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RoBin: meeting the requirements of the IEC 61400-11 standard for measuring the acoustic emission of wind turbines with a one-man operated system

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Summary

Wind power becomes a real alternative to solutions based on fossil fuel as corresponding reserves diminish rapidly. Several technical challenges linked with the implementation of wind farms in numerous locations worldwide must be considered, and noise emission by wind turbines is one of these.

The international standard IEC 61400-11 and German "Technische Richtlinie für Windenergieanlagen, Teil 1" of the FGW were set up in order to unify the evaluation of noise emission of wind turbines. Measurements performed according to these standards need practical challenges to be considered, such as the installation of testing equipment and an efficient evaluation of the collected data.

The proposed paper will shortly review some parts of the IEC 61400-11 standard and discuss in detail operational constraint linked with on-site measurement and how modern communication technologies help in an easy system deployment and field operation for the benefits of all users.

1. Introduction

Wind turbines are built at more and more locations– and this makes of course their noise emission an important issue for the wind turbine field operator, as well as for the public authorities & communities who are living in immediate vicinity of wind farms. Part 11 of the international standard IEC 61400 and the German "Technische Richtlinie für Windenergieanlagen, Teil 1" of the FGW were set up in order to unify the evaluation of noise emission from this type of industrial site (please read [1], [2], [3] for more details).
Measurement of noise emission according to these standards is linked to formidable challenges, especially for the installation of testing equipment and evaluation of data. The RoBin system dedicated to this measurement task provides a complete and coherent hardware and software package, which implements the measurement complying with the applicable standards comfortably and efficiently.

2. The IEC61400-11 standard

The introductory words to this standard state that: it shall "provide guidance in the measurement, analysis and reporting of complex acoustic emissions from wind turbine generator systems.

The standard will benefit those parties involved in the manufacture, installation, planning and permitting, operation, utilization, and regulation of wind turbines. The recommended measurement and analysis techniques should be applied by all parties to insure that continuing development and operation of wind turbines is carried out in an atmosphere of consistent and accurate communication relative to environmental concerns. This standard presents measurement and reporting procedures expected to provide accurate results that can be replicated by others."

As a brief reminder, Figure 1 below gives some details about the locations of the different system components and their respective distance to the wind turbine. Usually only one reference measurement position is considered for acoustic measurement, located downstream of the wind turbine as indicated on Figure 2. Positions shall be accurate within ±15° relative to the wind direction at the time of measurement.

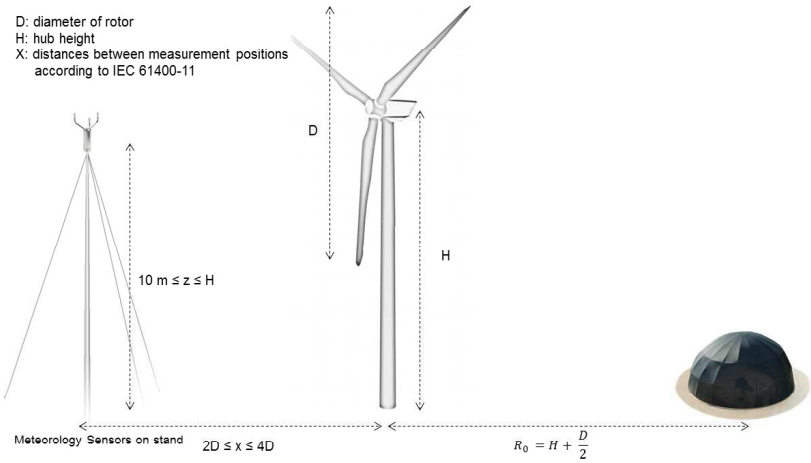


FIGURE 1. Relative locations of the different system components involved in a measurement according to the IEC 61400-11 standard.

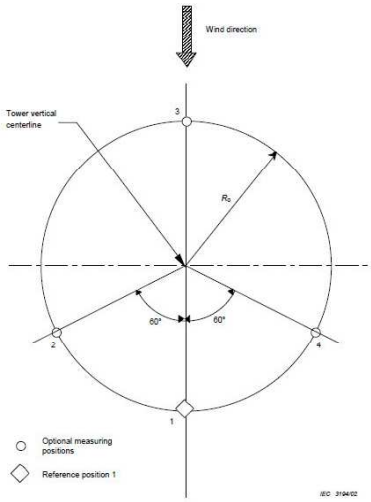


FIGURE 2. More details about reference location (diamond) and optional points (circles) for acoustic measurements

3. Noise measurement on site

Running out these measurements on site means facing multiple technical challenges:

- a multitude of single measurement components and equipment is needed,
- distances between the different measurement positions are far away from each other and from the wind turbine itself,
- it's necessary to determine the different parameters synchronously,
- there's no standardized interface to connect to the operating data of wind turbines,
- different ranges of wind speed must be captured,
- complex evaluation methods and computing time are the consequence.

The main component of the RoBin system is the Class 1 smart noise monitor DUO[4], a sound-level meter meeting the requirements of the IEC 61672 standard[5] taking into account noise incidence from the horizontal and vertical directions. DUO detects noise by means of a double shielded outside microphone. A flexibly applicable data logger with 8 freely configurable analogue inputs, a USB- and a fieldbus access undertakes the task of detecting the operation data of the wind turbine.

Meteorological data are detected by weather sensors which are consistent with the required class of accuracy. Transmissions of data between the different spots are carried out via Wi-Fi – all measurement points are equipped with Lithium battery technology. A radio remote control tags the measurement status (operating and background noise) and marks disturbing noise. Wind bin administration is done automatically in real time. The operator can thus comfortably monitor the measurement via tablet PC (see picture next page), possibly managing the measurement of several wind turbines at the same time.

FIGURE 3. Using a Tablet PC during on-site measurement and getting an easy access to the measurements in real–time

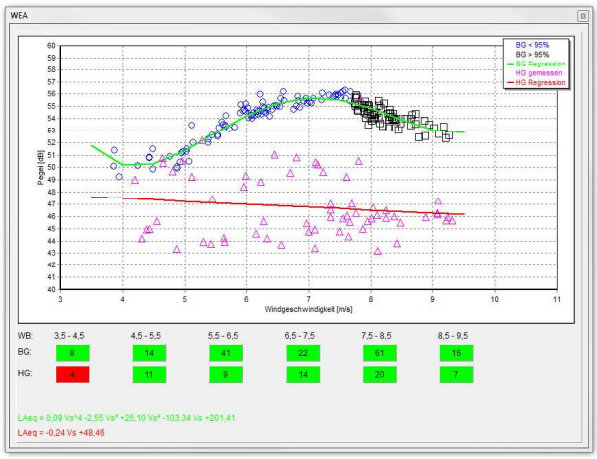


FIGURE 4. Online-View during a RoBin measurement: Sound level as function of wind speed

4. Embedded processing and off-line data processing

The noise emission software Noisy with its option RoBin & DUO evaluates the measured data. In a clearly arranged evaluation mask the operator can select the appropriate options and start the evaluation at the push of a button.

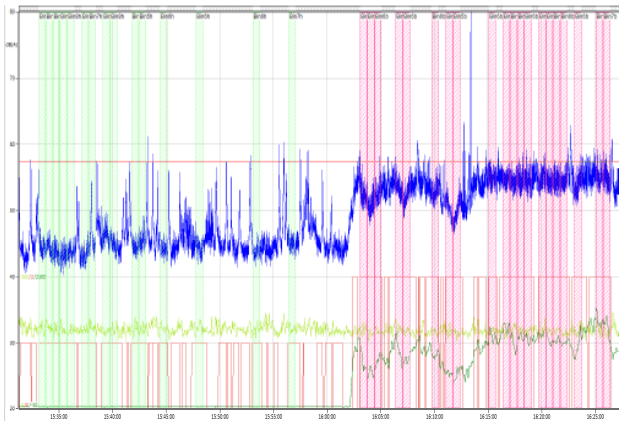
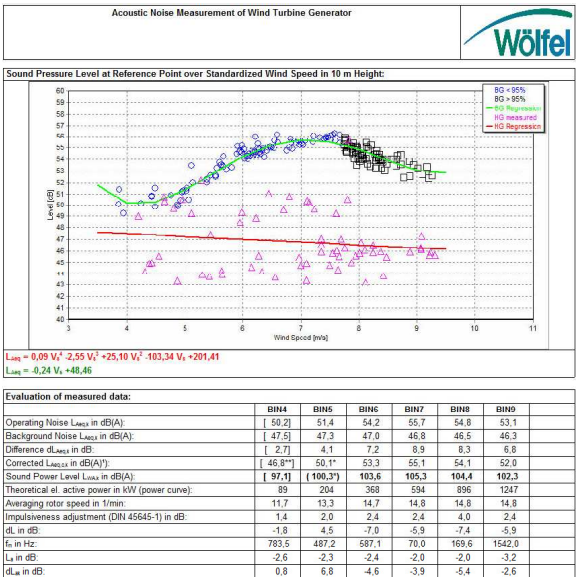


FIGURE 5. Sound level as a function of time with marked wind-bins



	BIN4	BIN5	BIN6	BIN7	BIN8	BIN9
Operating Noise L_{AeqX} in dB(A):	[50,2]	51,4	54,2	55,7	54,8	53,1
Background Noise L_{AeqX} in dB(A):	[47,5]	47,3	47,0	46,8	46,5	46,3
Difference dL_{AeqX} in dB:	[2,7]	4,1	7,2	8,9	8,3	6,8
Corrected $L_{AeqX,K}$ in dB(A)[1]:	[46,8**]	50,1*	53,3	55,1	54,1	52,0
Sound Power Level L_{WAX} in dB(A):	**[97,1]**	**(100,3*)**	**103,6**	**105,3**	**104,4**	**102,3**
Theoretical el. active power in kW (power curve):	89	204	368	594	896	1247
Averaging rotor speed in 1/min:	11,7	13,3	14,7	14,8	14,8	14,8
Impulsiveness adjustment (DIN 45645-1) in dB:	1,4	2,0	2,4	2,4	4,0	2,4
dL in dB:	-1,8	4,5	-7,0	-5,9	-7,4	-5,9
f_m in Hz:	783,5	487,2	587,1	70,0	169,6	1542,0
L_K in dB:	-2,6	-2,3	-2,4	-2,0	-2,0	-3,2
dL_{IM} in dB:	0,8	6,8	-4,6	-3,9	-5,4	-2,6

FIGURE 6. Selected part of an evaluation report qualifying wind turbine noise emission using RoBin

The report includes all required data from the standard – automatically created graphs and diagrams, tonality and impulsivity. The automatic report generator makes the process extremely efficient, which is of great benefit for users who were often used to take hours for report generation when done manually…

5. Advantages and benefits of using RoBin

Numerous advantages are linked with RoBin for operators performing the measurements defined in the IEC 61400-11, as compared to a classical approach based on less communicating devices:

- **No measurement cables:** Wireless transfer of meteorology data, operation data of wind turbine and microphone data over a self-sustaining WiFi-network
- **Handy:** Standard accessory comes in feasible and handy portable tool boxes
- **Flexible:** Digital, analogue and software interfaces to detect operating data of turbines from different OEMs
- **Clearly arranged:** Online evaluation together with a display of the current progress of measurement
- **Relying on certified Class 1 instrumentation:** Sound recording with DUO, the first and single Class 1 sound level meter approved in France[6], in Germany[7] and in Switzerland[8] with reference directions 0° and 90°
- **Exact:** Remote control to tag disturbing noise

Such advantages benefit to any user, all the more that Robin makes now measurements according to the IEC 61400-11standard possible with a single person, which was hardly the case before. This is another valuable improvement, as the system proves to be:

- **Simple to apply on the spot:** Only one person needed
- **Ready to use:** All components carry their own functions and are ideally coordinated
- **Easy and fast:** Evaluation of data and generation of report at the simple push of a button
- **Efficient:** The complete system consisting of soft- and hardware is made of one shape!

6. Conclusions

This papers briefly outlined the field of application and interest of using the RoBin system to make acoustic measurements according to the IEC 61400-11 standard more efficient.
Consultants who offer measurements of noise emission conforming to official standards, OEMs of wind turbines who want to optimize and document the acoustic noise emission of their wind turbines, public authorities who want to proof possible variations of complaints, designers and operators of wind farms who have to proof their compliance with official requirements: all of them will benefit from the numerous advantages offered by this powerful system, relying on state of the art technologies in measurement and data communication.

References

[1] IEC 61400-11, Edition 2.1 2006-11, Wind turbine generator systems – Part 11: Acoustic noise measurement techniques

[2] Technische Richtlinien für Windenergieanlagen, Teil 1: Bestimmung der Schallemissionswerte, Revision 18, Stand 01.02.2008

[3] IEC 61400-11 Edition 3 (draft): Wind turbines - Part 11: Acoustic noise measurement techniques

[4] 01dB, a brand of ACOEM: “DUO Product data sheet: NOT 1507" – December 2011

[5] IEC 61672-1 2002-05 “Electroacoustics-sound level meters – part 1: Specifications”

[6] Certificat d’examen de type LNE-21674 (21 Juillet 2011) delivered by LNE (Laboratoire National d’Essais), France

[7] PTB-1.63-4052726 (February 6, 2012) delivered by PTB (Physikalisch-Technische Bundesanstalt), Germany

[8] Zulassungszertifikat CH-A3-12096-00 (February 20, 2012) by Bundesamt für Metrologie METAS, Switzerland