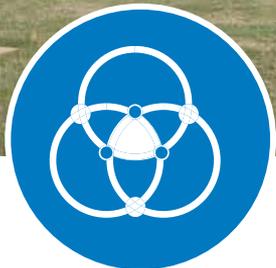




Flatirons Campus Research Laboratories & Facilities

Technical Lead: David Simms
david.simms@nrel.gov



Advanced Research on Integrated Energy Systems (ARIES)

Facilities that support scaling up the physical size of new energy technologies and the number of interconnected devices into larger systems



Structural Research Facilities

Facilities that enable the characterization and validation of wind turbine blades and components



Field and Technology Research Validation Facilities

Field research pads, expert engineers, and specialized facilities at one of the best meteorologically characterized research sites in the world



Dynamometer Research Facilities

Dynamometers that can perform research validation on wind turbine drivetrains and generators from 1 kW to 5 MW



Composites Manufacturing Education and Technology

An industrial-scale workspace, research, and education center for wind industry composites research



Advanced Research on Integrated Energy Systems (ARIES)

A research platform that can match the complexity of the modern energy system and conduct integrated research that supports the development of groundbreaking new energy technologies. ARIES is transforming the Flatirons Campus from a single-program site to a multiple-program campus and will:

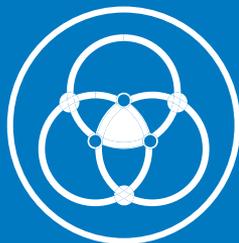
- Address the fundamental challenges of how to scale up the physical size of new energy technologies and the number of interconnected devices into larger systems.
- Determine how the integration of multiple diverse technologies into future energy systems can provide a range of benefits including improved efficiency, security, resiliency, lower costs, and greater customer choice.

Areas of Expertise

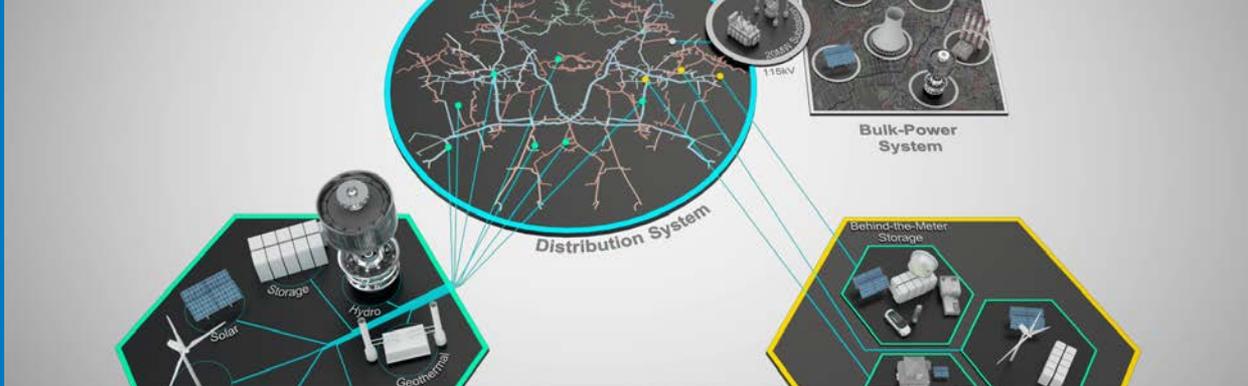
- Grid integration
- Wind energy, water power, solar photovoltaics
- Energy storage
- Advanced manufacturing

Current Projects

Integrated Energy Systems at Scale (IESS)



ARIES



CHALLENGE

Ensuring the grid of the future can manage a growing base of intelligent energy devices, variable renewable energy, advanced controls, integration, and distributed and variable generation sources will be required to provide a resilient and secure grid.

APPROACH

NREL is expanding its research capabilities at the Flatirons campus to enable grid integration research at the multi-megawatt scale.

IMPACT

- ARIES will make it possible to understand the impact of—and get the most value from—the millions of new devices that are connected to the grid daily (i.e. electric vehicles, renewable generation, hydrogen, energy storage, and grid-interactive efficient buildings).
- ARIES' scale will make it possible to consider opportunities and risks with the growing interdependencies between the power system and other infrastructure (i.e. natural gas, transportation, water, and telecommunications).



Structural Research Facilities

- NREL helps verify and improve new component designs, analyze structural properties, and improve manufacturing processes.
- State-of-the-art equipment and data acquisition systems are capable of validating blades and components from 1 meter to 50+ meters in length
- Three structural research facilities offer 1,800 square meters of laboratory space that share servo-hydraulic control and actuation equipment.
- Accredited to IEC 61400-23 for wind turbine blade testing
- NREL combines custom data acquisition software tailored for static strength and fatigue validation with a data acquisition system capable of recording hundreds of data channels.

Areas of Expertise

- Experimental design and performance for material and structural validation
- Composite multiscale validations
- Composite performance characterization.

Current Projects

Investigating core gaps and developing subcomponent validation methods for wind turbine blades



STRUCTURAL
RESEARCH FACILITIES



CHALLENGE

Reduce the necessity for costly and time-intensive validation of complete wind turbine blades.

APPROACH

Develop methods to validate structural details and interfaces at the subcomponent level. Core gaps are one example of a manufacturing defect observed in wind blade composite sandwich construction. Beam specimens are characterized with and without core gaps in sandwich panels using multiple types of infusion resins. Results are used to develop appropriate methodologies for more complex subcomponents – all as part of a broad wind blade structural validation and damage tolerance program.

IMPACT

This research enables state-of-the-art validation methods that will inform standards development to certify large blades at the subcomponent level.



Field and Technology Research Validation Facilities

- NREL designs and executes experiments to support validation of models and characterize new technology throughout the R&D portfolio—and develops new validation methods for wind turbine technology to address industry needs
- NWTC field research validation staff belong to these committees: International Electrotechnical Commission (IEC), International Measuring Network of Wind Energy Institutes (MEASNET), American Wind Energy Association (AWEA)
- Accredited to perform acoustic noise to IEC 61400-11 and MEASNET, power performance to IEC 61400-12-1 and MEASNET, mechanical loads to IEC 61400-13, power quality to IEC 61400-21 and MEASNET, duration testing to IEC 61400-2, safety and function to IEC 61400-2 and IEC 61400-22.

Areas of Expertise

- Design and execute bespoke experiments
- Facilities and capabilities that anticipate R&D needs
- Field tests conducted according to set standards—domestic and international.

Current Projects

Segmented Ultralight Morphing Rotor (SUMR) Blades



FIELD AND TECHNOLOGY
RESEARCH VALIDATION FACILITIES



CHALLENGE

Strong and variable wind speeds can adversely affect the durability of wind blades and increase costs for offshore wind applications. Will highly flexible, segmented ultralight morphing rotor (SUMR) blades make a difference?

APPROACH

- Use the 600-kilowatt CART2 to support a University of Virginia (UVA) project funded by the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-e)
- Retrofit the CART2 wind turbine with two SUMR blades

IMPACT

This project shows how flexible blades can help offshore wind turbines withstand strong, hurricane-force winds and how these blades perform in a downwind configuration.



Dynamometer Research Facilities

- NREL experts can assess a variety of components and subsystems, including generators, gearboxes, power converters, bearings, brakes, lubrication, cooling, and control systems
- Manufacturers and design engineers use NREL facilities to perform accelerated lifetime experiments, to develop customized software, and to study generator and power electronics system performance and grid integration
- NREL's dynamometer research facilities help ensure wind turbine reliability, which reduces both risk and cost.

Areas of Expertise

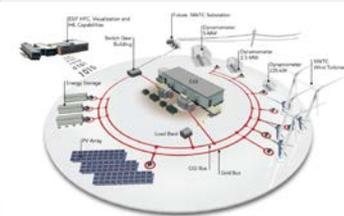
- Mechanical and electrical power system validation
- Infrastructure and hardware—225-kW, 2.5-MW, and 5-MW dynamometers
- Data acquisition and results—to emulate rotor, tower, pitch, and yaw systems—and computer simulations operating in real time.

Current Projects

Impedance characterization of inverter-based generation



DYNAMOMETER
RESEARCH FACILITIES



CHALLENGE

With increased penetration of inverter-based renewable generation, increased risk exists for control interactions between different generators.

APPROACH

NREL researchers developed a new power-hardware-in-the-loop impedance characterization method and demonstrated it using the controllable grid interface, a 4-megawatt wind turbine generator, and a power converter connected to the 5-megawatt dynamometer.

IMPACT

New impedance characterization methods help improve dynamic generator models, which, in turn, allow for higher penetration of inverter-based renewable generation on the grid.



CoMET

The Flatirons Campus hosts the Composites Manufacturing, Education, and Technology (CoMET) facility to enable NREL to lead composite research for renewable energy. The CoMET is:

- Accelerating the manufacture of advanced wind turbine components
- Driving composites science and education
- Demonstrating initial work on the Manufacturing USA Institute for Advanced Composites Manufacturing Innovation (IACMI)
- Providing a real-world classroom to educate tomorrow's highly trained advanced composites workforce
- Partnering with research universities and industry.

Areas of Expertise

- Rapid prototyping of new blade materials and production methods
- Full-scale blade component tooling and fixtures (root, spar cap, tip, shear web)
- Modeling and manufacturing simulation

Current Projects

Thermoplastic resin for wind turbine blades



CoMET



CHALLENGE

Thermoset (epoxy, polyester) resins used to manufacture wind turbine blades are hard to recycle and require high-cost adhesive joints.

APPROACH

Design, manufacture, and validate thermoplastic articles with increasing complexity to develop manufacturing processes, characterize new materials, and validate their performance.

IMPACT

Characterization of thermoplastic materials and thermo-welded joints at different scales and complexity enables adoption of new, fully-recyclable materials by the wind energy industry.

Accomplishments & Impacts



NREL's Flatirons Campus is a world-class research facility for renewable energy. Its equipment, technical experts, and facilities support fundamental research, development, experimentation, and validation of components and systems, including:

- Enabling future research initiatives that are aimed at ensuring reliability and resiliency of the U.S. power grid as increasing levels of megawatt-scale renewable energy generation and storage technologies are added
- Partnering with industry and research institutes to provide insight into the design of offshore wind blades and improving blade service life
- Performing cutting-edge research on the performance, cost, reliability, sustainability, manufacturability, and resilience of complex hybrid energy systems
- Demonstrating the potential for renewable power generation to not only integrate onto the grid but to positively contribute to grid stability by providing grid services.

