U.S. DEPARTMENT OF
ENERGY

*Office of*
ENERGY EFFICIENCY & RENEWABLE ENERGY

# Solar Research Spotlight: Systems Integration

A worker checks an inverter at the 2MW CoServ Solar Station in Krugerville, Texas.
*Photo credit Ken Oltmann/CoServ.*

The systems integration subprogram within the Solar Energy Technologies Office supports early-stage research that advances the reliable, resilient, secure, and affordable integration of solar energy onto the U.S. electric grid. The research focuses on addressing unique challenges related to the integration of utility-scale and distributed solar, such as generation variability, power flow control, and visibility of behind-the-meter solar generation. Recent technology advances present new opportunities for holistic solar grid integration solutions that provide solar dispatchability and grid-support functions like improved grid operations, rapid detection and mitigation of grid disturbances, protections from cyber and physical risks, and power recovery during system-wide outages. The systems integration subprogram funds research and development projects in five broad, interrelated focus areas: planning and operation, solar plus X, power electronics, sensing and communication, and codes and standards.

### Solar Energy Technologies Office

The U.S. Department of Energy Solar Energy Technologies Office (SETO) supports early-stage research and development to improve the affordability, reliability, and performance of solar technologies on the grid. The office invests in innovative research efforts that securely integrate more solar energy into the grid, enhance the use and storage of solar energy, and lower solar electricity costs.

## Planning and Operation

This area focuses on understanding the impacts of increasing penetration of solar energy on grid reliability. Solutions in this area focus on mitigating impacts of solar variability, managing two-way power flow, improving grid flexibility, and enabling better planning and operation decisions when there are increasing amounts of distributed energy resources connected to the grid.

## Solar Plus X

Solar plus X refers to an integrated behind-the-meter system that consists of distributed photovoltaics (PV), energy storage, smart building load, electric vehicles, and optimized local control software, among others. This research aims to leverage the inherent flexibility of each technology and reduce the total integration and operation costs of these distributed energy resource assets. Projects focus on creating holistic designs, device improvements, standard interfaces, and other solutions that can store solar energy for on-demand dispatch and control energy loads for increased system flexibility and community resilience.

## Power Electronics

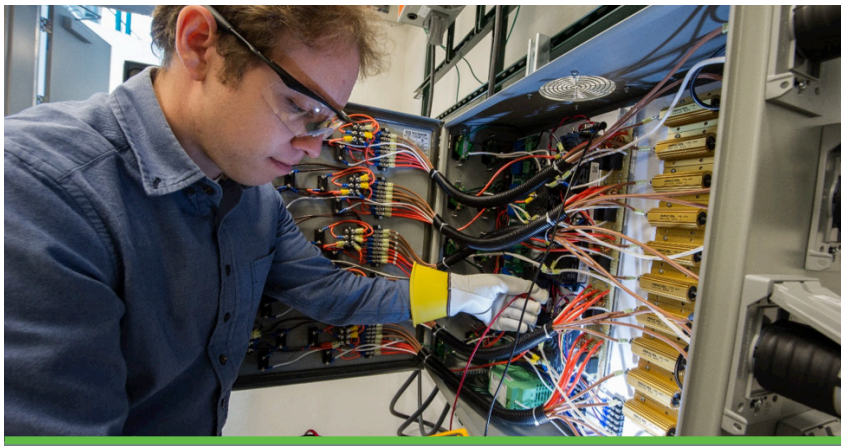
Power electronics are the critical link between a solar array and the electric grid, in terms of both physical power flow and informational exchange. Improvements to inverter design and components can lower system costs, extend service lifetimes, and increase equipment reliability. Power electronics projects also focus on improving advanced inverter functionalities that can provide coordinated power flow control, protect against cyber and physical attacks, and provide a suite of essential grid services like voltage and frequency control and power recovery.

## Sensing and Communication

As more solar and other distributed energy resources connect to the grid, sensing, communications, and advanced data analytics technologies are critical for utilities to see how much solar energy is being generated and to improve visibility of distributed energy resources. Projects focus on making planning and operation decisions easier by developing solutions that create more points of observation on the grid, improve cyber security, and enhance situational awareness for grid operators.

## Codes and Standards

Technology advances have outpaced the base codes and standards for the interconnection and interoperability of PV systems connected to the grid. Solar, storage, and load control technologies all have different requirements and the use of these technologies together demand harmonization of their respective rules. Projects feature strong industry engagement and focus on accelerating the creation and revision of technical standards and test procedures for grid connected devices and systems in a clear and organized manner.



SETO-funded researcher Brian Johnson measures electrical characteristics that emulate the characteristics of distribution lines in power systems at the National Renewable Energy Laboratory. *Photo credit NREL.*

## Current Funding Programs and Partnerships

The systems integration subprogram manages several funding efforts to address each of its focus areas and participates in the Energy Department's Grid Modernization Initiative. Current active funding programs include:

- *Power Electronics* – These projects explore hardware solutions that aim to reduce PV plant lifetime costs by half, while enhancing the capabilities for real-time PV power flow control and enabling increased amounts of solar energy on the nation's electric grid.
- *Solar Forecasting 2* – This program supports projects that enable grid operators to better forecast how much solar energy will be added to the grid in order to improve the management of solar power's variability and uncertainty and lower grid integration costs.
- *Enabling Extreme Real-time Grid Integration of Solar Energy (ENERGISE)* – This program develops distribution planning and operation solutions to enable dynamic, automated, and cost-effective management of distributed and variable generation sources, like solar, onto the grid.

Screenshot of IBM's Self-Learning Weather Modeling Forecasting Technology (SMT) tool, which provides operationally gridded forecasts for the renewable energy industry. *Photo credit IBM.*

- *Sustainable and Holistic Integration of Energy Storage and Solar PV (SHINES)* – This program develops and tests integrated PV and energy storage solutions and works to dramatically increase solar-generated electricity that can be dispatched day or night to meet consumer electricity needs.
- *SunShot National Laboratory Multiyear Partnership (SuNLaMP)* – In this program, national labs partner with the DOE solar office to conduct research and development that will enable hundreds of gigawatts of solar energy and other distributed energy resources to be integrated onto the electricity grid.
- *Grid Modernization Lab Consortium Lab Call* – This crosscutting research effort at the Energy Department aims to prepare for a modern grid and solar research focuses on safely and reliably connecting more solar systems to the grid.
- *Resilient Distribution Systems Lab Call* – This program develops and validates innovative approaches to enhance the resilience of distribution systems, including microgrids, when there are high penetrations of renewable distributed energy resources on the grid.

## Funding Opportunities

For more information on open funding opportunities, visit SETO's funding opportunities webpage: ***www.energy.gov/eere/solar/funding-opportunities***. ■

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE

**For more information, visit:** *energy.gov/eere/solar*

DOE/EE-1789 · June 2018