Transformer Resilience and Advanced Components (TRAC) Program Laboratory Call

Office of Electricity (OE)

The Department of Energy's (DOE's) National Energy Technology Laboratory (NETL) on behalf of the Office of Electricity (OE) is seeking proposals under this Research Call (RC) to conduct research, development, and demonstrations (RD&D) for grid components in accordance with the TRAC Program Vision and Framework[1], and the Power Electronics Accelerator Consortium for Electrification (PACE)[2].

Partnerships with the national laboratories, manufacturers, electric utilities, and academia have helped OE advance RD&D efforts over the years. Although not required, applicants are encouraged to partner with the private sector and/or academia on proposals.

DOE anticipates several awards of varying sizes up to $1,200,000 per award. Estimated total available funding up to $16,000,000.

Topic Area 1 – Component Design and Development: up to $1,200,000 per award
Topic Area 2 – Market and System Impact Analysis: up to $800,000 per award
Topic Area 3 – Advanced Materials: up to $750,000 per award

DOE anticipates making awards with an estimated project period not to exceed three (3) years. The DOE reserves the right to set the expected period of performance to meet DOE's objectives.

Introduction

The U.S. electric power system consists of an extensive infrastructure of more than 22,000 generators; 55,000 substations; 642,000 miles of high-voltage lines; and 6.3 million miles of distribution lines that serve 153 million customers[3]. To date, much of the "smart grid" transformation has focused on applying advanced digital information and communication technologies (ICT) to the power grid to improve system reliability, resiliency, efficiency, flexibility, and security. To realize the full potential of a modernized grid, advances in the grid's physical hardware are also needed. Next-generation grid components can improve the performance and lifetimes over current designs, simplify integration of advanced technologies, and provide new capabilities required for the future grid.

Transformers, power lines, and other substation equipment (i.e., grid hardware components) are often exposed to the elements and are vulnerable to an increasing number of natural and man-made threats. To ensure a reliable and resilient electric power system, next-generation grid components need to be designed and built to better withstand and rapidly recover from the impact of lightning strikes, extreme

[1] trac-program-vision-and-framework
[2] Power Electronics Accelerator Consortium for Electrification | ORNL
[3] Electric Grid Supply Chain Fact Sheet.pdf (energy.gov)

terrestrial or space weather events, electrical disturbances, accidents, equipment failures, deliberate attacks, and other unknowns. Failure of key components can lead to widespread outages and long recovery times.

TRAC Program Priorities

The TRAC program is focused on enhancing and advancing the components and technologies that make up the electric power T&D infrastructure (i.e., grid hardware). These assets are physically responsible for carrying and controlling the electrons that deliver electric power within the electric power system. Specific technologies include, but are not limited to transformers, cables and conductors, power flow and voltage controllers, protection equipment and switchgear, and equipment sensors. To realize the full potential of transforming to the grid of the future, these hardware components will need to evolve by leveraging innovative designs, new materials, and embedded intelligence.

While advances in communication and control systems, cybersecurity, and energy storage are all critical to grid modernization, these technologies and tools are not directly addressed within the TRAC program; they are covered under other U.S. DOE R&D programs. However, the evolution of these technologies, their impact on existing equipment, and their integration with T&D components is considered and will influence TRAC program activities. For example, research of advanced transformers and their integration with energy storage systems are within the scope of the TRAC program, but the research of the energy storage system itself is not. Furthermore, cybersecurity requirements will be incorporated into the R&D of next-generation T&D components, but the advancement of cybersecurity solutions for networked systems by itself will not be pursued under the TRAC program.

Topics of Interest

Topic Area 1 – Component Design and Development

This topic area is focused on the design and development of next generation grid components, including but not limited to advanced transformers, advanced power electronics, and high voltage direct current (HVDC) transmission, to meet the functionality, cost and performance targets, and resilience needed for the future grid -- a seamless, cost-effective electricity system, from generation to end-use, capable of meeting all clean energy demands and capacity requirements.

Technologies of interest and key objectives are shown in Table 1. It is important to note that technologies of interest are not limited to those shown Table 1.

Table 1: Topic area 1 key technologies and objectives

Technologies	Objectives
Advanced Transformers	• Flexible and adaptable designs that promote interchangeability, greater standardization, and can help alleviate transformer supply chain challenges.

Technologies	Objectives
	• High-efficiency, long-lifetime, and modular prototypes/designs that can facilitate replacement of existing transformers. • More efficient designs that incorporate additional functionalities, including the use of power electronics • Novel converter topologies with efficient thermal management to expand Solid State Transformer (SST) functionalities and further advance SST technologies towards the long-term goal of SSTs with 2x the power density of conventional units, and the costs (e.g., $25–$35 per kVA) and reliability comparable to conventional units • Innovations in components and support systems (e.g., bushings, cooling systems), and advanced health monitoring technologies that can improve reliability and extend transformer lifetime.
Direct Current (DC) Circuit Breakers	• R&D activities that support advancing HVDC circuit breakers to enable higher voltage and power for Voltage Source Converter (VSC)-based Multi Terminal DC (MTDC). • R&D of innovative and modular DC breaker topologies that can enhance reliability, current breaking capability, and speed of operation.
Power Flow Controllers (PFCs)	• RD&D activities that support advancing, as well as wider industry acceptance, adoption, and the deployment of PFCs.
Medium-Voltage Direct Current (MVDC) and/or High Voltage Direct Current (HVDC)	• R&D that supports reducing HVDC converter station costs 35% by 2035 in accordance with DOE's HVDC Cost Reduction (CORE) initiative[4] • R&D that supports at least one of the following: (1) increasing DC converter station power capacity, (2) increasing the voltage limits of VSC DC stations, (3) increasing DC converter station power density, (4) decreasing DC converter station footprint, and (5) increasing component reliability
Solid State Power Substations (SSPS)	• Research, development, characterization, and demonstration of MV SSPS modules and converters with advanced components, and enhanced reliability. • Research, and design of modular components and substation infrastructure that can be connected to form in any bus configuration allowing for rapid replacement.
WBG Semiconductor Devices	• Devices beyond 1.7 kV and up to 10 kV are available as R&D prototypes but challenges with manufacturing yields, wafer size, and process reliability persist • Higher voltage (> 6.5 kV) WBG devices are maturing, however they lack the high current carrying capability needed for high power

[4] HVDC COst REduction (CORE) Initiative | Department of Energy

Technologies	Objectives
	(MW) applications. While modules can be scaled for higher currents with more devices, challenges remain with thermal management, packaging, and reliability.
Sulfur Hexafluoride (SF6) Alternatives	• R&D to advance safe and effective alternatives to SF6 in transmission equipment above 72 kV, including in circuit breakers, reclosers, sectionalizers, load break switches, switchgear and gas insulated lines.

Topic Area 2 – Market and System Impact Analysis

The Market and System Impact analysis under TRAC is focused on advancing modeling tools, simulation capabilities, and conducting system modeling and analysis to improve the understanding of the barriers, supply chain considerations, costs, benefits, and impacts of deploying next-generation grid component technologies, including interactions between power electronic converters, novel controls and operating methods.

Activities include improved new component models, advancing design tools for next-generation components, and conducting system studies and scenario analyses. These activities will advance capabilities to analyze the technical, economic, and risk implications of deploying advanced hardware technologies (e.g., HVDC, advanced transformers, SSPS).

Topics/Technologies of interest include, but are not limited to:

- Dynamic and stability analysis
- Production cost modeling
- Techno-economic analysis of grid components
- Analysis to inform standards development

Topic Area 3 – Advanced Materials

Materials and their physical properties are fundamental to the performance of all T&D grid components. This topic area is focused on overcoming the limitations imposed by existing materials. Some new functions and enhancements possible with advanced materials include self-healing capabilities, added strength, increased lifetimes, smaller sizes, lighter weight, higher power density, and environmental sustainability. In addition, materials that can mitigate supply chain risks, now and in the future, are of interest in this topic area. Below are some TRAC Program goals for material performance metrics. Technologies of interest and key objectives are shown in Table 2. It is important to note that technologies of interest are not limited to those shown Table 2.

Table 2. Topic Area 3 Technologies of interest and key objectives[5]

Technologies	Objectives
Dielectrics and Insulators	• Dielectric strength of > 120 kV per centimeter (kV/cm) at the same price as conventional materials • Dielectric loss angle (tan delta) of < 0.05% at 60 hertz (Hz) at upper limit of operating conditions • Enhanced material properties remain stable over useful life of assets (e.g., 20–40 years) • Withstand temperatures >130°C in continuous operation, >180°C in emergency situations
Magnetics	• 50% reduction in energy losses for line frequency transformers compared to silicon steel at the same flux density • 50% reduction in eddy current losses for high power (kilowatts to megawatts), high frequency (10–100 kilohertz (kHz)) transformers compared to state-of-the art materials • Costs comparable to materials used today • R&D of Grain Oriented Electrical Steel (GOES) alternatives that show improved ductility and magnetic properties while maintaining cost parity with currently available GOES.
Cables and Conductors	• Electric conductivity 50% better compared to copper or aluminum • Mechanical strength and thermal conductivity 25% better compared to copper or aluminum • Costs comparable to copper or aluminum
Semiconductor Materials	• Packaged diodes and transistors that cost <$0.10/amp at 1,200 volts (V) • Packaged diodes and transistors that can block >5 kV and carry >20 amps (A) • Packaged transistors with switching frequencies up to 100 kHz and low losses

Evaluation of Proposals

OE will evaluate proposals internally according to the following criteria:

CRITERION 1: TECHNICAL MERIT AND INNOVATION (40%) This criterion will evaluate the proposed project's technical merit, innovation, and feasibility in comparison to contemporary technology, along

[5] trac-program-vision-and-framework

with the effectiveness of the proposal in addressing the technical requirements specified in the Laboratory Call.

CRITERION 2: SIGNIFICANCE AND IMPACT (40%) This criterion will evaluate the significance of implementation of the proposed technical concept/project and associated timeline, with respect to grid component operational efficiency, reliability, cost-effectiveness, resiliency, and supply chain risk mitigation.

CRITERION 3: PROJECT EXECUTION AND MANAGEMENT APPROACH (10%) This criterion will evaluate the adequacy, appropriateness, and reasonableness of the proposed project management and risk strategies to achieve the stated goals and DOE's mission objectives.

CRITERION 4: TEAM AND RESOURCES (10%) This criterion will evaluate the likelihood that the identified project team, facilities, and other resources are appropriate and sufficient to achieve the project's proposed goals and objectives.

Eligible Applicants

Only DOE sponsored National Laboratories are eligible to apply for funding as a Prime awardee. DOE-National Laboratories may also be proposed as a project team member. All DOE-National Laboratories will be direct funded from DOE Headquarters.

Entities from the private sector and/or academia are allowed to be a subrecipient of these awards, however, the Prime awardee needs to account for at least 51% of the project costs.

Submission Process

Labs must provide no more than a 2-page letter of intent (LOI) detailing the basic concepts, the proposed solutions and basic project structure, including key partners and requested funding, and how the project contributes to the strategic references listed. No more than 10 LOI submissions should be made from a single lab.

Following LOI submissions and a responsiveness evaluation, submissions that have been deemed responsive will be invited to submit a full application and presentation. Full applications will consist of the Project Management Plan (PMP) and presentation template. These templates will be provided in the invitation to submit a full proposal. Selections will be made following the presentations. The selected projects will submit statements of work during negotiations leading to award.

ALL letters of intent submitted in response to this Laboratory Call must be submitted to TRACLabCallFY25@netl.doe.gov All submissions must be in accordance with the included template documents associated with this lab call.

Government Right to Reject or Negotiate

DOE reserves the right, without qualification, to reject any or all proposals received in response to this Laboratory Call and to select any proposal, in whole or in part, as a basis for negotiation and/or award.

Estimated Timeline

Research Call Issue Date:	**09/12/2024**
Submission Deadline for Letters of Intent:	**10/24/2024 at 03:00 PM ET**
Letter of Intent Notification to Proceed	**11/05/2024**
Full Proposal Submission Deadline - by invitation only:	**01/08/2025 at 03:00 PM ET**
Full Proposal Presentations	**01/13/2025 - 01/17/2025**
Expected Date for Selection Notifications:	**02/03/2025**
Expected Date for Award:	**03/03/2025**

Questions and Comments

Questions or comments on this opportunity should be directed to the TRACLabCallFY25@netl.doe.gov