ECN Wind Energy Industrial Support

TURBU

EWIS

Being one of the leading institutes on wind energy research, ECN established the EWIS (ECN Wind Industrial Support) group in 2009 to better bring the R&D results to the market. During the last three decades, ECN has developed expertise on aerodynamics, structural analyses, turbine control, offshore operation and maintenance, and grid connection. With the growing wind industry, ECN received more requests for assistance and EWIS has become the vehicle to support the wind energy industry in their product developments.

EWIS's focus is on the high end of the market which means that we will make use of tools and knowledge that have been developed in-house and include the latest R&D results!

The EWIS team is a mixture of young professionals and experienced researchers which ensures a fast response and high quality.

More information

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Product description

The Software

The ECN computer code TURBU is a fast integrated wind turbine design and analysis tool. The unique feature of TURBU is that it generates an analytic linearised time-invariant model, which can be used in time and frequency domain. This makes TURBU the preferred code for stability analysis, control design and evaluation, and scoping of design variations and load cases.

The Model

TURBU allows for very accurate aeroelastic modelling through a multibody model which enables to include essential structural details (i.e. pre-bend, shear offset) as well as advanced aerodynamics (i.e. unsteady and wake dynamics). The model also includes a hydrodynamic formulation based on Airy theory and Morison equation, to enable offshore wind turbine modelling.

The linearised equations of motion are derived in the working point equilibrium (average deformation and induction state) that TURBU determines in advance using the nonlinear multibody model. The rotating part (rotor and drive train) is converted to fixed frame using the Coleman transformation. Connecting all parts results in a linear time-invariant model of the complete wind turbine, including aero-, hydro- and structural dynamics and, if applied, control.

To reduce complexity and calculation time, TURBU allows for modal reduction in the structural blade and tower models and has several flags for including or excluding degrees of freedom and modelling complexity. The in/output setup of the model is configurable, which increases speed but also reduces the amount of data to handle. TURBU can create a full wind turbine model (with aero- and hydrodynamics included) driven by wind speed variations and waves, or a structural model driven by wind and wave loads from external modules. Furthermore, TURBU is strongly based on a modular approach, which facilitates convenient modification of parts and implementation of extensions in the future.

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Specifications

Description of software:	• TURBU source code (MATLAB .m files library) • TURBU application and example files • User manual and technical documentation
Designated sites:	Single site
Licence fee:	€ 25 000 for the first licence € 17 500 for the second licence € 12 500 for the following licences
Licence term:	Unlimited use
Services:	16 man-hours software support (by telephone or e-mail, not on-site) and small updates of the software during the first year
Optional maintenance and service contract:	24 man-hours software support (by telephone or e-mail, not on-site) and small updates of the software for € 6 000 per year
Optional course:	A one-week training in TURBU basics and use given by ECN product specialists is offered as an option for € 10 000

For more information about this service, please contact:

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The use

TURBU is programmed in MATLAB and delivered as licensed open source, which allows users to modify and extend the code to their needs. This is also supported by the modular setup of the TURBU model and version and configuration management.
TURBU contains built-in applications for derivation of the wind turbine model and stability analysis, load calculation and control design evaluation. Along with the TURBU source code, example application files and models are provided.

Input for the analysis consists of turbine data, a controller structure and, depending on the type of analysis, disturbance from wind, wave, water current and gravity loading.
Output also depends on the type of calculation, ranging from modal properties (Campbell diagram) for stability analysis, transfer functions (Bode plot) for control evaluation and time series for load calculation.

The experience

Working with a linearised model, the results obtained with TURBU will be a compromise between accuracy and speed. However, calculation of the correct equilibrium conditions (with the full nonlinear model) improves accuracy, while speed of the analysis is almost unaffected. By linking several models TURBU can even be used for transient load cases such as shutdown of the wind turbine.
The results from TURBU have been verified within the EU STABCON project [1] (stability analysis) and against the validated code PHATAS (equilibrium conditions and power spectra) in the Dutch research program We@Sea [2].

[1] Thomsen, K. et.al. (2006): Aeroelastic stability and control of large wind turbines. Technical report NNE5-2001-00536, Roskilde, Denmark, 2006.

[2] Savenije, F.J. and Peeringa, J.M. (2009): Aeroelastic simulation of offshore wind turbines in the frequency domain; TURBU@Sea. Technical report ECN-E--09-060, Petten, The Netherlands, 2009.