EMPIR Call 2019 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g04**
Version: 1.0

Title: Traceable mechanical and electrical power measurement for efficiency determination of wind turbines

Abstract

In times of energy transition towards renewable energy sources, the importance of traceable energy conversion and, therefore, traceable efficiency determination increases. The renewable energy sector is still competing with fossil energy sources in terms of energy production costs. To improve the efficiency of wind turbines, a reliable efficiency determination is required. A standardised power curve determination for wind turbines is available however these field tests are very time consuming and costly. Methods for a traceable efficiency determination of all relevant mechanical and electrical components of wind turbines on a test bench are required.

Keywords

Mechanical power measurement, electrical power measurement, efficiency determination, nacelle test benches, torque measurement, rotation speed measurement

Background to the Metrological Challenges

The EU is aiming to become a world leader in renewables, as detailed in their energy and climate policy. In 2017, wind energy remained the second largest form of power generation capacity in Europe after gas installations. To ensure that European manufacturers remain at the leading edge, and that wind energy is at the top position in renewables, future wind turbines must meet three main targets: highest innovation potential, quick cost reduction, improved performance and energy efficiency. The highest innovation potential is required for shortening the time to market of new innovations and for reducing the cost of mainstream technologies in the wind energy sector. Costs can be reduced through investments in research and innovation, installation of test benches, and improvements of the entire value chain. To ensure resilience, security and reliable power production, extensive testing of prototype wind turbines and improved performance are essential. Using knowledge about components through comparable and repeatable testing, technical risks of manufacturing can be reduced, and the performance of the components can be optimised. To fulfil enhanced efficiency demands, an advanced framework for reliable efficiency determination must be generated. Establishing a standard for reliable efficiency determination prior to the installation in the field by traceable and therefore comparable methods, can accelerate the time to market and the time to operation of new wind power plants. For example, a profit and loss account of a planned wind park can vary significantly for a determined efficiency of 95 % with a measurement uncertainty of 2 % of a wind turbine. For the world's biggest offshore wind park, Walney Extension in the UK, the energy amount covered by the uncertainty of the efficiency per year could power about 14 000 four-person households. Thus, a traceable efficiency determination for nacelle and their components would strengthen the industrial competitiveness of the renewable energy technology wind.

Currently power performance measurement of electricity producing wind turbines are carried out in the field according to IEC 61400-12-1. This uniform methodology ensures a permanent development and operation of wind turbines including a consistent, accurate and reproducible determination of wind turbine power performance. However, there are no standardised methods for the efficiency determination of nacelles or single components on test benches. In EMPIR project 14IND14 methods for calibrating torque measurement in nacelle test benches up to 1.1 MNm were developed however an extrapolation method to characterise a torque transfer standard up to 5 MNm had to be used. Advanced methods are needed to address this. For the efficiency determination of electrical components in wind turbines, e.g., the converter and filter, measurements of the electrical power under non-sinusoidal conditions at high voltage have to be carried out. Such commercial measurement systems require traceable conditions. For the power analysis, traceable calibrations for the measurand "active ac power" are obtainable, but not for the efficiency, which is determined with multi-channel power analysers in a synchronised fashion.

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The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the traceable measurement and characterisation of mechanical and electrical power for efficiency determination of wind turbines.

The specific objectives are

1. To carry out detailed assessment of available power and efficiency determination methods and measurements including all boundary conditions. This will also include the evaluation of power curve measurements both in the field and in test benches, and comparison of direct and indirect efficiency determination where the ratio of output to input and the power dissipation are calculated respectively.
2. To develop and implement traceable measurement methods with a target uncertainty below 0.5 % for mechanical power based on torque measurements up to 5 MNm with synchronised measurements of rotational speed up to 20 min^{-1} on the low-speed shaft respectively torque measurements up to 100 kNm with synchronised measurements of rotational speed up to 1600 min^{-1} on the high-speed shaft.
3. To develop and implement traceable measurement methods for electrical power components from the generator, the converter and the filter, which suppress harmonics.
4. To develop and apply traceable methods for the efficiency determination of devices on test benches with a target uncertainty of 1 % by combining and synchronising the mechanical and electrical power measurements including an uncertainty model. Standardised guidelines for traceable efficiency determination on test benches will be developed.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain, standards developing organisations (IEC TC88) and end users (wind turbine manufacturers, wind park planners, test bench operators).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this.

In particular, proposers should outline the achievements of the EMPIR project 14IND14 and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35 % of the total EU Contribution across all selected projects in this TP.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the wind turbine sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1]. M/087 Standardisation mandate to CEN and CENELEC for standardization in the field of wind turbines