Attachment A

Specific INL Research Areas of Interest

CSVFP offers subcategories for some specific INL research areas of interest. Selecting from this list is completely optional but highly encouraged if one aligns well with your goals. Applications only listing a general CAES focus area or including an INL research area of interest will be equally evaluated.

Nuclear Energy

Synthesis and Characterization of Multi-Principal Component Element Alloys (MPEA) for Nuclear Fuels

The Nuclear Materials Discovery and Qualification Initiative (NMDQi) is a program launched in 2020 to address the need for development of new nuclear materials on shorter timelines. The NMDQi has a goal to accelerate nuclear materials qualification to fulfill the promises of early and advanced reactor technologies as a safe, clean, and low-cost baseload energy. Materials development and qualification in the nuclear industry is by definition challenging due to stringent safety requirements, limited availability of specialized facilities for materials irradiation and testing, and the challenging high-temperature, high-radiation environment. Focus will be on generating tools and capabilities that integrate experimental and computational techniques, allowing materials to be selected prior to fabrication, and providing crucial data to improve upon modeling.

Multi-principal component element alloys (MPEAs) are a major evolution in alloy design strategy and a focus area for the NMDQi. This strategy is intended to promote new "base" element compositions or otherwise achieve material properties that are inaccessible with current alloys. Unlike traditional alloy development, MPEAs contain five or more elements in nearly equimolar amounts to promote solid solution phase formation (single or multiple phases) resulting in an enormous design space of alloy compositions. As traditional approaches to alloy design and testing are too intensive to perform for MPEAs, a different strategy is required for rapid and cost-effective alloy development. The NMDQi seeks proposals for combinatorial MPEA alloy synthesis, characterization, and optimization techniques for nuclear fuel. Additionally, NMDQi seeks structural alloys to tailor the thermal conductivity of MPEAs invoking atomistic physics, mesoscale physics, or both. The intended focus is primarily experimental in nature, but computational or theoretical approaches that aid in the experimental portion will be considered.

Innovation in Fission Battery Development and Deployment

The vision of the Fission Battery Initiative is to develop technologies to achieve greatly simplified, safe, secure, and affordable operation of reactors that function like batteries (i.e., plug and play) to enable flexibility to support expanded market applications and markets for the nuclear energy. A fission battery is a microreactor with the extraordinary characteristics of being economical, standardized, easily installed, unattended, and reliable.

The Fission Battery Initiative seeks proposals that develop innovative strategies for:

1. Reducing the overall life-cycle cost of the technology including costs associated with manufacturing, transportation, deployment, operation, replacement, and decommissioning.
2. Increasing reliability, resiliency, site independence, and autonomous operation.

3. Developing standardized reactor technologies that are fully factory manufactured, assembled, and transported in large volume nationally and internationally.
4. Designing a remote monitoring center with intelligent decision-making capabilities with minimal human intervention.

Cybersecurity

Securing Photovoltaic (PV) Systems

Increasing penetration of PV devices expands the cyber-attack surface and demands stringent requirements to establish highly secured communications. In this context, the current and previous DOE and NSF funded projects on cybersecurity for distributed energy resources (DER) have been focused but limited to the adoption of conventional device-centric and protocol-centric cybersecurity properties for securing DER devices integrated to the grid. These methodologies may fail to provide adequate cybersecurity as the number of DER devices increase in the grid operation. Our project goal is to significantly advance the existing device-centric/protocol-centric cybersecurity of DERs to network-and-control-system-centric cybersecurity including attack-resiliency and self-healing properties. Development of such data-driven attack-resilient systems using cloud platform is first-of-its-kind cybersecurity technology for the PV systems in energy critical infrastructure while simultaneously enhancing systems reliability, security, and resiliency.

5G Security through Artificial Intelligence/Machine Learning (AI/ML)

5G (the 5th generation of the cellular networks) are being trialed for worldwide deployment. 5G will not only transform wireless communications; but will improve economies and quality of life through its key capabilities of Ultra-Reliable Low Latency (URLLC) and massive Machine-Type Communications (mMTC) along with increasing cellular data rates by at least 10 times.

Attacks on 5G networks are going to happen through Zero-Day vulnerabilities – the ones that are not yet discovered and mitigated. The INL Wireless Security Institute (WSI) intends to “prove the principle” that detection and collection of relevant data for “data forensics” of these attacks are possible by utilizing the advancement of the AI/ML techniques. If successful, these novel methods can be used towards protecting the critical infrastructure including the national power grid.

Innovative Energy Systems

Hybrid Sulfur Cycle

Concepts relating to integrated energy systems focusing on the hybrid sulfur cycle for hydrogen production. The hybrid sulfur cycle uses high temperature heat from an advanced nuclear reactor and a low voltage electrolysis step for hydrogen evolution.

Coordinated Buildings

Concepts relating to innovative energy systems that involve and coordinate buildings, solar and heat (PV, concentrated solar power [CSP], combined heat and power [CHP]), EV, and fuel cells/electrolyzers to provide grid services and be able to island as a microgrid during power system outages to improve the grid reliability and resilience.