



Independent Noise Working Group

Briefing Paper

Onshore wind turbine noise guidance

The public are not afforded the same degree of protection from wind turbine noise as they are from the majority of other industrial and commercial noise sources.

Mounting evidence points to the need to change this status quo so that wind turbine noise, in line with similar noise polluting industries, is properly regulated and controlled through the use of British Standard, BS4142.

This is a briefing paper by the Independent Noise Working Group (INWG) [INWG.org.uk](https://inwg.org.uk) on their critical analysis of: ‘*A review of noise guidance for onshore wind turbines*’ conducted by WSP on behalf of the UK Government and published in February 2023.

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Note

Web links are provided to access documents referred to in the text. All these documents are in the public domain and we believe that all the websites accessed via these links are safe to use.

Part 1 – Introduction

- The public are not afforded the same degree of protection from wind turbine noise as they are from other industrial and commercial noise sources. The noise guidance exclusively for wind turbines, known as ETSU-R-97 exists as an outdated anomaly, outside of British Standards and the permit regime of the Environment Agency. ETSU-R-97 was created during 1996 with the, “*thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development*”. This “*thought*” does not translate to protecting public health and well-being.
- Mounting evidence points to the need to change this status quo so that wind turbine noise, in line with similar noise polluting industries, is properly regulated and controlled through the use of British Standard, BS4142.
- The Independent Noise Working Group (INWG) seeks to bring about this change so that public health and wellbeing are properly protected from wind turbine noise.
- This is a briefing paper by the INWG summarising their critical analysis of the recent ‘*review of current onshore wind turbine noise guidance*’ prepared for the Government by the WSP consultancy.

Part 2 - Preamble

A report commissioned by the then UK Government Department for Business, Energy & Industrial Strategy (DBEIS) dated Oct 2022 was prepared by WSP and published on the WSP website during February 2023. The WSP report titled '*A review of noise guidance for onshore wind turbines*' is available at, www.wsp.com.

An initial review by the INWG of the WSP report online summary raised several concerns leading to a decision by the INWG to conduct a detailed analysis of the 400-page WSP report. The report covering this analysis was subsequently submitted to the Department of Energy Security and Net Zero on 17 April 2023. The INWG report titled, '*INWG Analysis of WSP report*' is available at [INWG-Analysis-of-WPS-Report-15-April-2023.pdf](https://www.inwg.org.uk/INWG-Analysis-of-WPS-Report-15-April-2023.pdf).

It is noted that the WSP authors have since revised their report, with revision 4 dated May 2023 and revision 5 dated September 2023. These revisions have not been analysed but are claimed to include only minor corrections so are thought not to affect the overall report conclusions and recommendations, or the validity of the INWG analysis.

WSP subsequently published a two-part article in the Institute of Acoustics bi-monthly publication Acoustics Bulletin. Part 1 (Reference 1) appeared in the Sept / Oct 2023 edition and Part 2 (Reference 2) appeared in the Nov / Dec 2023 edition. This article is described as a summary of the main WSP report. **However, the article largely ignores the report's findings, conclusions and recommendations, instead focuses on a defence to criticism of the main report, possibly the INWG critique, and includes several significant changes from the original report.**

This briefing paper summarises the INWG analysis, generally following the WSP report structure and also comments on the WSP article appearing in the Acoustics Bulletin. Also included is a consideration of the replacement of the existing ETSU-R-97 wind turbine noise assessment guidance with BS4142.

References are made in this briefing paper to work packages from the INWG study completed during 2015. These are identified as **WPxx**, and available at www.inwg.org.uk.

Part 3 - Summary

The main objective of the WSP study was to determine whether the ETSU-R-97 wind turbine noise guidance, written during 1996 and its associated Good Practice Guide dated 2013 are fit-for-purpose. Additionally, whether it should be updated or replaced and to make recommendations to government.

WSP's subsequent report recommended that the guidance would benefit from further review and updating, with roughly half of the consulted stakeholders of the view that it requires a substantial revision.

Given the documented evidence in the WSP report, there is a clear disconnect with the report's conclusions and recommendations. The nature and number of criticisms, especially from the stakeholder survey, suggests faults with the fundamental methodology underlying ETSU-R-97. These are faults that cannot be fixed by more revisions or studies.

Arguably the most glaring omission from the report is consideration of an alternative to ETSU-R-97. The INWG tested BS4142 with wind turbine noise data and recommended that ETSU be replaced with the BS4142 noise assessment standard during 2015. The update to BS4142 during 2019 and the government MID guidance issued March 2023 (see appendix 3) further support the use of BS4142.

There is no technical reason why BS4142 should not be used and its use would bring onshore wind in line with similar noise polluting industries.

The WSP report claims insufficient evidence of any health effects from wind turbine noise including low frequency sound. These claims are carried forward into the Acoustics Bulletin article. The apparent absence of participation by suitably qualified health professionals must call this claim into question. If the WSP authors have involved health professionals and have supporting evidence, then this should be made available for scrutiny.

When reviewing guidance applying to industrial noise sources it is apparent that ETSU-R-97 exists as an outdated anomaly, dating from 1996. ETSU-R-97 sits outside of the scientific rigour of British Standards and the permit regime of the Environment Agency; this is addressed in the INWG analysis report.

Part 4 - Analysis of WSP report

Methodology and process

The scope and objectives taken from the government procurement website break down to:

- 1 - Determine whether the ETSU-R-97 noise guidance dating from 1996 and its associated Good Practice Guide dated 2013 are fit-for-purpose;
- 2 - If not, should the guidance be updated or replaced;
- 3 - Based on this determination, to make recommendations to government.

Evidence review

The stated findings from the WSP evidence review at section 3.5 would appear to reflect many of the earlier findings by the INWG.

However, the WSP report dismisses low frequency noise as being of any significance without presenting any supporting medical evidence, simply claiming a lack of evidence. The report discusses this on pages 101, 114, 115, 116 and 117.

Then at page 232, the report is recommending that government make a position statement indicating that; *“infrasound from wind turbines at typical exposure levels has no direct adverse effects on health”*.

We believe that this recommendation is not evidence based and conflicts with the position taken by the World Health Organisation (WHO) in the Environmental Noise Guidelines for the European Region from 2018 or the justification underlying DEFRA NANR45 (rev 1, 2011).

This recommendation also conflicts with the medical evidence provided by Dr Hanning in INWG [WP 3.2](#), or the more recent evidence from the International Acoustics Research Organisation (IARO), including the IARO commentary included as an Appendix to the INWG analysis report.

In the recent Acoustics Bulletin article Part 2 at page 36, the WSP authors have cited evidence from a 2017 French report claiming to dismiss the relevance of the 2018 WHO statements, saying; *“that there was no evidence to support a connection between wind turbine infrasound and health effects”*. This contrasts with the evidence provided by Dr Hanning, by the IARO and others.

It should be noted that ‘no evidence of harm’ is not the same as ‘evidence of no harm’.

At section 3.3.3, the report makes minimal mention regarding uncertainty or its significance within the assessment process. ETSU-R-97 fails to allow for uncertainty so may be the only field of science that works with zero error. The INWG has previously estimated the overall uncertainty for a wind farm noise assessment could be as high as +/-10dB. This is highly significant considering that many noise assessments have shown the headroom between predicted noise and the derived limits can be less than 1dB.

Stakeholder engagement

The stakeholder survey is arguably the most important workstream of the WSP review of ETSU-R-97.

Participation in the survey was by invitation only and was promoted exclusively to central government, local planning authorities (LPAs) and industry professional organisations. The INWG was only permitted to participate late in the process after lobbying DBEIS.

For the survey analysis to be meaningful, participation by LPAs is critical. Out of the 204 LPAs invited, only 19 are shown as having participated in the survey. This 9% response rate compares poorly with the response rate of 77% obtained by the INWG during a similar survey of LPAs during 2014. INWG [WP3.1](#) shows 205 LPAs responded from the 265 invited. One would have expected a significantly higher LPA response rate to a government sponsored survey than to a civic group survey.

Despite these stakeholder limitations the survey analysis has yielded some useful information. In response to survey question 1.2, (WSP report page 141) 13 out of 31, (42%) consider that the guidance is **“inadequate and requires substantial revision”**. When we look at the LPA only responses, 11 out of the 19 (58%) considered the guidance **“inadequate and requires substantial revision”**. One can only speculate what the overall percentage would have been had the LPA survey response rate been higher and if the survey had been more inclusive.

Survey question 1.3 (WSP report page 142-144) breaks down responses into 11 topics. Fig 4.7 shows the response analysis where in 10 out of the 11 topics, a majority are considered, **“inadequate and requires substantial revision”**. The most notable topics being:

- Fundamental approach
- Evaluation of sound characteristics
- Sound predictions
- Noise controls
- Compliance determination

Stakeholder responses to survey question 1.4 (WSP report page 144) highlight the large number of issues raised with the current guidance.

This survey confirms the widespread criticism of ETSU-R-97 made over the last two decades and more recent criticisms of the Good Practice Guide. The top 5 stakeholder issues, from Figs 4-12 & 12-20 (WSP report pages 152 & 376) are:

- 1 - Guidance needs to establish how AM impact should be taken into account
- 2 – ETSU-R-97 is outdated and needs to be reviewed: technology and understanding have advanced since publication
- 3 - Difficult, costly or time-consuming to robustly establish compliance/non-compliance
- 4 - More / updated guidance on cumulative assessments is needed
- 5 - The ETSU-R-97 principles underlying the limits need to be reviewed

These critical stakeholder responses go to the heart of ETSU-R-97 and its underlying assessment methodology centred on derived noise limit curves. This survey evidence should remove any remaining thought that ETSU-R-97 could be safely retained, even with the peripheral changes being suggested by WSP.

Field survey measurements

The field survey workstream, section 5 of the WSP report, with the objective to obtain a snapshot of detectable amplitude modulation (AM) has realised some helpful results, despite the short measurement duration at each site. The report confirms that AM was detected for about half the total measurement duration with modulation depths of up to 5dB.

The report also confirms that the measurements represent non-TEDCAR-AM, this being the form of AM not addressed by ETSU-R-97 and responsible for most noise complaints. What this snapshot measurement survey confirms is that AM is a common and regular occurrence at these sites.

Part 5 - WSP Acoustic Bulletin article (parts 1 & 2)

Part 1 published September 2023, see Reference 1, describes the project background, aims and methodologies employed. As such it generally summarises content from the main report.

Part 2 published 2 months later, see Reference 2, was therefore expected to continue with a summary of the evidence, conclusions and recommendations. However, the article has instead focused on what appears to be a response to criticisms including the earlier INWG critique of the main WSP report. There are now also some significant U-turns in the article compared to the main WSP report, as follows:

Noise Limits

The WSP authors discuss noise limits at length at page 28, pointing out that the ETSU-R-97 pass/fail outcome is inconsistent with the wider policy frameworks in England and Northern Ireland. These frameworks require noise impacts to be addressed in a more nuanced way.

Adopting BS4142 as recommended by the INWG would deal with these new noise limit concerns directly without the need for additional studies as is being recommended by the WSP report.

Sound level index LA90 v LAeq

At pages 28 & 29, the WSP authors discuss and now appear to recommend the use of LAeq in place of LA90 as is currently mandated by ETSU-R-97. This is a significant change from the main WSP report.

Adopting BS4142 would implement the use of LAeq directly without the need for additional studies or for the need to investigate a proxy LAeq index as is now being recommended.

Amplitude Modulation (AM)

The WSP authors confirm that guidance on the control of AM (in common parlance, the “whoomp” as blades rotate) was one of the main issues raised during the stakeholder survey. The significance of AM is now widely acknowledged and a short explanation of the mechanisms responsible for AM is provided in Part 2, on pages 30/32. However, a more comprehensive description is provided by Dr Yelland in INWG [WP1](#) dating from 2015, shortly before the IOA AM Working Group released their preferred Reference Method.

Evidence relating to the occurrence of AM is provided in INWG [WP2.2](#). This report concludes at para 8.1 with; *“There exists an international history of evidence that documents the presence and regular occurrence of AM. Empirical data and subjective reports demonstrate that the manifestation of AM and the presence of AM within wind farm noise is effectively linked to increased annoyance “.*

On page 32 the WSP authors claim, *“The IOA Reference Method for AM measurement has been shown to be a robust and practical approach to quantifying AM”*. This claim is contested by Large of MAS in the Cotton Farm paper, inter.noise Aug 2017, Hong Kong, available at [Internoise 2017 Sarah Large MAS Environmental.pdf \(masenv.co.uk\)](#). Large discusses the difficulties in resolving noise complaints from AM and the limitations of ETSU-R-97. Additionally, she tested the IOA Reference Method and confirms it is; *“prone both to misuse and flaws within the methodology that ultimately results in significant periods of AM being missed or ignored. Such results could effectively be used to undermine community complaints. There are similar issues with the WSP penalty approach, which results in periods containing similar AM being penalised in one case but not in another.”*

Also: *“The long and technically complex processes employed by the IOA AM method do not have a significant advantage over a simple visual and auditory analysis of the data and they are subject to the same flaws that a more manual approach has historically been criticised for.”*

Infrasound

The WSP authors continue to dismiss infrasound as being of any significance in the article Part 2, pages 34-38, claiming a lack of evidence and suggesting complaints are a result of the nocebo effect.

Low frequency noise including infrasound is an integral component of wind turbine noise emissions. This is described by Dr Yelland at INWG [WP1](#) at Paragraph 2.3 and where his Figure 2 shows the typical wind turbine noise spectrum. Additionally, in paragraph 6.4 Dr Yelland contests and explains the wind industry’s use of the term Nocebo.

The ill health effects of wind turbine noise have been shown to be quite real as described by Dr Hanning at INWG [WP 3.2](#), where he states in paragraph 1.5: *“A large body of evidence, presented below, demonstrates that human sleep and health are adversely affected at wind turbine noise levels permitted by ETSU.”* INWG [WP 3.2](#), is recommended reading for anyone interested in the health effects of wind turbine noise.

Bearing in mind the known impacts of low frequency noise and infrasound on human health, it is a further failing of ETSU-R-97 that it takes no account of these low frequency components of wind turbine noise.

Professor Alves-Pereira provides a very clear description of the measurement and significance of the scientific data gathered by the International Acoustics Research

Organisation (IARO) in the peer reviewed paper titled; '*Infrasound exposure: high resolution measurements near wind power plants*', published 16th December 2022:

<https://www.intechopen.com/chapters/85225>

BS4142

In what seems to be a major U-turn, the WSP authors now recognises that there may be some merit in the BS4142 type assessment methodology and use of LAeq in place of LA90 (see page 32). In the main report they make only minimal mention of BS4142 and not in any context of its replacement for ETSU. Therefore, this statement in the Acoustics Bulletin article Part 2 is a significant U-turn by WSP.

WSP article conclusions

The WSP authors conclude in Part 2 with a revised list of studies. While these studies would no doubt be individually useful, the INWG consider them unnecessary. So, despite some encouraging movement through these recent U-turns, the WSP authors fall short of actually recommending the adoption of BS4142 as a replacement for ETSU-R-97.

What is also unclear is whether these revised recommendations have been conveyed to government or what has driven these changes.

Part 6 - The argument for BS4142

During the late 1990s when ETSU-R-97 was developed it was claimed that the then version of BS4142 was unsuitable for use with wind turbine noise. There was concern that the BS4142 use of LAeq would be too easily influenced by extraneous noise and that the use of LA90 was claimed to provide a better representation of the underlying wind farm noise. This was at a time when the unique characteristics of wind turbine noise were poorly acknowledged. Further, the substantial increase in wind turbine height since the 1990s, from around 70m to 200m, has brought increased noise problems.

The 2014 revision of BS4142 overcame these earlier concerns and has been tested as being suitable for wind turbine noise assessment. BS4142 is widely used on comparable industrial noise sources that could be located in rural areas.

Testing of BS4142:2014 was carried out on behalf of the INWG and reported in INWG [WPS5](#) titled: 'Towards a draft AM condition' dated November 2015. Chapter 8 provides a detailed assessment of the suitability of BS4142 for wind turbine noise. Additionally, the paper presented at the 2015 INCE conference at Glasgow 'Cotton Farm Wind Farm – Long term community noise monitoring' by Stigwood, Large & Stigwood, available at www.masenv.co.uk/publications provides a very strong argument for adopting BS4142.

Table 1 - BS4142 v ETSU-R-97 Comparisons

Feature / Topic	BS4142:2014+A1:2019	ETSU-R-97
What is it used for?	For rating and assessing sound of an industrial and/or commercial nature.	For noise assessment of wind turbines only.
What are the main concepts or differences between ETSU-R-97 and BS4142?	Utilises the 'Rating' method of assessment. Determines the noise impact at a specific location by assessing noise loudness and character (Rating) compared with the actual background noise level.	Utilises a 'derived limit' method of assessment. Compares either predicted or measured noise with noise limits derived from data from a background noise and wind speed survey.
Does the guidance control for tonal, impulse and amplitude modulation?	Yes - Applies graduated corrections for tonal and impulsive character including AM.	Tonal only. Does not control impulsive, character, intermittency or AM.
Is low frequency noise (LFN) controlled?	Requires LFN to be assessed using DEFRA NANR45.	No
ETSU-R-97 is criticised for using the LA90 _{10min} index whereas BS4142 uses the LAeq measurement index. What are the implications?	Uses the LAeq measurement index that effectively averages all the sound energy over the measurement period. A separate frequency analysis using fast time data is used to identify tonal and for impulsive calculations.	Uses the LA90 _{10min} measurement index effectively recording a sound level exceeded for 90% of the time over a 10-minute period. As such it fails to identify impulsive or modulating sound including AM.
Does the guidance allow for uncertainty in the process?	Yes - The latest versions now require consideration of uncertainty.	No - Has been criticised as being possibly the only field of science where uncertainty has not been recognised.
There has been criticism of the ETSU-R-97 derived noise limits, what are the issues?	Does not use fixed limits or require derived noise limit curves. The Rating assessment method compares the impact of the noise at the receptor location. This eliminates the ambiguity of derived wind speeds, derived noise limits and the effects of wind shear.	Limits are derived via a complex and opaque process to create limit curves based on background noise and wind speed survey data with minimum limits. This can result in significant adverse noise impact, typically during evenings and night and for extended periods while still remaining 'compliant'. Failing to account correctly for high wind shear conditions is a fundamental fault.
Is the guidance designed for compliance testing or complaint resolution?	Yes	Ambiguity on this allows considerable latitude in the assessment process such that the wind farm can be claimed as compliant, yet the complaints can continue.
How long does it take to do a compliance test or complaints investigation?	Can be completed in one day	Can take many weeks to assess with recent assessments taking months.

Stigwood concludes with; *“The revised standard BS4142: 2014 has addressed concerns which led to its exclusion when ETSU-R-97 was written and now includes extended analysis of special characteristics in noise. This renders it suitable to WTN containing AM. Comparative tests show it is better suited at determining impact than ETSU-R-97 derived methods which are formulated on the absence of any significant character content.”*

Additionally, where low frequency sound is prevalent, BS4142 allows for additional assessment using the DEFRA NANR45 guidance.

BS4142:2014 has since been updated with minor revisions during 2019. During March 2023 the government released guidance on the use of BS4142 in the form of a method implementation document (MID). This MID includes detailed guidance on measurement procedures, rating level calculations including tonality, impulsivity & intermittency, uncertainty and assessment of impacts. See Reference 3 for the article by Tony Clayton of the Environment Agency appearing in the Acoustics Bulletin Nov/Dec 2023 edition on page 63, where Clayton discusses the reasoning behind the publication of the MID.

An abbreviated and updated version of Table 1 from the INWG analysis report is shown above providing further comparison of ETSU-R-97 with BS4142:2014+A1:2019.

Part 7 - INWG conclusions and recommendations

WSP's report recommendation that the guidance would benefit from further review and updating is not supported by the study findings. Given the documented evidence, there is a clear disconnect with the report's conclusions and recommendations.

The nature and number of criticisms, especially from the stakeholder survey, point to faults with the fundamental methodology underlying ETSU-R-97. These are faults that cannot be fixed by more revisions or studies.

Arguably the most glaring omission from the report is consideration of an alternative to ETSU-R-97. The INWG tested BS4142 with wind turbine noise data and recommended that ETSU be replaced with BS4142 during 2015. The update to BS4142 during 2019 and the government MID guidance issued March 2023 further support the use of BS4142.

There is no technical reason why BS4142 should not be used and its use would bring wind power in line with similar noise polluting industries.

It should be noted that neither ETSU-R-97 or BS4142 directly control low frequency noise. However, BS4142 requires assessment using DEFRA NANR45 where low frequency noise is prevalent. There is also recognition by some acousticians that if audible noise, specifically AM is properly controlled, then by default, problems associated with low frequency noise will potentially be reduced.

The WSP report claims insufficient evidence of any health effects from wind turbine noise including low frequency sound. These claims are carried forward into the Acoustics Bulletin article. The apparent absence of participation by suitably qualified health professionals must call this claim into question. If the WSP authors have involved health professionals and have supporting evidence, then this should be made available for scrutiny.

Additionally, recommendations concerning low frequency noise conflicts with the INWG findings at INWG [WP 3.2](#), the more recent research findings by the IARO and by others.

When reviewing guidance applying to industrial noise sources it is apparent that ETSU-R-97 exists as an outdated anomaly, outside of British Standards and the permit regime of the Environment Agency. While a discussion of this topic is outside the scope of this briefing document, it is addressed in the INWG analysis report with the recommendation that onshore wind should be licenced and subject to oversight by a national agency, such as the Environment Agency.

The recommendations made during April 2023 are repeated below at Table 2.

Table 2 – INWG Recommendations to Government

1	Reject the recommendation made by WSP for ETSU-R-97 to be retained albeit with some minor revisions.
2	Replace ETSU-R-97 with BS4142:2014+A1:2019 as the official guidance for wind turbine noise assessment.
3	Reject the WSP proposal for a government position statement on low frequency noise. This would set a dangerous precedent, is unsupported by the evidence and would conflict with the WHO position.
4	Conduct independent research into the effects on health and well-being of wind turbine noise including impacts from long term exposure, low frequency noise, infrasound, amplitude modulation and tonal noise as recommended by the WHO.
5	Introduce regulation of wind power generation by a national agency such as the Environment Agency.

About the Independent Noise Working Group (INWG)

The INWG formed during 2014 and was sponsored by Chris Heaton-Harris MP (Conservative, Daventry).

The INWG is a multi-discipline team fully independent of the wind industry and government.

The principal aim of the INWG is ensuring that the acoustic impacts from onshore wind turbines are properly controlled in order to protect public health and well-being.

Part 8 – References – (Institute of Acoustics copyright)

Reference 1 - WSP article Part 1

(Acoustics Bulletin Sept/Oct 2023 edition)

Reference 2 – WSP article Part 2

(Acoustics Bulletin Nov/Dec 2023 edition)

Reference 3 – Environment Agency article MID for BS4142

(Acoustics Bulletin Nov/Dec 2023 edition)