

NREL's Controllable Grid Interface Saves Time and Resources, Improves Reliability of Renewable Energy Technologies

Researchers at the National Renewable Energy Laboratory (NREL) developed a controllable grid interface (CGI) test system that can significantly reduce certification testing time and costs. The CGI also provides system engineers with a better understanding of how wind turbines, photovoltaic (PV) inverters, and energy storage systems interact with the grid and react to grid disturbances. For the energy industry, this will save time and resources while minimizing integration issues, improve reliability, and advance the development of grid-friendly renewable and emerging technologies.

The National Wind Technology Center (NWTC) is one of two user facilities at NREL capable of testing and analyzing the integration of megawatt-scale renewable energy systems. NREL's Energy Systems Integration Facility (ESIF) focuses on developing and testing large-scale distributed energy systems for various applications and is home to a high-performance computing data center that greatly expands the laboratory's modeling and simulation capabilities.

NREL's system engineers use the CGI to test multimegawatt-scale wind and PV technologies as well as energy storage devices, transformers, and protection equipment at transmission-level

voltages. With these capabilities, industry can now partner with NREL to test, optimize, and visualize the grid integration-related performance of a unit before it is deployed.

By including a virtual link with the ESIF's super-computing capabilities, researchers and industry partners can visualize complex systems in a virtual environment and observe advanced, real-time testing schemes that combine the flexibility of the CGI with the ESIF's grid simulator and smart-grid capabilities.

For example, the CGI allows wind turbine generator manufacturers to test both the mechanical and electrical characteristics of their machines in a controlled grid environment by replicating many electrical scenarios that are only partially available in field testing. The industry now has a platform on which to ensure that renewable energy systems meet stringent national and international electrical standards and to test grid compliance of innovative electrical topologies and controls. This will increase reliability and lower the cost of energy delivered by wind and solar power. CGI capabilities go beyond fault ride-through to provide comprehensive electrical testing solutions at the multimegawatt level.



The CGI provides insights into the impact of integrating renewable resources, such as wind energy, on the grid.
Photo by Dennis Schroeder, NREL 31732

NWTC Controllable Grid Interface

- Tests wind turbines and other technologies, PV inverters, and energy storage systems offline from the grid
- Tests both mechanical and electrical characteristics
- Verifies compliance with standards
- Provides grid operators with performance information in a controlled laboratory environment
- Is the first U.S. test site with fault-simulation capabilities.

Capabilities

- Balanced and unbalanced over-and-under voltage fault ride-through tests
- Frequency response tests
- Continuous operation under unbalanced voltage conditions
- Grid condition simulation (strong and weak)
- Reactive power, power factor, voltage control testing
- Protection system testing (over-and-under voltage and frequency limits)
- Islanding operation
- Sub-synchronous resonance conditions
- 50 Hz tests.

The NWTTC's CGI allows manufacturers and system operators to test many aspects of grid integration for utility-scale wind and solar generation technologies and storage technologies. *Illustration by Josh Bauer, NREL*

Technical Characteristics

Power rating:

- 13.2 kV
- 7 MVA continuous
- 39 MVA short circuit capacity for 2 seconds
- Total harmonic distortion < 3.5% at no load conditions (calculated for up to the 50th harmonic).

Possible test articles:

- Types 1, 2, 3, and 4 wind turbines
- PV inverters and energy storage systems
- Conventional generators
- Combinations of technologies can be tested in parallel.

Voltage control:

- Balanced and unbalanced voltage fault conditions

- Strong and weak grid conditions
- Voltage magnitude modulations.

Frequency control:

- Fast output frequency control (+/- 3 Hz) to simulate frequency response of various power systems
- 50/60 Hz operation
- Capable of performing real-time digital and hardware-in-loop simulations.

Partner With Us

Work with NREL to take advantage of state-of-the-art CGI capabilities for testing and improving grid integration aspects of renewable generation technologies. Partners at the CGI facility may include:

- Manufacturers of renewable generation and energy storage equipment
- Utility, plant, and system operators
- Microgrid and stand-alone power system integrators

- Certification laboratories
- Government agencies
- Universities
- Other national laboratories.

Contact

Vahan Gevorgian,
Vahan.Gevorgian@nrel.gov



National Renewable Energy Laboratory
15013 Denver West Parkway • Golden, CO 80401
303-275-3000 • www.nrel.gov

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