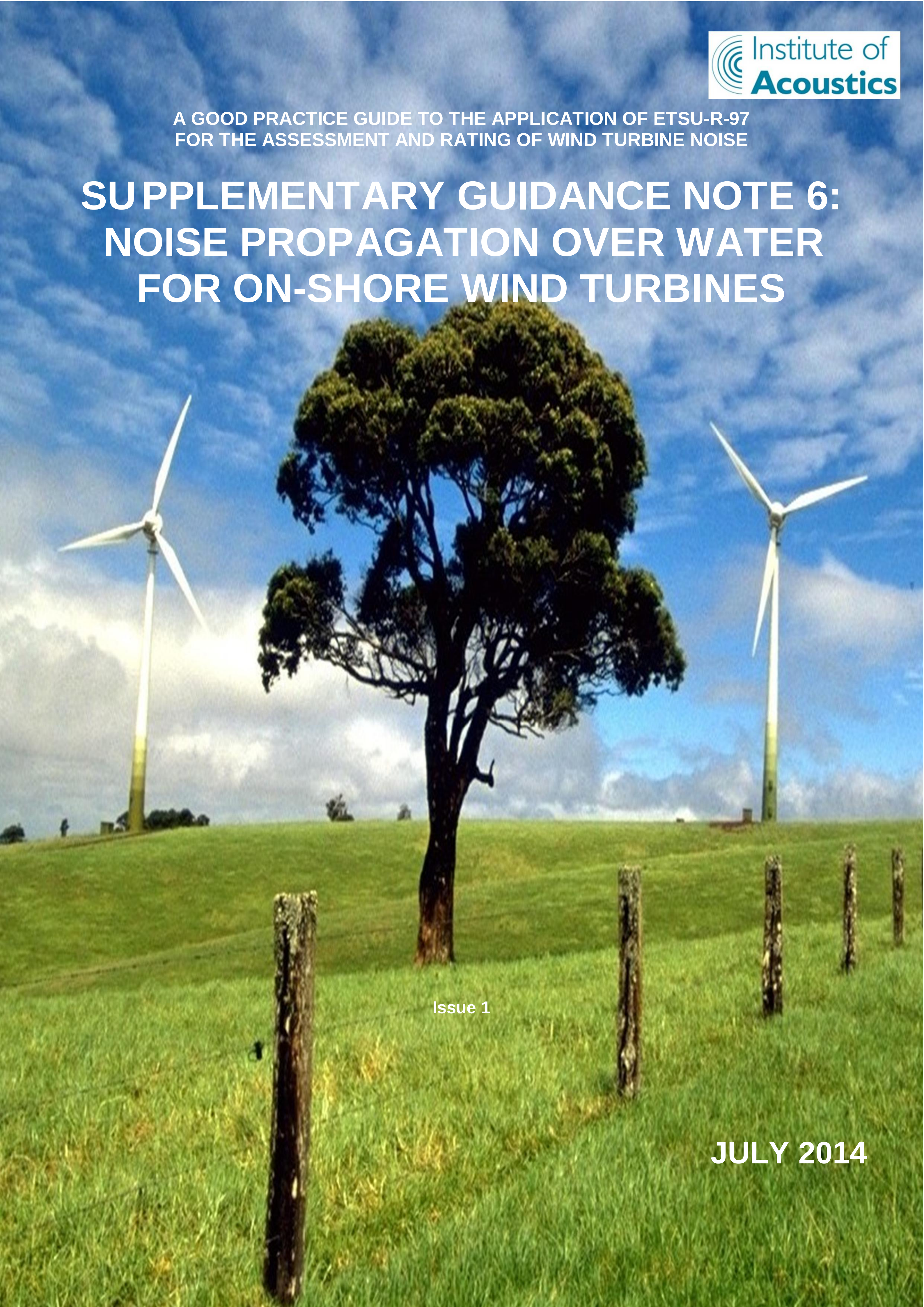
Institute of Acoustics

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



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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:

Matthew Cand — Hoare Lea Acoustics
Robert Davis — RD Associates
Chris Jordan — Northern Group Systems (Environmental Health)
Malcolm Hayes — Hayes McKenzie Partnership Ltd.
Richard Perkins — Parsons Brinckerhoff Ltd.

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/publications/good-practice-guide (checked 06.04.14).

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.

Richard Perkins
Working Group Chairman & Editor.

Institute of Acoustics

3rd Floor St Peter's House
45-49 Victoria Street
St. Albans
Hertfordshire
AL1 3WZ
United Kingdom
www.ioa.org.uk

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.

CONTENTS

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 in the UK on the propagation of noise over water. 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:

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

2.1.4 L is the sound pressure level at the observer, L_s is the turbine sound power (e.g. 105 dBA), 11 is 10 log (4π), 3 is 3 dBA 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 In summary, an under prediction of the propagation effects can occur over water due to a combination of refraction and reflection effects which results in cylindrical rather than spherical geometric divergence. Also, the attenuation due to atmospheric absorption is increased at higher frequencies.

2.2.2 The point at which the effect is observed varies in the literature; 700m is recommended. It should be noted that this distance is, like other numbers quoted for propagation effects, just a modeling parameter. In reality there is of course no sudden change in the attenuation law at some well defined distance. The effective changeover distance will vary, at least as a function of wind shear and sea state. The effect will be less for onshore propagation over water bodies, as ground reflection coefficients are generally much lower and, more importantly, setback distances are much shorter.

2.2.3 GPG Para 4.3.5 requires a G=0 Hard Ground Correction to be used for the calculation of noise propagation over large bodies of water which cover at least 50% of the distance.

Where the body of water is at least 700m in extent (or the turbine is offshore), the following formula should be used:

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

Atmospheric effects (ΔL_a) are frequency dependent as per ISO9613-1. Refer to the report[2] for more detail.

[2] http://www.elforsk.se/Global/Vindforsk/Rapporter%20fran%20Vindforsk%20II/V-201_TRANS_webb.pdf

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