Center for Electric & Hydrogen Technologies & Systems

Working Toward a New Energy Future

The energy paradigm is shifting. The world is slowly moving from a hydrocarbon (fossil fuel) economy to one based on distributed energy resources (DER) and hydrogen.

Instead of relying exclusively on electricity produced by large, central power plants, there is an increasing use of smaller, distributed generators to meet our nation's growing need for sustainable electricity supplies. These distributed generators — which include fuel cells, natural-gas turbines, solar power, wind turbines, diesel generators, and others — are typically located at or near the point of energy consumption.

Distributed generators can be used to stabilize power fluctuations in the electricity grid, provide off-grid power to homes and businesses, or provide a source of backup power in case of electricity grid outages. They are used to improve power reliability and to provide the high-quality electricity demanded by our increasingly digital economy. And they can be built and installed quickly — wherever and whenever they are needed.

But distributed power isn't the only new development to challenge the existing energy infrastructure. The federal government envisions a new energy future in which hydrogen will join gasoline, electricity, and natural gas as a primary energy carrier. Or replace them entirely, since hydrogen can play the part of all of the other energy carriers in today's hydrocarbon economy.

Because of its versatility, hydrogen also has the potential to solve two major energy challenges that confront the United States today: reducing dependence on petroleum imports and reducing pollution and greenhouse gas emissions.

There are a wide variety of technical challenges with effecting this transition to the new energy economy. How do we inexpensively produce hydrogen from water, its most abundant source? How do we create the new infrastructure that will be needed to deliver hydrogen to consumers in a clean, affordable, safe, and convenient manner? And how do we produce small, affordable fuel cells to turn that hydrogen into electrical power?

Distributed power systems raise their own set of questions. How do we safely connect distributed generators to the electricity grid? How will those generators communicate with each other, loads, and system operators to allow integrated control and distribution of electricity? How do we integrate renewables into the new energy infrastructure? Which locations have the best resources for distributed renewable energy systems?

NREL's Center for Electric and Hydrogen Technologies and Systems is addressing these issues and helping to facilitate a smooth transition to the new energy future. In collaboration with industry, other institutes, and national laboratories, the center provides the nation with expertise in distributed power systems integration, hydrogen technologies and systems, and renewable resource evaluation.

Distributed Power Systems Integration

When effectively integrated into an electric power system, distributed energy resources can provide high-value energy, additional capacity, and various ancillary services such as voltage regulation, improvements in power quality, and emergency power.

Achieving many of these benefits requires that DER be integrated with the electric power system in a coordinated manner. For this to proceed smoothly, questions on how to interconnect the growing number and variety of distributed generators with the grid have to be resolved. These questions arise because much of the existing infrastructure and regulatory policies were developed around centralized generation and transmission and distribution systems.

The Distributed Power Systems Integration (DPSI) Team addresses these and other concerns in several ways:

Engineering and Test Development — The Electric and Hydrogen Technologies and Systems Center operates a DER test facility to support standards development and to investigate emerging complex systems integration issues. Scientists and engineers at this facility:

- Characterize, test, and evaluate DER systems to determine if they operate properly and meet interconnection, communication, and other standards.
- Develop protocols and procedures for testing and evaluating systems to ensure that they meet performance, safety, and compatibility standards
- Test advanced designs for grid-connected, stand-alone, and hybrid systems.
- Coordinate laboratory and industry testing activities.

Interconnection Standards and Codes — The wide variety of utility and state requirements has led to a patchwork of prerequisites for interconnection, resulting in technical and economic inefficiencies, interconnection delays, and unnecessary expense. In response, the DPSI team provides expertise to support a national consensus effort to create a universal interconnection standard.

Regulatory Policy Issues — Market adoption of DER technologies requires profound changes in the traditional concepts and practices of state utility and environmental regulators. At the request of the Department of Energy, the DPSI team provides state regulators, their staff, and other policy makers with the background information and research needed to inform their decisions about policy issues related to distributed generation.

Applications and Analysis — The DPSI team also conducts research on potential DER applications to address systems integration issues and benchmark integrated systems. The results of this research are analyzed to identify potential issues and opportunities.

Hydrogen Technologies and Systems

Hydrogen is the key to a smooth transition from a fossil-fuel-based energy infrastructure to one based on renewable energy resources. It can be used in fuel cells, engines, and turbines to move our vehicles and provide power and heat for our homes, offices, and industries.

The use of domestic energy resources — whether fossil fuels, renewables, or nuclear power — to produce hydrogen can reduce our dependence on imported oil, strengthening the nation's energy security. Producing hydrogen from renewables can also help reduce air pollution and greenhouse gas emissions, giving us a cleaner, healthier environment.

One of the major obstacles to expanded use of renewable energy has been the intermittency of solar and wind resources. Hydrogen is an energy carrier and storage medium that allows electricity generated from renewables to be dispatchable. The distributed power plants of the future could use renewable energy to produce and store hydrogen on site. Colocated fuel cells could then use the hydrogen to generate electricity when the wind isn't blowing or the sun isn't shining. Because fuel cells have zero emissions, this scenario is a key component of a clean energy future.

The Hydrogen Technologies and Systems Group is facilitating the transition to a hydrogen economy by contributing to several key research areas, including:

- Infrastructure development — Making the shift from the current fossil-fuel supply infrastructure to a safe and widespread hydrogen production, storage, and delivery system.
- Development of codes and standards — Establishing a market-receptive environment for commercializing hydrogen-based products and systems by ensuring the safety of hydrogen in storage and transport.
- Coordination of analysis — Ensuring consistent methodologies are applied to the analysis being conducted on hydrogen and fuel cell systems.
- Hydrogen production and utilization:
  - Developing hybrid power systems incorporating renewable energy and fuel cells.
  - Producing hydrogen from water in a one-step process using semiconductor materials.
  - Improving the materials, manufacturability, and operation of fuel cells.

Resource Integration

Renewable resources can vary considerably from one geographic location to another. Consequently, optimal siting of renewable energy systems requires knowledge of the resource characteristics at any given location.

The Resource Integration Group provides high-quality renewable resource data for U.S. and international locations. This group also:

- Provides reliable time-series resource data for thousands of locations worldwide.
- Develops manuals, maps, and other data products on renewable resources to support system design and project planning.
- Uses GIS (geographic information system) mapping to manage, manipulate, and analyze resource, socioeconomic, and environmental data sets to evaluate development options.
- Maintains a Web site with access to data on geothermal, biomass, solar, and wind resources, allowing users to obtain customized resource analyses.
- Manages the Solar Radiation Research Laboratory in Golden, Colorado, which monitors and disseminates solar radiation and other meteorological information, and serves as the U.S. center for maintaining and transferring international radiometer standards to government, industry, and academic laboratories.

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