Systems Integration

As solar technologies provide an increasingly larger portion of the U.S. electricity supply, it is increasingly important that they be integrated seamlessly into the nation's electric power grid. This requires new ways of thinking about how we generate and distribute electricity. Specifically, it requires technologies for generation planning, interconnection, communication and control, and energy management that make it simple, safe, and reliable for solar electricity to feed into the grid. The U.S. Department of Energy (DOE) is making significant investments in these technologies to accelerate the integration of renewable energy into current systems. Research efforts, some of which are described below, include systems modeling and analysis, solar resource and safety, and grid integration of concentrating solar power and photovotaic (PV) systems.

Recognizing the Challenges

Breaking down the regulatory, technical, and economic barriers to integrating solar power into the electric grid is a priority for DOE.

These barriers are being addressed to advance the growth of distributed solar electric systems, in which energy is produced close to where it will be used. For example, interconnection standards, which historically have applied to centralized power plants, must also apply to the very different requirements of connecting many small generators to the grid. Consistent interconnection standards that make this process easy, inexpensive, and safe are important to growing a healthy solar industry.

Instituting net metering rules for measuring the energy production of smaller solar systems is also critical to market penetration of solar electricity. Technology and equipment that communicate with other systems and control real-time performance, such as advanced inverters that convert direct current to alternating current and controllers that protect electrical energy storage devices, will provide enhanced value to owners and utilities.

Credit: SunPower PIX/16607

Solar energy performance data are collected by DOE at this field location at Nellis Air Force Base in northeastern Nevada.

Other key technical issues need to be addressed within transmission and distribution systems. These include the need for advanced distribution operations such as microgrids that can operate independently of the utility power grid to allow two-way power flow into and from the utility grid. Technical issues also include the need for greater electric power system flexibility to address variations in amounts of solar electricity generated—especially under high-penetration scenarios—where energy storage that is integrated into the system can be used to manage two-way power flow. Demand management systems and net metering for residential PV systems are examples of technologies that can assimilate solar electricity with the interactive components and systems of a "smart" grid. Tackling these concerns will allow tomorrow's utilities, businesses, and consumers to maximize the value of their PV systems.

Responding to the Challenges

DOE is working closely with utilities and the solar industry to develop technologies and strategies that encourage the widespread market penetration of distributed PV systems.

Based on the results of the Renewable Systems Interconnection study published in 2008, the Solar Energy Grid Integration Systems (SEGIS) activities were initiated to develop advanced PV inverters, controllers for components and systems, and energy management systems for distributed PV systems. In addition, the SEGIS-ES (ES stands for energy storage) program draft concept paper outlines energy storage development needs for PV/grid integration applications.

To broaden and deepen stakeholder engagement in jointly planning and implementing research, development, and demonstration (RD&D) activities, the workshop "High Penetration of PV Systems into the Distribution Grid" was convened in February 2009 to identify technical barriers, high-priority RD&D activities, and performance requirements. The workshop summary is available at *http://www1.eere.energy.gov/solar/pdfs/pv_grid_penetration.pdf.*

In addition, a SEGIS-ES workshop was held in June 2009 to seek stakeholder input. A particular focus was application needs for energy storage and their associated RD&D activities to enable high penetration of PV. The workshop report will help guide DOE and RD&D activities on industry energy storage to meet high-penetration PV application needs for residential and commercial sectors.

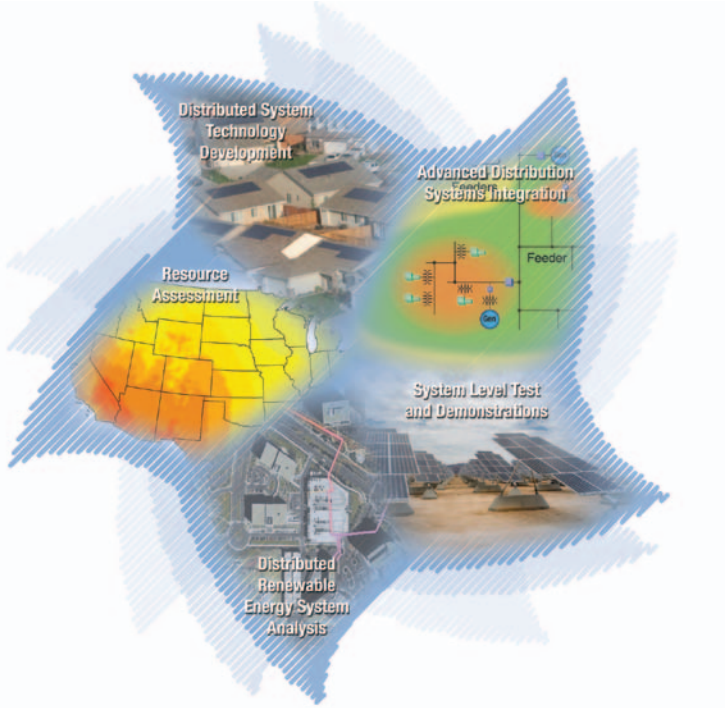
Bright Spots in SEGIS

In 2008, 12 industry teams received DOE funding awards to develop conceptual designs and market analyses for Solar Energy Grid Integration Systems (SEGIS) PV products. These products include inverters, controllers, and, in several cases, complete PV systems. The projects are developing systems that work with energy storage devices and "smart" appliances to respond to utility price signals, interact with building energy management systems, and communicate with an interactive utility grid and advanced power meters, among other functions. In 2009, five project teams were selected to progress to the second stage of prototype design and testing of innovative ideas for power conversion, control methodologies, communications, and energy management. Controls that use information flow from the utility, including cost of energy and utility needs, are being developed to optimize system value. In addition, features are being developed that address the intermittency of PV energy caused by cloud passage and grid instabilities that result from distributed sources of energy connected along the distribution system. The five project teams will advance to stage 3 in 2010 for pilot production design leading to commercialization of SEGIS products.

Investing in Projects

DOE plans to invest as much as $24 million, including funding from the American Recovery and Reinvestment Act, over three stages for SEGIS products that connect solar power systems with the electric grid in an interactive way. (See the Bright Spots in SEGIS sidebar.)

In addition, a total of $37.5 million over the next 5 years is planned for awards made through the 2009 Funding Opportunity Announcement for high-penetration PV development. This funding opportunity solicits industry-led projects to address topics in improved modeling tools, field verification of high-penetration PV use cases, modular power architecture, and demonstration of PV and energy storage for smart grids (which use digital technology to improve reliability, security, and efficiency). Collectively, these topics correspond to the high-priority needs identified in the workshop on high penetration of PV into the distribution grid.



The Systems Integration subprogram focuses on these R&D areas.

Systems Integration Projects at a Glance

DOE is supporting several systems integration projects around the country. At Nellis Air Force Base in Nevada, DOE will be collecting solar energy performance data at the 15-megawatt (MW) PV installation. In Alamosa, Colorado, performance data are collected on an 8-MW PV plant. DOE is also collecting data at the Anatolia subdivision of 91 energy-efficient homes equipped with PV systems (with an eventual reach of 600 Solar Smart homes) in Sacramento, California. And at Mesa del Sol in Albuquerque, New Mexico, data monitoring systems will collect PV performance data as this new sustainable community evolves to its capacity of 38,000 homes.

Solar Program Priorities

Systems Integration is one of four subprograms in the DOE Solar Energy Technologies Program (SETP), along with Photovoltaics, Concentrating Solar Power, and Market Transformation. The SETP subprograms focus on accelerating the advancement of solar energy technologies to make solar electricity cost competitive with conventional forms of electricity by 2015. To learn more about SETP activities, visit *www.solar.energy.gov.*

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