Fact Sheet: DOE Award Selections for the Research and Development of Designs for More Flexible and Adaptable Large Power Transformers (LPTs)

On November 14, 2018, the Department of Energy (DOE) announced the award of up to $7.5 million to support the research and development leading to transformers that can be shared and replaced more easily in the event of a failure, are smarter with embedded sensors and analytics, and are more secure to cyber-physical threats. Transformers are fundamental to the grid, with essentially all electricity generated and delivered through these devices. The innovative design of large power transformers (LPTs) that are more flexible and adaptable will increase the resilience of the Nation’s power grid. Funded by the Office of Electricity’s Transformer Resilience and Advanced Components (TRAC) Program and the Resilient Distribution Systems (RDS) Program, this investment builds on the Department’s ongoing efforts toward the development of technologies and capabilities that will help create a more secure and resilient electricity system.

LPTs can weigh hundreds of tons, cost millions of dollars, and are typically custom-made with procurement lead times of one year or more. Generally tailored to customer specifications, these transformers are not readily interchangeable with each other, and their high costs prohibit extensive spare inventories. In addition, many are approaching or exceeding their design lives, presenting an opportunity for next-generation transformers that can provide new capabilities needed in the grid of the future as well as reinvigorate domestic manufacturing.

Below are details about the four award recipients and the projects.

Performer: Georgia Tech Research Corporation
Partners: Delta Star Inc., Clemson University, Oak Ridge National Laboratory, Southern Company
Title: Demonstration of a 5 MVA Modular Controllable Transformer (MCT) for a Resilient and Controllable Grid
Amount: $1,798,315 (Fed) + $449,864 (Cost Share) = $ 2,248,179 (Total)
Summary: The project team will design, build and test a 5 MVA 24 kV/12 kV modular controllable transformer (MCT) and demonstrate its functionality, which includes modularity, interoperability through variable impedance and connection of multiple voltage levels, power flow control, storage integration, and fail-normal design. The transformer specifications will include voltage/impedance/angle control range, dimensions, manufacturing, weight, installation and commissioning, testing, fault current levels, basic insulation level, and operation under various types of corner cases (i.e., outside of normal operating parameters). At the same time, a detailed design of the 3-level neutral-point-clamped BTB converter will be done and include factors such as start-up, shut-down, normal operation, and operation under system and converter faults. The unit will also be extensively tested to give designers and customers validation of the design and provide a comfort level for deployment of MCTs for a future field-test. In addition, working with utility partners, specific use cases and scenarios will be developed to assess the impact and penetration level of the proposed MCT and evaluate cost-effectiveness compared to traditional LPTs.

Performer: The University of Texas at Austin
Partners: Temple University, Argonne National Laboratory, United Technology Research Center, Control Transformer, Siemens
Title: Modular Hybrid Solid State Transformer (H-SST) For Next Generation Flexible and Adaptable Large Power Transformer (LPT)
Amount: $1,730,824 (Fed) + $433,110 (Cost Share) = $ 2,163,934 (Total)
Summary: The project team will design and test a 500 kVA Hybrid Solid State Transformer (H-SST) as a full-scale building block for next generation flexible and adaptable LPTs. The selected power level and voltage level of the H-SST is suitable for constructing 138 kV LPTs with an output voltage of 4 kV, 35 kV, 69 kV, or 115 kV. The project team plans to demonstrate an efficiency of more than 98% in the H-SST, as well as additional functionalities in the H-SST including but not limited to voltage regulation, power flow control, and advanced protection. The project team will also develop and validate a model of the H-SST to enable the simulation of LPTs at various voltage and power levels. Advanced sensor technology will be used to collect data from the H-SST to monitor the health status of the H-SST and enable its long-term reliability.

Performer: NextWatt LLC
Partners: Silicon Power Corporation, University of Arkansas, University of Illinois at Chicago, Arkansas Electric Cooperative Corporation, Con Edison
Title: Next-Generation Modular Flexible Low-Cost SiC-based High-Frequency-Link Transformer
Amount: $1,499,976 (Fed) + $374,932 (Cost Share) = $1,874,908 (Total)
Summary: The project team will design, fabricate, and test a SiC high-frequency-link large power transformer (HFL-LPT) three-phase module for a 100-MVA 115 kV HFL-LPT design with energy-conversion efficiency of 99%, a large reduction in both volume and weight with regard to conventional low-frequency large power transformer (LF LPT), and with up to 50% reduction in number of devices compared to state of the art solid-state-transformer topology. This project will explore and demonstrate mechanisms for voltage, power, and frequency scalabilities using the proposed modular HFL-LPT and a modular power control approach with limited communication among the modules. The project will also investigate mechanisms for voltage and active/reactive compensation, protection, and overloading.

Performer: General Electric Company
Partners: Prolec GE
Title: Design, Deployment, and Characterization of the World's First Flexible Large Power Transformer
Amount: $2,375,923 (Fed) + $593,981 (Cost Share) = $2,969,904 (Total)
Summary: The project team will design, build, and test a prototype of a flexible large power transformer (LPT) to demonstrate the feasibility of the concept and its performance in operation. The prototype will be 60 MVA installed in a 230 kV substation for field demonstration. The key contributions in this project include: 1) addition of online adjustable leakage impedance, 2) field demonstration in a high voltage substation to demonstrate manufacturing feasibility, compliance to industry requirements and standards, and performance in real time operation, 3) development of an augmented transformer management relay to ensure the protection of flexible transformer with adjustable impedance, 4) validation of a new insulating fluid to further optimize the size and footprint of the flexible transformer, and 5) development of novel multivariable gas sensors for advanced dissolved gas analysis (DGA). The transformer will be exposed in a real-world environment for performance comparison with conventional transformers.