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Measurement of wind turbine noise characteristics in receptor position – A new IEC Technical Specification

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Summary

Following an initially rejected proposal for a new international standard on the measurement of wind turbine noise characteristics at receptor positions in 2017, the subsequently submitted revised 2nd proposal for a technical specification (TS) received approval by the IEC/TC88 member committees in April 2018. The International Electrotechnical Commission (IEC) Technical Committee TC88 tasked Mr. Bo Søndergaard from Denmark with organizing and convening the new project team, PT61400-11-2 (PT11-2), and the first meeting of the group took place in Hamburg in June 2018. Further meetings were since held in the US and in Denmark. At the second meeting in October 2018, the preliminary structure of the TS was defined, and the text of the individual chapters and appendices is currently being written in smaller project groups until the next update meeting in June 2019.

The TS comprises measurement and evaluation methods relating to topics such as sound pressure level, amplitude modulation, tonality, impulsivity, low frequency, and the determination of wind speed and other non-acoustic measures describing the details of the implementation of such measurements under conditions relevant to wind turbine noise. The project team currently includes 29 experts from 11 national committees, traditionally strongly represented from Europe and North America, but also a growing number of experts from Asia are interested in collaborating within the project team. The TS will be of particular interest in countries, where no guidance for the measurement of wind farm noise is available, but also in countries where guidelines and legislation for environmental noise measurements may not be sufficiently adapted to the specifics of immission measurement and characterization of sound from wind turbines under windy conditions.

This paper will cover the background of and intentions for the initiative, as well as a description of the items included in the TS and the current status of writing, including the estimated timeline of publication.

1. Introduction

In most of the countries known to the authors, wind turbines are structures that require a planning permission (permission for construction, operation and deconstruction at the end of the life-time), usually involving an environmental impact assessment which also includes the assessment of wind farm noise at the nearest residential properties. Subsequently, the building permit or permit to operate a wind farm is often issued with a number of conditions relating to the noise level and noise characteristics from wind turbines, the wind farm immissions impacting on the nearest residential neighbours. In order to show compliance with such conditions or in the event of complaints about wind farm noise and/or its characteristics, measurements at the receptor position may be required. Some countries have specific guidelines for the measurement of wind farm noise, many have only general guidance for the measurement of industrial noise and others have no guidance at all. Unless wind farm specific guidelines are available, national legislation or guidance often require adaptation to the peculiarities of wind turbine noise. Available guidance is usually created for wind speed independent sound sources and is therefore often not suitable for wind turbines which exhibit a wind speed dependent sound emission. In the absence of a well described guidance, the quality of measurements and reports is often poor, and/or not reproducible by another expert.
In order to simplify and standardize their work, wind turbine manufacturers, internationally operating energy providers, wind farm developers and operators prefer uniform and internationally recognized measurement and evaluation methods, especially in countries where there are no suitable regulations adequately adapted to wind turbines. Internationally it can be observed that many permitting authorities use ISO 1996-2, which should only be used for wind speeds up to 5 m/s at the location of the measurement.
In order to have a basis for wind farm measurements and assessments all over the world, and to fill a 'vacuum' in various countries, experts of wind turbine acoustics and stakeholders from the wind industry came together to discuss in which way an international standard would be suitable and under the guidance of which international standards organization (ISO or IEC) this standard should be placed. This process will be described in the following chapters.

2. History of the IEC/TS 61400-11-2 with the working title "Wind energy generation systems - Part 11-2: Measurement of wind turbine noise characteristics in receptor position"

2.1 IEC and ISO Standards

A collection of currently 32 published standards relating to wind turbines is in the care of the approximately 800 experts from 29 countries under the umbrella of the IEC[1] in the Technical Committee TC88 "Wind energy generation systems". Another 27 standards are under development (revision or new documents in progress). Amongst others, the IEC 61400 series describes topics from individual components of the wind turbine (mechanical and electronical), wind measurements, test procedures, stability, wind park regulation, site suitability and occupational safety for onshore and offshore wind turbines and wind power plants as a whole (including supply to the power grid). Further information can be found on the IEC website under 'TC 88 Dashboard'[2].

Standards dealing with sound measurements of sources and propagation calculations of industrial noise have traditionally been written and maintained by ISO[3]. An exception is the standard for the determination of sound power levels of wind turbines, which was included in

[1] International Electrotechnical Commission: International Standards and Conformity Assessment for all electrical, electronic and related technologies
[2] https://www.iec.ch/dyn/www/f?p=103:7:5599856330528:::FSP_ORG_ID,FSP_LANG_ID:1282,25 (last accessed 20/03/2019)
[3] International Organization for Standardization

the IEC series because it is strongly linked to the operation of this particular plant and therefore fits into the IEC series which describes this product. The IEC 61400-11 is an expansion of the ISO standards for the determination of sound power levels (especially ISO 3744), but which includes as a special feature the correlation of the sound power level with (hub height) wind speed and in particular describes measurements at higher wind speeds. The first version (Edition 1) was released in September 1998, with the latest version (Edition 3) published in December 2012 and Amendment 1 in June 2018.

2.2 A new IEC standard/technical specification

The existing ISO 1996 standard series has been written for the description, measurement and evaluation of environmental noise, which includes the sound sources road, rail and air traffic, as well as industrial plants. However, it is unsuitable for wind power plant immissions because it defines a maximum allowable wind speed range at which the wind turbines may not have reached their highest sound power level yet. It is required to avoid the influence of meteorological parameters on the measurements. Recently, there was a proposal to include wind turbines as a sound source in the ISO 1996 series, but this has not been followed up so far. Now that the IEC has taken this task on, it is expected that there will be reference to the new IEC document rather than their own creation. From the beginning, experts from the relevant acoustics committees at ISO collaborated with the with the IEC experts. This is to avoid doubling the work and possible contradictions between an ISO and an IEC standard.

In March 2017, the Chinese National Committee submitted a proposal for writing a new standard titled "Wind turbine aero acoustic noise measurement techniques (proposed IEC 61400-11-2)", which was accepted by the majority of P-members[4] but rejected owing to lack of experts from P-members (these two criteria must be met for a successful application). This was then taken as an opportunity to revise the Chinese proposal and submit it in a second proposal to the IEC, written by members of the MT11 maintenance team and submitted by the Danish National Committee. This included the removal of overlaps of the new proposal with the existing IEC 61400-11, a more integrated approach that included more parameters than just amplitude modulation and low frequency noise, changing from an international standard (IS) to a technical specification (TS) to speed up the process and the intention to collaborate with the relevant ISO working group. This revised proposal was adopted by the P-members and sufficient experts were put forward by the National Committees, so that at their annual meeting, TC88 mandated the formation of a new project team in April 2018.

Documents published by the IEC are classified based on their maturity and experience with the methods described. Some of the publication types produced by the IEC are listed here:

- International Standard (IS)
- Technical Specification (TS)
- Publicly available specifications (PAS - publicly available specifications)
- Technical reports (TR)

MT11 opted for a TS in this case, as it was felt that e.g. the topic amplitude modulation still requires further research and therefore standardization as an IS was considered as premature. A TS refers to international standards with respect of detail and completeness. Furthermore, a TS is similar to an IS in that it is normative and developed by consensus. A TS is approved by a two-thirds majority of the participating members of a technical committee of the IEC (TC) or a subcommittee (SC). The approval process for the TS is similar to that of the IS, but saves one round of voting and therefore goes through the IEC process faster for publication.

A TS goes through the following stages as shown in Figure 1 and further explained below.

[4] P-member: participating National Committees in TC88

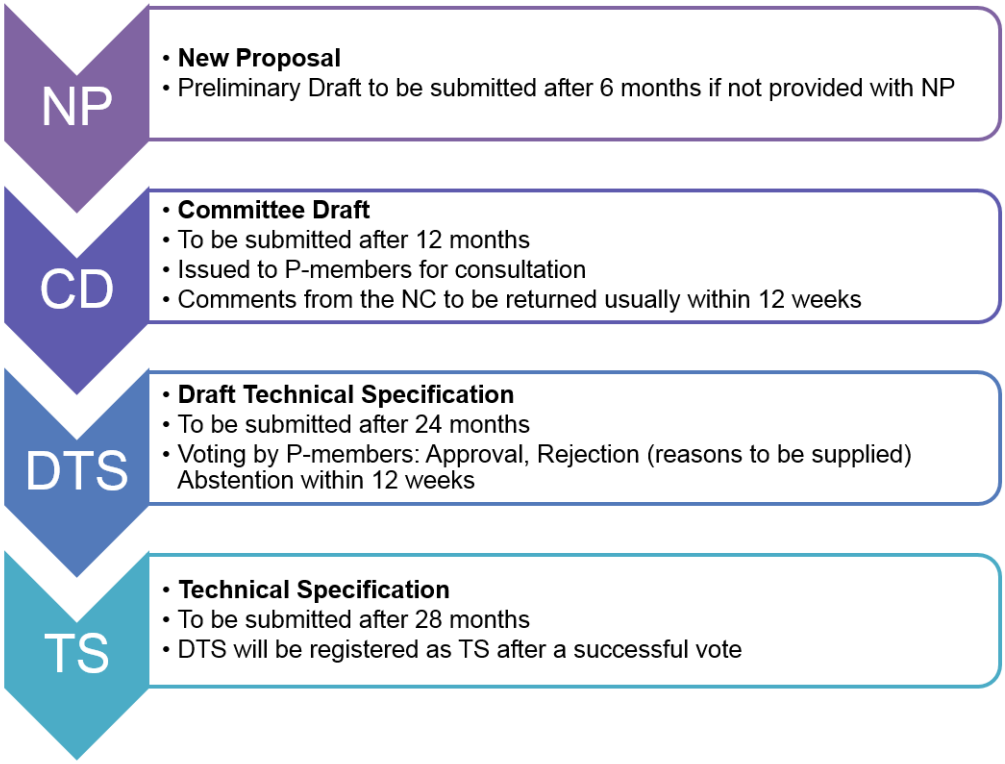

Figure 1: Milestones of an IEC/TS

A New Proposal (NP) is submitted by a National Committee and is usually written by experts with the required background in the topic. The expectations of the IEC on deliverables are as follows:

- If not present at the time of submission of the NP, a 'working draft' must be submitted within half a year. This can be done in the form of a table of contents or the schematic representation of the work processes.
- One year after accepting the NP and assigning the project team, the Committee Draft (CD) is expected. This is distributed to the P-members of the TC88 with the requests, to submit comments within 12 weeks, which will eventually lead to TS acceptance by that Member State.
- The project team must now consider all the comments received and decide whether they are justified and therefore passages need to be changed, whether it is a misunderstanding that can be resolved by a better description of the text, or whether it is a topic that may be known, but cannot be considered at the time and is therefore postponed until the next revision.
- Subsequently, the Draft Technical Specification (DTS) is prepared. This is sent out to the P-members again with a 12-week voting period. Each member state has three options: acceptance of the TS (positive), rejection of the TS (negative, reasons must be presented) and abstention. A case for the latter option could be if a National Committee does not have its own experts on the subject and therefore cannot form an opinion on the subject.

Ideally, the DTS is accepted by the National Committees and is then registered and published by the IEC as TS. If the criteria are not fulfilled at the election, the project team can rework the document. The text may then be reissued as a revised DTS, or, which would be one step before, being circulated as CD again. And the last option is to present it to TC88, and if well argued, it may be approved by TC88, however may also be rejected if there are good reasons for it.

2.3 Motivation

Writing a document that includes the characterization of the noise from wind turbines at the receptor location into an IEC standard is a consequence of the fact that sound power level measurements at the wind turbine do not describe the nature of far-field sound as perceived by the residents, and the need for a description of the measurement and evaluation of amplitude modulation (AM). It was decided that such a document should include the analysis of all wind farm sound characteristics, not as originally intended, just AM. It is not the aim to invent new methods e.g. for tonality or impulsivity, but to use existing standards and methods wherever possible.

It has already been found that the TS cannot consist of just one well-defined method for carrying out measurements and assessment per topic, as there are already many different methods in existence in various countries. The aim for the TS is therefore to describe available and reliable methods and give instructions on how to work with the relevant method for the required task. A toolbox will be created in which the expert can pick out the best fitting approach for a meaningful assessment.

It will be stated very clearly that the different measurement and evaluation methods are independent of each other and that they do not have to be applied all in one report. Before each measurement it should be defined which purpose the measurement will serve and the appropriate method should be selected appropriately. It is expected that only those assessments will be carried out which are purposeful for the task at hand.

2.4 The Project Team

The PT61400-11-2 (PT11-2) project team currently consists of 29 experts, representing eleven National Committees (shadow committees to TC88), and numbers are still growing. Only countries, where their national standards committee is a member of TC88, can send experts on their behalf. Experts of other countries can only take part in meetings of the project team in an advisory manner at the discretion of the Convenor. Traditionally strongly represented are Germany and Denmark, which together already made up half of all participants at the inaugural meeting and, with the exception of participating Goldwind from China, also have all the major international wind turbine manufacturers in their ranks. Project management for PT11-2 has been assigned to Mr. Bo Søndergaard of Sweco Danmark A / S, who is already in charge of the MT11 maintenance team. A project manager can be assisted by a secretary which in this case has been taken over by Ms Sylvia Broneske of Innogy Renewables UK Ltd.

3. State of Progress

The members of the Danish NC came prepared to the first meeting of PT11-2 with a proposal for the chapter structure and topics to be included in the TS. This was generally accepted by participants of the meeting and is shown in Figure 1 in a revised version representing the work in progress after the 3rd meeting.

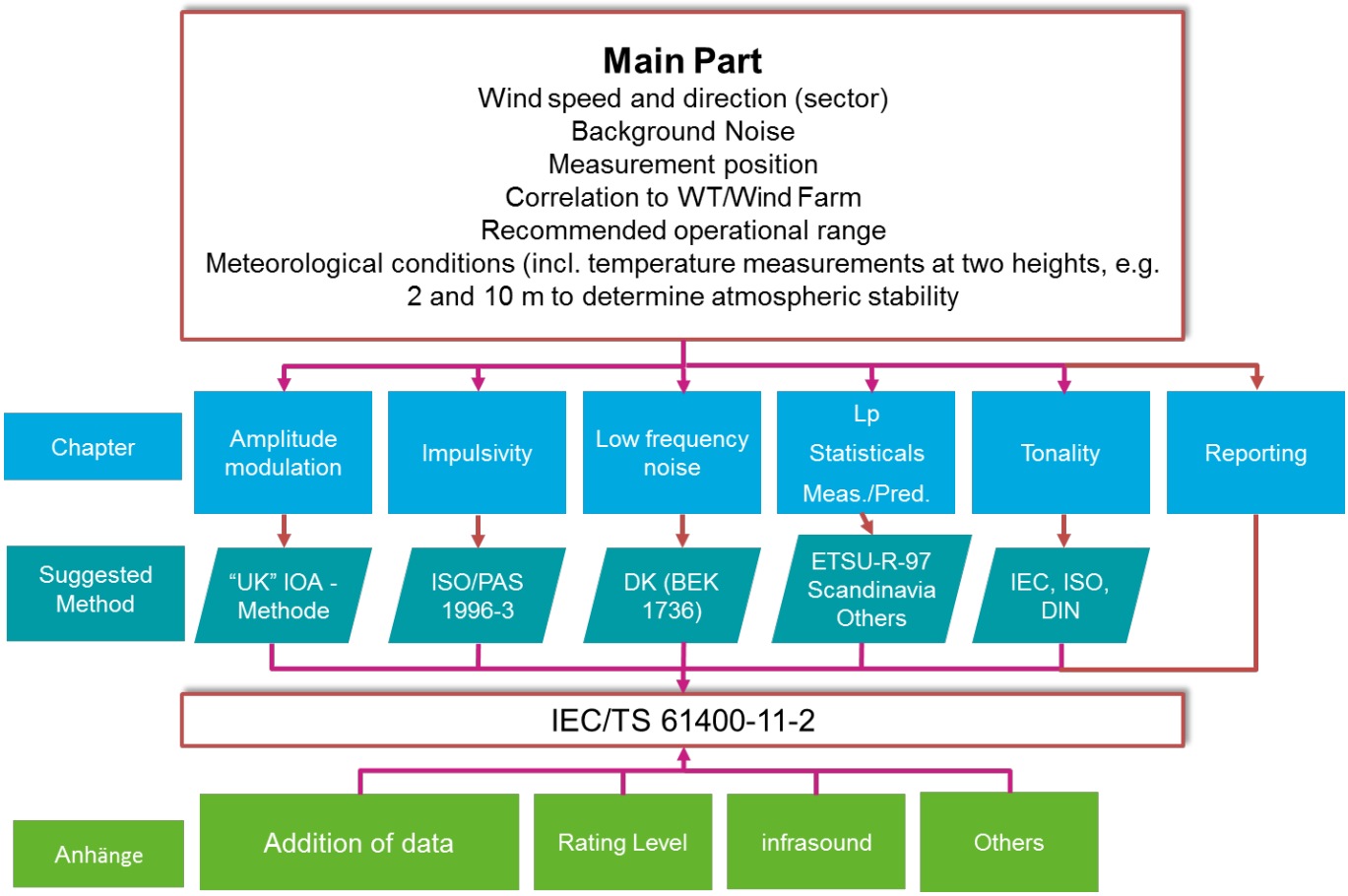

Figure 2: First draft of structure of IEC/TS 61400-11-2

It has also become very clear that it will not be possible to decide on only one method of measurement and evaluation per topic, since the tasks assigned to such measurements may vary considerably. For example, the effort and the requirements for a complaint measurement will differ from those for compliance testing or troubleshooting. Therefore, the goal is to offer a choice of possibilities that can be put together for the measurement depending on the task. The buzzword commonly used here is toolbox. Depending on the job you need a certain approach. If the task is not defined, a proposal for the minimum requirement will be defined so that the measurements provide a meaningful result.

The following schematic structure of the TS was provided by a member of PT11-2 and is included here as Figure 3.

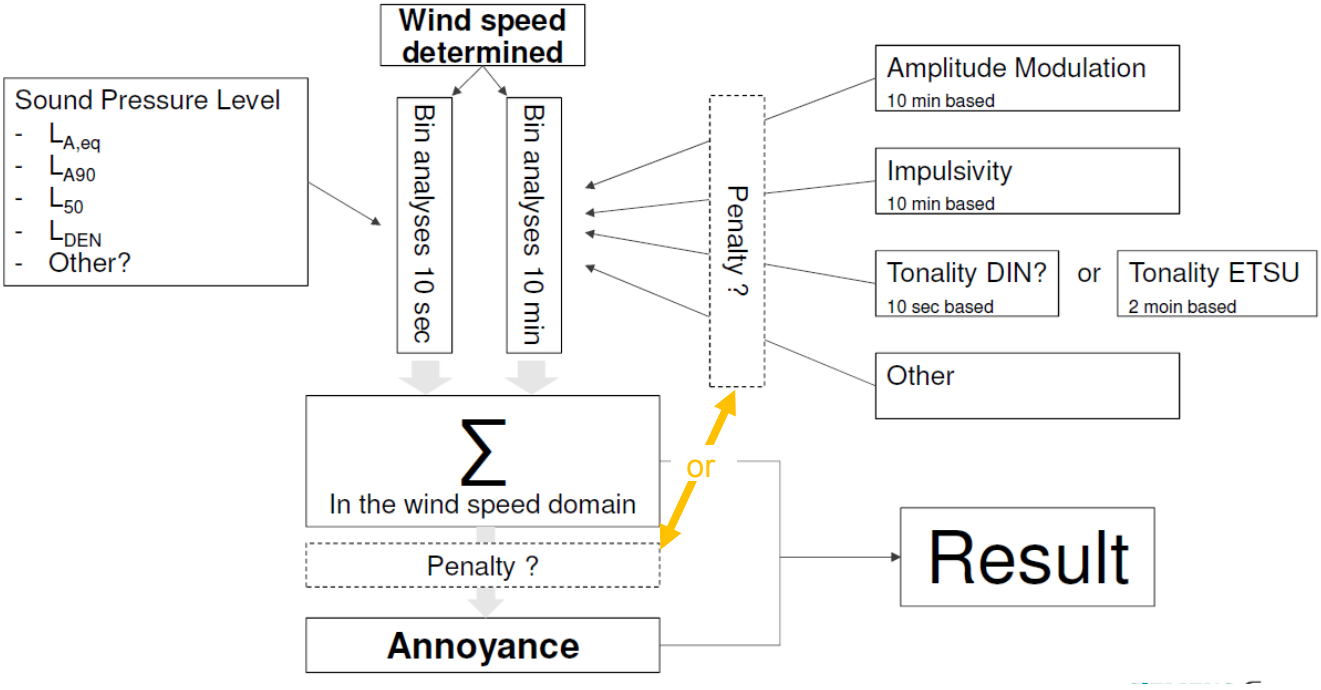

Figure 3: Overview of the preliminary work flow

The chapter breakdown of the current draft version is listed below. It follows the specifications of the IEC, as far as the introductory, non-technical chapters are concerned. Each technical chapter is subdivided as follows:

- Outline
- Instrumentation
- Acoustic measurements
- Non-acoustic measurements
- Data reduction
- Reporting

If similarities of all described measurements and evaluations are found, these are described in the main introductory chapters. For topic-specific explanations that are not useful in any other case, there will be a description in each individual chapter. Care must be taken to ensure that no repetitions of the same facts of the main text occur in the individual chapters.

The preliminary list of contents is provided in Figure 4 below.

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Figure 4: Preliminary list of contents

For the evaluation of the tonality, no final decision has yet been made yet, which of the available methods represents the preferred method of the PT11-2. Søndergaard et al. carried out a round robin in which individual spectra were evaluated according to different standards, namely IEC 61400-11 and ISO/PAS 20065. At the last session of the PT11-2 it was also suggested to include the evaluation according to ETSU R-97. After a complete evaluation of the round robin, the results will be presented at the Wind Turbine Noise Conference in June 2019

and subsequently PT11-2 may be able to decide on just one method to assess tones in wind turbine noise immissions.

The description of amplitude modulation (AM) is currently based on the publication of the British Institute of Acoustics, though the expert group on AM also discusses improvements and extensions of the evaluation procedure and, as far as possible in the short time, incorporates this into the text of the TS. There is another large study on AM currently conducted in Germany under the sponsorship from the German Umweltbundesamt[5] (UBA) and results are eagerly awaited[6]. However, their project plan extents to 2021 which will be too late for the anticipated publication of this TS.

For the assessment of impulsivity, the TS will refer to the future ISO/PAS 1996-3, which is expected to be published within the next three years. This ISO/PAS is based on the publicly available Nordtest NT ACOU 112: 2002-05.

4. Challenges

The challenge of writing an international norm or even report of a working group, is to balance the interests of the various stakeholders at the table. In PT11-2 all major wind turbine manufacturers from Europe are represented and for the first time there is also an Asian manufacturer present. Another large group in the project team are the experts from the measuring institutes from various countries, while operators / project developers and universities / research institutes are present only in a small number. All these various groups, and indeed individual members, aim to bring forward and defend their own interests. As representatives of the National Committees, experts are also expected to represent the opinion and interests of their home countries. An IS / TS is the result of long discussions based on consensus. This is not always easy, as can be imagined.

Consensus is defined as follows:

> ***consensus****: General agreement, characterized by the absence of sustained opposition to substantial issues by any important part of the concerned interests and by a process that involves seeking to take into account the views of all parties concerned and to reconcile any conflicting arguments.*
> *NOTE: Consensus need not imply unanimity.*

Even the selection of topics to be covered in the TS 11-2 led to lively discussions, which are not yet completed. Should e.g. the evaluation of a noise characteristic be complete with the determination of a value (example: tonal perceptibility or depth of the amplitude modulation)? Should a typical "normal" value be defined? Does the PT11-2 want to attempt a definition for penalties and a rating level? The latter would be of particular interest to countries in which there are no regulations with regard to immission standards and pollution control. The text would have to be phrased in such way that it does not cancel out existing rules and regulations about the allocation of penalties such as tonality, impulsivity and AM.

Details must be clarified, such as, which of several existing nearly equivalent evaluation methods would be listed as the preferred method, how are uncertainties to be calculated, how and where should wind speed be measured or determined, or where should the microphone be placed for the measurement.

There are also administrative challenges. Working with a group of international experts across the world brings challenges in finding suitable time slots for webconferencing. Attending face to

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[5] Federal Environment Agency

[66] Research Project “Geraeuschwirkungen bei der Nutzung von Windenergie an Land“ carried out by deBAKOM Gesellschaft fuer sensorische Messtechnik mbH

face meetings is not an option for every expert as this depends on their availability to take out 2 days for each meeting and additional travel time, but also on the willingness of their company to pay for expenses and allow them to take the required time out of a usually busy work schedule. Writing a TS or IS is time intensive, so that availability of 'free' time to carry out the required work and attend meetings could easily have a major impact on meeting the deadlines set out by IEC as described in Section 2.2 above.

5. Outlook

It had already emerged at the first meeting of the new project team that the original idea of referring exclusively to existing standards and only occasionally writing explanatory words to adapt existing methods for wind farm noise was too simplistic. Therefore, the original timetable has turned out to be too ambitious. The plan was to hand over the CD to IEC in January 2019, so that after passing through the necessary processes, the TS could be published in June 2020. PT11-2 has requested an extension of the deadline by a year, so that the new deadline is to finalize the Committee Draft by the end of January 2020 and if everything goes smoothly[7], to have the TS available for mid-2021.
Again, this is a tight schedule, which requires a lot of engagement from the participants, not only at further meetings, but also in the current phase of working out individual chapters in the different subgroups away from the larger PT11-2 meetings.

It will be interesting to see if there are any more presentations at the Wind Turbine Noise 2019 that need to be considered in the TS. Furthermore, we invite the discussion with members of PT11-2 to either confirm that we have taken the right approach so far or, if we missed out on important topics, to make us aware at this stage where topics can still be discussed and included if required.

It looks like the results of the German research project will be too late to be considered for this version of the TS, but their findings may then be incorporated into a revision of the TS or, if results confirm previous research, into an IS.

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[7] … and when does that ever happen???

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