Electricity, Resources, & Building Systems Integration

Distributed Energy Systems Integration Group

As our nation's electric power system ages, it is faced with increasingly difficult load and power quality demands. Physical, technical, and economic constraints have combined to place heavy burdens on an already taxed system. NREL is working to strengthen the electric power system by integrating distributed energy and renewable energy systems along with advanced power electronics and control systems.

As part of the Electricity, Resources, and Building Systems Integration Center, R&D performed by NREL's Distributed Energy Systems Integration (DESI) group focuses on developing solutions to the technical and analytical challenges of enabling high penetration of renewable and distributed energy resources at the distribution level. This includes testing and characterization, modeling and analysis, and developing standards and codes. DESI researchers work on advanced approaches to interconnection and control technologies, energy management, and grid support applications.

Renewable Energy Grid Integration

As the market share for renewable energy grows, concern about potential impacts on the operation and stability of the electricity grid may create barriers to its future expansion. DESI researchers are working to understand the potential impacts of high penetration levels of renewable energy on the electricity grid and how to optimize systems based on benefits to both customers and utilities.

An emerging challenge to achieving this market potential is the ability of the electricity grid to handle photovoltaic (PV) systems and other renewable energy technologies. Addressing grid integration issues is a necessary prerequisite for the long-term viability of the distributed renewable energy industry in general and the distributed PV industry in particular.

Smart Grids

The most vital function of the modern grid is the ability to enable seamless integration of many types of generation and storage systems with a simplified interconnection process analogous to "plug and play." The DESI group researches a variety of Smart Grid technologies to allow communications and controls between smart devices to improve the efficiency of the electric power system and allow for safe and reliable interconnection of distributed energy systems.

DESI Group Capabilities

Testing and Data Collection

- Field and laboratory testing
- Data acquisition systems
- Distributed and renewable system models and simulations
- Electric power system models and simulations

Modeling and Simulations

- Power electronics and interface models

Analysis and Reporting

Standards Development and Outreach

Warren Gretz, NREL/PIX 12529

10 kW PV array installed at NREL's Hybrid Power Test Bed-DERTest Facility.

Smart Grid Interoperability Standards

DESI researchers are helping to develop IEEE P2030 "Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS) and End-Use Applications and Loads." This document provides guidelines in understanding and defining Smart Grid interoperability of the electric power system with end-use applications and loads. It focuses on the integration of energy technology and information and communications technology to achieve seamless operation for electric generation, delivery, and end-use benefits to permit two-way power flow with communication and control.

NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

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Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

Microgrids and Hybrid Power Systems

The DESI group also conducts research on advanced grid configurations like microgrids and hybrid power systems. Microgrids are intentional electrical islands that contain distributed generation and load that can parallel to, and disconnect from, the main grid to provide improved reliability. Hybrid power systems are electric power systems that do not connect to the main grid, but contain multiple sources of energy.

Testing and Evaluation

The DESI group conducts testing and evaluation of interconnection and Smart Grid technologies at the Distributed Energy Resources Test Facility (DERTF). Researchers use advanced state-of-the-art laboratories and outdoor test beds to characterize the performance and reliability of distributed power systems, support standards development, and investigate other emerging complex system integration issues for renewable, distributed energy, and Smart Grid technologies.

Industry and standards associations have taken advantage of NREL's distributed energy capabilities to evaluate and validate their products and processes. Researchers in the DESI group developed and validated the procedures for IEEE 1547 "Standard for Distributed Resources Interconnected with Electric Power Systems" series of standards. The test facility is capable of conducting all of the testing in the standard series, including tests for voltage and frequency disturbances including voltage sags, momentary interruptions and switching transients, islanding conditions, surge withstand (lightning strikes), power quality, DC injection, harmonics, and flicker. Interconnection testing has been conducted on microturbines, photovoltaic inverters, synchronous generator paralleling switchgear, and protective relays.

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For More Information

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Jim Yost/PIX 11165

30-kW micro-turbine powered by propane at the DER Test Facility.

Advanced Power Electronic Interface Development

DESI researchers have been working with industry to develop and test advanced power electronic interfaces for distributed energy applications. One of the goals is to develop a standardized, highly integrated, modularized power electronic interconnection technology that will come as close as possible to "plug-and-play" for distributed energy platforms.

Integration of Renewables with Electrolyzers

NREL is working with Xcel Energy to establish and understand state-of-the-art renewable electrolysis equipment and the operation of a renewable hydrogen production facility. The Wind2H2 system was approved for initial operation in March 2007 and is enjoying success as a demonstration project, producing hydrogen directly from renewable energy sources.

This unique research-oriented project uses solar and wind energy to produce and store hydrogen. The stored hydrogen can be used as both a transportation fuel and an energy storage medium, effectively allowing renewable energy to be stored and converted back to electricity at a later time. The Wind2H2 project is helping researchers understand the hurdles and potential areas for improvement in emerging renewable electrolysis technologies.

Vehicle to Grid Applications

DESI researchers also characterize plug-in hybrid and electric vehicles for compatibility with the grid. With several industry partners, NREL is helping to develop appropriate testing protocols to evaluate the ability to have vehicle charge and discharge power to and from the grid.

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