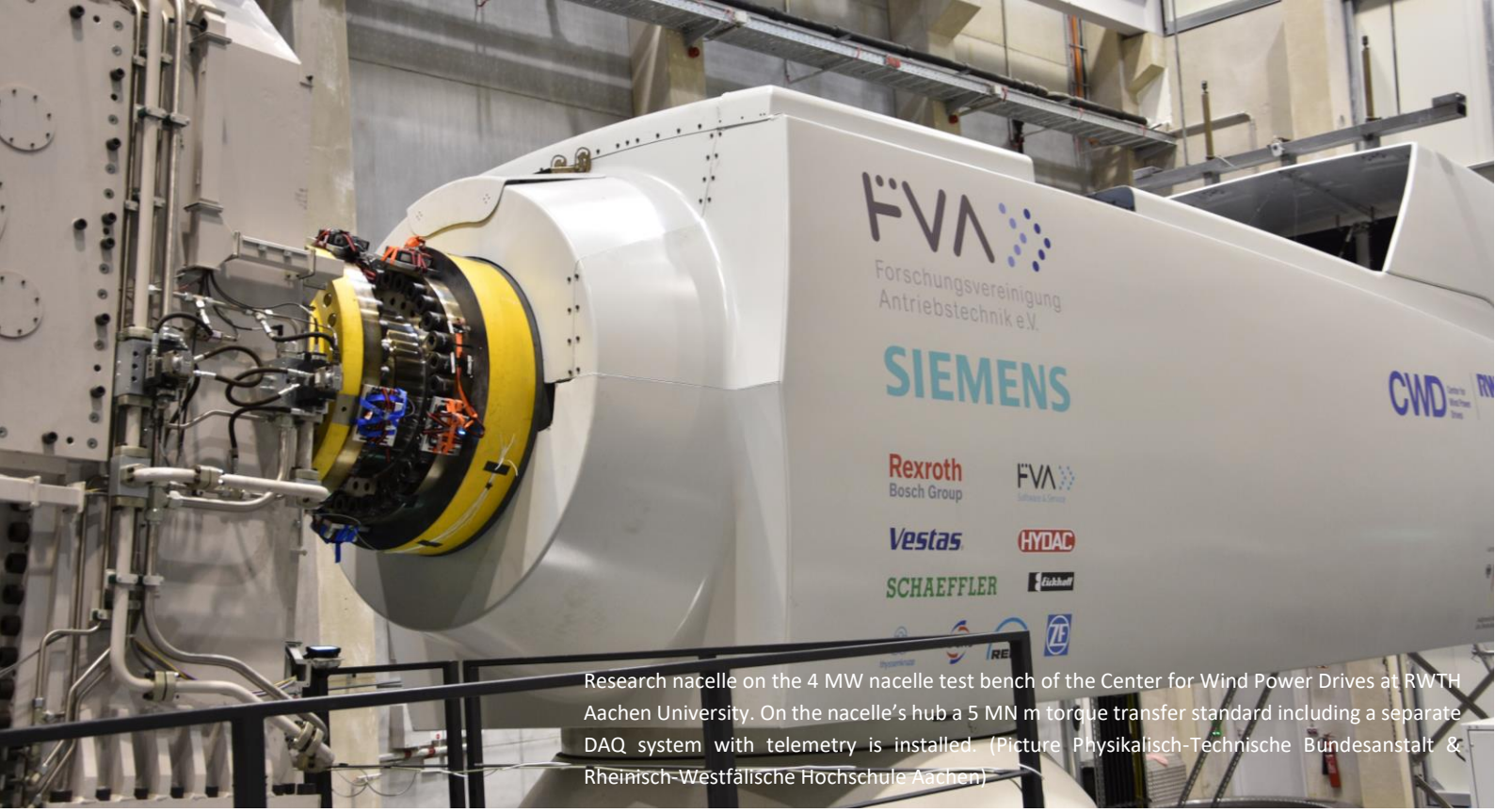

Research nacelle on the 4 MW nacelle test bench of the Center for Wind Power Drives at RWTH Aachen University. On the nacelle's hub a 5 MN m torque transfer standard including a separate DAQ system with telemetry is installed. (Picture Physikalisch-Technische Bundesanstalt & Rheinisch-Westfälische Hochschule Aachen)

New Research Project for the Wind Industry

Newsletter No. 1 – January 2021

Welcome to the first edition of our newsletter for the project *WindEFCY*. Over the next three years, the newsletter will provide you with information about ongoing research and results of this project.

Introduction

Future wind turbines must be innovative, have reduced costs and, above all, improved performance in order to assert themselves on the market. Standardised tests and validation methods are particularly important for the performance optimisation, but also for quality assurance. The guideline needed to determine the efficiency of wind turbines on test benches is being developed for the first time as part of an interdisciplinary EMPIR project called "Traceable mechanical and electrical power measurement for efficiency determination of wind turbines", short 19ENG08 *WindEFCY*. EMPIR is the European Metrology Programme for Innovation and Research.

Project Overview

The project, that started in September 2020, runs for a period of three years, and is coordinated by Physikalisch-Technische Bundesanstalt (PTB) – the German National Metrology Institute (NMI). The eleven international project partners work across disciplines to develop a method for a traceable efficiency determination of wind turbines and their components on nacelle test benches. The collaboration of national metrology institutes, test bench operators, research institutes, and industrial partners, which are united within this project, will tackle the lack of traceable mechanical and electrical measurements in test benches and reproducible efficiency determination.

The project is divided into five main areas (Figure 1) each focusing on a certain issue of the efficiency determination of nacelles on test benches: state-of-the-art, mechanical power measurement, electrical power measurement, efficiency determination, and creating impact.

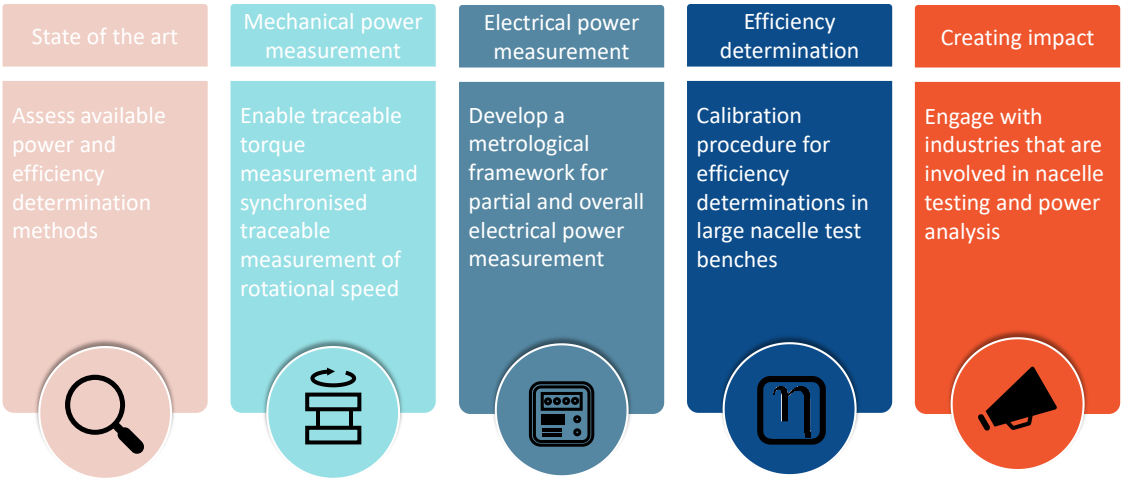

Figure 1 Project overview.

Before developing something new, a detailed assessment of available power determination methods for wind turbines on one side and efficiency determination methods for electrical machines on the other side will be carried out. This *state-of-the-art* analysis includes all required measurement procedures as well as their boundary conditions.

The *mechanical power measurement* consists of rotational speed and torque measurements. A calibration procedure including a measurement uncertainty analysis and suitable transfer standards for mechanical power measurement is currently missing. In this part of the project the aim is to develop the missing procedure and the associated transfer standards working in a timewise synchronised manner.

So far, there is no metrological framework for *electrical power measurements* of a nacelle and its components on a test bench. This part of the project will focus on identifying the requirements for electrical power measurements in test benches and, subsequently, on providing guidance and reference standards to calibrate these electrical power measurements.

Based on the previous three main areas, a practical and traceable procedure for determining the efficiency of nacelles and their components on test benches will be developed. This procedure will combine the calibrated mechanical and electrical power measurements in a synchronised way. An *efficiency determination* will be executed exemplarily on two different full-scale nacelle test benches: at the Dynamic Nacelle Testing Laboratory (DyNaLab) of Fraunhofer IWES in Bremerhaven (Germany) and at the Center for Wind Power Drives (CWD) of RWTH Aachen University in Aachen (Germany).

The mechanical power can either be measured on the low-speed-shaft (LSS) with torque up to 5 MN m and rotational speed up to 20 min^{-1} or on the high-speed-shaft (HSS) with torque up to 100 kN m and rotational speed up to 1600 min^{-1}. In doing so, both wind turbine types existing on the market and their components can be tested: direct-drive wind turbines where the synchronous generator is directly powered by the rotor, and gearbox wind turbines (as depicted in Figure 2) with a gearbox between the low-speed rotor and the high-speed electrical generator.

The electrical power can be measured on various points in a nacelle. Within this project traceable electrical power measurement at the generator and at the frequency converter output of a nacelle on a test bench will be provided.

Figure 2 shows the possible measurement points for mechanical and electrical power measurement and the set-up of a nacelle test bench. It consists of a motor, a load application system (LAS), and an artificial grid. The device under test on such a test bench is a wind turbine without a rotor, called nacelle, and its components.

The fifth area addresses the engagement of the project with relevant industries that are involved in nacelle testing and power analysis. A knowledge transfer between the project consortium and the stakeholders will be realised in form of two workshops and one seminar.

The Consortium

The project consortium consists of eleven partners from Europe and South America working together interdisciplinarily. Involved in the project are six NMIs, three test bench operators, one research institute, and one industrial partner.

Project coordinator is the PTB, the German NMI bringing expertise in torque realisation, the calibration of instrument transformers and the determination of the efficiency of electrical drive systems. CMI is the Czech NMI supporting the project by their experience in designing, building and maintaining national torque standards gathered in over 25 years. The Polish NMI, GUM, with more than seven years of experience in torque measurement. Expertise in the domain of measurement of electrical AC quantities comes from the NMI of Switzerland, METAS. VTT, the Finnish NMI, provides mechanical as well as electrical expertise. Inmetro is the Brazilian NMI and enhances the project not only with its insight into the South American wind energy sector but also with its knowledge in dynamic torque measurement.

The three nacelle test bench operators aboard the project are CENER, Fraunhofer IWES, and CWD. CENER is the laboratory with the longest experience in testing drive trains: 15 years. The DyNaLab of Fraunhofer IWES provides its full-size nacelle test bench with a capacity of testing offshore nacelles with up to 10 MW power for the project. And the CWD of RWTH Aachen University will perform measurements on its 4 MW nacelle test bench with multi-component loading within the project.

The research partner involved is TH Aschaffenburg, University of applied sciences. Their core competency is in highly sophisticated and accurate power measurement on inverter-fed drives. Dinnteco Factory Gasteiz, S.L.U. is a Spanish

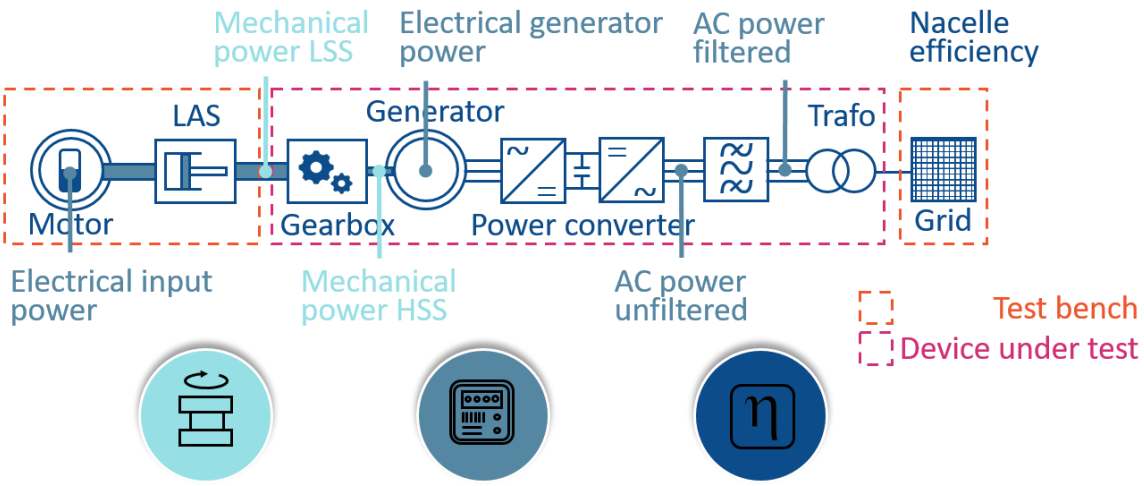

Figure 2 Schematic overview of a nacelle on a nacelle test bench including possible measurement points. Diagram based on Tobias Duda et al 2018 J. Phys.: Conf. Ser. 1037 052031.

technology company and the industrial partner in this project. It is dedicated to designing, developing, and manufacturing variable electromagnetic field devices to compensate electric charges and radio frequency fields.

Involvement in the Project

You are interested in our project, want to stay informed and get first-hand information and training on traceable efficiency determination of wind turbines and their components on nacelle test benches? Become part of the project's Stakeholder Committee without financial or any other obligations. The main matter of the Stakeholder Committee is to keep the project focused on industry and test bench operator needs. Just drop us a message via the project website.

How to contact us

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https://www.ptb.de/empir2020/windefcy/home/

The Consortium

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