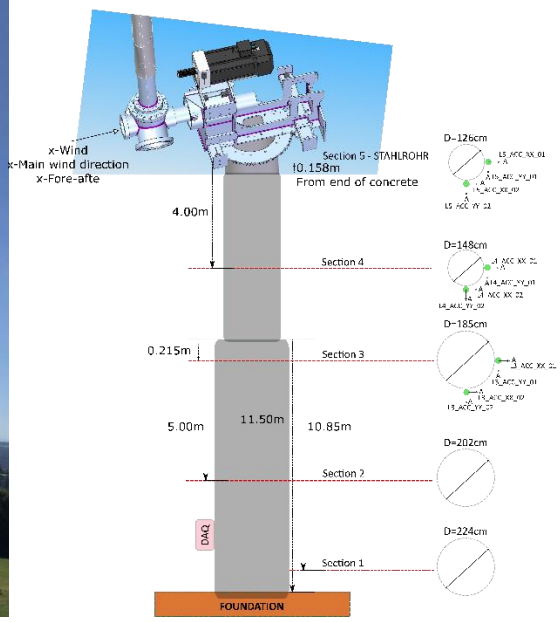
## Name of facilities/site: The ETH Aventa research wind turbine facility




## General description of turbine/facilities

This is one of two wind turbines used for research purposes, with one turbine owned by ETH Zurich (Chair of Structural mechanics and Monitoring) and one turbine owned by OST (described in a separate sheet). The ETH owned wind turbine is Aventa AV-7, manufactured by Aventa AG in Switzerland and was commissioned in December 2002. The turbine is operated via a belt-driven generator and a frequency converter with a variable speed drive. The rated power of the Aventa AV-7 is 6.5 kW, beginning production at a wind speed of 2 m/s and having a cut-off speed of 14 m/s. The rotor diameter is 12.8 m with 3 rotor blades, and a hub height is 18m. The maximum rotational speed of the turbine is 63 rpm. The tower is a tubular steel-reinforced concrete structure, supported on concrete foundation, while the blades are made of glassfiber with a tubular steel main-spar. The turbine is regulated via a variable-speed and variable pitch control system.

In addition, we have a full-scale standalone blade (similar to the one in the field), which we use to perform experimental modal analysis and structural model identification for the purpose of the aeroelastic model calibration.

We have built a standalone OpenFast aeroelastic model of the wind turbine. The numerical aerodynamic and structural models are currently being calibrated via measurements. The only missing block is the control system.

## Location of site

The wind turbine is located in Taggenberg, about 5 km from the city centre of Winterthur, Switzerland. This site is easily accessible by public transport and on foot with direct road access right next to the turbine. This prime location reduces the cost of site visits and allows for frequent personal monitoring of the site when test equipment is installed. The coordinates of the site are: 47°31'12.2"N 8°40'55.7"E.

## Control and measurement systems and signals.

The turbine is regulated via a variable-speed and collective variable pitch control system. For all intents and purposes, we are not willing to modify the control system parameters nor its design architecture. The tower and nacelle have been instrumented with 11 accelerometers and inclinometers distributed along the length of the tower, nacelle main frame, main bearing and generator. Two full bridge strain gauges are installed on the tower bottom measuring strain (and can be converted to bending moments) – all signals sampled at 200Hz. In additional we are collecting operational performance data (SCADA), namely: wind speed, wind direction, rotor RPM, power output and turbine status. Since Dec. 2021 and until May/June 2022, a LiDAR is used for measuring the inflow conditions.

## Research possibilities

**WINDMIL and WINDMIL RT-DT:** The turbine was instrumented as part of the WINDMIL and WINDMIL RT-DT projects and a complementrary SNSF R'Equip project, which are concerned with investigation of structural monitoring solutions for data-drien diagnostics and prognostics of wind energy infrastructures. Designed and commissioned in 2002, the Aventa wind turbine in Winterthur is soon reaching its end of design lifetime. In order to assess data-driven and hybrid modelling techniques for Remaining Useful Life (RUUL) estimation, a Structural Health Monitoring (SHM) campaign was implemented by ETH Zurich. The setup is used as a research platform on topics such as system identification, operational modal analysis, as well as non-stationary analysis (e.g. PCE-SP-TARMA) to investigate abnormal/faulty turbine characteristics under varying environmental and operational influences. We analyze the influence of operational and environmental conditions on the modal parameters and to further infer Performance Indicators (PIs) for assessing structural behaviour in terms of deterioration processes.

**Open Task:** The generated data can be used to calibrate/update/tune the (many) mechanical, structural and aerodynamic parameters of an OpenFAST aeroelastic model using field measurements from the Aventa wind turbine. This includes the calibration of the Blade aerodynamics (from CFD to aeroelastic model input), blade structural properties (stiffness distribution & mass distribution), and tower and foundation structural properties (stiffness and mass distribution & damping). For such a task, one could consider Bayesian inverse techniques for numerical model calibration or machine learning/deep learning techniques for numerical model calibration.

**AEROSENSE:** The aim of this project (shared by the OST turbine) is to develop a MEMS-based surface pressure and acoustic measurement system for wind turbines that is thin, non-intrusive, robust, modular, energy-autonomous, wireless, easy to install and cost-effective. The system will integrate novel embedded signal processing solutions, including artificial intelligence where appropriate, for on-board calibration and correction of measured variables, as well as a digital twin platform for effective data utilisation and value creation. Its modular and scalable design will enable wind turbine monitoring at a completely new scale (https://www.aerosense.ai/).

## Contact data and more information

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Website: in the near future, the measurement system architecture, samples of the raw data as well as the OpenFAST numerical model will be available to the public on this repository:
https://zenodo.org/record/4972789#.YMsuovn7Sbg