EVALUATION OF WIND TURBINE NOISE

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1. INTRODUCTION

Virtually anything with moving parts will make some sound, and wind turbines are no exception. Well-designed wind turbines are generally quiet in operation. Wind turbine noise is very low compared to the noise from road traffic, trains, aircraft and construction activities and can also be compared to the sound level inside a typical living room, the reading room of a library or in an unoccupied, quiet, air-conditioned office. Typically, the sound of a working wind farm is actually less than normal road traffic or an office.

2. NOISE MEASUREMENT

The noise a wind turbine creates is normally expressed in terms of its sound power level. Although this is measured in dB(A), it is not a measurement of the noise level which we hear but of the noise power emitted by the machine. The sound power level from a single wind turbine is usually between 90 and 100 dB(A). This creates a sound pressure level of 50-60 dB(A) at a distance of 40 metres from the turbine (about the same level as conversational speech). At a house 500 metres away, the equivalent sound pressure level would be 25-35 dB(A) when the wind is blowing from the turbine towards the house. Ten such wind turbines, all at a distance of 500 metres, would create a noise level of 35-45 dB(A) under the same conditions. With the wind blowing in the opposite direction, the noise level would be about 10 dB(A) lower. It must be noted that the turbine noise estimates do not take into consideration the wind noise that is providing a masking effect.

3. TURBINE TECHNOLOGY

3.1 Turbine Description

Almost all wind turbines that produce electricity for the grid consist of a tower between 40 and 80 metres high, a nacelle (housing) containing the gearbox and generator mounted on top of the tower, and three blades that rotate around a horizontal hub protruding from the nacelle. This type of turbine is referred to as a horizontal axis machine.

There are two potential sources of noise: the turbine blades passing through the air as the hub rotates, and the gearbox and generator in the nacelle. Noise from the blades is minimised by careful attention to the design and manufacture of the blades. The noise from the gearbox and generator is contained within the nacelle by sound insulation and isolation materials. Standing next to the turbine, it is usually possible to hear a swishing sound as the blades rotate, and the whirr of the gearbox and generator may also be audible. However, as distance from the turbine increases, these effects are reduced.

3.2 Turbine Types

Wind turbines may be designed in different ways and many of the differences have come about from a desire to minimize noise emissions.

Upwind & Downwind Machines: The majority of horizontal axis turbines are designed in such a way that the blades are always upwind of the tower. This has the effect of minimizing any airflow changes as the blades pass the tower. Some turbine designs, particularly some of those installed in the USA, have the turbine blades downwind of the tower. With this type of design, a strong pulse can sometimes be heard with each passing of a blade behind the tower. However, most turbines currently operating in Alberta are of the upwind design.

Twin Speed and Variable Speed Machines: Most horizontal axis turbines rotate at a constant speed, usually between 25 and 50 rpm, irrespective of wind speed. However, twin speed machines operate at a reduced speed when the wind is light. This produces less noise and means the noise of the turbine is also significantly lower by up to 10 dB(A). Variable speed machines change speed continuously in response to changes in wind speed and, although noise output may be higher at higher wind speeds, it is lower at low wind speeds where the low background levels occur.

Direct Drive Machines: Direct drive turbines are the latest design concept in turbine technology. Simply put, these machines have no gearbox or drive train, and consequently no high speed mechanical (or electrical) components. Direct drive turbines are therefore much quieter than gearbox machines as they do not produce mechanical or tonal noise. An example of this type of turbine is the 1.5MW 'Ecotricity' turbine.

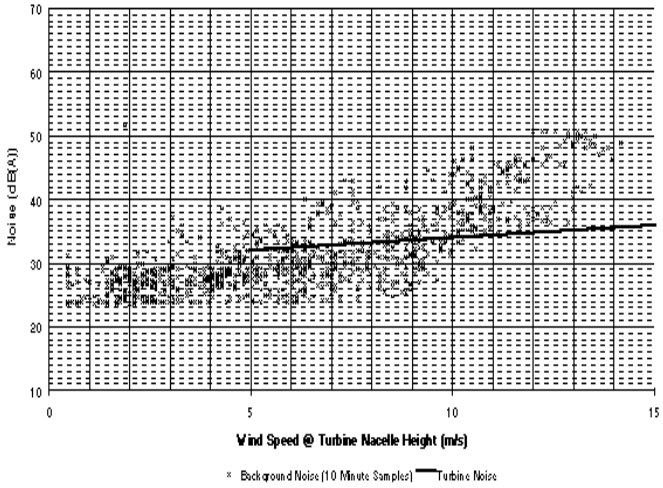
3.3 Considerations for New Wind Projects:

When planning a wind turbine project, careful consideration must be given to any noise that might be heard outside nearby houses. Inside, the level is likely to be much lower even with windows open. The potential noise impact is usually assessed by predicting the noise that will be produced when the wind is blowing from the turbines towards the houses. This is then compared to the background noise that already exists in the area, without the wind farm operating.

There is an increase in turbine noise level as wind speed increases. However, as seen in the Graph below, the noise from wind in nearby trees and hedgerows, around buildings and over local topography also increases with wind speed but at a faster rate. Thus, it is difficult to detect an increase in turbine noise because of the increase in the background sound level. Also, wind turbines do not operate below a specified wind speed referred to as the cut-in speed (usually around 15 km's per hour). Wind data from typical sites suggests that wind speeds are usually below the cut-in speed for about 30% of the time.

It has been suggested by some regulators that turbine noise level should be kept within 5 dB(A) of the average existing evening or night-time background noise level. This is consistent with standard approach the EUB uses for noise impact assessment of energy industry sources, except for construction related noise that currently has no specific limit.

Background Noise and Turbine Noise vs. Wind Speed



3.4 Resident Views:

Despite technical evidence that suggests otherwise, a small number of residents living near wind farms in Europe have stated that in their experience mechanical noise is insignificant compared to the aerodynamic noise, and characterized by some as "blade thump". Residents have also pointed out that the mechanical noise is usually only audible within 100 meters of the turbine, but the blade thump can be heard at distances of up to 1.5 km away. Although measurements indicate the noise is not particularly loud at this distance, residents claim it can be extremely irritating when exposed to it for any length of time because of its rhythmic nature making it hard to disregard.

It is believed that the blade thump is caused by the blades passing the tower of the turbine. The rotational speed of 3-bladed turbines is about 28 rpm at maximum rotational velocity. This results in a rhythmic sound comprised of about 84 beats per minute from each turbine. This sound rises and falls in volume due to slight changes in wind direction. Some residents have described the effects of this sound as a feeling of anxiety, and sometimes nausea. Some have expressed belief that the frequency of the blade thump is close to the human heart rate; and some residents feel that their own pulse rate is trying to match that of the turbines.

Statistics however, taken from recent surveys suggest that the number of those concerned about noise dropped from 86% immediately after construction to 20% a year later. Of these only 3% of respondents indicated that they were bothered by the wind plant's noise.

4. CONCLUSION

Wind and other renewable energy sources enjoy strong popularity with the public, a logical outgrowth of increasing concern about the environment and the perception that renewable energy sources have less environmental impact than their fossil and nuclear counterparts. As its visibility grows, wind is likely to add to its already strong latent public support and to become one of the most preferred electricity generation options of the next decade.

With respect to noise produced by typical wind farms, the level is so low that they would not be noticeable in most urban residential areas. However, the areas suitable for such developments tend to be in quiet but exposed areas of countryside. Therefore some amount of effort must be put into minimizing any noise impact. Nonetheless, it should be emphasized that typical noise levels from wind farms are so low that at a carefully considered site they would normally be masked by other background sources.

References

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***Note**: The above is taken directly from an extensive literature search into wind turbine noise and the findings in the above publications validated by field research conducted by the EUB in cooperation with wind power generators Canadian Hydro. and Vision Quest Wind Electric Inc.*