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The relationship between background noise levels and acoustic impact of the qr5 wind turbine

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INTRODUCTION

To date there is no singularly accepted standard or set of guidelines that advise how to assess the likely impact of wind turbines on noise sensitive locations. The Sustainable Development Commission report, "Wind Power in the UK May 2005" states "there are a number of guidelines that are used to determine acceptable levels of noise, such as:

- The World Health Organisation's (WHO) publication 'Guidelines for Community Noise'[1].
- The British Standard BS 4142, which offers a well-understood framework for measuring all industrial noise [2].
- A report produced for the DTI, "The Assessment and Rating of Noise from Wind Farms", describes a framework for measuring wind farm noise and offers indicative acceptable noise levels for developments [3]. "

The guidelines and standards generally agree that a noise source that is 5dB above background will rarely impact on peoples quality of life, while 10dB above background is likely to have an impact, giving rise to loss of sleep or other unwanted disruption.

It is generally accepted that when background noise levels are low (i.e. below 37dBA, a noise level produced by a specific source of greater than 45dBA is likely to be problematic[3]. However, wind turbines rarely operate at low wind speeds, which is when background noise levels are at their lowest. It is clear from what published data exists [4], [5], [7] that background noise levels increase significantly with increases in wind speed.

KEY ISSUES

1) In low wind conditions, background noise from the effects of the wind and the noise produced by wind turbines are both very low. The wind turbine in question may even be stationary.

2) As wind speed increases, both background and turbine noise levels increase.

3) Different wind turbines have different acoustic characteristics; some will produce higher noise levels than others over a range of wind speeds.

4) Some wind turbines exhibit 'tonal' characteristics during operation and these turbines are usually subjected to a 5dB acoustic penalty when assessing their likely impact [3]. The qr5 turbine has been specifically designed for use in close proximity to occupied buildings. Limiting acoustic impact and the avoidance of tonal characteristics has been a major consideration during the design and development of the qr5 turbine.

5) quiet**revolution** have undertaken an independent assessment of the QR5 turbine and it has been confirmed that NO tonal penalty should be applied [7].

6) The QR5 turbine is probably the quietest turbine available on the market of its size.

7) quiet**revolution** have installations that are mounted on-top of school classrooms and within 25m of noise sensitive locations. To date we have no reports of noise complaints for our turbines.

BACKGROUND NOISE LEVELS

In light of the widespread confusion over what noise levels are acceptable from wind turbines in the built environment, quiet**revolution** are seeking an independent research group to investigate and document how background noise levels rise as wind speeds increase on various typical sites. The goal being to publish a series of case studies as an aid to Planning Authorities in assessing an individual site, so that in many instances the expense of a site specific noise study can be avoided.

Background noise levels will vary greatly from location to location, items that effect the background noise level include: traffic; air conditioning and other plant; people; buildings; trees and bushes; construction; walls; and other obstructions.

In urban locations the main contributors to noise are: traffic, building plants, general construction, people and music.

In rural or suburban locations the effects from trees, bushes, buildings, farming and animals are more likely contributing factors to background noise levels.

It is known that background noise levels rise with increases in wind speed. The reasons for the noise increase are numerous but in particular are caused by objects with square corners such as buildings, signs, pylons etc and from objects that move with the wind such as trees.

The issue is how to determine for any particular site what the increase in background noise is likely to be as the wind speed increases.

The paper "Wind Turbine Acoustics" [6], states that background noise is "...an important factor in determining people's response to wind turbine noise (and) must be carefully accounted for in site measurements. Sources of background noise are the wind itself; its interaction with structures, trees, and vegetation; human activities; and, to a lesser extent, birds and animals. Natural wind noises are particularly important because they can mask wind turbine noise (the broadband spectra of both are the similar). Measuring background noise, at the same locations and with the same techniques used for measuring wind turbine noise is an integral part of assessing receiver response."

The British Standard BS 4142 [2] states: "Because of the importance of background noise in determining the acceptability of the overall noise level, it is crucial to measure the background ambient noise levels for all the wind conditions in which the wind turbine will be operating. Sound propagation is a function of the source sound characteristics (direction and height), distance, air absorption, reflection and absorption and weather effects such as changes of wind speed and temperature with height."

Despite this, BS 4142 recommends noise measurements are undertaken in wind speeds of 0-5 m/s when the majority of small scale turbines would in fact not be operational.

From site specific measurements published in [4], [5], [7] and [8], background noise levels have been shown to increase by up to 25 dB over a wind speed range of 1.5 – 14.5m/s [8].

WORLD HEALTH ORGANISATION GUIDELINES [1]

The WHO guidelines indicate that a noise level of 45 dBA is the maximum that should be considered permissible from a man made noise source outside a noise sensitive location; this recommendation also assumes that the background levels are below 45 dBA. If the background levels are higher than 45 dBA then the impact from plant producing 45 dBA is low.

The WHO guidelines are a good guide when background noise levels are low. They are applicable for noise sources that are operating when there is little or no background noise, such as AC plant / air source heat-pumps etc.

Items of plant [AC / heat pumps etc.] tend to produce most noise when the air is still, hot and humid - conditions when windows will be open and people trying to sleep or enjoying external spaces would be disturbed. However the opposite is true of wind turbines as they produce their maximum noise levels when weather conditions are adverse and properties are more likely to have closed windows and people are indoors.

OUR AIM

Our aim is to gather independently corroborated data, relating wind speed to background noise levels, to confirm our expectations that for the majority of sites, background noise levels will increase either in tandem or faster than the increase in noise from the qr5 turbine.

We are confident that once a series of typical sites have been studied it will demonstrate that, if the qr5 turbine has no impact on noise sensitive properties at ~ 7m/s wind speed, it is probable that it will also have no impact at higher wind speeds, despite the turbine being a source of greater noise at higher wind speeds.

EXAMPLES

The following table gives examples of background noise measurements to be expected at various typical sites. The collection of background noise data for typical sites shall be the subject of a further study [either by quiet**revolution** or in partnership with other organisations].

Wind speed	Likely background noise level [night-time] (dBA)			QR5 turbine noise level at 20m	QR5 turbine noise level at 35m	QR5 turbine noise level at 50m	likely impact on noise sensitive property
	Rural Village	Sub-urban	Urban				
2 m/s	32	36	40	0 dBA	0 dBA	0 dBA	None
4 m/s	38	42	46	0 dBA	0 dBA	0 dBA	None
7 m/s	44	50	54	48 dBA	45 dBA	42 dBA	Minimal and rare
10 m/s	54	60	64	56 dBA	50 dBA	47 dBA	Minimal and rare
13 m/s	60	66	71	61 dBA	55 dBA	52 dBA	None *[peak noise level from turbine]*
16 m/s	68	74	80	47 dBA	43 dBA	40 dBA	None
20 m/s	78	84	90	0 dBA	0 dBA	0 dBA	None

UNCERTAINTY

The only sure way of demonstrating whether the turbine noise is likely to impact on neighbouring properties is to assess the noise profile of the site at a variety of wind speeds and compare these to measured turbine noise levels for the same wind speeds.

The ideal location for setting up the measuring equipment is as close to as possible to the noise sensitive location.

Typically it takes 4-5 weeks from setting up equipment to the production of the report, however the data collection is weather dependant and a full range of wind speeds between 3m/s and 10m/s is ideal to properly assess the site.

It is usually not practical to assume that data from periods when wind speeds are higher than 10m/s can be collected as these higher wind speeds are rare and account for approx. 300 hours / year (<3.5%), or less, on a typical site [even 9m/s and 10m/s wind data may be difficult to collect depending on the weather conditions at the time of survey].

A typical cost for undertaking a background noise assessment, including a weather station measuring wind speed is IRO £1,500 to £3,000 and would typically take 2-4 weeks to collect the data, depending on weather and windspeeds.

To reduce the uncertainty level when undertaking acoustic surveys it is vital to follow existing standards and to use professional and calibrated equipment. quiet**revolution** have documents available on the methods for collecting noise and wind speed measurements.

CONCLUSION

Assuming a clear line of site between turbine and the noise sensitive location, quiet**revolution** anticipate that a turbine located at 35m distance or greater, would have minimal acoustic impact and the turbine is unlikely to be a problem.

In quiet rural or edge of town locations, at distance less than 35m the risk of adversely affecting noise sensitive locations begins to increase, however any trees, buildings or other obstructions located between the turbine and the noise sensitive location are likely to considerably reduce the impact of the turbine, either because the obstruction is itself a source of wind noise or due to the absorbing and defracting effects of the obstructions.

REFERENCES

[1] World Health Organisation "*Guidelines for Community Noise*" 1999

[2] BS 4142: 1997 – *Method for rating industrial noise affecting mixed residential and industrial areas*

[3] ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*. ETSU for the Department of Trade and Industry, 1996

[4] McKenzie, A.R., Bullmore, A.J. and Flindell, I.H. 2002 *The effects of wind speed and direction on ambient and background noise levels in the suburban environment.* Proceedings of the Institute of Acoustics, 24, (3), 15-22.

[5] Ontario Ministry of the Environment, "*Interpretation for Applying MOE NPC Technical Publications to Wind Turbine Generators.*" PIBS 4709e, 6 July, 2004.

[6] Hubbard, H.H. and Shepherd, K.P. "*Wind Turbine Acoustics*", NASA Technical Paper 3057 DOE/NASA/20320-77, December 1990

[7] quiet**revolution** Noise Statement for the qr5 wind turbine, June 2008, extract from ISVR Consultancy Report Ref. 7837-R01 "*Wind turbine noise measurements*".

[8] McKenzie, Dr A.R.: *"Background Noise Measurements for Wind Farm Noise Assessment", 2005,* Institute of Acoustics Wind Farm Noise.