Category: 03

PROTEST – Procedures for Testing and Measuring Wind Energy Systems Drive Train Case Study

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1. General

Economic exploitation of wind energy requires reliable wind turbines. To this end it has been recognized that there is a need for improving knowledge on the actual loads acting on wind turbine components s. a. drive trains, pitch systems, and yaw systems. These components are seen to require substantial maintenance and repair efforts or even retrofits even in up-to-date wind turbine models.

Under the 7th frame work programme of the EU the PROTEST project has been kicked off in March 2008 with the objective to improve the procedures for testing and measuring the loading on the named mechanical wind turbine components. The idea is to set up a methodology that enables a standardized and uniform specification of design loads for mechanical components in wind turbines such as the drive train, pitch system, and yaw system. The focus is placed on developing guidelines for measuring load spectra at the interface of the components to the remaining structure during prototype measurements and to compare them with the initial design loads.

The project has a budget of app. 2.6Mio € for a duration of 2.5 years and is conducted by a consortium of 7 members active in wind energy industries: ECN (NL), CRES(GR), Ustutt (GER), Hansen Transmissions(BEL), SUZLON Energy GmbH (GER, INDIA), GL (GER) and DEWI(GER).

2. Motivation

Reliability of turbines is a pre-requisite for economic exploitation of wind energy. However, statistics say: wind turbines show 2 to 5 failures per year that require attendance and electrical components fail more often than others while larger cost and downtime are caused by failures of mechanical systems s.a. drive train, pitch and yaw systems, bearings.
Reasons for such failures of mechanical systems as mentioned in studies and expert discussions are seen in the lack of knowledge on loads at the component level and also in shortcomings of standard load simulation models. In the light of ever larger turbines with short time for development a strategic tackling of this problem is deemed necessary to further ensure a strong an sound development of wind turbine technology.

3. Concept and Objectives

From the above the PROTEST project consortium has concluded that the design procedures for mechanical components other than blades and tower need improvement and the overall objective of PROTEST has been defined to set up a methodology that enables standardized specification of design loads for

mechanical components s.a. drive train, pitch system and yaw system.
More specifically the project will try to claerly define the loads at the interfaces of the component under consideration to turbine structure. Also recommended practices on how to assess and communicate the actual loading of the component by prototype/validation testing shall be developed.

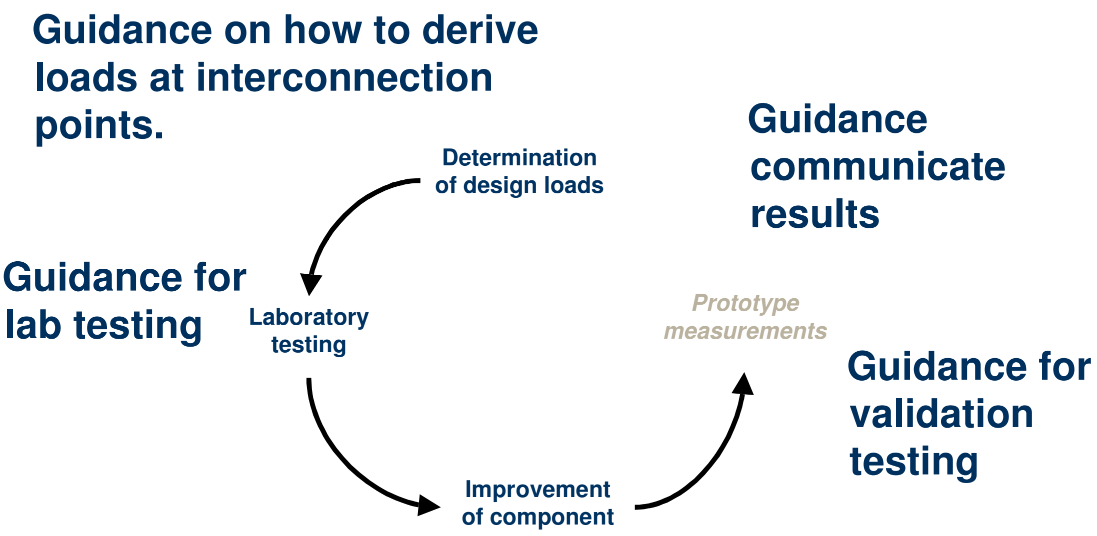

Fig.1 Component development cycle

4. Approach taken

In the approach taken by the PROTEST consortium the assessment of common practice in a state-of-the-art-report is the starting point. In questionnaires the project partners are giving their statements on load cases and design drivers to be considered as well as on measurement procedures to be followed. During this phase white spots and bottle necks in teh current practices shall be indentified. Based on the findings improved procedures for prototype measurement shall be set up and applied in three case studies:

- Case study on drive train loads (SUZLON, HANSEN, DEWI)
- Case study on pitch system loads (ECN, CRES)
- Case study on yaw system loads (ECN, CRES)

5. Case Study: Drive Train

For a SUZLON S82 1.5MW wind turbine with a gearbox of Hansen Transmissions a case study for the drive train is currently carried out. The case study comprises extensive modelling of the drive train using advanced simulation techniques and an extensive measurement program. The measurements include a number of signals with special relevance for drive train load assessment in addition to the standard meteorological, operational and mechanical load measurement signals as commonly used in type testing s.a :

- loads on the main shaft:
  bending loads
  torque
- torque on the high speed shaft
- rotational speed levels:
  high speed shaft

intermediate speed shaft
main shaft

- rotor position
- axial displacement of
  high speed shaft,
  intermediate speed shaft and
  low speed shaft
- displacement of the gearbox in the nacelle
- temperatures:
  outdoor
  ambient
  air flow (cooler input & output)
  bearings high speed shaft
  bearings intermediate speed shaft
  oil sump
  oil in cooler
- oil pressures

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The measurements will be taken in manual campaigns for recording transient events and during normal power production operation. While in the first category main focus will be place on time series recording and analysis the assessment of long term monitoring data will require statistical methods as well s.a. load duration distributions. Figure 2 demonstrates by means of artificially disturbed signals how the load duration distribution LDD on the right hand side change according to the time series signals that were analysed to produce the LDD.

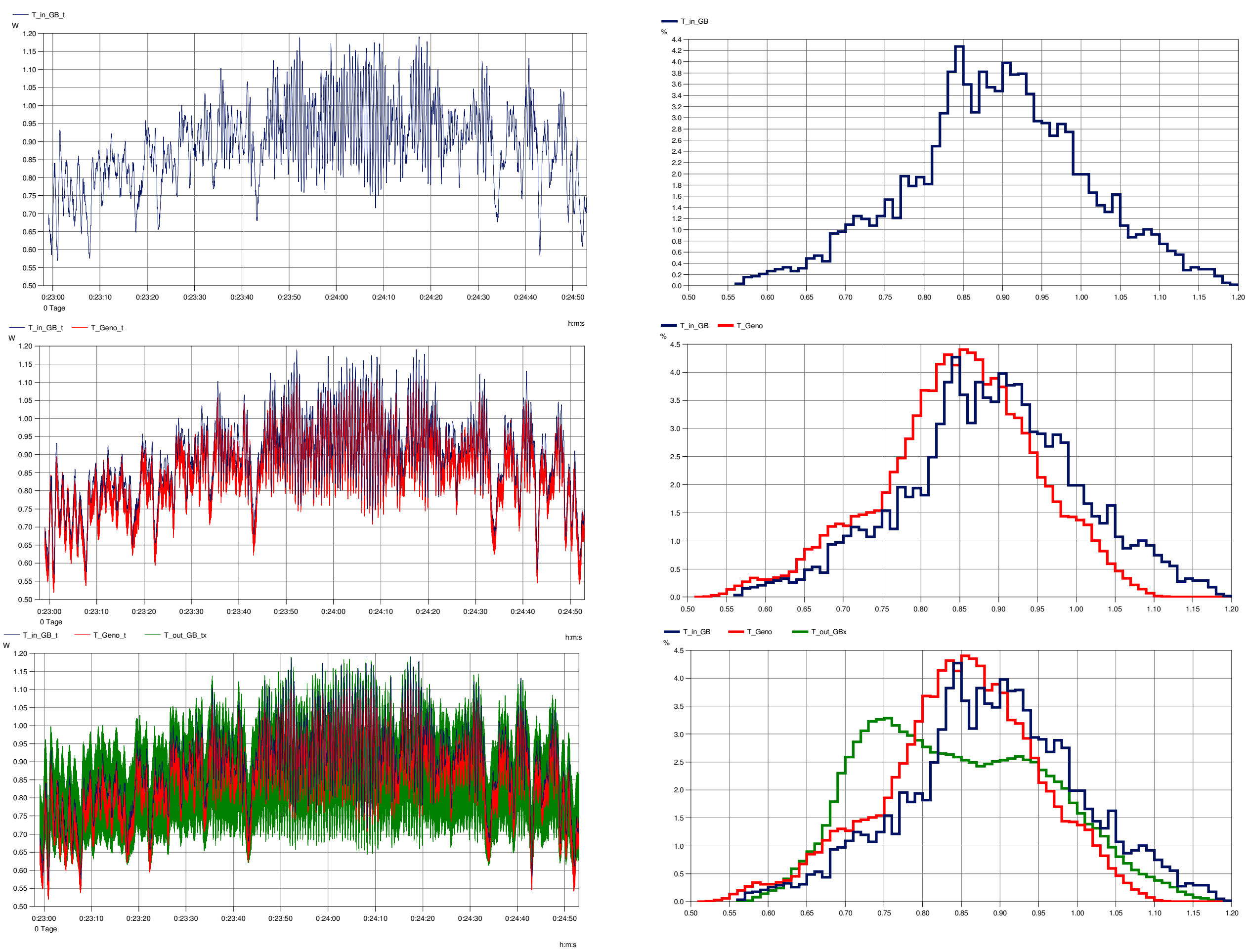

Figure 2. Time series and derived load duration distributions

The idea is to determine the relevant measurement quantities and to establish the most adequate way of analysing and presenting such data. The results shall be used for comparison to the sophistcated multi-body simulations that are carried out in the case study by Ustutt and SUZLON.
Finally the findings of the case study shall be fed back into the project task on definition of procedures for prototype measurements for mechanical components.

Up to now two manual campaigns and a longer montoring period have been carried out. The assessment and evaluation of the recorded data is ongoing.

6. References

Web site: to be published