WINSENT – wind science and engineering test site in complex terrain, Germany

General description of turbine/facilities

WINSENT, the test facility of the Southern German wind energy research cluster WindForS[1], focuses on research questions in complex terrain. It is built and operated by the WindForS member ZSW[2]. In parallel to the technology developments, the WINSENT test site supports answering questions regarding social acceptance of wind energy and to align wind energy with nature conservation.

WINSENT will consist out of two accessible, open-source, modifiable research wind turbines, four met masts and several measurements, located in the surroundings. The two turbines will have hub heights of 73m and a rotor diameter of 54m and thus an overall height of 100m. Their electrical power output is 750kW each, they are variable speed and have individually driven pitch motors.

This turbine size still allows transferring knowledge of parameters such as loads, controller settings and turbine behaviour to larger wind turbines as the different detailed and validated simulation models exist. The turbines will be erected side by side to have the possibility to directly compare the behaviours of the modified turbine and the reference turbine. The met masts are positioned in front of and behind each research turbine. The top anemometer is as high as the top blade tip position of the turbines. The masts are equipped with various meteorological sensors as well as with bat microphones and bird detection cameras. The turbines will be installed in late summer 2022.

Location of WINSENT test site

The WINSENT test site is located at the Stöttener Berg near Geislingen an der Steige in the Swabian Alps in Baden-Württemberg, about 1hr east of Stuttgart. The location on a forest-free plateau near a

[1] https://www.windfors.de/en/home/
[2] https://www.zsw-bw.de/en.html

steep slope, the so-called Albtrauf, was defined and finally found in the course of a research project. Due to the steep slope, the turbines are exposed to inclined flow and high turbulence.

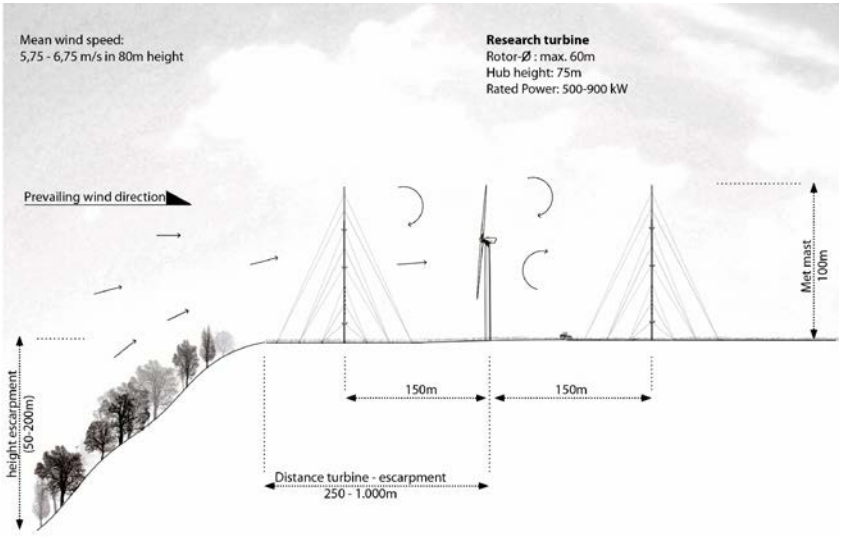

Figure 1. *Illustration of test site layout: two research wind turbines in forest-free terrain near a slope and meteorological masts upstream and downstream [source: TUM-LAREG].*

Control and measurement systems and signals

The measurement equipment consists presently of two meteorological masts, synchronized scanning lidar systems, eddy-covariance systems, ceilometer, measurement drones, bird radar and bat microphones. Two remaining masts will be erected and instrumented in spring 2022.

Numerical models of simple aero-elastic codes up to FSI-coupled or multi body codes of the research turbines have been developed by WindForS partners. A new baseline turbine controller has been developed which will be open to any research institution together with an OpenFAST model of the turbines after the completion of the test site. The turbines are of open-access and have modifications to facilitate the work of researchers. The machines are heavily equipped with sensors to gather data of mechanical loading from tower bottom up to the blade tip, various turbine parameters and seismic vibrations in the surrounding.

Research possibilities

The test site is intended to be used to prepare, test and validate new technologies for example in the fields of turbine control, aerodynamics, operational management, measuring instruments and techniques, and monitoring. For the development and verification of simulation tools for designing wind turbines as overall systems, for designing wind turbine components and for modelling environmental influences (flow etc.) actual measurement data is essential. The measurement data obtained from the research turbines and the meteorological masts will be stored in a research data base. 10-min average data from the met masts as well as high resolution turbine load data from specific cases will be accessible to the public. Further data will be accessible for R&D activities upon request.

On account of the topological and topographical location, basic research on meteorological conditions with a view to wind energy use in complex-mountainous terrain is also envisaged. Icing (turbine loading, reduction in yield, testing of icing detectors etc.) and the increased number of lightning

strokes should also be mentioned here. What is more, mesoscale wind field modelling for complex terrain is not yet fully developed. It can be used for forecasting wind yields from current weather data (short term prognosis) and thus improve yield prognoses for complex terrain. Accurate forecasting systems are also essential for the optimum design and use of storage technologies and hybrid power plants.

The WINSENT test site will also be available for use for nature conservation research, with a focus on studies of birds and bats. The test site allows both to develop and test mitigation measures for birds and bats and also to close gaps in knowledge about the behaviour of animals at wind turbines.

For these reasons red kites have been fitted with GPS transmitters to monitor and evaluate their movements continuously. Parallel to this a bird radar device was installed that continuously monitors the airspace of the test site for bird movements. By using a combination of the movement data with the comprehensive meteorological data collected at the test site such as wind speed, temperature, visibility, etc. correlations of bird activity with these parameters can be studied. Bat activity will also be continuously acoustically recorded at all four measurement masts and later at the wind turbines at four different heights and combined with the meteorological data to study any possible further development of switch-off algorithms. A test design was developed for the large number of technical prevention systems which are now being discussed or are already on the market, and are based on detecting the presence of birds. Two systems have been validated already during the last two years by the use of laser-range finder systems, human observers and the GPS fitted red kites.

Contact data and more information

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