



NATIONAL WIND
TECHNOLOGY CENTER

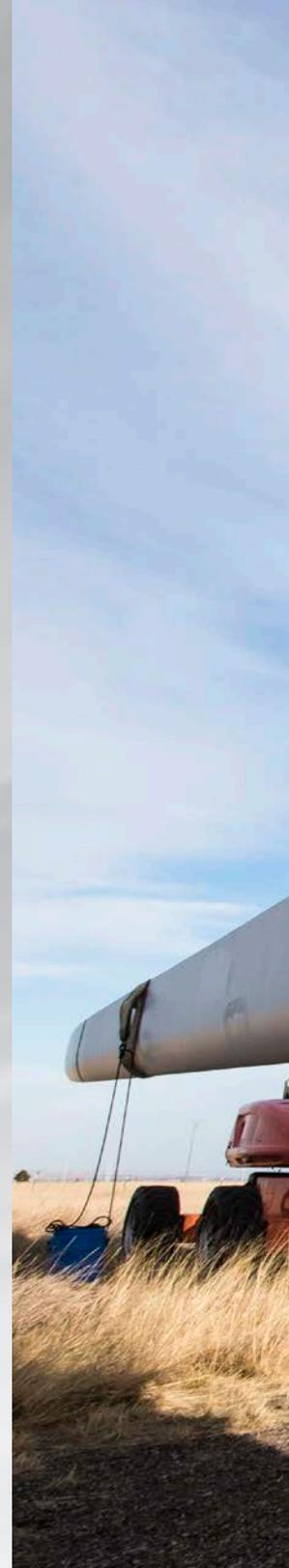
40 YEARS OF INNOVATION LEADING THE WAY TO A RENEWABLE ENERGY FUTURE

Core Capabilities Overview | May 2018



The U.S. Department of Energy's *National Wind Technology Center (NWTC)* at the *National Renewable Energy Laboratory (NREL)* is at the forefront of energy innovation and is the nation's premier renewable energy technology research facility. Since the earliest days of the wind industry, the NWTC has provided an ideal environment for the research and development of advanced energy technologies. Now, more than ever, as renewables are expected to fulfill an ever-larger portion of our nation's energy needs, the NWTC's research and development efforts are critically important to meeting our future clean energy goals.

Researchers are working with industry partners toward an energy future that features significant levels of reliable, affordable, and sustainable renewable energy. The combination of our broad-based technical expertise along with our world-class capabilities and facilities has made the NWTC an indispensable resource for the wind industry. We leverage this expertise to provide the wind industry with a better understanding of fundamental physics, high-performance computing-enabled simulation tools, and physical validation necessary to significantly lower the cost of wind energy.





40 Years of Advanced Energy Innovation

During the past 40 years of wind research and development, NREL has pioneered many of the components and systems that have taken wind energy technologies to new heights. Through its expertise and one-of-a-kind assets, NREL research has become a guiding force, advancing wind technologies from initial concepts to deployment in the following areas:

Land-Based Wind

Offshore Wind

Distributed Wind

Grid Integration

Market Acceleration

Manufacturing Research

NREL works with industry partners to design and optimize the performance of cost-effective and grid-friendly wind power turbines and plants that will enable the deployment of wind across the entire United States. From controls and reliability to full-scale field research validation, NREL's wind capabilities run the gamut.

Controls

NWTC researchers design, research, and validate advanced *control systems* to maximize energy production and reduce structural loads for wind power plants. This research leads to innovative control strategies that reduce aerodynamic structural loads, improve performance, and reduce costs.

Reliability

Through the use of its on-site facilities, NREL simulates wind turbine drivetrains, collects and analyzes data, and evaluates a variety of technologies and systems. This research helps increase *wind turbine reliability*, which minimizes maintenance costs, improves capacity factors, and ultimately drives down the levelized cost of wind energy.

Design Methods, Tools, and Standards

NREL has developed and maintains robust open-source modeling tools capable of simulating a wide range of wind systems. The two primary modeling efforts include *computer-aided engineering tools* and *systems engineering tools*. NREL researchers work with industry partners to conduct technical assistance, validate and verify models, and engage in collaborative research. Learn more about NREL's wind modeling software suites: *FAST v8* and *WISDEM™*.

Energy and Economic Analysis

Wind energy analysis capabilities inform policy and investment decisions that lead to more resilient, reliable, and efficient energy systems. With objective, technology-neutral analysis, NREL aims to increase understanding of energy policies, markets, resources, technologies, and infrastructure to address U.S. economic, security, and environmental priorities.

Technology Research Validation and Certification

Private industry, laboratory researchers, and academics use the NWTC's *technology research validation and certification facilities* to drive new wind technology development — from designing more efficient blades to creating stronger, more durable drivetrains. Validating and demonstrating a

complete turbine design requires assessing the full system in the natural operating environment to help industry improve the performance of individual wind turbines and their components, while analyzing the interactions of multiple wind turbines in a wind farm allows researchers and developers to improve overall reliability and efficiency of entire wind plants.

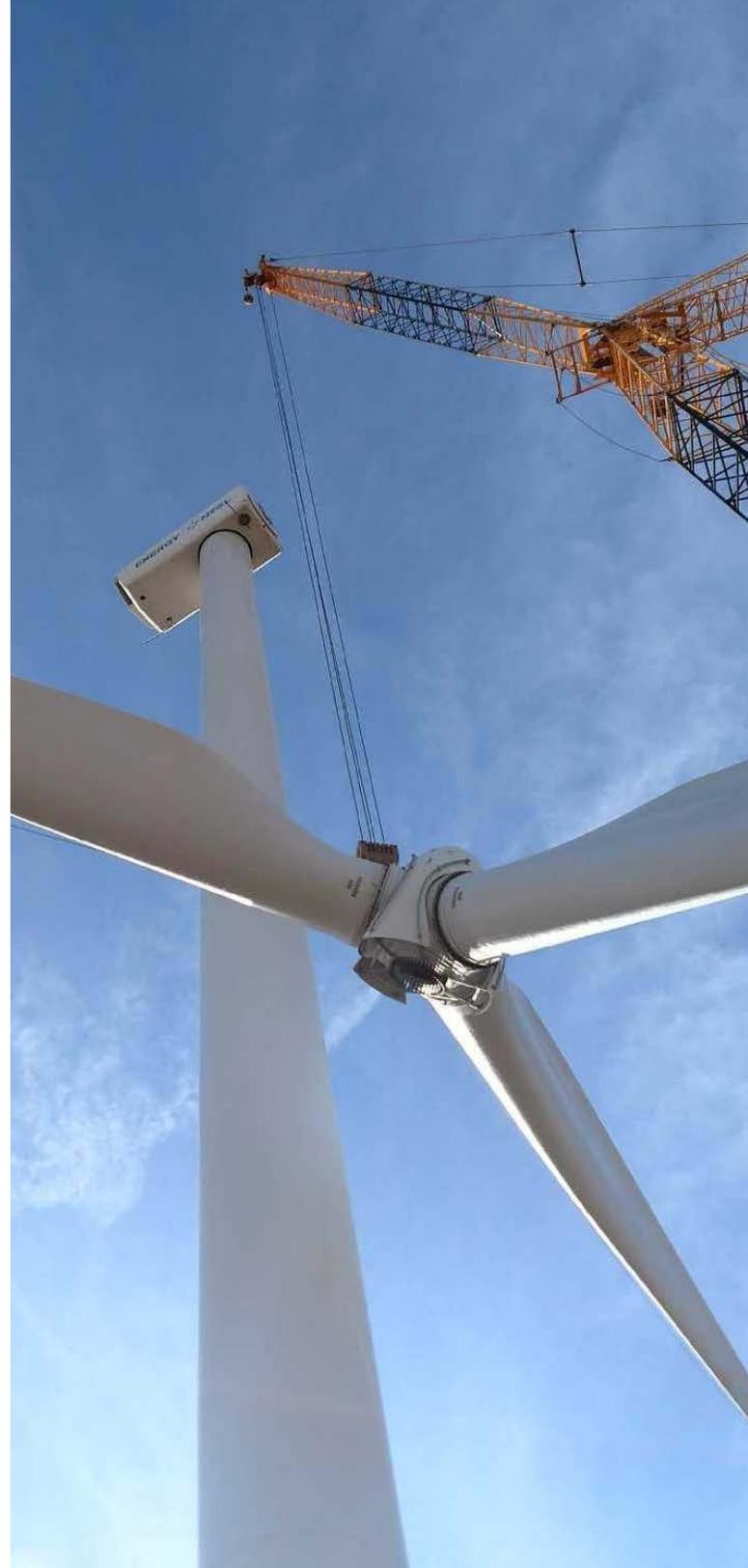
NREL's validation and testing capabilities are accredited by the American Association for Laboratory Accreditation (A2LA). Tests include acoustic noise emissions, duration, mechanical loads, power performance, power quality, safety and function, structural blades, and mechanical and electrical characteristics of drivetrains. Such high-quality testing enables turbine manufacturers and wind plant developers to meet requirements levied by wind turbine certification agencies, financial institutions, and other oversight organizations worldwide.

Resource Characterization, Forecasting, and Maps

NREL produces *high-resolution maps of select regions* around the world that supply wind power plant developers with estimates of the wind resource potential as well as a national database called the *WINDToolkit* for wind integration and forecasting. NREL researchers are also advancing the science of wind measurements and observations through numerous industry partnerships.

Utility Grid Integration

NREL's *grid system integration analysts* work with the U.S. Department of Energy, university researchers, independent system operators, and regional transmission organizations to provide system characterization data and models that empower electric power system operators to more efficiently manage wind grid integration.



Renewable Energy Generation and Storage Models

Renewable energy generation and storage models enable researchers to study the impact of integrating large-scale renewable energy resources into the electric power grid. This research enables renewable energy system planners, manufacturers, owners, operators, and developers to simulate remedial action schemes and ultimately improve grid stability.

Wind Power Plant Modeling and Simulation

Engineers and scientists have worked with the industry to develop advanced high-fidelity simulation and optimization tools for wind power plant and turbine interactions with the atmosphere. These tools are capable of modeling the processes needed to *predict plant interactions* or produce state-of-the-art simulation and analysis capabilities that allow industry stakeholders to perform a wide variety of optimization studies to lower the cost of energy. Learn more about *modeling and simulation at NREL*.

Technology Development

A wide variety of research and development activities are aimed at reducing the cost of energy for individual wind turbines, utility-scale wind plants, and integrated hybrid power systems. NREL uses computational and validation capabilities to generate novel solutions to technical challenges. Industry partnerships work to improve fundamental design capabilities and evaluate the performance of innovative technology solutions.

Manufacturing Research

As the only federal laboratory dedicated to clean energy research and development, NREL is uniquely positioned

to help manufacturers find the most energy-efficient and sustainable solutions for their products and processes. Our scientific and engineering research in *advanced manufacturing* is focused on the identification and development of advanced materials and advanced processes that drive the impact of new energy technologies. Our world-class manufacturing analysis yields insights that support industry decisions about R&D targets, investment strategies, and policy evaluation.

We partner with industry to bridge innovation gaps in advanced manufacturing research, helping to accelerate the commercialization of next-generation technologies and processes. We also have facilities dedicated to the R&D needs of manufacturers and other facilities that have the flexibility to adapt to those needs.

The Institute for Advanced Composites Manufacturing Innovation (IACMI)

Building on its 40-year history of collaboration with major wind turbine original equipment manufacturers and U.S. blade manufacturers, NREL leads IACMI's wind turbine technology area. Analysts perform techno-economic analyses and assessments of manufacturing technologies and trends, deployment barriers, and competitiveness factors that affect the U.S. wind turbine supply chain and *technology investment decisions* for wind power plants.

Siting Considerations and Environmental Impacts

NREL performs research and analysis on wind energy siting and permitting issues, costs, and how policies and regulations affect wind energy developers and local communities. The NWTC also serves as a research validation site for *environmental detection and deterrent technologies* (e.g., for eagles and other birds of prey). Discover the effects

that wind energy technology has on wildlife and habitats with the [Wind-Wildlife Impacts Literature Database](#).

Workforce Development and Education

NREL performs in-depth analysis on the [domestic wind energy workforce](#) and has published numerous reports on jobs and economic development from wind using the [Jobs and Economic Development Impacts \(JEDI\) model](#). Insights from this research into the domestic wind workforce will allow the private sector, educational institutions, and federal and state governmental organizations to make better informed workforce-related decisions based on the current data and future projections.

Our State-of-the-Art Facilities

NREL's state-of-the-art wind research facilities at the National Wind Technology Center include prototypes rated from 400 watts to 3 megawatts, providing a venue for groundbreaking innovations and collaboration with partners.

[Dynamometers](#)

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[Field Validation Sites](#)

[Controllable Grid Interface](#)

[Energy Storage](#)

[Composites Manufacturing Education and Technology Facility \(CoMET\)](#)



Dynamometers

The NWTC features *three dynamometers* that can perform research validation on wind turbine systems from 1 kW to 5 MW. The dynamometers replicate realistic operational conditions to assess drivetrain designs and increase the technical readiness of innovations.

Structural Research

The NWTC offers three *structural research laboratories* that can validate blades and components smaller than 1 m to more than 50 m in length, performed to the IEC 61400-23 standard. These world-class facilities simulate the extreme operating loads experienced by blades during field operation and accelerated fatigue lifetime loading. In addition, modal, acoustic emission, thermography, and surface characterization systems are available.

Field Research Validation Sites

NWTC's *field research facility* can support up to 32 possible field-research sites and currently offers six wind turbines and four fully instrumented meteorological (met) towers. NWTC's unique location leverages staff expertise and research facilities enabling an integrated research environment for system to full-scale evaluation of renewable energy systems at transmission and distribution grid integration levels. Facilities support kW to multi-Mw validation for wind turbines, PV arrays, energy storage, and hybrid power systems tied to an integrated grid and multi-MW grid simulator.

Controllable Grid Interface

The *controllable grid interface* (CGI), part of the NWTC at NREL, can evaluate both the mechanical and electrical characteristics of wind turbines in a controlled grid

environment by replicating many electrical scenarios that are only partially available in field validation.

The CGI can assess frequency and voltage control under a variety of grid conditions and is the first U.S. facility that can evaluate wind turbines under balanced and unbalanced voltage fault conditions. This platform ensures that wind turbines meet stringent national and international standards while assessing the grid compliance of innovative electrical topologies and controls.

Energy Storage

Renewable energy generation and storage models and MW-scale field research validation pads enable researchers to study the impact of integrating large-scale hybrid renewable energy power systems into the electric grid.

Composites Manufacturing Education and Technology Facility (CoMET)

The *CoMET facility* paves the way for innovative wind turbine components and accelerated manufacturing and is critical to NREL's exploration of thermoplastic resins for wind turbine blades. Available for use by industry partners and university researchers, the 10,000-square-foot facility expedites manufacturing innovation by enabling researchers to design, prototype, evaluate, and manufacture composite wind turbine blades and other components in one location.

High-Performance Computing Center at the Energy Systems Integration Facility

NREL has the largest *HPC system* in the world dedicated to advancing renewable energy and energy efficiency

technologies. Located at the Energy Systems Integration Facility, the system features a 2.24-petaFLOP supercomputer called Peregrine, which helps researchers investigate wind turbine wakes using computational fluid dynamics and software developed by NREL such as the *Simulator for Wind Farm Applications* (SOWFA).

Work with Us

Flexibility is the key to government-industry collaborations at the NWTC, where companies get the support they need and can take full advantage of the center's facilities and research and development capabilities.

We have an *outstanding performance record* for working with the wind industry to advance wind turbine science and lower the cost of wind-generated electricity. Companies *partner with NREL* when they have science and design challenges, and need to validate their technology for certification and commercialization.



Join Us in Building a Renewable Energy Future

NREL offers many opportunities to industry, organizations, government, researchers, businesses, students, educators, and vendors. At NREL, we work with organizations large and small through research partnerships, licensing of NREL technologies, supporting cleantech stakeholders, and fostering the renewable energy economy. Join us to accelerate the movement of renewable energy and energy-efficient solutions into practical applications and take advantage of our state-of-the-art facilities for researching and developing groundbreaking energy technologies.

Partner with us through [technology partnership agreements](#).

Participate in subcontracted wind research through [solicitations and requests for proposals](#).

Use our [cutting-edge research facilities](#) to develop and evaluate wind technologies.

License Our Technology

License our technologies with [licensing agreements](#).

See what technologies are available for licensing on the U.S. Department of Energy's [Energy Innovation Portal](#).





Contact Us

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www.nrel.gov/wind



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