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# IEA Wind Task 35 - Full Size Ground Testing of Wind Turbine Nacelles

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## Abstract

As Wind Turbine Generators (WTG) become more and more important for the electric power supply, the design standards for WTG also improved. Along with those improvements the test standards for WTG need also further development.
In-field tests for new prototypes are state of the art, but are time consuming and expensive. In the last years several ground based test facilities were built up to enhance the understanding of complex interactions between subsystems and components in WTG's drivetrains. These ground-based test rigs for WTG nacelles also have the potential to substitute parts of in-field tests for type certification.
The international energy agency (IEA) established Task 35 to address the demand for reliable and cost-effective ground testing of WTG. IEA Wind Task 35 members develop recommendations for test methods for full size ground test rigs comparable to in-field tests. Within the IEA Wind Task 35 established nacelle test laboratories collaborate to develop novel tests and define test procedures for design and model validation for nacelles, subsystems and components. The test descriptions of the novel tests include the requirements for emulation of wind and grid load cases for each test procedure.

## Objectives

» Develop test methods for ground-based nacelle testing

» Investigate influences of simplifications in test rig facilities

» Recommend specific load cases for test procedures

» Improvement of test procedures either for system or component tests

## Approach

Recommended test procedures should…

» enhance the certification process

» improve the quality of WTG nacelles and blades

» reduce the design and development time of WTG

» support the evaluation of in-field performance and possible failure modes of blade and drivetrain components

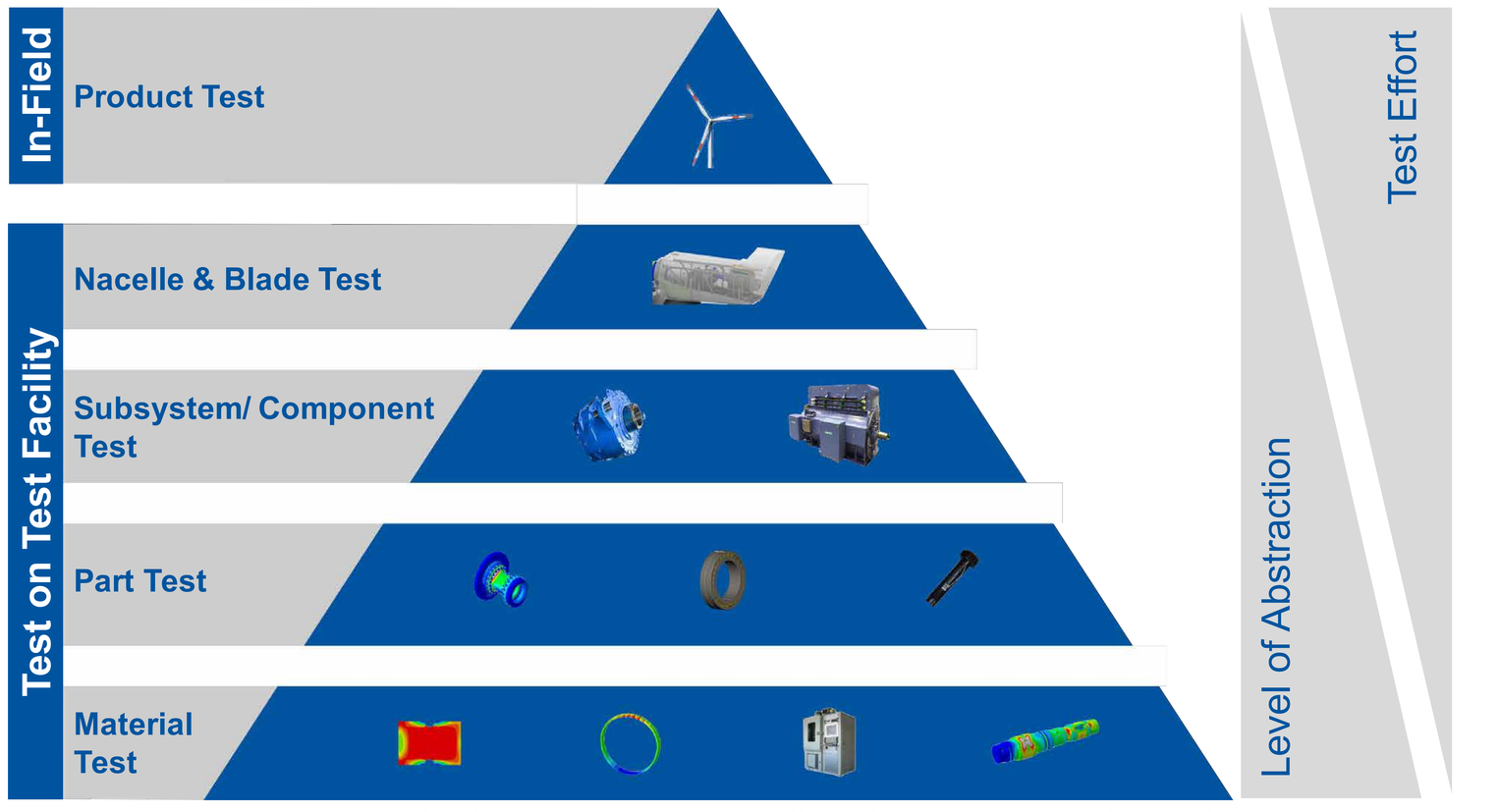


Fig.1: Test Pyramid: Levels of abstraction and test effort of test campaigns for WTG.

## Realistic emulation of wind and grid conditions

Test configurations on a test rig are simplifications of the real system, because interactions and interfaces between the device under test and its environment are neglected. The grade of abstraction varies between different kind of tests, going from product to material tests on the test pyramid (see Fig. 1) the grade of abstraction increases and with it the possibility of missing key influences of abstraction.
In-field tests are the most realistic approach for WTG tests and their certification. However, testing in-field is expensive and limited to site-specific load cases and it doesn't support accelerated test campaigns.
For a realistic approach of WTG nacelles, subsystem or component tests on test rigs, load cases must be applied comparable to in-field conditions. To accomplish these realistic load cases, emulated wind and grid conditions are necessary.
For evaluating the comparability of ground based tests for WTG nacelles, it is crucial to consider the influence of abstraction that are made when emulating realistic in-field conditions on a test rig (see Fig.2). To capture all these effects, IEA Wind Task 35 experts elaborated an overview of 29 abstractions and their influences on test procedures for ground based test facilities.
This overview contains the description of these effects, their relevance for testing procedures and methods for their compensation, either physically or by calculation. Problematic is that the magnitude and significance of abstraction effects may vary between different test facilities due to specific test rig configurations.
For example the prime mover of a test rig could be executed as a direct-drive or with a gearbox system.
Independent of the test rig configuration, the missing rotor changes the dynamic behavior of the test rig significantly. The rotational inertia and stiffness of the coupled drivetrains have an effect on local loads and dynamic behavior. To mitigate these effects the test controller needs to be adjusted to ensure adequate damping of false eigenfrequencies and to ensure that the dynamic behavior of the drivetrain is as close to in-field tests as possible. To enable this, drivetrain stiffness, rotor inertia and aerodynamic response behavior need to be implemented into torque load simulation. Still, a rigid drivetrain and a sufficient dynamic prime mover are recommended.
Not only the mechanical behavior of the drivetrain has to be considered, also the grid connection and emulation is limited to the performance of grid emulation hardware and power electronics. Emulation of wind farm power level above 100 MW and strong grids require adequate performance capability of grid the emulator.
Also, the harmonic emission of up to 1kHz and time signal delays of the emulation hardware result in an accuracy loss of the grid emulation. Therefore it is recommended that the grid emulation controller reacts 2-3 times faster than the power electronic hardware to reproduce sufficient dynamic nacelle-to-grid response.
IEA Task 35 members estimate that 80% of electrical certification can be done at ground base test facilities.

Abstractions

- rotor
- tower
- grid
- environment
- (auxiliary systems)
- (controller)

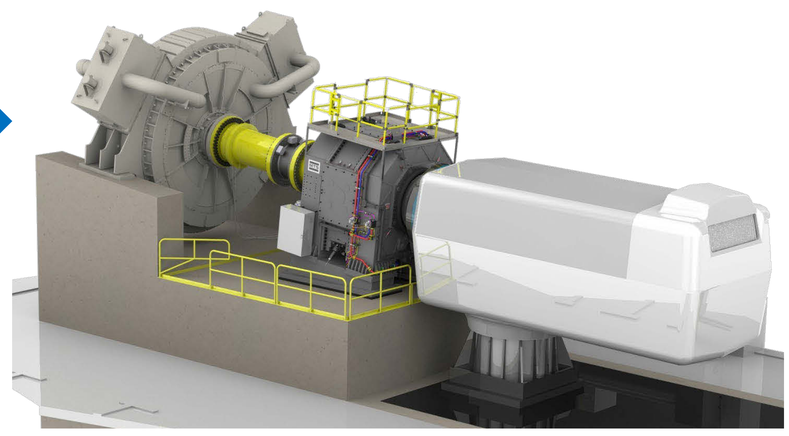

Fig.2: Influences of abstraction: Comparing in-field conditions with abstract laboratory conditions.

## Conclusions

After evaluating the influences of abstraction IEA Task 35's consortium concluded that most abstractions, can be compensated. The compensation could be executed physically (via hardware) or by simulation models and other calculative approaches. The test results are expected to be comparable and transferable to in-field conditions.
The ability to reproduce load scenarios and tests on ground based test rigs are crucial for understanding subsystem interactions and system behavior. This reproducibility also has the potential to significantly decrease the time and effort for in-field certification tests.