Wind Turbine Noise

The use of wind turbines for the production of electricity is expanding rapidly throughout the world. Turbine noise is an important environmental issue. The National Wind Technology Center at Golden, near Denver, Colorado uses a PULSE™ system to measure noise produced by wind turbines and their components. The test data is used in the design and development of wind turbine generating systems and to ensure that the noise produced by a design is within specified levels.

Research & Development
The National Renewable Energy Laboratory (NREL) is operated for the U.S. Government's Department of Energy by the Midwest Research Institute, Battelle, and Bechtel. Within NREL, the National Wind Technology Center carries out research into all aspects of wind turbines and provides global support to the wind turbine industry. NREL's location provides almost perfect conditions for wind turbine testing with constant wind-speeds that vary from hurricane force down to still-air conditions.

The research carried out includes the latest aerodynamic research into the performance of turbine blades, the design of components used in wind turbine construction, efficient location, and a range of environmental issues that especially focus on wind turbine noise. Investigations extend to the affects on wildlife and the problems of bird-strikes.

Although funded by the U.S. Government, the National Wind Technology Center also operates as a consultant organisation and carries out specific research and testing for many companies that manufacture components and wind turbine power generation systems.

Related Links
PULSE
Visit IEC to download the 61400-11 standard

Engineering Expertise
NREL has assembled a group of engineers with extensive wind turbine expertise. Jeroen J.D. van Dam is a Dutchman. Before joining the National Wind Technology Center, Jeroen worked at The Netherlands Energy Research Foundation for five years. His colleague, Arlinda A. Huskey, has worked at Golden for eight years. Arlinda says, "The noise produced by wind turbines is a major factor in Europe, and it's becoming an increasingly important issue, not only in the U.S., but throughout the world. Much of our investigative work is in this area and it occupies about 50% of my time".

Jeroen continues, "We carry out a lot of research on components with a view to decreasing the cost of wind turbines and to reduce their environmental impact. Most blades are currently made of glass fibre but there is a move towards carbon fibre with the advantages of a much higher strength to weight ratio and lower total weight. The critical factor is the power curve of the design – the power output compared to the wind speed. Some models are very large and the blades rotate at about 30 rpm – the slower the blade, the less noise but this affects the power output so, there are many factors to be considered".

PULSE
The National Wind Technology Center purchased a 6/1-channel Portable PULSE system for general noise and vibration analysis, and investigations into turbine noise with respect to noise legislation. Before the acquisition of PULSE, noise data was stored on a DAT recorder and post-processing analysis was subsequently carried out in the laboratory. With PULSE, analyses can be made in real-time on a laptop PC and the portability of the system enables it to be easily transported to sites around the world. In the future, PULSE can be easily expanded to provide more functionality – another key reason for selecting it.

Testing
To determine the noise characteristic of a wind turbine, the microphones must be placed at a number of different positions. Parameters such as the wind direction, wind speed and turbine power output are also measured and stored in PULSE. Four microphones are normally used, and are positioned around the turbine. The microphone positions are determined by the tower height and blade diameter. The data from the microphones can be analysed in real-time and also stored in PULSE for further analysis.

Arlinda explains, "Because a noise test depends on the wind blowing from the right direction and at a correct speed, a typical test could last from just a few hours up to more than a week".
Jeroen adds, "The noise, typically over a frequency range from 20Hz to 10kHz, must be measured with both the turbine running and parked. We must make sure that there is no 'external' noise present during the measurement process. This includes trains, planes, dogs barking, etc. So it's vital that we can listen to the noise recorded by the system as the measurements are made".

IEC Measurement Standard
Many countries around the world have introduced legislation that sets wind turbine noise levels. Typical SPL values are 40dB(A) during the day and 35dB(A) at night.
A new IEC Standard 61400–11 specifies the techniques for the noise measurement of wind turbines. All relevant test parameters are included:

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- Instrumentation – instruments, traceable calibration
- Measurements and procedures
- Data reduction procedures
- Wind speed
- Correction for background noise
- Apparent sound power (A-weighted)
- 1/3-octave (CPB) levels
- Tonality (using FFT analysis)
- Directivity (optional) – how much the noise varies with the wind direction
- Information to be reported

Arlinda and Jeroen were members of the IEC committee that drafted the new standard. Arlinda represented the U.S.A. and Jeroen represented The Netherlands.

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