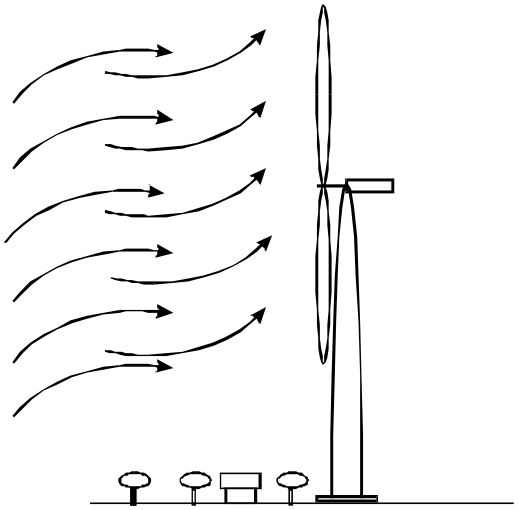
Stable Atmosphere Thanks to work by an academic sound expert in the Netherlands, we know and understand the wind in the lower atmosphere. With a stable atmosphere, typical of night-time and the Fall and Winter, the wind speed increases with height above the ground. For example, at Kincardine the ratio of wind speed at 100m, the height of a turbine hub, to

the wind speed at the ground is 2 on average, higher at night and away from the Summer.



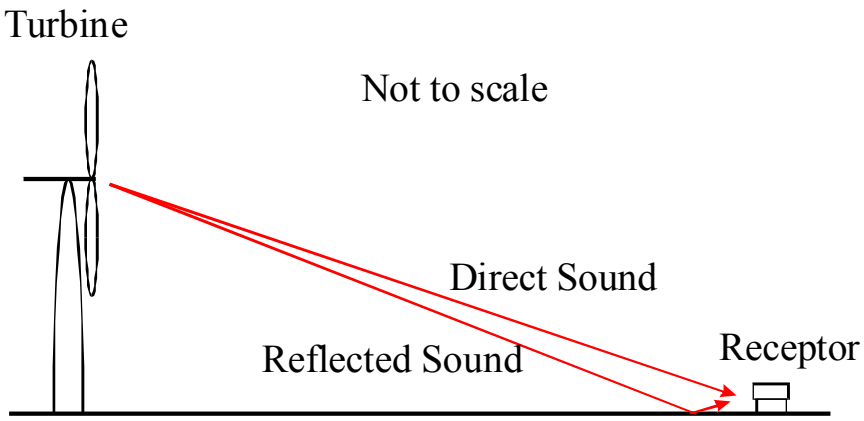
In my diagram, you see a wind speed at the hub of 30 km/hr whereas the speed at the ground is 15 km/hr. The significance is that the extra turbine noise is not masked by extra background noise as the wind blows past the house and through the trees

Turbulent Inflow During daytime in the summer and as a result of interference from other turbines, the wind into the turbine blades will be turbulent.



This increases the low frequency noise from the turbine dramatically. The wind industry ignores this problem, as it does the stable atmosphere problem because the Ontario regulations specify predictable worst case and the industry claim not to be able to predict turbulence and stability.

Reflection Sound reaches a receptor via a direct pressure wave and an indirect pressure wave that reflects from the ground.



Below 3000 Hz, these pressures add, increasing the sound by 6 dBA.

Summary Turbines are noisy. Guidelines suggest 400 – 500m setbacks but there are health problems and torment out beyond 1 km. The calculations are clearly faulty and the Ontario guidelines are inadequate.

I believe that the reasons are:
Much of the noise is cyclic which adds up to 10 dBA or more.
The stable atmosphere prevents masking of the turbine noise.
Turbulence causes low frequency noise.
Reflection from the ground adds 6 dBA.
The Ontario guidelines are over-generous to the wind industry.

The addition of 16 dBA will push the setbacks to 1.5km

The Ministry of the Environment must take action on and responsibility for the turbine noise problem. It is unrealistic to expect local municipalities to have the resources or the will to address the noise problem. I had hoped that our municipality would support Arren-Elderslie township in their call for a moratorium on all proposals until Ontario had made a full study of all of the problems associated with wind plants, but it seems not to be.

Still to be understood is the source of infra-sound; I hope to have something on this at a later time.