University of Salford
A Greater Manchester University

Defra NANR244

Noise and vibration from building-mounted micro wind turbines

Part 3:
Prediction methodology

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Prepared by

Andy Moorhouse[1], Andy Elliott[1], Graham Eastwick[2], Tomos Evans[1], Andy Ryan[1], Sabine von Hunerbein[1], Valentin le Bescond[1], David Waddington[1]

1: Acoustics Research Centre, University of Salford, M5 4WT, www.acoustics.salford.ac.uk
2: Encraft Ltd, Perseus House, 3 Chapel Court, Holly Walk, Leamington Spa, CV32 4YS

Department of Energy & Climate Change

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defra
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Executive Summary

This brief report describes a simplified method for estimation of levels of structure-borne sound in buildings to which a micro-wind turbine (MWT) is attached. The method is applicable to two specific designs of MWT, each for three lengths of mounting pole and for masonry buildings. The output gives expected noise level for given rotational speed of the MWT. Applicability and limitations of the method are described.

A more general methodology is provided in companion reports but requires specialist knowledge to implement.

Structure-borne sound is notoriously difficult to predict and several assumptions have been necessary in order to produce a sufficiently simple estimation method. Therefore, caution is required in relying on the predictions until sufficient confidence has been built up through experience of real installations.

Contents

1 Introduction

This report defines a simple methodology for prediction of structure-borne sound from building-mounted micro wind turbines (MWTs). It is one of the outputs of the project reference NANR244 funded jointly by Defra, DECC and CLG from October 2009 to September 2010.

The purpose of the project was to "research the quantification of vibration from a micro turbine, and to develop a method of prediction of vibration and structure borne noise in a wide variety of installations in the UK". The project was motivated by a desire to stimulate use of renewable energy generation by removal of planning restrictions. Permitted development rights are currently granted for some renewable energy generating technologies but building-mounted MWTs are excluded due to concerns about the potential impact of structure-borne noise and vibration on attached neighbouring dwellings.

The outcomes of the project are described in three reports:

Part 1: Review and proposed methodology[1];
Part 2: Development of prediction method[2];
Part 3: Prediction method.

This report is Part 3, the aim of which is to present a simple form of the prediction methodology suitable for use by non-specialists. Parts 1 and 2 include detailed supporting information, together with a more general prediction methodology suitable for use by specialists in situations not covered by the simple method.

Whenever operating machinery is connected to a building there is potential for structure-borne sound; the simple method presented here predicts the level of structure-borne sound inside a room in a building to which an MWT is attached. However, it is not intended to provide guidance on the acceptability or otherwise of the resulting noise levels.

The prediction method employs the concept of a 'reference installation', defined as a solid brick building with a micro-wind turbine (MWT) attached to the façade directly backing onto the 'most exposed room'. The most exposed room is defined as having a volume of 50 m^3 and a reverberation time of 0.5 seconds which is typical for many living rooms and bedrooms. The expected levels of structure-borne sound in such an installation are presented in graphs. Adjustments can then be made for cavity or solid brick walls, for room volume and for building layout, in particular where the room of interest is not immediately adjacent to the MWT.

Prediction of tactile (feelable) vibration was included in the original aims of the project. However, no incidences of perceptible vibration were encountered in field trials[2] and therefore, in the interests of simplicity, no method for prediction of vibration is provided in this report. Guidance is given in Part 2[2] so as to enable suitably qualified specialists to carry out such predictions should the need arise in the future. Rattling of fixtures and fittings and building damage due to vibration was also considered in parts 1 and 2 but, again, since no cases were encountered in field trials these potential sources of disturbance are not dealt with here.

It is important to take account of the limitations of the method as described in the following section.

2 Applicability and limitations

The prediction method applies to structure-borne sound, i.e. sound transmitted through the building structure from the points of attachment of the MWT. Airborne sound, which is transmitted through the air, through windows etc., is not included but could be significant in various common scenarios. Therefore, a separate assessment of airborne sound is recommended.

The simplified method presented in this report applies to two specific models of MWT, masonry buildings and wall mountings of three different lengths (where mast length is defined as the free pole length, i.e. from the top bracket). The majority of current domestic installations are of these types. The more general methodology, presented in the companion reports (particularly Part 2) is applicable to other MWT models, different mounting systems including roof mountings and building types other than masonry. However, the method is more complicated and will require an assessment of the properties of the relevant MWT, mast or building by a specialist and will possibly also require measurements to be made of the component to be changed.

For the two models of MWT studied here the dominant frequency range for structure-borne sound was in the range 160-300 Hz. The corrections given in Figure 3, Table 1 and Table 2 are optimised for this frequency range. If, for other models of MWT or mounting system, there is significant structure-borne sound outside this frequency range then this will need to be taken into account and potentially a new set of corrections will need to be derived.

Corrections given for cavity walls are derived from a small number of measurements and should be treated with some caution since the acoustic performance of cavity walls is known to vary significantly with details such as the type of wall ties and junctions.

Based on the field trials reported in Part 2 the predicted noise levels are expected to lie within about plus or minus 5dB of the measured values. Considering the complexity of the phenomena involved in generation and transmission of sound this is considered to be a reasonable accuracy. However, it also indicates that variations are likely from site to site depending on wind conditions and direction and building construction details.

The noise levels are given as a function of rotational speed of the MWT. Ideally, noise levels would be given in terms of wind speed but there is insufficient knowledge of how rotor speed varies with wind speed to be able to provide the results in this form. In part 2, sound levels are given in terms of wind speed for some specific wind conditions which can be related to NOABL databases. However, the results cannot easily be generalised to other wind conditions.

3 Prediction method

A flow chart for the prediction is given in Figure 1. The starting point is the noise levels in the reference installation obtained from Figure 2 or Table 1. Having selected a type of MWT and mast length the noise level in the reference installation is read from the appropriate curve of Figure 2 or column of Table 1 for a given rotational speed.

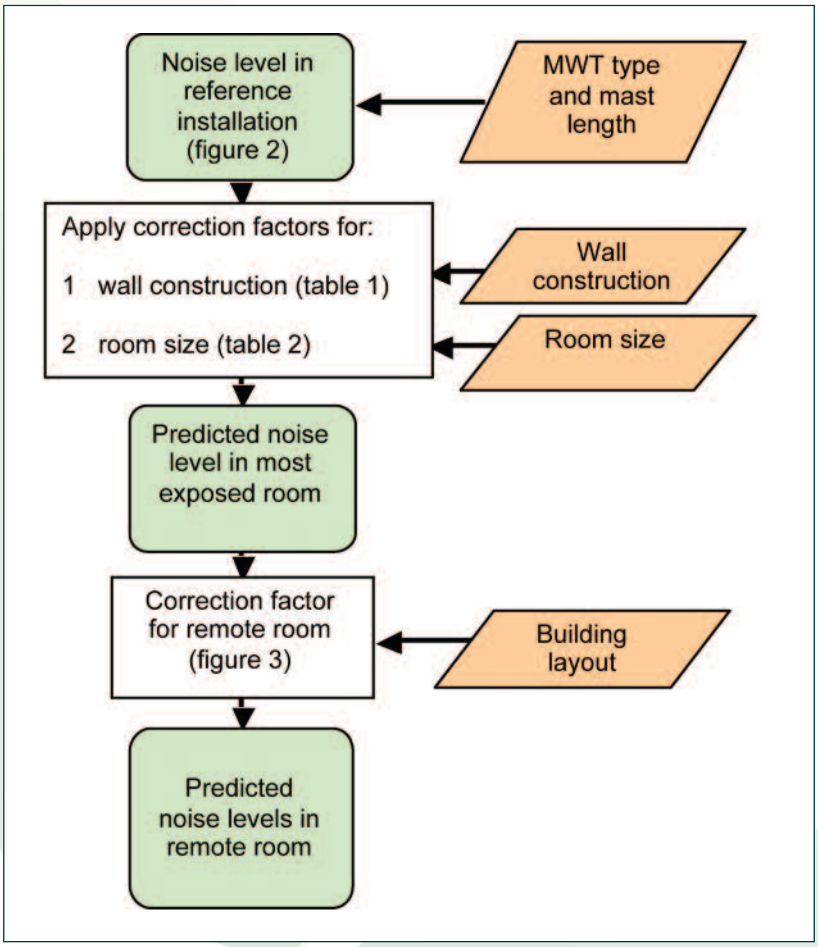

Figure 1: Flow chart for prediction of noise levels as a function of rotor speed.

A correction can also be made for room volume according to Table 3. The correction is zero for 50 m^3 volume since this is the assumed size of most exposed room of the reference installation. For larger rooms, slightly lower sound levels are expected and for smaller rooms slightly higher values.

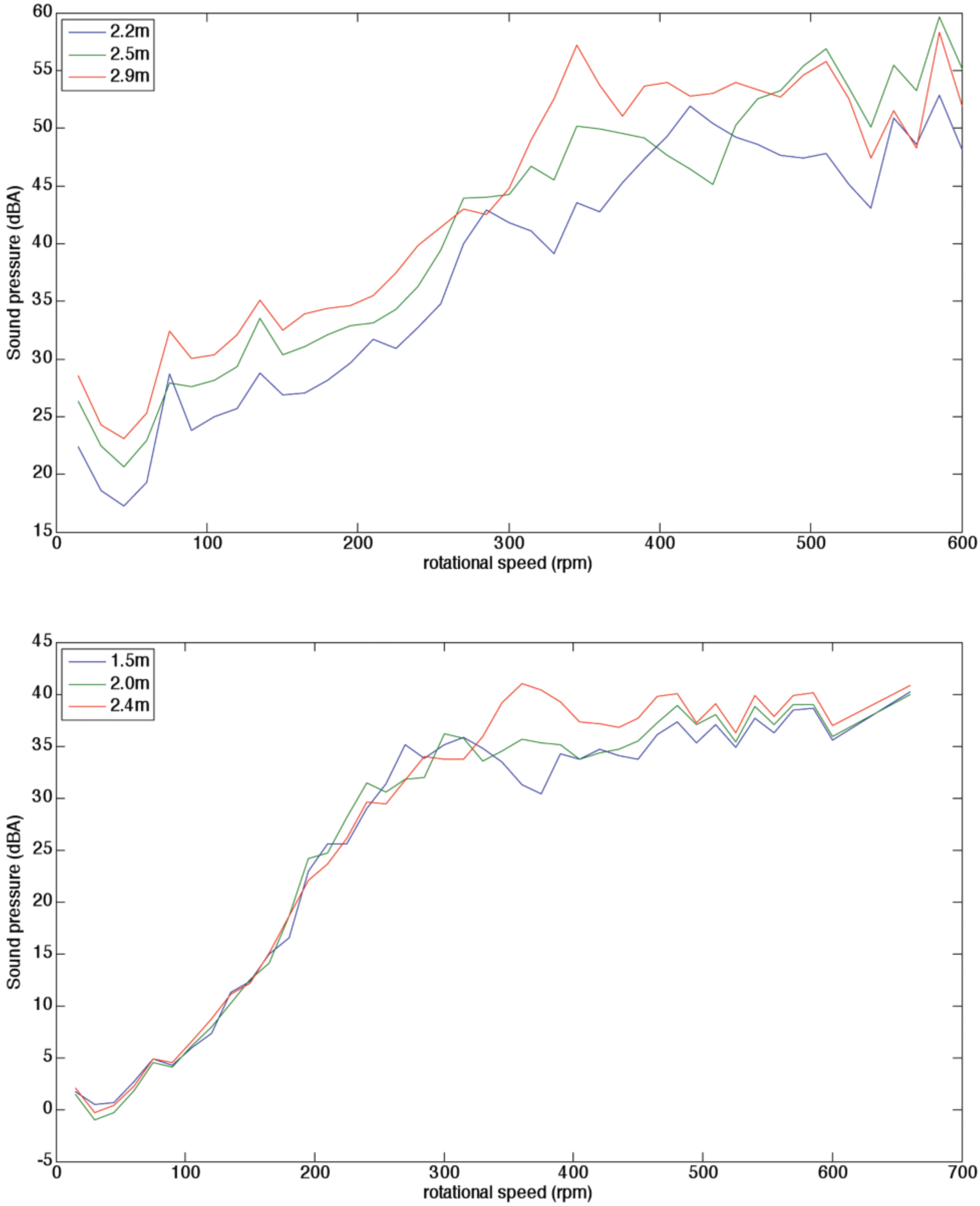

Figure 2: Sound pressure level in the reference installation for three different mast lengths. Upper: MWT1. Lower: MWT2.

Table 1: Tabulated sound pressure level in the reference installation for three different mast lengths for MWT1 and MWT2

rotational speed (RPM)	MWT1 2.2 m mast (dBA)	MWT1 2.5 m mast (dBA)	MWT1 2.9 m mast (dBA)	MWT2 1.5 m mast (dBA)	MWT2 2.0 m mast (dBA)	MWT2 2.4 m mast (dBA)
15	22.4	26.3	28.6	1.7	1.4	2.1
30	18.6	22.5	24.2	0.5	-1.0	-0.3
45	17.2	20.6	23.1	0.7	-0.3	0.4
60	19.3	22.9	25.3	2.7	1.8	2.2
75	28.7	27.9	32.4	4.9	4.5	4.9
90	23.8	27.6	30.0	4.2	4.1	4.5
105	25.0	28.1	30.4	5.9	6.1	6.6
120	25.7	29.3	32.1	7.3	7.9	8.8
135	28.8	33.5	35.1	11.3	10.2	11.1
150	26.9	30.4	32.5	12.3	12.5	12.2
165	27.1	31.0	33.9	15.0	14.1	15.0
180	28.1	32.1	34.3	16.5	18.7	18.6
195	29.7	32.9	34.7	23.0	24.2	22.1
210	31.7	33.1	35.5	25.5	24.7	23.7
225	30.9	34.3	37.4	25.6	28.1	26.1
240	32.7	36.3	39.8	29.0	31.4	29.6
255	34.8	39.4	41.4	31.3	30.6	29.4
270	40.0	43.9	43.0	35.1	31.8	31.7
285	42.9	44.0	42.5	33.8	32.0	34.0
300	41.8	44.3	44.8	35.1	36.2	33.7
315	41.1	46.7	49.0	35.8	35.7	33.8
330	39.1	45.5	52.6	34.8	33.6	35.9
345	43.5	50.2	57.2	33.5	34.5	39.2
360	42.8	49.9	53.7	31.3	35.7	41.0
375	45.3	49.5	51.0	30.4	35.3	40.4
390	47.3	49.1	53.6	34.2	35.1	39.3
405	49.3	47.7	53.9	33.8	33.7	37.4
420	51.9	46.5	52.8	34.7	34.3	37.1
435	50.4	45.1	53.0	34.1	34.7	36.8
450	49.2	50.2	54.0	33.7	35.5	37.7
465	48.6	52.6	53.4	36.1	37.3	39.8
480	47.6	53.3	52.7	37.3	38.9	40.1
495	47.4	55.4	54.6	35.3	37.1	37.2
510	47.8	56.9	55.8	37.0	38.0	39.1
525	45.1	53.5	52.5	34.9	35.4	36.3
540	43.1	50.1	47.4	37.7	38.8	39.9
555	50.9	55.5	51.5	36.3	37.1	37.8
570	48.6	53.2	48.3	38.5	39.0	39.8
585	52.8	59.6	58.3	38.6	39.0	40.1
600	48.1	55.1	51.9	35.6	36.0	37.0
615	-	-	-	40.2	39.9	40.9

Correction for solid brick constructions	**0 dB**
Correction for cavity brick construction	**-10 dB**

Table 2: correction for wall construction

Volume (m3)	**25**	**30**	**40**	**50**	**60**	**80**	**100**	**120**	**150**
Correction (dB)	**3**	**2**	**1**	**0**	**-1**	**-2**	**-3**	**-4**	**-5**

Table 3: correction for room size

Finally, in many situations the room of interest will not be the most exposed room. An adjustment may be made for more remote rooms by using the corrections given in Figure 3.

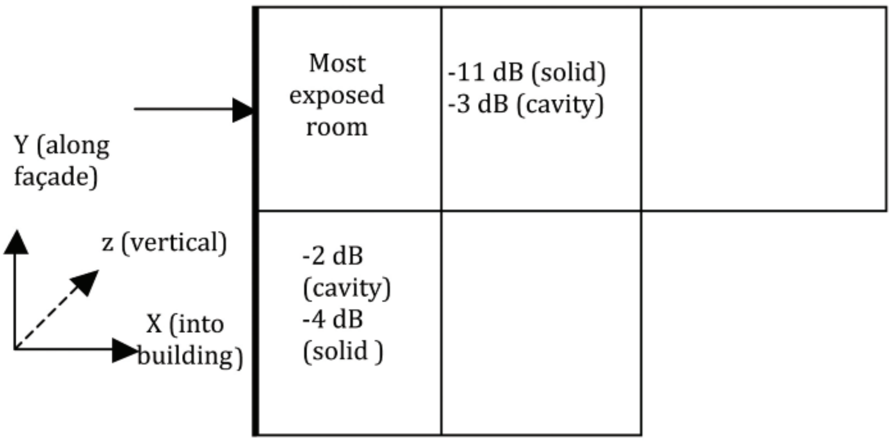

Figure 3: Corrections for remote rooms (the corrections for vertical transmission are the same as those for horizontal transmission)

4 Concluding remarks

Using the above procedure it is possible to estimate the noise level in a masonry building caused by an attached MWT.

The noise levels are given as a function of the rotor speed. Ideally, noise levels would be given as function of wind speed but there is insufficient knowledge of how rotor speed varies with wind speed to be able to provide the results in this form. In part 2, sound levels are given in terms of wind speed for some specific wind conditions but these cannot easily be generalised to other wind conditions.

Due to guidelines for government reports the makes and model of MWT has been anonymised in this series of reports.

Due to the large number of assumptions made in order to create a method of sufficient simplicity it is advisable to exercise caution in relying on the predictions until there is a sufficient body of data from field trials.

5 References

1. Andy Moorhouse, Andy Elliott, Tomos Evans, Andy Ryan, Sabine von Hunerbein, Graham Eastwick, Valentin le Bescond, David Waddington (2010). Noise and vibration from building-mounted micro wind turbines: Part 2 Results of measurements and analysis. University of Salford report ref NANR244.

2. Andy Moorhouse, Andy Elliott, Sabine von Hunerbein, Graham Eastwick, David Waddington (2010). Noise and vibration from building-mounted micro wind turbines: Part 1 Review and proposed methodology. University of Salford report ref NANR244.

University of Salford
Salford
Greater Manchester
M6 6PU
United Kingdom

T +44 (0)161 295 5000
F +44 (0)161 295 5999

www.salford.ac.uk