Software Development, Modeling, and Analysis

We're developing advanced design tools to support the wind industry with "state-of-the-art" analysis capability

The wind industry relies extensively on design tool software for wind turbine performance, loads, and stability analyses. The fundamental tools are comprehensive "aero-hydro-servo-elastic" models, meaning that they incorporate integrated models for aerodynamic loads, hydrodynamic loads (for offshore systems), control system (servo) behavior, and structural-dynamic (elastic) loads (gravitational, inertial, centrifugal, gyroscopic, etc.). Ancillary tools—such as data analysis tools—are also needed to support the design and analysis process.

The NWTC has developed a collection of design tools, including preprocessors to help build the models, postprocessors to analyze the results, and utilities to run and manage the processing tasks. Our design tools have become the industry standard for analysis and development and are used by all of the major U.S.-based (as well as many foreign) wind turbine designers, manufacturers, consultants, and researchers.

In 2005, NWTC researchers worked with Germanischer Lloyd of Hamburg, Germany, to approve two of the NWTC's wind turbine design tools for calculating land-based wind turbine loads for design and certification. Although many U.S. wind turbine manufacturers have relied on these design codes to estimate the design loads of their turbines in the past, until recently, the codes were not accepted by certifying agencies in Europe.

The NWTC is committed to improving the design tools because limitations in the tools limit the advancement of wind power. Improving these tools is critical to the successful long-term performance, operation, and reliability of wind turbines and becomes even more important as turbines grow in size, incorporate novel load control technologies, and are installed on compliant offshore support platforms.

A simulation of a 5-MW wind turbine on an offshore barge with catenary moorings.

Diagram showing the NWTC design tools and their interaction.

NWTC-Developed Design Tools and Features

AirfoilPrep

- Generates airfoil data files from 2-D data
- Adjusts 2-D data for rotational augmentation (3D effects)
- Extrapolates to high AoA
- Computes dynamic stall parameters
- Blends aerodynamic coefficients

TurbSim

- Computes full-field stochastic wind realizations
- Inputs are the desired wind profile and turbulence characteristics
- Includes IEC- and site-specific turbulence models
- Option to generate coherent structures

PreComp

- Computes coupled section properties of composite blades for beam-type models
- Inputs are the airfoil shape and internal lay-up of composite laminas
- Uses a combined laminate theory (modified) with shear flow approach

BModes

- Computes coupled mode shapes and frequencies of blades and towers
- Inputs are the boundary conditions and distributed isotropic beam properties
- Considers axial-flap-lag-torsion coupling
- Uses a 15-DOF FE developed to handle rotation-related terms

WT_Perf

- Calculates steady-state rotor performance
- Inputs are the rotor geometry, airfoil data, wind, pitch, and rotor speed
- Uses BEM theory

AeroDyn

- Computes aerodynamics as part of the aero-elastic solution
- Equilibrium (BEM) and dynamic (GDW) wake
- Beddoes-Leishman dynamic stall
- Turbulent and uniform wind input

HydroDyn

- Computes hydrodynamics as part of the hydro-elastic solution
- Morison's equation for monopiles
- Linear radiation/diffraction theory for floating platforms
- Regular or irregular linear waves

FAST

- Computes structural-dynamic and control-system responses as part of the aero-hydro-servo-elastic solution
- Uses a combined modal and multi-body representation through 24 DOFs
- Control system modeling through subroutines, DLLs, or Simulink® with MATLAB®
- Nonlinear time-domain solution for loads analysis
- Linearization procedure for controls & stability analysis
- Preprocessor for building turbine models in MSC.ADAMS

MCrunch

- A MATLAB®-based postprocessor for data analysis
- Scales, offsets, and calculated channels
- Statistics and extreme events
- Probability density functions
- Power spectral density
- Rainflow counting, DELs, and life estimates
- Plotting

MBC3

- A MATLAB®-based postprocessor for Multi-Blade-Coordinate transformation
- Transforms the cumulative dynamics of spinning rotor blades into the non-rotating frame
- Handles system, controls, and disturbance matrices for states and outputs
- Applicable to controls design and stability analysis for 3-bladed rotors

For more information, contact the National Wind Technology Center at 303-384-6900.

Helpful Web Sites

The National Wind Technology Center
www.nrel.gov/wind

Department of Energy Wind and Hydropower Technologies Program
www1.eere.energy.gov/windandhydro

National Renewable Energy Laboratory

15013 Denver West Parkway, Golden, Colorado 80401 • 303-275-3000 • www.nrel.gov

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