★ There has been a massive boom in Europe's wind energy industry in recent years; which is showing no signs of letting up. But turbine reliability is still a problem, especially for offshore installations. **Jessica Holierhoek** reports on a Dutch-led project to investigate why and to develop better standards

Addressing the reliability of wind turbines

Wind is rapidly becoming a key player in Europe's energy supply as it moves steadily away from conventional power sources and towards the European Council's target of 20 per cent of electricity from renewables by 2020.

Wind capacity has quadrupled since 2000 and Europe is now a global pioneer in wind turbine technology, according to the European Wind Energy Association (EWEA). Wind power accounted for 40 per cent of annual EU capacity installed in 2007 and increased more than any other power-generating technology in Europe, including natural gas.

Europe now has 57 GW of the global 94 GW wind energy capacity, mostly in Germany, Spain and Denmark, and the growth trend is still climbing. "Overall, the European wind market is expected to grow at a rate of over 9 GW annually through 2010, which translates into annual investments pushing 11 billion Euros," says the EWEA's latest research publication, Windfacts, published last year.

But one serious deterrent to even greater investment in wind energy is the relatively high failure rate of turbines, says Jessica Holierhoek of the Energy research Centre of the Netherlands (ECN), one of seven partners in the European Union co-funded PROTEST project investigating the reasons why.

Other partners in PROTEST 'PROcedures for TESTing and measuring wind energy systems' include the University of Stuttgart, Greece's Centre for Renewable Energy Sources (CRES) and four industry members: Suzlon Energy GmbH, Germanischer Lloyd (GL), Hansen Transmissions International and the German Wind Energy Institute (DEWI).

"Present-day wind turbines still show failure rates between two to five failures per year that need visits from technicians," says Jessica Holierhoek. That's a nuisance (and a cost) for land-based turbines but it's an even bigger problem for offshore installations, which are increasingly popular because winds are steadier and bigger turbines may be used.

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Unfortunately, offshore wind energy is not yet economically viable, she says: "High reliability of wind turbines and their components is one of the prerequisites for an economically viable exploitation of wind farms, especially for offshore. Therefore the reliability needs to be increased".

High cost of failures

"Most failures are seen in the electrical components and control systems but it's the high cost of problems in the mechanical systems – the gearbox, drive train, pitch and yaw systems, for example – that causes the biggest financial burden. If you have to replace a bearing, for example, that can lead to a significant amount of down time and the actual replacement can be a very big operation and very expensive. So you have to make sure that this bearing can handle what it gets," she says.

Previous studies have shown that the loads on mechanical components are not being calculated with sufficient accuracy, unlike the procedures for rotor blades and towers which are much more specific because they are critical for safety.

That's why the main aim of PROTEST, which began in 2008 and is due to finish in August this year, has been to determine the load cases and critical design variables of mechanical components: "Ultimately, this project should generate procedures for designing mechanical components that are as high as the existing start-of-the-art procedures for rotor blades and towers," she says.

One problem is that the fast pace of development has put pressure on suppliers to come up with frequent new designs and produce them in large numbers. "There is no time to check

whether the components are loaded beyond the design load limits, or to improve the design procedures," says Jessica Holierhoek.

The risk is that a large number of new turbines may be equipped with components that are not up to the job. And unlike the airline industry, where design failures are very public, even the components manufacturer may not realise that his product is failing - or why.

Another difficulty is that wind turbines are subject to very variable loads, which are difficult to assess at the design stage. "With all the tools we have, we cannot completely predict the loads on a wind turbine, and the differences between what you measure on a wind turbine prototype in real wind conditions (which are not well known) and what you have calculated beforehand are quite large," she says.

Even less is known about the effect of such loads on individual mechanical components, mainly because of the limitations in existing tools used to assess them. The problem is further exacerbated by the fact these components are supplied by other manufacturers.

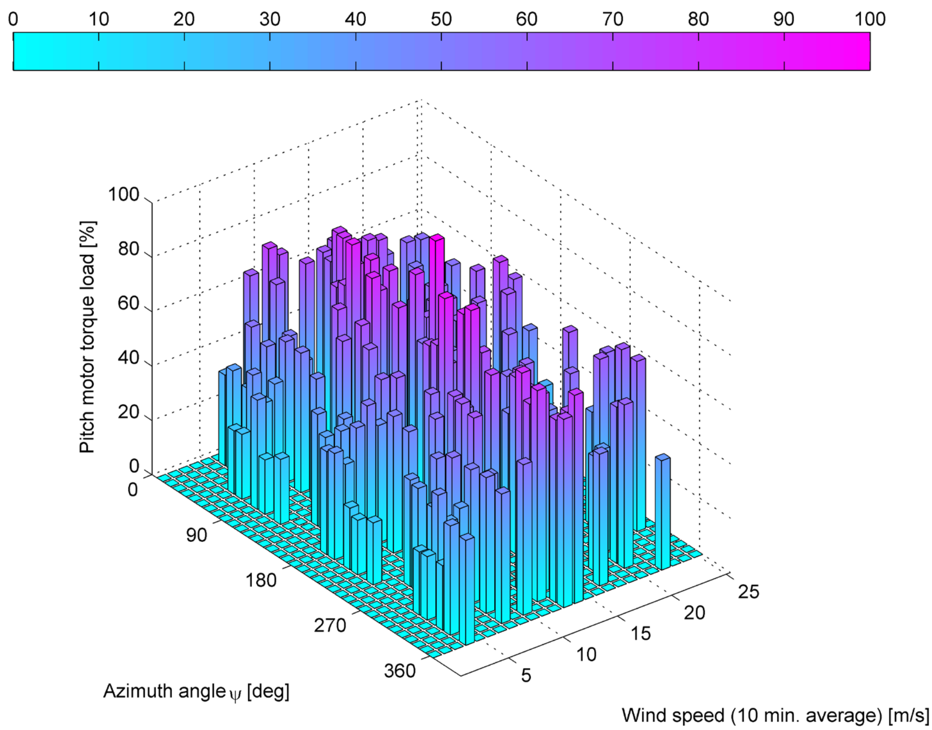
"So with this project we have tried to develop a method for a manufacturer to measure his prototype to see whether his original calculations were good enough for these mechanical components, and to enable him to show the measurement results to the manufacturer of the bearing or the drive train shaft, for example," she explains.

Flexible new approach

The project has not yet finished but already one conclusion is that three new design load cases "misalignment, resonance and low voltage ride through "should be added to existing standards. In all three cases, the current state-of-the-art codes do not enable the necessary detailed analysis.

The most significant find, however, is that it is probably not possible to devise a strict set of standards for all manufacturers due to the huge variety of wind turbines: "Blades will always be blades and the tower will always be the tower, but there are so many options for the pitch system, yaw system and drive train," she says.

Instead, the researchers suggest a more flexible six-step approach be



Pitch motor starting torque at an emergency stop (dimensionless) is calculated from PROTEST's model for different wind speeds and different azimuth angles. The result will be compared with the measured pitch motor torque to find discrepancies in the model. Discrepancies could signify possible early failure of the pitch system

applied to any component, which they illustrated using the pitch system. This should involve:

- Identifying critical failure modes or phenomena for the component;
- Designing a measurement campaign to verify models and quantify parameters;
- Processing measurement data and checking or improving the models or the model parameters.

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- Designing the model (simple analytical to multi body);
- Running a model for various design load cases (critical DLCs can be different for the different phenomena);
- Determining input and output parameters of the model that has been used, determining how 'certain' they are, and if they need to be verified/measured;

This kind of improved structural modelling, combined with the aerodynamic modelling of wind turbine components, is critical and more research is needed, says Jessica Holierhoek: "We need a better insight into what's critical and also which properties are important to model correctly." ★

At a glance

Full Project Title
PROcedures for TESTing and measuring wind energy systems (PROTEST)

Project Objectives
Within the PROTEST project the objective is to set up a methodology enabling standardisation of the design load specification for mechanical components.

Project Funding
PROTEST is co-funded by the European Commission within the Seventh Framework Programme

Project Partners
• Energy research Centre of the Netherlands (ECN) • The Centre for Renewable Energy Sources (CRES) • University of Stuttgart, Germanischer Lloyd (GL) • Hansen Transmissions • DEWI • Suzlon

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