NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Wind and Water Power Modeling and Simulation at the NWTC

Researchers at the National Wind Technology Center (NWTC) at the National Renewable Energy Laboratory (NREL) have developed a variety of computer modeling and simulation software tools to support the wind and water power industries and research communities with state-of-the-art design and analysis capabilities.

Computer modeling and simulations allow designers to analyze many factors affecting wind turbines and plants, at a fraction of the time and cost that physical testing would require. For example, during design, research, and development, turbine components often undergo extensive and numerous changes. In addition, turbines and their components are intended to operate under a wide range of complex environments—storm winds, waves offshore, earthquake loading, and extreme turbulence. Further, the arrangement of turbine arrays in a wind plant can have a dramatic effect on their performance.

The NWTC's software tools produce realistic models that simulate the behavior of wind and water power technologies in operating environments. These tools can model the effects of turbulent inflow, unsteady aerodynamic forces, structural dynamics, drivetrain response, control systems, and hydrodynamic loading for offshore applications.

Senior engineer demonstrates the power of SOWFA to simulate wind turbine wakes to Secretary of Energy Ernest Moniz. *Photo by Dennis Schroeder, NREL 27476*

Using NREL's Modeling and Simulation Software Tools

NREL's computer-aided engineering, design, and integrated system software tools are developed as free, professional-grade products and are widely used by thousands of United States-based and international wind turbine designers, manufacturers, consultants, certifiers, researchers, educators, and students. Although these tools are publicly available and open source, they may be used with proprietary modules, enabling usage without any loss of intellectual property. Download any of the following tools at *https://nwtc.nrel.gov/Software*.

Software tools include:

- Preprocessors for building models
- Simulators of dynamics, aerodynamics, and other multiphysical effects on turbines and components
- Postprocessors to analyze simulation results
- Models for the design, performance, and cost of turbine components, individual turbines, and wind plants (land-based and offshore)
- Models simulating marine and hydrokinetic turbines.

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Software Tools

FAST simulates coupled nonlinear aero-hydro-servo-elastic dynamics in the time domain. It enables the analysis of a variety of wind turbine configurations, including two- or three-bladed horizontal-axis rotors, pitch or stall regulation, rigid or teetering hubs, upwind or downwind rotors, and lattice or tubular towers. The wind turbine can be modeled on land or offshore on fixed-bottom or floating substructures. The latest version of FAST (v8) includes a modularization framework that enables coupling between model components.

The Simulator fOr Wind Farm Applications (SOWFA) is a set of computational fluid dynamics solvers, boundary conditions, and turbine models. It allows users to investigate wind turbine and wind plant performance under the full range of atmospheric conditions and terrain. SOWFA includes a boundary layer solver, wind plant solver, an actuator line turbine model, as well as atmospheric/wind plant specific boundary conditions, utilities for flow field initialization, and a utility to convert precursor-sampled boundary data to inflow data.

The Wind-Plant Integrated System Design & Engineering Model (WISDEM™) is a set of models for assessing the overall cost of energy (COE) of a wind plant. WISDEM uses wind turbine and plant cost and energy production as well as financial models to estimate COE and other wind plant system attributes.

Wave Energy Converter SIMulator (WEC-Sim) is an open-source wave energy converter simulation (WEC) tool. The software is coded in MATLAB/Simulink using the multibody dynamics solver SimMechanics. WEC-Sim can model devices that are comprised of rigid bodies, power take-off systems, and mooring systems. Simulations are performed in the time domain by solving the governing WEC equations of motion in six degrees of freedom.

Supporting Modules

Computer-Aided Engineering Tools			
Preprocessors	Simulators	Postprocessors	Utilities
AirfoilPrep	ADAMS2AD	Crunch	NWTC Subroutine Library v2
BModes	BladeFS	GenStats	
IECWind	Gear-SCouP	GPP	
PreComp	IceFloe	MBC	
SS Fitting	NAFNoise	MCrunch	
TurbSim		MExtremes	
		MLife	

Design, Sizing, and Cost Tools	
Design and Sizing	Cost Analysis
DriveWPACT	NREL CSM
RotorSE	Plant_CostsSE
TowerSE	Plant_FinanceSE
TurbineSE	Turbine_CostsSE
Performance Analysis	Utilities
AeroelasticSE	AirfoilPrep.py
Plant EnergySE	CCBlade
	pBeam
	pyFrame3DD

Marine and Hydrokinetics
HARP Opt
OpenWARP-Nemoh
TurbSim
WEC Extreme Conditions Modeling

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