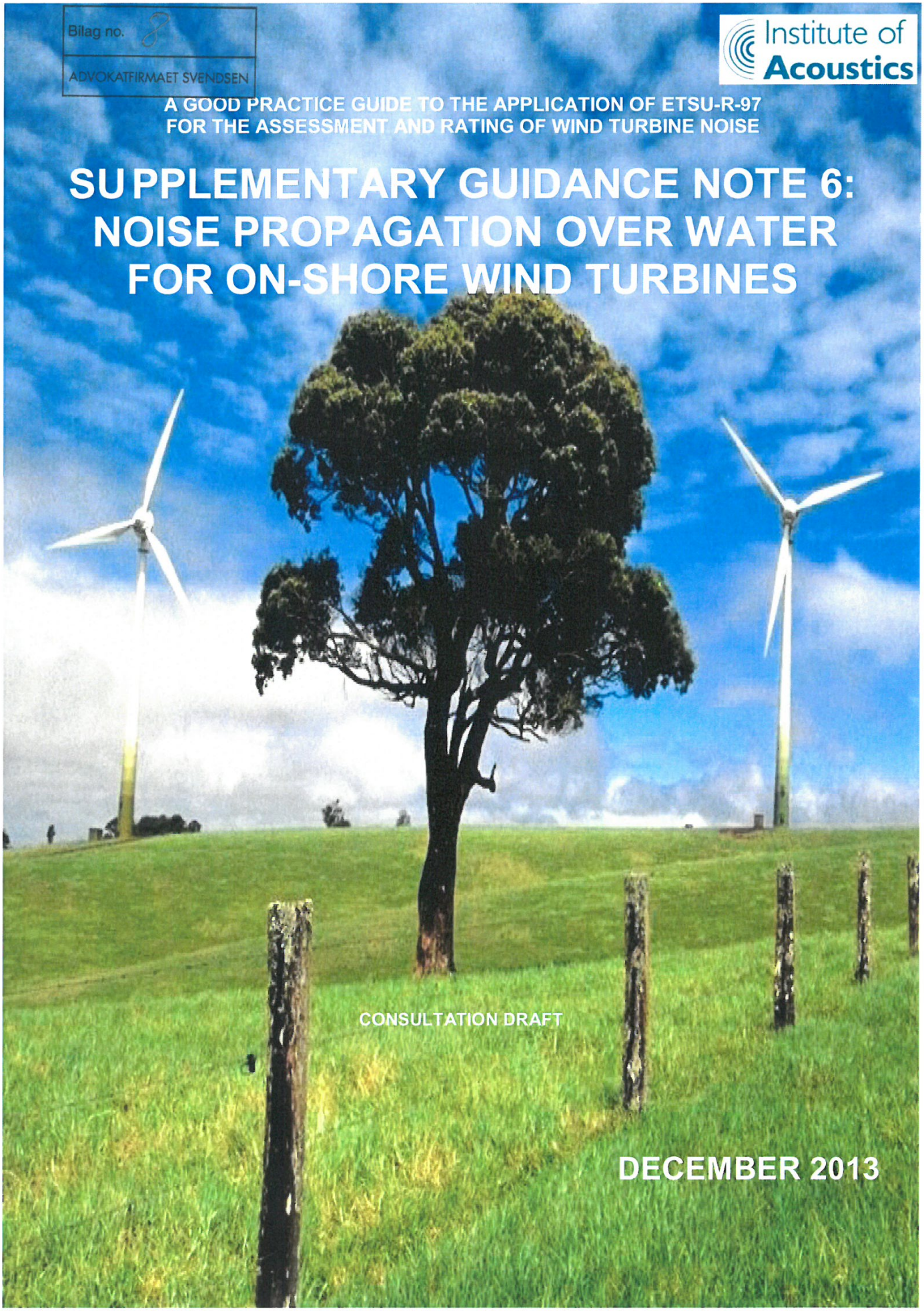
Institute of Acoustics

A GOOD PRACTICE GUIDE TO THE APPLICATION OF ETSU-R-97 FOR THE ASSESSMENT AND RATING OF WIND TURBINE NOISE

SUPPLEMENTARY GUIDANCE NOTE 6: NOISE PROPAGATION OVER WATER FOR ON-SHORE WIND TURBINES



CONSULTATION DRAFT

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PREFACE

This document has been produced by a working group on behalf of the Institute of Acoustics consisting of the following members:

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The working group gratefully acknowledges the assistance provided by Mark Lawson from nPower Renewables, Toby Dudman and Philip Evans from RPS Planning and Environment in the drafting of this note.

This supplementary guidance note has been produced to supplement the IOA document 'A GOOD PRACTICE GUIDE TO THE APPLICATION OF ETSU-R-97 FOR THE ASSESSMENT AND RATING OF WIND TURBINE NOISE' which is available on the IOA website at the following link: http://www.ioa.org.uk/pdf/ioa-gpg-on-wtna-issue-01-05-2013.pdf (checked 04.11.13).

Prior to publication of this note, a peer review was undertaken by a separate group.

Any comments on this document should be sent to ETSUCONSULT@IOA.ORG.UK. The IOA will keep the document under review, and consider updating when significant changes to current good practice have occurred.

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Supplementary Guidance Notes

Number	Title	Information
1	**Data Collection**	Equipment specifications; measurement surveys: Practical considerations and set-up guidance and examples.
2	**Data Processing & Derivation of ETSU-R-97 background curves**	Data filtering, processing and regression analysis for different types of noise environments.
3	**Sound Power Level Data**	Manufacturer's data and warranties analysis.
4	**Wind Shear**	Wind speed references and long-term data analysis.
5	**Post Completion measurements**	Examples, considerations and strategies.
6	**Noise Propagation over water for on-shore wind turbines**	Noise propagation for on – shore turbines, or those close to the shore over large bodies of water.

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1 Context

1.1 Background

1.1.1 The Institute of Acoustics (IOA) published 'A GOOD PRACTICE GUIDE TO THE APPLICATION OF ETSU-R-97 FOR THE ASSESSMENT AND RATING OF WIND TURBINE NOISE' (GPG) in May 2013 to provide technical assistance for the undertaking of wind turbine noise assessments using the ETSU-R-97 document. In order to keep the GPG to a reasonable length, but not to lose clarifications and case studies, it was decided to produce a number of supplementary guidance notes which would support the GPG.

1.1.2 This guidance note will be of relevance to:

i. Acoustics consultants;
ii. Local Planning Authority (LPA) Environmental Health and Planning departments;
iii. Developers;
iv. The Planning Inspectorate or equivalent regulating authority;
v. The general public.

1.2 Scope of the Document

1.2.1 A series of six Supplementary Guidance Notes have been produced. This Supplementary Guidance Note 6 supports Section 4 of the GPG. It provides additional information on the calculation of noise propagation over bodies of water such as for a turbine close to the shore, or over large areas of onshore water such as lakes and reservoirs.

1.2.2 This SGN does not cover noise propagation for offshore wind farms.

1.3 Statutory Context

1.3.1 This Supplementary Guidance Note has been approved by the IOA Council for use by IOA Members and others involved in the assessment and rating of wind turbine noise using ETSU-R-97. It covers technical matters of an acoustic nature which the IOA-NWG believes represent current good practice.

2 Noise Propagation over water for on-shore wind turbines

2.1 Previous Research

2.1.1 There is little published research or guidance on the propagation of noise over water in the UK. ISO 9613 considers the water surface as being acoustically hard, but this does not explain the under-predictions found on some sites where large bodies of water are found between source and receiver.

2.1.2 Hubbard and Shepherd[1] in 1991 measured turbine noise propagation over desert sand, and like water, found it to be an acoustically hard surface. Their research showed good correlation with spherical spreading and air absorption of sound for "high" frequency sound (630 Hz). However, in the infrasound region the results were better described by cylindrical spreading. They did not discover where the crossover to cylindrical spreading occurred.

2.1.3 In 2001, a Swedish report specifically addressed large propagation distances over ground and over water. The model assumed a transition from spherical spreading to cylindrical spreading at a distance of 200 metres. This 200 metre break point was a function of the sound speed gradient in the atmosphere. In turn, the sound speed gradient depends upon the wind speed gradient and the temperature gradient. Both of these gradients, and therefore the sound speed gradient, vary with time. This Swedish propagation model, for distances larger than 200 metres, is written as:

$$L = L_s - 20\log(r) - 11 + 3 - \Delta L_a + 10\log\left(\frac{r}{200}\right)$$

2.1.4 L is the sound pressure level at the observer, L_s is the turbine sound power (e.g. 105 dB(A)), 11 is 10 log (4π), 3 is 3 dB(A) of ground reflection, ΔL_a is the integrated frequency dependent absorption coefficient, a function of r, and r is the distance from turbine hub to the observer. The second term on the right gives the spherical spreading and the final term corrects for cylindrical spreading beyond 200 metres.

[1] H.H. Hubbard, K.P. Shepherd: Aeroacoustics of large wind turbines, J. Acoust. Soc. Am 89(6), pp 2495-2508, 1991

2.1.5 In a report for the Swedish Energy Agency[2] - "Long-Range Sound Propagation over the Sea with Application to Wind Turbine Noise", Boué investigated the Swedish propagation model by making sound propagation measurements over sea in the Kalmar Strait between Sweden and the island Öland in the Baltic Sea. The separation between source and receiver was 9.7 km. Measurements of average sound transmission loss showed agreement with the Swedish propagation model with a break between spherical and cylindrical spreading at 700 metres rather than the 200 metres in the Swedish model.

2.2 Working Group Recommendation

2.2.1 The working group considers that current good practice for the calculation of noise propagation over large bodies of water (at least 700m in extent, i.e. propagation over the sea / lake / reservoir) is as follows:

- To assume a G=0 Hard Ground Correction
- To assume cylindrical spreading at 700m from the turbine, i.e.

$$L = Ls - 20Log(r) - 11 + 3 - \Delta L_a + 10\log\left(\frac{r}{700}\right)$$

2.2.2 *L* is the sound pressure level at the observer, *Ls* is the turbine sound power (e.g. 105 dB(A)), 11 is 10 log (4π), 3 is 3 dB(A) of ground reflection, ΔLa is the integrated frequency dependent absorption coefficient, a function of r, and r is the distance from turbine hub to the observer. The second term on the right gives the spherical spreading and the final term corrects for cylindrical spreading beyond 700 metres.

1.1.1 [2] http://www.vindenergi.org/Vindforskrapporter/V-201_TRANS_webb.pdf


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