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From Good Practice Guidance to solving Amplitude Modulation for wind turbine noise assessment in the UK

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Summary

The IOA has now published its GPG and six SGN's, which are being widely used in practice for wind turbine noise assessment. Work is currently underway by the IOA AM working group to derive a metric to quantify AM. UK Government is about to commission a research project, and the IOA will work closely with the appointed researcher to help develop a rating and penalty scheme to deal with AM.

1.0 Introduction

Wind turbine noise assessment has come a long way in the last five years in the United Kingdom, and the completion of an Institute of Acoustics sponsored initiative to produce Good Practice Guidance has done much to codify extant practice. In this paper the hurdles overcome on the path to the production of the Institute of Acoustics (IOA) Good Practice Guide (GPG) and six Supplementary Guidance Notes (SGN) will be reported, noting how the IOA separated the technical and the policy elements of the process. The paper will then consider how to bridge the gap between the current IOA programme of work providing a metric and methodology to quantify and assess the amplitude modulation within turbine noise, and a full rating method that can relate dose response from justified complaints in order to set appropriate thresholds and penalties.

2. Background

2.1 Good Practice Guidance

In the UK, noise assessments for wind farm developments are undertaken using the methodology set out in ETSU-R-97 'The Assessment & Rating of Noise from Wind Farms' published in September 1996. The Government Department of Energy and Climate Change (DECC), which has policy responsibility for ETSU-R-97, wrote to the UK Institute of Acoustics (IOA) in Summer 2011 to invite them to produce a 'Good Practice Guide' (GPG). A noise working group was formed (IOA-NWG), and less than two years later in May 2013, *'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'* was duly published. My paper to the Wind Turbine Noise 2013 conference in Denver details the work undertaken up to the production of the GPG.

2.2 Supplementary Guidance

Following the publication of the GPG, the IOA NWG continued to produce six Supplementary Guidance Notes (SGN). The purpose of these notes was to provide additional guidance on topics covered in the GPG, along with examples and case studies. The topics covered are listed in Table 1, and are to be read in conjunction with the GPG.

Table 1. Supplementary Guidance Notes

Number	Title	Content
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.

2.3 Amplitude Modulation

The IOA-NWG was not able to find any good practice on the assessment and rating of amplitude modulation (AM) at the time of producing the GPG, and recognised that more research was needed. A recommendation was made to IOA Council to undertake more work on AM, and an AM working group was formed in 2014 as a sub group to the IOA-NWG. Other papers will be presented at WTN2015 covering the activities of the sub group. This paper will report on the work expected to be funded by the UK Government starting in spring 2015 to answer the questions of how much AM is too much, and what form should a penalty scheme take?

3.0 SGN Production

In keeping the GPG as concise as possible, a large amount of detail was stripped out from the earlier GPG consultation draft which the IOA-NWG felt was useful information in its own right. It was therefore decided to create a number of notes to contain this information. Following the same procedure as that adopted for the GPG's production, six draft documents were published for consultation in early 2014, and the set of six SGN's were published in Summer 2014. As with the GPG, the

SGN's were subject to peer reviews before consultation and before final publication.

The SGN's were subject to a minor review in winter 2014, and the second issue of the SGN's should be published by Easter 2015. It is still the intention of the IOA to seek formal endorsement of the SGN's from the various Government Departments.

The SGN material was first presented as part of the GPG consultation, to which there were over 50 consultation responses. Several of these responses sought to challenge the very basis of the ETSU-R-97 methodology, but this aspect was outside the scope of the IOA-NWG. All of the material submitted in support of these opinions was considered by the IOA-NWG to be based on flawed arguments and anecdotal evidence, and subject to repeated rebuttal at Public Inquiries (part of the UK planning process).

The IOA limited the review to technical aspects to ensure that the guide was limited to scientific evidence on the methodology only. Noise limits for wind farms are set by the Government in the UK, and take account of a number of factors, balancing the impacts of wind farms against the wider climate change agenda. In restricting the scope of the working group, it was possible for the IOA-NWG to gain a consensus view on the methodology. It is unlikely that this could have been achieved had the scope included discussion on the limits – the original ETSU-R-97 working group could not agree on suitable limits, and a compromise was reached based on the knowledge of noise impacts at the time. Subsequent Governments have reviewed the limits and continue to support them, although clarity has been provided that the limits should be seen as exactly that; limits that should not be exceeded. Each scheme should be assessed on its merits, and it is of note that recent decisions on large UK wind farms have been turned down where the schemes were within the limits.

There were substantially fewer responses for the SGN consultation, and no fundamental challenges were made to the notes proposed. No new evidence had emerged on the methodology since the GPG was published, so few changes were made to the SGN's prior to publication. The UK approach is considered to closely follow the approach taken in most other countries where guidance exists.

4.0 Amplitude Modulation

The focus of the last five years or so in wind farm noise assessment has shifted away from wind shear to that of amplitude modulation. A number of research projects have already been completed and many more will be reported on shortly.

The IOA AM working group was set up to review the available evidence, and to produce guidance on the technical elements for the assessment of AM in wind turbine noise. The overarching aim of the group is to develop the technical elements of an assessment method for amplitude modulated noise from wind turbines and wind farms.

This will be:

- based on best available science;
- based on the most up-to-date psycho-acoustic and technical information on modulation available;
- provided in the format to allow straightforward inclusion in 'standard' forms of planning conditions for wind turbines [subject to thresholds or penalties set by

others];

- accompanied by software where necessary to allow the condition to be implemented by all parties.

To achieve this, the assessment method will need to contain a means of characterising a sample of amplitude modulated wind turbine noise data, with an agreed format and length, by means of a single metric uniquely defining the level of AM within it. Other papers at the conference will report on the group's progress to date.

In the same manner that the GPG was produced, the thresholds and penalty system were excluded from the work scope. The IOA has lobbied the UK Government to consider funding a research project to advise on thresholds and penalties, which is expected to be out to tender at the time of writing. I am hoping to report the early progress of this project with my conference slides.

The IOA AM working group has considered what this research should cover. It is expected that this research project will review all research into the human response to amplitude modulation in wind farm noise and from other noise sources in residential environments, and look to see if a robust relationship can be established, and the conflicting evidence rationalised. Dose response studies undertaken to date have been on a small scale and under different test conditions; as a result, it has been difficult to compare studies and draw conclusions on them. For example, Renewable UK published their research in December 2013, and derived a penalty scheme from the results of a small number of laboratory listening tests. A derivative of this method has now been accepted on a high profile wind farm in the UK (Denbrook), but this is still subject to legal challenge at the time of writing.

The review will then need to consider the format and thresholds for a penalty scheme. Using the metric determined from the IOA AM Group's work, the format for a penalty scheme will be considered. A number of key aspects will need to be resolved to get to the penalty scheme. This will include the threshold of acceptability of the AM, the duration of the AM, the frequency of occurrence, and other non-acoustic factors which influence human response. It is expected that the measurements will continue to be external rather than internal as this is the planning convention for most noise sources, but the scheme will need to consider whether a reduction in the overall noise level is sufficient to alleviate the impact from AM noise (as is used in the ETSU-R-97 penalty for tonal noise), or whether the penalty should be to alleviate the AM at source by either reducing the operating speed or pitch angle of the blades to reduce the AM level.

Any scheme to mitigate excessive AM could reduce the power generating capacity of the turbines, so the penalty scheme will require the backing of Government to ensure that a balance is struck. It is not anticipated that this research project will reveal a clear 'threshold' for AM. The response to a noise varies from person to person, and is affected by many factors including our attitude towards it. Dose response curves are routinely used in deciding where to set noise thresholds, and it therefore follows that those who have the highest annoyance at the lowest levels of exposure are likely to be disappointed from any subsequent decision on the 'threshold'. The ultimate decision will involve more than just technical considerations.

5.0 Conclusions

The IOA has now published its GPG and six SGN's, which are being widely used in practice for wind turbine noise assessment. Work is currently underway by the IOA AM working group to derive a metric to quantify AM. UK Government is about to commission a research project, and the IOA will work closely with the appointed researcher to help develop a rating and penalty scheme to deal with AM.

References

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