SuNLaMP

SUNSHOT NATIONAL LABORATORY MULTIYEAR PARTNERSHIP PROGRAM

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

BACKGROUND

The sun is a powerful source of energy, but the reliability of solar is affected by many factors, including cloud cover, weather patterns and more. This variability makes it challenging for many to count on solar power to meet their energy needs. To expand solar energy use in the United States, scientists must find an efficient and cost-effective way to combat the natural intermittency of photovoltaic (PV) power.

The U.S. Department of Energy's SunShot National Laboratory Multiyear Partnership (SuNLaMP) funding program is enabling solutions to this challenge. SuNLaMP is allowing the nation's national laboratories to conduct research and development that will permit hundreds of gigawatts of solar energy to be reliably and cost-effectively integrated onto the U.S. electric power grid.

In support of the SuNLaMP program, NETL researchers are working to develop new power electronics devices, systems and materials to address power electronic and dispatchability challenges that result from connecting large amounts of solar energy onto the electricity grid. These devices will incorporate advanced high-frequency (HF) magnetics along with the latest wide bandgap silicon carbide (SiC) switches. This design enables cost-effective grid integration of PV while increasing its dispatchability. Partners include Eaton Corp., North Carolina State University, Carnegie Mellon University and NASA's Glenn Research Center.

OVERVIEW

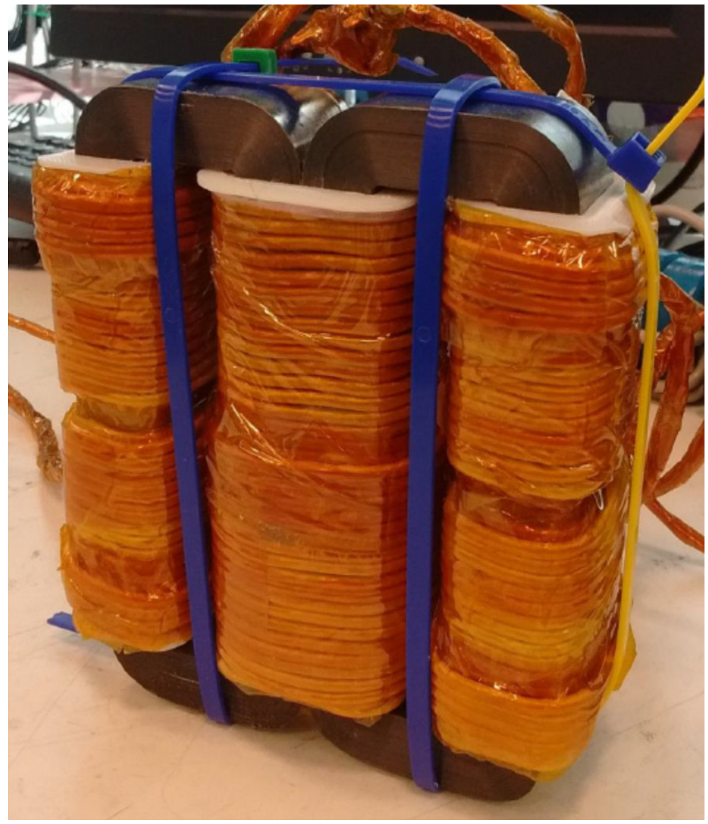
NETL's advanced research in this project will offer novel opportunities to boost efficiency, spur economic investment and reduce infrastructure as industry looks toward smaller, more efficient power technology capable of meeting the diverse demands of the modern world.

For instance, NETL researchers and their partners have designed a three-port transformer to allow a PV energy source to hook into the same transformer as an energy storage or battery device – rather than connecting each energy source to separate alternating current-coupled transformers, which then connect to the electric grid. The design of the transformers can vary, but the researchers have reconfigured the windings in a scheme that maximizes power flow and enhances flexibility. The transformers are also designed to transfer electrical energy at a higher frequency (10-50 kilohertz versus 60 hertz), which makes them smaller and substantially increases power density.

Combined PV/battery grid integration helps manage the inherent variability of solar power by storing energy during peak periods of sunlight for future use, allowing for a constant average power delivery and smoothing sudden spikes in voltage. Leveraging this unique topology with the high-frequency, three-port transformer and connecting PV and energy storage on the direct current side achieves key advantages in efficiency, power density, lifetime savings and reliability. Initial estimates suggest an increase in power density by 10 times or more for commercial-scale installations as compared to traditional technologies.

As part of this research, NETL has also advanced the development of promising new soft magnetic materials and the application of advanced processing technologies for optimizing electromagnetic components. These components feature metal amorphous nanocomposites alloy cores made with a cobalt-rich alloy system. Researchers use a specialized manufacturing process to anneal the material under tension, adjusting the strain as needed to optimize electromagnetic capability. The technology has unique advantages compared to more traditional inductive components – including improved temperature control and lower overall power losses.

A new Electromagnetic Component Fabrication and Testing Laboratory is in the works at NETL to fabricate advanced prototype components and support research on electric grid modernization, among other projects. Further development of this technology, in partnership with private-sector companies to promote commercialization, could have a major impact on the aerospace, aviation, automotive and many more industries. The advanced magnetic core technology has already enabled researchers to achieve significant milestones in a project to advance combined solar photovoltaic and battery grid integration.



High Frequency Transformer

Prototype converters up to 10 kilowatts (kW) were built using this technology and demonstrated with successful power flow, increased power density and efficiencies approaching 99 percent versus traditional efficiencies of about 94 percent. Prototype converters of 30kW and 50kW are being built and tested for demonstration in ongoing research under the project, and system-level simulations demonstrated the potential for successful operation of full-scale 1-megawatt combined solar/energy storage inverter architecture for utility-scale grid-tie inverter applications.

EXPECTED OUTCOMES

- Successful demonstration of 3-port DC-DC converter technology at commercial-scale (50kW)
- System-level studies to show feasibility of implementation at full utility scale (>1MW)
- Development of new enabling magnetics technology for the next generation of high frequency transformers
- Technology transfer of intellectual property and know-how to the private sector to promote near-term commercialization
- Successful completion of these outcomes will enable greater penetration of solar generation through simultaneously

The project's continued success will enhance the reliability of solar power systems, while also cutting costs and boosting efficiency as compared to more traditional inverters. Successful outcomes will also enable greater penetration of solar generation by reducing costs, increasing power density and increasing reliability of grid interconnection hardware while simultaneously managing the inherent variability of solar. Technological innovations like those being developed at NETL will enable more widespread commercial and residential use of solar through combined PV/energy storage integration into America's electric grid.

OTHER INFORMATION

Projects under the Systems Integration SuNLaMP funding program are part of the Energy Department's Grid Modernization Laboratory Consortium, which supports critical research and development in advanced storage systems, clean energy integration, standards and test procedures, and a number of other key grid modernization areas. This effort recognizes regional differences and will strengthen regional strategies while defining a diverse and balanced national strategy.

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