Topic areas for U.S. University-led R&D Projects and NSUF Access with R&D (NSUF-1) Projects

TOPIC AREA 1 - REACTOR DEVELOPMENT AND PLANT OPTIMIZATION

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000; NEST ELIGIBLE, SEE PART VIII, SECTION K)

Advanced reactor concepts have the potential to offer significant benefits, including lower costs, enhanced safety and security, greater resource utilization, and simplified operations. NE performs research and development (R&D) to support a range of advanced reactor concepts, including high temperature gas-cooled reactors (HTGRs), sodium-cooled fast reactors (SFRs), molten salt reactors (MSRs), microreactors, and other concepts. Proposals are being sought for activities that could help reduce the technical risks associated with these designs. Some potential challenges that could be addressed include, but are not limited to, advanced reactor component development and testing; advanced reactor transient and safety analysis, including experiments for software validation; innovative solutions to material and operational challenges presented by molten salts (as distinct from fuel development described in Topic Area 5); core and system design optimization or modifications; characterization of system changes over time, such as to the reflector geometry in pebble-bed reactors; optimization of fueling strategies; and materials surveillance during reactor operations.

Additionally of interest are advances in reactor development, design, and testing that improve technical, cost, safety, and security metrics associated with advanced reactor technologies across a broad range of sizes, coolants, fuels, neutron spectra, and applications. NE is also interested in research related to plant optimization including, but not limited to, siting; economics; construction and scheduling outcomes; reducing cost and deployment timelines; remote deployment of reactors; environmental justice and equity considerations; secure operations; and other relevant topics of interest. Activities related to non-traditional and non-electric applications for nuclear energy are also of interest including the development and testing of hardware supporting the integration of nuclear reactors with process heat applications such as pyrolysis, hydrothermal liquefaction, or CO_2 separation and purification, including intermediate heat exchangers and thermal transport components required for interfacing nuclear reactors.

Proposals should clearly identify the challenge being addressed and how proposed activities will advance the development, demonstration, and future deployment of advanced reactor concepts.

TOPIC AREA 2 – EXISTING PLANT OPTIMIZATION

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

The United States benefits from the largest existing fleet of nuclear reactors in the world. Maintaining access to the carbon-free energy supplied by our current fleet of nuclear reactors is essential to reducing carbon emissions. To support this goal, NE is seeking proposals for research projects to develop technologies or other solutions to significantly reduce operating costs, improve economic competitiveness of existing plants, and extend plant operational lifetimes.

Reduced operating costs could arise from innovation in areas including, but not limited to, implementation of human-factors-informed digital technologies, risk-informed reductions in security conservatism, and plant asset management. Meanwhile, research underpinning the scientific bases for reactor power uprates and reactor restarts also have the potential to increase the clean power capacity of our nation's electric grid. Similarly, understanding the aging of structures, systems, and components (SSCs), have the potential to optimize and extend the safe, cost-effective operational lifetimes of existing reactors.

Successful proposals in this topic area will pioneer discoveries, methods, and solutions that bolster the economic and technical sustainability of the current fleet of nuclear reactors.

Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

TOPIC AREA 3 – NUCLEAR FUEL RECYCLE TECHNOLOGIES

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

Deployment of advanced nuclear reactors will inevitably introduce new challenges for devising and implementing an efficient, safe, secure, and economical nuclear fuel cycle that meets society's need for clean energy and expectations for environmental stewardship. Innovative technologies and processes for the recovery, recycle and reuse of valuable components from used nuclear fuel such as uranium, transuranic elements, noble metals and cladding, including development of transmutation targets to destroy long lived isotopes, will enable sustainable nuclear energy development.

NE seeks proposals for R&D on advanced fuel recycle technologies that have the potential to improve resource utilization and energy generation, reduce long-term radiotoxicity, reduce waste generation, and incorporate the highest standards of safety and security. Specific emphasis is on:

- Developing advanced fuel recycling technologies for used fuel from existing and advanced reactors and
- Addressing fundamental materials separations and recovery challenges that present significant degrees of technical risks and financial uncertainties.

Areas for emerging technologies and future research directions are described in the following workshop reports: (1) Innovative Separations R&D Needs for Advanced Fuel Cycles (https://info.ornl.gov/sites/publications/Files/Pub172641.pdf),
and (2) Technology and Applied R&D Needs for Molten Salt Chemistry (https://www.ornl.gov/sites/default/files/Molten%20Salt%20Workshop_Final_092917.pdf).

TOPIC AREA 4 – FUELS

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

NE has cooperated with U.S. fuel suppliers to develop accident tolerant fuel (ATF) concepts with significant support from the U.S national laboratories and universities. Near-term concepts include coated zirconium cladding and doped UO2 pellets. Longer term concepts include iron-chromium-aluminum cladding, silicon carbide composite cladding, and high uranium density fuels. Proposals are sought, but not limited to, areas that can contribute to enhancing LWR safety and performance, including potential applications of ATF concepts to next generation Small Modular Reactors (SMRs).

Silicon Carbide fuel cladding is being studied as part of the ATF Program in order to provide robust safety performance for high temperature thermal hydraulic transient conditions. Proposals are sought for activities that enable the goal of licensing silicon carbide cladding for operating in light water reactors (LWR) and helium-cooled fast and thermal reactors. Potential focus areas could include, but are not limited to, non-destructive evaluation methods, quality assurance characterization techniques, and advances in silicon carbide fuel cladding fabrication methods.

TRISO-particle fuel has demonstrated robust safety performance for high temperature applications. Numerous U.S. companies are pursuing the use of TRISO fuel in their advanced high temperature reactor concepts. Proposals are sought for activities that enable the goal of licensing and operating nuclear reactors that utilize TRISO fuel. Potential focus areas could include, but are not limited to, a comprehensive understanding of fuel and fuel matrix properties under irradiated conditions; addressing unique challenges associated with the use of TRISO fuel in non-typical (i.e., non-helium) environments; and activities to evaluate or develop novel TRISO-fuel forms, including new fuel kernel compositions.

Metallic fuels for advanced reactors can operate in open or closed fuel cycles. Both open and closed metal fuel cycle applications place a high priority on manufacturability, economics, safety, and resource utilization. Proposals are sought, but not limited to, research that will develop and evaluate new or already proposed metallic fuel innovations. Bond-free metallic fuel concepts have led towards annular fuel concepts which introduce very different irradiation behavior and add additional challenges in the manufacturing and assembly process. Ideally, results will support modeling of metallic fuel performance.

Molten salt fuels are liquid fuels used in several molten salt reactor (MSR) concepts in which the fissile material is dissolved in a molten fluoride or molten chloride solution. Typically, the molten salt fuel also serves as the MSR primary coolant/heat transfer media. There continues to be a need to support the design and optimization of MSRs by characterizing and modeling the thermophysical and thermochemical properties of molten salt solutions as well as the atomic level structure and chemistry of potential molten salt fuels as a function of composition. Molten salt fuel R&D under this topic area also needs to be expanded to address the process chemistry and technology needs and gaps of entire molten salt entire fuel cycle. In 2023 a workshop was held at Argonne National Laboratory on the MSR Fuel Cycle Chemistry R&D needs. The Molten Salt Reactor Fuel Cycle Chemistry Workshop Report*

TOPIC AREA 4 – FUELS (ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)
summarizes the current state of the art and identifies R&D needs under the following nine headings: 1)conversion of fuel sources to salt; 2)fresh fuel salt purification; 3)scale-up of fuel synthesis, packaging and delivery; 4)fuel salt characterization and qualification; 5)technologies for recovering actinides; 6)used salt purification for recycle; 7)recovery and transmutation of long-lived isotopes; 8)noble metal and insoluble fission product recovery; and 9)safeguards approaches for liquid fuels and fuel cycle facilities. *https://publications.anl.gov/anlpubs/2024/02/187645.pdf Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

TOPIC AREA 5 – DISPOSAL RESEARCH

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

The Disposal Research area seeks to develop a sound technical basis for multiple viable disposal options, identify and research sources of uncertainty that challenge the viability of disposal concepts, increase confidence in robustness of disposal concepts to site-specific complexity, and develop the science and engineering tools required to address these needs. The areas of highest priority for disposal research are described in the following document: Sevougian, et al. 2019, 'DOE SFWST Campaign R&D Roadmap Update Rev. 1' SAND2019-9033R, which can be found at https://www.osti.gov/biblio/1559571. Topics of interest could include, but are not limited to, the following topics.

1. **Improving THMC Modeling through Improving Interfaces between Various Model Scales**

Over the past several years, process models for various performance aspects of waste form, canister materials, and back fill behavior under the Thermal-Hydrological-Mechanical-Chemical (THMC) conditions expected in a repository have been developed for spent fuel. Individually, these models have been developed at nano, molecular, micro or macro scales. Incorporating these diverse model scales into a system model becomes challenging, and can result in significant computation run times, instabilities, and convergence issues. Approaches to address these issues, including developing high-fidelity surrogate models employing machine learning (ML) and artificial Intelligence (AI) techniques, are being sought.

2. **Improving Geologic Characterization through Field Tests**

The Spent Fuel and Waste Science and Technology (SFWST) program has developed geologic mapping and cross-section structural data for the continental United States (see https://gis.inl.gov/regionalgeology/). Scientific methodologies are being sought for both laboratory and field evaluation of the performance of geological features and processes. This would include development of pertinent sensor technologies, as well as computational or experimental methodologies.

3. **Improving PA Models through Improved Uncertainty Quantification**

The long-term disposal of high-level nuclear waste may exceed conventional human timescales (e.g., one million years.) The high-level waste components, particularly long-lived radionuclides that contribute to dose to the accessible environment, are important when considering the performance of a repository. A repository may rely on an approach to isolate waste by using multiple engineered and natural barriers, with various uncertainties inherent in the performance of the barriers. Over the past several years, uncertainty quantification has been incorporated into system performance assessment models. Further evaluation and development of uncertainty quantification methodology is solicited, including approaches that enable higher fidelity performance assessments.

Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

TOPIC AREA 6 – STORAGE AND TRANSPORTATION RESEARCH

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

Spent nuclear fuel (SNF) will continue to be stored, until a determination on final disposition is made, in welded steel canisters. The SNF canisters are typically fabricated from 5/8-inch thick (Type 304 or 316) stainless steel and stored either vertically, in concrete casks, or horizontally, in concrete modules. The U.S. Nuclear Regulatory Commission has identified key safety functional areas for SNF storage, including retrievability, thermal performance, confinement, radiation protection, and subcriticality. It is important to demonstrate that these safety functions are met during extended storage and after transportation. The areas of highest priority for storage and transportation are described in the following document: Teague et al. 2019, 'Gap Analysis to Guide DOE R&D in Supporting Extended Storage and Transportation of Spent Nuclear Fuel: An FY2019 Assessment', SAND2019- 15479R, which can be found at https://www.osti.gov/servlets/purl/1592862. Topics of interest could include, but are not limited to, the following topics.

1. **3D Imaging of SNF Canister Internals**
   There is a requirement to maintain configuration control of the SNF canister internals to prevent criticality and to facilitate retrieving the contents for possible future reasons. There are several 3-D imaging technologies used in other applications that could possibly be adapted to imaging the interior on an SNF canister to determine the condition and location of the fuel, cladding, and hardware. There is an opportunity for a research project to develop an imaging technology to enhance the accuracy, precision, and speed of the 3-D rendering.

2. **Canister Fill – geometric stability, moderator exclusion, neutron poisoning**
   There is a potential in some of the older SNF canisters that were designed for storage- and/or transportation-only for the neutron poisons to be insufficient to prevent criticality during the life of the repository under all probable circumstances, including accident scenarios and water ingress. There is an opportunity for a research project to develop a technology that provides the necessary geometric stability, moderator exclusion, and neutron absorbing/poisoning for the fuel, assemblies, and internals of such canisters, by introducing a material that performs these functions with minimal damage to the canister. The material could be solid beads, solid foam, liquid, or gas, which could be injected through existing vent and drain valves, drilled holes, hot tap valves, or other resealable opening; the process must introduce minimal heat and vibration. Total fill is not essential, only enough to prevent criticality under the circumstances listed above.

3. Structural Health Monitoring of the SNF Canister Wall
The SNF canister structure is the primary containment boundary for the radioactive contents of the canister, so it's important to monitor the structural health of the canister walls. Chlorine induced stress corrosion cracking in the longitudinal fabrication welds and heat affected zones is a postulated mechanism for breaching the canister walls. Therefore, there is an opportunity for a research project to develop a structural health monitoring (SHM) technology that can

TOPIC AREA 6 – STORAGE AND TRANSPORTATION RESEARCH

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

detect the existence of such cracks, including their initiation or propagation, in the SNF canister while inside its dry storage cask or module.

4. Novel Materials and/or Manufacturing Methods for Impact Limiters
Spent nuclear fuel (SNF) and high-level radioactive waste (HLW) are commonly transported in the US in Type B packages that are right cylinders with impact limiters on either end to protect the package and its contents in the event of a transport accident. Impact limiters consist of a metal shell filled with energy-absorbing materials, including plastic foams and metal honeycombs. During an accident, impact limiters function by being crushed and absorbing impact forces. The materials encased in the shell are therefore crucial for the proper function of impact limiters. Furthering the NE mission to advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs, research and development on novel materials and/or manufacturing methods to be used as Type B impact limiters are sought. NE is particularly interested in research projects supporting the efficient and cost-effective fabrication of impact limiters that 1) meet U.S. Nuclear Regulatory Commission certification requirements in 10 CFR Part 71, and 2) use manufactured materials (and not natural materials, such as wood).

Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

TOPIC AREA 7 – PUBLIC PERCEPTIONS OF AN INTEGRATED WASTE MANAGEMENT SYSTEM (ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)
The DOE Office of Nuclear Energy's Office of Integrated Waste Management (IWM) is preparing to construct one or more federal interim storage facilities (CISF), sited using a consent-based process, ready to receive commercial spent nuclear fuel (SNF) as soon as practicable. A consent-based siting process prioritizes the well-being and needs of people and communities, centers upon equity and environmental justice, and is collaborative, phased, and adaptive. The siting and operations of the facility or facilities will involve extensive meaningful public engagement, broad participation, planning, emergency responder training, and more. IWM will need to understand the factors that may influence the long-term vision, design, construction, and maintenance of a major infrastructure development project (e.g., CISF), as well as to gain public trust and confidence for the successful transport of SNF and subsequent operation of interim storage and final disposal facilities. In support of these efforts, IWM seeks innovative research projects related to 1) facility designs that are reflective of community values and 2) public perceptions about SNF transportation, storage, and disposal. Proposals should clearly identify the challenge being addressed and how the proposed activities will advance IWM efforts.

TOPIC AREA 8 – MODELING AND SIMULATION **(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)**
Science-based, verified, and validated modeling and simulation capabilities are essential for the design, implementation, and operation of nuclear energy systems and fuel cycle technologies. This topic area focuses on nuclear energy related modeling and simulation projects that develop or improve tools for many different applications including, but not limited to: high fidelity reactor modeling, including neutronics, structural dynamics, and thermal hydraulics; multi-scale, multi-physics models for characterizing complex neutron kinetics, dynamics, microstructural, and thermomechanical phenomena; verification and validation; uncertainty quantification; and flow modeling, among other relevant areas. Applications under this Topic Area should primarily focus on development or improvement of modeling tools, while the use or benchmarking of modeling and simulation tools, including the generation of supporting data, would need to be included in one of the other Topic Areas that best relates to the reactor, fuel type or technology being investigated or supported. Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

TOPIC AREA 9 – MEASURING, MONITORING, AND CONTROLS

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

Robust sensors, instrumentation, and controls are needed to enhance capabilities, provide for higher accuracy, and to accommodate new and challenging operational environments in the existing fleet and advanced reactors. NE seeks proposals for sensor development that add new capabilities to existing technologies or develops novel technologies to support relevant and challenging operational conditions.

NE has identified artificial intelligence (AI) and machine learning (ML) methods can complement the development and operation of sensors, as well as enhance advanced control systems, such as autonomous or remote operations, in the nuclear energy industry. Additionally, the utilization of digital twin platforms is considered a high impact tool as part of the research progression from benchtop experimentation to reactor demonstration.

Topics of interest in this area could include, but are not limited to:

1. Development of AI/ML techniques and/or applications relevant to the current fleet or advanced reactors.
2. Capability enhancement of existing sensor technologies, or development of novel instruments that fill identified measurement technology gaps.
3. Construction of a digital twin to compliment a physical reactor system or architecture.

Applicants with AI/ML focused proposal should provide details regarding training data and discuss whether access to High Performance Computing (HPC) resources will be necessary to complete project objectives.

Applicants with instrumentation focused proposals should provide a roadmap of development anticipated during the project and should provide commentary on experimental testing; whether it is conducted on the benchtop or in relevant reactor conditions.

Applicants with digital twin focused proposals should describe the physical twin system and provide details regarding digital twin operational accuracy validation.

*Note – applications with scope primarily focused on cybersecurity should review and consider applying to Topic Area 10.

Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

TOPIC AREA 10 – LICENSING, SAFETY, AND SECURITY

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000; NEST ELIGIBLE, SEE PART VIII, SECTION K)

There is a continued need for enhancing understanding of licensing and safety requirements as they apply to the safe and secure operations of reactors and all fuel cycle related facilities. NE is seeking proposals in the areas of safeguards and security, nuclear materials control and accountability (MC&A), cybersecurity, safety analysis methods, regulatory frameworks, and systems engineering and integration of these areas.

Topics of interest include, but are not limited to, enhancing the applicability, usability and efficiency of PRA tools or other innovative risk assessment methodologies; combined hazard PRA models; innovative methods and tools for licensing, security, and safeguards of nuclear fuel cycle including advanced reactors, and fuel fabrication and recycling processes; cost-effective means of managing advanced cybersecurity threats; enabling the cyber-secure deployment of advanced digital technologies; and addressing specific gaps in licensing technical requirements for advanced reactors.

Proposals should clearly identify the challenge being addressed and how proposed activities will reduce regulatory uncertainties and/or enhance the safety, security and/or safeguards of the concept being considered.

TOPIC AREA 11 – ADVANCED NUCLEAR MATERIALS AND MANUFACTURING TECHNOLOGIES (ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)

Revolutionary technologies in crosscutting materials science have the potential for radical improvement in reactor or fuel cycle performance, safety, and economics. The emerging fleet of advanced reactors is supported by its strongest business case when coupled with advanced materials and manufacturing techniques that offer enhanced performance and/or significant reductions to the costs of original construction and major component replacement. The concepts under consideration include advanced materials and/or classes of materials, and advances in manufacturing with applications ranging from components through complete factory fabrication of reactors for delivery and installation at the site.

NE is seeking proposals for R&D to better understand core and structural materials, advanced testing of existing materials, to explore and develop new classes of materials for identified applications, and to support the development of nuclear qualification, and/or regulatory acceptance of advanced manufacturing processes, methods, equipment, and/or materials or components manufactured using such techniques. Topics of interest most closely related to advanced materials include, but are not limited to, environmental, thermal and irradiation effects on materials, materials to efficiently immobilize fission products and off-gas capture species, development of comprehensive frameworks to characterize and model degradation of key materials, components and structures such as concrete or polymers, development of relevant advanced metal alloys for core materials and cladding, and development of materials to support waste minimization and management, such as sorbents and transmutation targets.

Advanced manufacturing topics of interest include, but are not limited to, processing and fabrication methods for composites, concrete, and metals; joining and repair; and specific applications to components, sub-systems, systems, structures and non-destructive examination. NE recognizes that advanced materials and their manufacturing methods are often not distinct categories of R&D, so it is not necessary to align applications with one of the elements within this topic area.

Proposals are also sought to support the development and characterization of innovative fuel cladding materials for fuel cycle applications. Specific interests in this area include materials design (novel metallic alloy and/or new coating), material performance under extreme conditions (e.g., fuel element-to-cladding and cladding-to-coolant interactions, high temperatures, dose/dose rate, and corrosive chemical environments), material fabrication and manufacturing technologies, and test and characterization capabilities.

Developing capture and immobilization materials for the next generation nuclear fuel recycle plant that reduces the size and associated capital and operating cost to the portions of the facility, while maintaining and improving the safety to the public. In this proposal, we are looking for materials that can effectively capture and immobilize volatile chemical species during the recycling process. Reference: Soelberg, NR, Jubin RT, 2023. *Technology Development Roadmap for Volatile Radionuclide Capture and Immobilization*. Report No. ANL/NSE-23/63.

TOPIC AREA 11 – ADVANCED NUCLEAR MATERIALS AND MANUFACTURING TECHNOLOGIES (ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)
Cermets are composite materials composed of ceramic and metallic phases that possess novel properties, such as flexible capacity, high thermal/electrical conductivity, extra waste loading, robust durability and efficient fabricability. In this proposal, we are looking for ideas to develop innovative cermet composite as a flexible platform to accommodate complex waste streams arising from various advanced fuel cycle designs. Reference: Gattu, VK, Asmussen M, 2023. *Suitability of Cermets as Nuclear Waste Forms; 2023 Cermet Workshop. Report* No. ANL/CFCT-23/47. Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology, partner with industrial applications, demonstrate viability, and understanding supply chain challenges

TOPIC AREA 12 – STRATEGIC NEEDS BLUE SKY **(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $1,000,000)**
NE is seeking proposals to advance foundational models, methods, and theory. Maintaining fundamental skills and knowledge in key nuclear engineering topics is important to maintaining and establishing research excellence and expertise. Areas of interest could include, but are not limited to, thermal hydraulics, heat transfer, reactor physics, and nuclear chemistry. A response should address innovative research in the identified area and could include any aspect (experiments, modeling, etc.) that is necessary to accomplish the proposed scope. Proposals should clearly identify the challenge being addressed and how the proposed activities will advance the proposed technology.

NUCLEAR SCIENCE USER FACILITIES (NSUF) JOINT R&D AND ACCESS (NSUF-1)

Applicants interested in a joint R&D and Nuclear Science User Facilities (NSUF) project should submit under this topic area. Proposals with NSUF access can include ion, neutron, and gamma irradiation, x-ray synchrotron beam or neutron beam interrogation, post-irradiation examination, advanced materials characterization, and high-performance computing. Applicants are encouraged to contact the NSUF directly with questions prior to submitting and review the full list of NSUF capabilities at https://nsuf.inl.gov/. In this topic area, R&D support is only permitted for tasks associated with the execution of the requested NSUF capabilities. This would include compilation and interpretation of irradiation and post-irradiation examination results, complementary modeling and simulation studies, and related activities. NSUF readiness requirements are provided in Appendix D.

NSUF is focused on providing access to unique and highly specialized nuclear research facilities and technical expertise to advance nuclear energy technologies that crosscut a range of NE topic areas. These topic areas include, but are not limited to, (1) fuel and core materials, (2) advanced materials and manufacturing technologies, and (3) sensor materials and active components. Separate effects or integral experimental testing focused on verification and validation of modeling and simulation topics that leverage high performance computing is encouraged.

Fuel and Core Materials: Proposals are sought for projects in the areas of fuels irradiation performance and combined effects of irradiation and environment on fuels and materials. Fuel types include, but are not limited to, light-water reactor accident tolerant fuels, oxide fuels, metallic fuels, TRISO-particle fuels, and new innovative fuel concepts. Additional topics of interest under this area include, but are not limited to, existing and innovative cladding materials such as chromium-coated zirconium alloys and silicon-carbide cladding and novel neutron-absorbing materials. Activities can be aimed at irradiation experiments (neutron steady state or transient, ion, and gamma) and post-irradiation examination that utilize NSUF capabilities to explore fundamental, novel, and applied aspects of fuel performance such as radiation damage, amorphization, fuel restructuring, species diffusion, fission product behavior, thermophysical properties, and mechanical properties.

Advanced Materials and Manufacturing Methods: Proposals are sought in the areas of advanced nuclear materials, novel or cost-effective manufacturing methods, and related topics that leverage NSUF irradiation and post-irradiation examination capabilities. For advanced materials, areas of interest include, but are not limited to, the evaluation of materials degradation mechanisms and aging, fundamental or applied irradiation effects, and testing of other nuclear energy related materials. This topic also includes the irradiation and post-irradiation examination of innovative advanced manufacturing technologies to support reductions in construction cost and schedule, and significant performance improvements.

Sensor Materials, Instrumentation, and Active Component Systems: Proposals are sought for irradiation testing and post-irradiation examination that support the development of advanced

NUCLEAR SCIENCE USER FACILITIES (NSUF) JOINT R&D AND ACCESS (NSUF-1)
sensor materials, and the development of advanced instrumentation or measurement systems to enhance the long-term viability and competitiveness of the existing fleet, and to develop an advanced reactor pipeline, and to implement and maintain national strategic fuel cycle and supply chain infrastructure. For this topic, areas of interest include irradiation testing and post irradiation examination of sensor materials and candidate instrumentation systems. Proposed projects can include irradiations and post-irradiation examination to address fundamental and applied technology gaps. Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

Topic areas for U.S. University-led IRPs

IRP-1: GRAND CHALLENGE IRP – ACCELERATING REACTOR DEVELOPMENT

(FEDERAL POC – JANELLE EDDINS)

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $3,000,000; NEST ELIGIBLE, SEE PART VIII, SECTION K)

NE's goal of demonstrating several advanced reactor types within this decade resulting in advanced reactor deployment in the 2030s, is a core aspect of addressing U.S. clean energy climate change goals. One of the primary challenges is reducing overall capital and operating and maintenance (O&M) costs while also de-risking the technologies for more rapid adoption by industry. NE solicits applications for this scope that take a holistic, multi-disciplinary approach to reactor deployment considerations for specific reactor technologies. Applications can cover a wide variety of topics including innovative component, instrumentation, and fuel handling systems; design optimization including integrated systems or reducing the size of the core or number of components; technologies to reduce the cost and schedule for construction; and siting infrastructure considerations for remote applications; development of AI/ML applications to improve plant technical, economic, and/or safety performance; and transition from fossil generation sources, including environmental justice considerations. Proposals that suggest innovative ideas for cost reduction or shortening the deployment timeline by developing a holistic, multi-faceted approach, including a focus on key technical needs areas, like nuclear economics, accelerated testing, and reactor/plant design expertise, are desired.

Proposals should clearly identify the challenge being addressed and how proposed activities will accelerate the development, demonstration, and future deployment of advanced reactor concepts.

IRP -2: GRAND CHALLENGE IRP: ADVANCED REACTOR SNF DISPOSITION

(FEDERAL POC – TBD, NE-8)

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $3,000,000)

The DOE Office of Spent Fuel and Waste Disposition is interested in supporting Integrated Research Projects aimed at the development of backend of the fuel cycle considerations for advanced reactor designs that have made significant progress towards demonstration. Through this research, advanced reactor vendors, universities, and national laboratories can partner up to conduct research that will characterize the anticipated spent nuclear fuel (SNF) types and other waste forms. This work will quantify the amount of SNF and other waste forms that would be generated during the operating lifetime of the reactors. This research seeks to determine if advanced reactor SNF types are suitable for disposal in a generic repository site, and the type of treatment(s) that will be required to do so. Other considerations that are part of the integrated waste management system such as advanced reactor SNF transportation and extended storage will be explored. Below are additional considerations that this IRP will explore.

- Advanced reactor designs that will result in the generation of the following SNF types will be considered: TRISO-based SNF fabricated in pebble and compact forms, metallic SNF designed with sodium bond and without it, molten salt SNF, and small modular LWR SNF
- Disposal of advanced reactor SNF in a generic repository research could include but is not limited to performance considerations for repositories with SNF from multiple types of reactors, or single SNF type only repositories (e.g., TRISO SNF only repository); disposal of residuals from treatment of the SNF; heat dispersion technology, evaluations, or strategies; disposal package design and package handling technology; and waste retrievability considerations.
- Transportation and extended storage research for advanced reactor SNF could include but is not limited to considerations and strategies for transport and storage of SNF using existing canister and overpack designs. However, this can be extended to propose conceptual designs for canisters, overpacks, tanks, and containers that could support transportation, and extended storage.
- Treatment of advanced reactor SNF research should only be considered to make an advanced reactor SNF type suitable for disposal in a generic repository. This research could include but is not limited to encapsulation technology such as cermet, polymers, or other coating materials; high and low temperature processes for waste treatment; technology or processes to minimize off gassing of fission products during treatment; waste treatment processes and process technology compatible with hot cell operations, neutron radiation, and radiolysis; and investigation of treated waste forms suitability for transportation and disposal.

Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

IRP-3: GRAND CHALLENGE RESEARCH AND DEVELOPMENT AT MINORITY SERVING INSTITUTIONS (MSIs)

FEDERAL POC – JENNA PAYNE

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY; UP TO 3 YEARS AND $3,000,000

NE's mission is to advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs. Toward this mission, NE has identified goals to address challenges in the nuclear energy sector, to help realize the potential of advanced technology, and to leverage the unique role of the government in spurring innovation:

- Enable continued operation of existing U.S. nuclear reactors.
- Enable deployment of advanced nuclear reactors.
- Develop advanced nuclear fuel cycles and spent nuclear fuel management options.

This opportunity is restricted to MSI lead institutions, including historically black colleges and universities (HBCUs), tribally controlled colleges and universities, (TCCUs), Asian American and Native American Pacific Islander-serving institution (AANAPISI) and Hispanic-serving institutions (HSIs), as defined in Title III and Title V of the Higher Education Act. This scope solicits applications that address one or more NE mission related technical areas that advance nuclear engineering research and development at MSI institutions.

NE is allowing a flexible framework for consortia construction and recognizes several viable and effective models including partnering in a multi-MSI consortia style model, partnering with national laboratories, other institutions of higher education, or industry collaborators. This scope is intended to develop nuclear expertise and capabilities at Minority Serving Institutions. Therefore, 80% of the total budget request should directly support lead or collaborating partners that are MSIs. Other institutions of higher education, national laboratories, or industry may participate in a supporting capacity at no more than 20% of total budget in composite.

Applications should focus on addressing an important NE mission related topic area with a particular focus on broad student involvement and capacity building to support the next generation workforce in nuclear energy.

Proposals should clearly identify the challenge being addressed and how proposed activities will advance the technology.

Topic areas for U.S. University-, National Laboratory-, or Industry-led NSUF Access Only (NSUF-2) Projects

NUCLEAR SCIENCE USER FACILITIES (NSUF) ACCESS ONLY (NSUF-2)

Applicants interested in utilizing Nuclear Science User Facilities (NSUF) capabilities only should submit under this topic areas. **This topic does not provide R&D support**. Proposals with NSUF access can include ion, neutron, and gamma irradiation, x-ray synchrotron beam or neutron beam interrogation, post-irradiation examination, advanced materials characterization, and high-performance computing. Applicants are encouraged to contact the NSUF directly with questions prior to submitting and review the full list of NSUF capabilities at https://nsuf.inl.gov/. In this topic area, NSUF access can be requested by university, industry, and national laboratory led projects. NSUF readiness requirements are provided in Appendix D.

NSUF is focused on providing access to unique and highly specialized nuclear research facilities and technical expertise to advance nuclear energy technologies that crosscut a range of NE topic areas. These topic areas include, but are not limited to, (1) fuel and core materials, (2) advanced materials and manufacturing technologies, and (3) sensor materials and active components. Separate effects or integral experimental testing focused on verification and validation of modeling and simulation topics that leverage high performance computing is encouraged.

Fuel and Core Materials: Proposals are sought for projects in the areas of fuels irradiation performance and combined effects of irradiation and environment on fuels and materials. Fuel types include, but are not limited to, light-water reactor accident tolerant fuels, oxide fuels, metallic fuels, TRISO-particle fuels, and new innovative fuel concepts. Additional topics of interest under this area include, but are not limited to, existing and innovative cladding materials such as chromium-coated zirconium alloys and silicon-carbide cladding and novel neutron-absorbing materials. Activities can be aimed at irradiation experiments (neutron steady state or transient, ion, and gamma) and post-irradiation examination that utilize NSUF capabilities to explore fundamental, novel, and applied aspects of fuel performance such as radiation damage, amorphization, fuel restructuring, species diffusion, fission product behavior, thermophysical properties, and mechanical properties.

Advanced Materials and Manufacturing Methods: Proposals are sought in the areas of advanced nuclear materials, novel or cost-effective manufacturing methods, and related topics that leverage NSUF irradiation and post-irradiation examination capabilities. For advanced materials, areas of interest include, but are not limited to, the evaluation of materials degradation mechanisms and aging, fundamental or applied irradiation effects, and testing of other nuclear energy related materials. This topic also includes the irradiation and post-irradiation examination of innovative advanced manufacturing technologies to support reductions in construction cost and schedule, and significant performance improvements.

Sensor Materials, Instrumentation, and Active Component Systems: Proposals are sought for irradiation testing and post-irradiation examination that support the development of advanced sensor materials, and the development of advanced instrumentation or measurement systems to enhance the long-term viability and competitiveness of the existing fleet, and to develop an advanced reactor pipeline, and to implement and maintain national strategic fuel cycle and supply chain infrastructure. For this topic, areas of interest include irradiation testing and post irradiation examination of sensor materials and candidate instrumentation systems. Proposed projects can include irradiations and post-irradiation examination to address fundamental and applied technology gaps.