CASE STUDY

The Energy research Centre of the Netherlands
Noise Measurements on Wind Turbines

The Netherlands

Industrial

PULSE, Software, Transducers, Calibrators

The Energy research Centre of the Netherlands (ECN) is an independent, market-orientated organisation for research, development, consultancy and knowledge transfer in energy and related topics. With sustainable development as its guiding principle, ECN develops and markets technology and products for safe, efficient and environmentally friendly energy supply.

A Brüel & Kjær PULSE™ data acquisition system and ½" free-field microphones are used to record wind-turbine noise and for post-process analyses of the recorded data.

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Noise Measurements on Wind Turbines

The Wind Energy Department is one of the seven focus areas of The Energy research Center of the Netherlands, and it has been active in this field for over 25 years. With 55 employees, the unit holds a strategic position between universities and industry covering all relevant wind energy disciplines, from wind-turbine technology and aerodynamics, to wind-farm design. And from operation and maintenance of wind farms to experimental research.

The experimental research includes condition monitoring, wind-tunnel experiments and standardised measurements such as noise, power performance, mechanical loads and power quality measurements.

Accreditation

Fig. 1
The microphone at the center is placed on a flat, acoustically hard board with its diaphragm in a plane normal to the board and with the axis of the microphone pointing towards the wind turbine

Photo by kind permission of ECN

Among others, ECN Wind Energy is accredited for noise measurements on wind turbines according to IEC 61400-11 and MEASNET (the international Measuring Network of Wind Energy Institutes). MEASNET is a global cooperation of institutes that are engaged in the field of wind energy and want to ensure high quality measurements, uniform interpretation of standards and recommendations as well as interchangeability of results.

The accredited noise measurements are intended to provide the apparent A-weighted sound power levels, spectra, and tonality at integer wind speeds from 6 to 10 m/s of an individual wind turbine. Optionally, directivity may also be determined.

PULSE

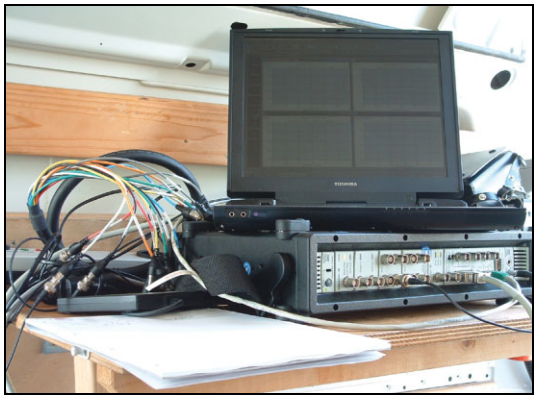

Fig. 2
A Brüel & Kjær PULSE data acquisition system and ½" free-field microphones are used to record wind-turbine noise and for post-process analysis

Photo by kind permission of ECN

ECN began using Brüel & Kjær products some two years ago. This was the result of a technology upgrade for acoustic measurements on wind turbines.

Dr. P.J. Eecen is the senior scientist in the Experiments Group of ECN Wind Energy and responsible for the introduction of the new technology and the validation of the process.

The Brüel & Kjær data acquisition and analysis system comprises the PULSE front-end, with 10 Mbit LAN Interface Module Type 7533 and 4/2-channel Generator, Input/Output Module Type 3109. ½″ Free-field Microphones Type 4176 collect the noise and a Sound Level Calibrator Type 4231 is used to accurately calibrate each microphone channel.

IEC 61400-11

The total system satisfies the requirements of IEC 61400-11 as follows:

- Microphones – must be type 1 sound level meters, and in addition, must have a constant frequency response over at least the frequency range from 45 Hz to 11.2 kHz The filters must meet the requirements of IEC 61260 for Class 1 filters
- Calibrator – must fulfil the requirements of IEC 60942 Class 1
- Data recording/playback and analysis system is a required part of the measurement instrumentation, and the entire chain of measurement instruments must fulfil the relevant requirements of IEC 60651 for type 1 instrumentation

Data Acquisition and Analysis

Fig. 3
The relationship between noise measurements and wind speed is determined using the wind speed and direction measurements at a height of 10 m

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Dr. Eecen explains, "The measurements require the acquisition of noise from one to four microphones as well as wind speed and wind direction at a height of 10 m, the electrical power output of the turbine, air temperature and air pressure".

He continues, "The non-acoustic signals can also be processed by the PULSE system, using the newly developed Auxiliary Parameter Logging Type 7769".

Type 7769 enables the synchronised recording of the acoustic (dynamic) and non-acoustic DC signals in a single data file. Auxiliary Parameter Logging Type 7769 samples the signals with 10 Hz, which is more than sufficient for accurate measurement and analysis of these meteorological signals.

The main advantage of Type 7769 is that it enables the scalar averaging of these signals, unlike the RMS averaging of acoustic signals. Moreover, it provides the ability to capture up to 12 additional DC signals simultaneously with the dynamic channels.

Noise Measurements

Fig. 4
At the integer wind speeds from 6 m/s to 10 m/s, the sound level measurements are corrected for background noise

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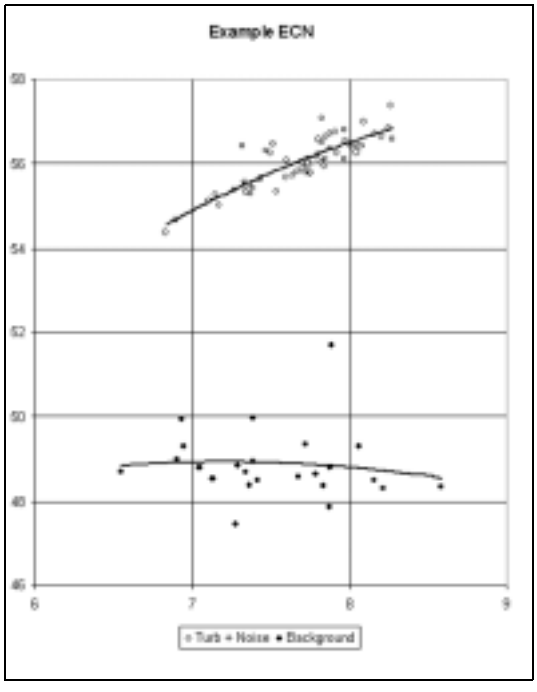

Dr. Eecen continues, "The noise measurements on wind turbines are performed by measuring the sound level at the downwind position, located at a distance of the hub height plus half a rotor diameter away from the turbine".

"This is shown in Fig. 1, where noise measurements have been performed on a 'Zephyros' 1.5 MW wind turbine. At the same time, the air temperature and pressure are measured together with the output power of the turbine. With the power curve (the relation between wind speed at hub height, and electrical power output for each turbine type) the wind speed is determined."

"From these measurements the apparent sound power level at the rotor is determined. It has been prescribed to mount the microphone at the centre on a flat, acoustically

hard board with the diaphragm of the microphone in a plane normal to the board and with the axis of the microphone pointing towards the wind turbine. In this way the influence of the ground reflection on the sound measurements is fixed and determined."

"The background noise level is then determined by turning the turbine off. The relation between noise measurements and wind speed is determined using the wind speed and direction measurements at 10 m height (see Fig. 3). A regression is made on the noise measurements as a function of standardised wind speed for both turbine noise and background noise."

Dr. Eecen concludes, "At the integer wind speeds from 6 m/s to 10 m/s, the sound level measurements are corrected for background noise. A typical example of the results is shown in Fig. 4."

The analyses on the acoustic signals are performed using the latest version of the PULSE software.

Key Facts

- The Energy research Centre of the Netherlands is an independent, market-orientated organisation for research, development, consultancy and knowledge transfer in energy and related topics
- ECN's Wind Energy Department is one of seven focus areas and has been active in this field for over 25 years
- ECN holds a strategic position between universities and industry
- Experimental research includes condition monitoring, wind-tunnel experiments and standardised measurements such as noise, power, mechanical loads and power quality measurements
- MEASNET is a global cooperation of institutes that are engaged in the field of wind energy and want to ensure high quality measurements, uniform interpretation of standards and recommendations as well as interchangeability of results
- Accredited noise measurements are intended to provide the apparent A-weighted sound power levels, spectra, and tonality at integer wind speeds from 6 to 10 m/s of an individual wind turbine
- ECN purchased a Brüel & Kjær PULSE system two years ago. This was the result of a technology upgrade for acoustic measurements on wind turbines
- The Brüel & Kjær PULSE data acquisition and analysis solution satisfies the requirements of IEC 61400-11
- DC signals can also be processed by the PULSE system, using the newly developed Auxiliary Parameter Logging Type 7769
- A major benefit of Type 7769 is that it enables the scalar averaging of DC signals, unlike the RMS averaging of acoustic signals.
- Type 7769 provides the ability to capture up to 12 additional DC signals simultaneously with to the dynamic channels

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