FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

U. S. Department of Energy

Idaho Operations Office

Fiscal Year 2022 Consolidated Innovative Nuclear Research

Funding Opportunity Announcement:
DE-FOA-0002516

Announcement Type: Initial – August 30, 2021
Amendment 001- December 1, 2021

CFDA Number: 81.121

Informational Webinar: August 9-12, 2021
(Video links and presentations are available at www.neup.gov)

Issue Date: August 30, 2021

Letter of Intent (Mandatory only for NSUF Applications)
Due Date: September 9, 2021 at 7 p.m. ET

R&D/NSUF Pre-Applications (Mandatory except for IRPs)
Due Date: September 22, 2021 at 7:00 p.m. ET

NSUF Preliminary Statement of Work
Due Date: November 10, 2021 at 7:00 p.m. ET

NSUF Final Statement of Work
Due Date: January 20, 2022 at 7:00 p.m. ET

Full R&D/NSUF and IRP Applications
Due Date: February 9, 2022 at 7:00 p.m. ET

NOTE: Deadlines are the dates/times by which DOE must receive the specified submittal.

AMENDMENT 001: This amendment is an administrative amendment that updates links and templates for applicants as well as updates listed technical points of contact. Updates include:

- Clarifies where to find information Minority Serving Institution information
- Provides an updated link to the NSUF Statement of Work template
- Updates the FC-5 and MS-NE-1 techncial points of contact.
- Part III, Section A- clarifies that non-university collaborators can have no more than 20% of the overall budget in both Appendix A and C.

Registration Requirements

There are several one-time actions applicants must complete in order to submit an application in response to this Announcement (e.g., obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number, register with the System for Award Management (SAM) and create an account on NEUP.gov. Applicants, who are not registered with SAM, should allow up to five weeks to complete this requirement. It is suggested that the process be started as soon as possible.

If an applicant has not already done so, it must:

1. Obtain a DUNS number. DUNS website: http://fedgov.dnb.com/webform.

2. Register with the SAM. SAM website: https://www.sam.gov/SAM/.

3. Create an account on the NEUP.gov website at www.NEUP.gov using the 'Sign In' tab in the top right hand corner. To create an account: 1) Click "Create a new account"; 2) Fill out the required information and click "Create User"; and 3) Fill out the information in the "My Information" section.

Questions

Questions regarding the content of the funding opportunity announcement (FOA) must be submitted using the contact information found in Part VII, Section B of this FOA. DOE will try to respond to a question within three (3) business days, unless a similar question and answer have already been posted on the website.

Application Preparation

Applicants must prepare the application package and application forms from the NEUP.gov website: **https://neup.inl.gov/SitePages/Home.aspx**

Additional instructions are provided in Section IV of this FOA.

Application Submission

Apply for this FOA at www.NEUP.gov. Electronic applications and instructions are available at the NEUP.gov website. To access these materials: (1) go to www.NEUP.gov; (2) select "Sign In" from the top right hand corner of the screen; (3) enter your user credentials; (4) select "Applications" from the menu; and (5) click on "Create New Application" for the type of application you are creating. Apply at www.NEUP.gov. If you have any questions about your registration, contact the INR Integration Office at 208-526-1602 or at neup@inl.gov.

CHECKLIST FOR AVOIDING COMMON ERRORS

Item	Issue
Page Limits	Strictly followed throughout application, including particular attention to: - Technical Abstract - Technical Narrative - CVs
Protected Personally Identifiable Information	Ensure none are present in the application.
Collaborators	List all collaborators in application form. This includes any individual appearing in the project summary, technical narrative, benefit of collaboration, coordination and management plan, or budget documents.
Project Summary / Abstract	Name of applicant, Principal Investigator (PI), PI's institutional affiliation(s).
Budget	- Use current negotiated indirect cost and fringe benefit rates. - Include separate subward budgets, if applicable.
Budget Justification (attached to budget)	- Justify all requested costs. - Include separate subaward budget justifications, if applicable.
Current and Pending Support	Ensure complete listing of all activities including brief abstract of scope of work for all items listed, regardless of source of funding.
Certifications and Assurances	Ensure that signatures are completed for both sections of the Certifications and Assurances documentation.
R&R Other Project Information	- If marking proprietary information, clearly mark the sections where proprietary information is in the narrative or other documents using the procedure outlined in the FOA. - If marking 'yes' to international collaboration, list all institutions and countries.

TABLE OF CONTENTS

LIST OF ACRONYMS

CFDA	Catalog of Federal Domestic Assistance
CFA	Call for Full Applications
CFR	Code of Federal Regulations
CINR	Consolidated Innovative Nuclear Research
COI	Conflict of Interest
CTD	Crosscutting Technology Development
DE	Department of Energy (FOA Number)
DMP	Data Management Plan
DOE	Department of Energy
DUNS	Data Universal Numbering System
EPSRC	Engineering and Physical Science Research Council
FC R&D	Fuel Cycle Research and Development
FFATA	Federal Funding and Transparency Act of 2006
FFRDC	Federally Funded Research and Development Center
FOA	Funding Opportunity Announcement
FSRS	FFATA Subaward Reporting System
FWP	Field Work Proposal
FY	Fiscal Year
GAIN	Gateway for Accelerated Innovation in Nuclear
HBCU	Historically Black Colleges and Universities
HTGCR	High-temperature Gas-cooled Reactor
ID	Identification
IHE	Institute of Higher Education
IRP	Integrated Research Project
LOI	Letter of Intent
LWRS	Light Water Reactor Sustainability
M&O	Management and Operating
M&TE	Measuring and Test Equipment
MOOSE	Multiphysics Object Oriented Simulation Environment
MS	Mission Supporting
MSI	Minority Serving Institution
MSR	Molten Salt Reactor
NCE	No Cost Extension

NE	Office of Nuclear Energy
NEAMS	Nuclear Energy Advanced Modeling and Simulation
NEET	Nuclear Energy Enabling Technologies
NEUP	Nuclear Energy University Program
NFML	NSUF Nuclear Fuels and Materials Library
NRC	Nuclear Regulatory Commission
NSUF	Nuclear Science User Facilities
NNSA	National Nuclear Security Administration
OMI	Other Minority Institutions
PD	Program Directed
PDF	Adobe Portable Document Format
PIE	Post-irradiation Examination
PI	Principal Investigator
POC	Point of Contact
PS	Program Supporting
QA	Quality Assurance
R&D	Research and Development
RC RD&D	Reactor Concepts Research, Development and Demonstration
RCUK	Research Councils United Kingdom
RPA	Request for Pre-applications
SAM	System for Award Management
SF	Standard Form
SMR	Small Modular Reactors
SOW	Statement of Work
TCU	Tribal Colleges and Universities
UK	United Kingdom
U.S.	United States

PART I – FUNDING OPPORTUNITY DESCRIPTIONS

A. STATEMENT OF OBJECTIVES

This FOA is for Consolidated Innovative Nuclear Research (CINR) and is thus referred to in this document as the "CINR FOA".

A.1 Background and Objectives

The Department of Energy (DOE), Office of Nuclear Energy's (DOE-NE) mission is to advance U.S. nuclear power in order to meet the nation's energy needs by:

1. Enhancing the long-term viability and competitiveness of the existing U.S. reactor fleet;
2. Developing an advanced reactor pipeline; and,
3. Implementing and maintaining the national strategic fuel cycle and supply chain infrastructure.

Collectively, all NE-sponsored activities support the Department's priorities to combat the climate crisis, create clean energy jobs with the free and fair chance to join a union and bargain collectively, and promote equity and environmental justice by delivering innovative clean energy technologies for nuclear energy systems.

All applications submitted under this CINR FOA must demonstrate a strong tie to at least one of these three mission priorities and highlight how it supports the DOE priorities.

NE conducts crosscutting nuclear energy research and development (R&D) and associated infrastructure support activities to develop innovative technologies that offer the promise of dramatically improved performance for its mission needs as stated above, while maximizing the impact of DOE resources.

DOE has established a Gateway for Accelerated Innovation in Nuclear (GAIN) team, which has been working closely with the advanced nuclear design community to identify R&D objectives and work scopes that may be appropriately addressed through DOE programs. Several of the work scopes contain explicit language as guidance; however, there are many additional work scopes that, at least tangentially, address needs identified in technology specific workshops. Work scopes that may be addressed in activities funded under this CINR FOA are identified in Part IX, Appendices A-C of this CINR FOA. Generally speaking, applications that offer flexibility or provision for addressing measurements, materials, and conditions relevant to private sector developers of fast-spectrum reactors (lead-cooled, sodium cooled, and gas cooled), molten salt reactors (MSR), or high-temperature gas-cooled reactors (HTGCR) are encouraged.

NE strives to promote integrated and collaborative research conducted by national laboratory, university, industry, and international partners under the direction of DOE-NE's programs, and to deploy innovative nuclear energy technologies to the market in order to meet the strategic goals and optimize the benefits of nuclear energy. DOE-NE funds research

activities, through both competitive and direct mechanisms, as required to best meet the needs of DOE-NE. This approach ensures a balanced R&D portfolio and encourages new nuclear power deployment with creative solutions to the universe of nuclear energy challenges. This CINR FOA addresses the competitive portion of DOE-NE's R&D portfolio, as executed through the Nuclear Energy University Program (NEUP) and the Nuclear Science User Facilities (NSUF). NEUP utilizes up to 20% of funds appropriated to DOE-NE's R&D program for university-based infrastructure support and R&D in key DOE-NE program-related areas: Fuel Cycle Research and Development (FC R&D), Reactor Concepts Research Development and Demonstration (RC RD&D), Nuclear Energy Advanced Modeling and Simulation (NEAMS), and Nuclear Energy Enabling Technologies Crosscutting Technology Development (NEET CTD). By establishing the NSUF in 2007, DOE-NE opened up access to material test reactors, beam lines, and post-irradiation examination facilities to researchers from U.S. universities, industry, and national laboratories, by granting no-cost access to world-class nuclear research facilities.

While this CINR FOA specifies many of DOE-NE's current and upcoming R&D priorities, DOE-NE reserves the right to respond to potential shifts in R&D priorities during Fiscal Year (FY) 2022 that may be driven by events, policy developments, or Congressional/budget direction. Further, DOE-NE reserves the right to fund all or part of an application to this CINR FOA.

A.2 Major DOE-NE Funded Research Programs

A.2.1 Fuel Cycle Research and Development (FC R&D) Program

The mission of the FC R&D program is to develop used nuclear fuel management strategies and technologies to support meeting the federal government responsibility to manage and dispose of the Nation's commercial used nuclear fuel and high-level waste and to develop sustainable fuel cycle technologies and options that improve resource utilization and energy generation, reduce waste generation, enhance safety, and limit proliferation risk.

The program's vision is that by mid-century, strategies and technologies for the safe, long-term management and eventual disposal of U.S. commercial used nuclear fuel, and any associated fuel cycle technologies that enhance the accident tolerance of light-water reactors and enable sustainable fuel cycles are demonstrated and deployed. Together, these technologies and solutions support the enhanced availability, affordability, safety, and security of nuclear-generated electricity in the United States.

Current challenges include the development of high burn-up fuel and cladding materials to withstand irradiation for longer periods of time with improved accident tolerance; development of simplified materials recovery technologies, waste management (including storage, transportation, and disposal), and proliferation risk reduction methods; and development of processes and tools to evaluate sustainable fuel cycle system options, and to effectively communicate the evaluation results to stakeholders.

A.2.2 Reactor Concepts Research, Development and Demonstration (RC RD&D) Program

The RC RD&D program supports research and development (R&D) on existing and advanced reactor designs and technologies to enable industry to address technical challenges with maintaining the existing fleet of nuclear reactors, and to promote the development of a robust pipeline of advanced reactor designs and technologies and supply chain capabilities. Program activities are designed to address technical, cost, safety, and security issues associated with the existing commercial light water reactor fleet and advanced reactor technologies, such as small modular reactor (SMR) and microreactor designs, fast reactors using liquid metal coolants, and high temperature reactors using gas or liquid salt coolants.

A.2.3 Nuclear Energy Advanced Modeling and Simulation (NEAMS) Program

The mission of the NEAMS program is to accelerate early-stage development of advanced reactor concepts and enable improved economics of new and existing designs by providing leading-edge computational tools to U.S. industry. The primary program objective is to develop and deploy these predictive tools and methods to industry, academia, and government, including the Nuclear Regulatory Commission (NRC), for research, analysis, design and regulatory acceptance of advanced reactor and fuel cycle systems These advanced computational tools employ scalable simulation methods on high performance computing architectures in combination with a science-based, mechanistic approach to physics modeling to allow scientists and engineers to better understand reactor materials properties and coupled phenomena in nuclear energy systems. Consequently these tools span length scales from atomic to mesoscale to engineering and time scales from picoseconds to seconds to days. These tools are currently being used to move certain advanced reactor concepts forward to commercialization in several key ways, including design optimization, which is required to fully realize the economic and technological advantages of those concepts. NEAMS capabilities also support development of advanced nuclear fuels, design and analysis of nuclear fuel experiments, and expansion of NRC confirmatory analysis capabilities in the advanced reactor area.

A.2.4 Nuclear Energy Enabling Technologies (NEET) Crosscutting Technology Development (CTD)

The NEET CTD program supports R&D in crosscutting technologies that directly support and enable the development of new and advanced reactor designs and fuel cycle technologies. These technologies will advance the state of nuclear technology, improve its competitiveness, and promote continued contribution to meeting our Nation’s energy and environmental challenges. The activities undertaken in this program complement those within the RC RD&D and FC R&D programs, and support the DOE-NE’s mission to advance U.S. nuclear power in order to meet the nation's energy needs by: 1) enhancing the long-term viability and competitiveness of the existing U.S. reactor fleet; 2) developing an advanced reactor pipeline; and 3) implementing and maintaining the national strategic fuel cycle and supply chain infrastructure. The knowledge generated through these activities will allow DOE-NE to address key challenges affecting nuclear reactor and fuel cycle deployment with a focus on crosscutting innovative technologies.

A.2.5 Nuclear Science User Facilities (NSUF)

DOE-NE funds access to world-class capabilities to facilitate the advancement of nuclear science and technology. This mission is supported by providing access, at no cost to the user, to state-of-the-art experimental irradiation testing and Post-Irradiation Examination (PIE) facilities as well as technical assistance, including the design and analysis of reactor experiments. This unique model is best described as a distributed partnership with each facility bringing exceptional capabilities and expertise to the relationship, including reactors, beamlines, state-of-the-art instruments, hot cells, and, most importantly, expert technical and scientific assistance. Together, these capabilities and people create a nation-wide infrastructure that allows the best ideas to be proven using the most advanced capabilities. Through NSUF, researchers and their collaborators are building on current knowledge to better understand the complex behavior of materials and fuels under irradiation.

The NSUF allows research teams to obtain access to designated capabilities at various unique facilities provided on the NSUF website at NSUF.inl.gov/.

Part I, Section B.2 of this CINR FOA describes application options for projects requiring NSUF capabilities.

NOTE: Applicants may request funding for NSUF "Access Only" projects and/or joint NSUF access combined with R&D funding. Applicants requesting R&D financial support with a joint request for NSUF access will be limited to the work scopes in NSUF. Work scopes in eligible areas have been tailored to align NSUF capabilities with focused DOE-NE program and mission priorities. Applicants requesting NSUF Access Only will apply to one of the NSUF-2 work scopes, a broader set of work scopes focused on DOE-NE mission priorities and also tailored to align with NSUF capabilities.

All NSUF research must be non-proprietary and awarded projects must publish their results at the DOE, Office of Scientific and Technical Information (OSTI) website for public access (https://www.osti.gov/).

A.2.6 NSUF Nuclear Fuels and Materials Library

The NSUF Nuclear Fuels and Materials Library (NFML), which is owned by DOE-NE and curated by the NSUF, is a collection of specialized information and nuclear fuel and material specimens from past and ongoing neutron irradiation test campaigns, as well as real-world components retrieved from decommissioned power reactors, and donations from other sources. The NFML can be accessed at NSUF.inl.gov/. In order to continue the expansion of the NFML, any specimens created as the result of an awarded NSUF neutron irradiation project will be added to the NFML. The project lead will be given exclusive rights to the specimens for a three-year period of PIE following completion of the neutron irradiation portion of the project. The specimens will be listed as *Not Available* in the NFML throughout the three-year exclusivity period. In order to populate the NFML, the NSUF program office may recommend irradiating a larger number of specimens than required for an awarded project. These extra specimens, not subject to the three-year exclusivity period, will be added to the NFML and made available for further research immediately after the completion of irradiation. Principal Investigators (PIs) of all future awarded applications requesting

specimens from previous awarded neutron irradiation tests are encouraged to contact the original PI(s) for potential collaboration. Although collaboration with original PI(s) is encouraged, permission from the original PI(s) to use previously generated materials that are currently *Available* in the NFML is not required. It is strongly suggested that CINR FOA applicants contact the NFML Coordinator, listed at NSUF.inl.gov/Home/Staff, to confirm availability of specimens to be requested.

B. FUNDING OPPORTUNITIES

DOE is seeking applications from U.S. universities, national laboratories, and industry to conduct Program Supporting (PS), Mission Supporting (MS), and NSUF supported nuclear energy-related research to help meet the objectives of the major DOE-NE funded research programs.

Specifically, this CINR FOA contains the following three separate funding opportunity areas: U.S. University-led PS/MS R&D Projects; U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects; and University-led Integrated Research Projects (IRP) Projects. These three funding opportunity areas are described in detail in Part I, Sections B.1-B.3 below:

B.1 U.S. University-led PS/MS R&D Projects

The U.S. University-led PS/MS R&D Projects funding opportunity area is are available to U.S. university-led teams. In general, PS R&D is focused more directly on programmatic needs and is defined by the statement of objectives developed by the responsible programs. PS R&D and NSUF affiliated work scopes must be focused and responsive to the representative statement of objectives, which is not specific to a discipline, but can be limiting as defined by the project objective. In comparison, MS R&D is generally more creative, innovative, and transformative than PS R&D, but it must also support the DOE-NE mission. MS R&D activities could also produce breakthroughs in nuclear technology or could include research in the fields or disciplines of nuclear science and engineering that are relevant to DOE-NE's mission, but may not fully align with the specific initiatives and programs represented by PS objectives. U.S. university PIs are invited to propose research projects in response to this area of the CINR FOA, and the associated PS and MS work scopes contained in Part IX, Appendix A of this CINR FOA.

International Collaboration - The Research Councils United Kingdom (RCUK) Energy Program, led by the Engineering and Physical Science Research Council (EPSRC) in the United Kingdom (UK) has announced a UK funding opportunity for certain workscopes in Appendix A. The UK funding opportunity will support UK researchers in US/UK collaborations in the following areas:

- Understanding, Predicting, and Optimizing the Physical Properties, Structure, and Dynamics of Molten Salts (FC-1.2)
- Next Generation LWR Fuels for SMR Applications (FC-2.1)
- Spent Fuel and Waste Disposition: Disposal (FC-4.1)
- Advanced Small Modular Reactor R&D (RC-6)

- Automated Optimization for Reactor Core Design (NEAMS-2)

B.1.1 Note for U.S. University-led Nuclear Science User Facilities (NSUF-1) Access Projects

NSUF access project applications require a Letter of Intent (LOI) in addition to the pre-application and, if invited (see Part V, Section B.1 of this CINR FOA), a full application. NSUF access project applications will also require a feasibility review and readiness review in addition to the relevancy and technical reviews. Important aspects of NSUF access applications are described in Appendix D of this CINR FOA and should be seriously considered when preparing applications. It is strongly recommended that all potential proposers review the contents of the NSUF website for vital information at NSUF.inl.gov/.

The NSUF does not provide funding to the PI to support salaries, tuition, travel, or other costs typically supported via DOE-NE Program R&D funds.

DOE intends to fully fund all awarded NSUF access projects for the entire duration of the project, subject to any conditions or limitations contained in the award instruments. NSUF access project attributes include:

- U.S. university PIs may apply for NSUF access with a joint request for R&D financial support as stated in the NSUF-1 work scope.

Eligible work scopes for a NSUF R&D project are found in Part IX, Appendices A and B of this CINR FOA, and applications must comply with the provisions of Part IX, Appendix D of this CINR FOA. **Since NSUF projects involving reactor neutron irradiation and PIE combined may last up to seven years in duration, greater flexibility in the R&D funding distribution can be established in order to better accommodate the actual resource allocation requirements of the project.** Those applications requesting research support may request a project period of performance to spread the funding over the entire length of the project. The PIE phase of all NSUF projects is limited to three years in duration. R&D funding shall not be utilized to directly supplement activities funded by NSUF.

B.1.2 NSUF Readiness

Applicants must demonstrate readiness for NSUF access. In the NSUF pre-application, a summary (one or two paragraphs) of readiness is required. In the full application, a detailed description (up to one page) of readiness is required. Applications that do not adequately demonstrate readiness will not be considered for selection. Awarded projects that are found to not be ready for NSUF access may be cancelled. Additional information on the NSUF process is included in Part IX, Appendix D.

The following items must be completed prior to submitting a Pre-Application requesting NSUF access:

- Development and qualification of fabrication techniques, processes and methods;
- Pre-irradiation characterization (physical, mechanical, thermal, chemical and other applicable properties);
- Material interaction studies (at irradiation temperature and chemistry);

- Corrosion studies (at irradiation temperature and chemistry); and
- Pre-irradiation qualification of sensors, including functional and operational testing, and endurance testing at the irradiation environmental conditions (pressure, temperature, corrosion, etc.).

A plan for delivery of fuel, material, or sensors must be addressed with specific attention to the following:

- Structural and cladding materials for neutron irradiation must be supplied to NSUF three months after project initiation in order for the material to be machined to proper sample configuration prior to encapsulation. Provide a statement of the supplier's commitments including lead times.
- For previously irradiated fuels and materials not residing in the NSUF NFML, the location (as specific as possible), condition, provenience, pedigree, radioactivity levels, isotopic content, material composition, configuration, ownership, and any other available information that will be needed in order to ship and/or prepare the fuel or material for examination must be identified.
- For fuels and materials residing in the NSUF NFML, identify the specific specimen(s).
- For any fuels or materials supplied for the purpose of neutron irradiation, the applicant must own and have full authority to transfer ownership and title (free of any liens, claims of ownership, or other liabilities) to DOE.
- Supplier information and lead times for sensors needs to be provided.
- For fuels or materials coming from other DOE programs (not NSUF), a statement of program commitment is required. If invited to submit a full application, a statement that includes concurrence from the DOE federal program manager or national technical director is to be attached in the Pre Application in the section titled Post Submission Attachments.
    - Name File: 2022 Program Concurrence "Insert ID #"

Projects whose relevancy is based solely or primarily on fusion energy needs will not be considered. Pre-applications must include a list of publications that resulted from previous NSUF supported projects.

Projects not requiring R&D financial support, but rather just seek access to NSUF capabilities to perform research in nuclear science, may apply for **NSUF access only** work scopes in response to this area of the CINR FOA and the associated work scope contained in Part IX, Appendix B of this CINR FOA.

NOTE: Access to NSUF capabilities will require agreement and final signature to the User Agreement (copy provided in Part IX, Appendix D).**The terms and conditions of the User Agreement are non-negotiable, and failure to accept the terms and conditions of the User Agreement will terminate processing and review of the NSUF applications.** In order to ensure compliance throughout the application review process, applicants must indicate in the LOI and full application submission that the User Agreement has been read, understood, and the terms and conditions are accepted. Further, submission of a pre-

application and a full application indicates the applicant will comply with and agree to the terms and conditions of the User Agreement. Upon award of an NSUF supported project, the User Agreement must be signed before activities will begin on the project. Failure to sign the non-negotiable User Agreement within 30 days of receipt of the User Agreement may result in cancellation of an awarded project.

B.2 U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects

NSUF access project applications require an LOI in addition to the pre-application and, if invited (see Part V, Section B.1), a full application. NSUF access project applications will also require a feasibility review and readiness review in addition to the relevancy and technical reviews. Important aspects of NSUF access applications are described in Appendix D of this CINR FOA and should be seriously considered when preparing applications. It is strongly recommended that all potential proposers review the contents of the NSUF website for vital information at NSUF.inl.gov/.

DOE intends to fully fund all awarded NSUF access projects for the entire duration of the project, subject to any conditions or limitations contained in the award instruments. NSUF access project attributes include:

U.S. university, national laboratory, and industry PIs may apply for NSUF access without a joint request for R&D financial support as stated in the NSUF-2 work scope.

Eligible work scopes for a NSUF R&D project are found in Part IX, Appendices A and B, and applications must comply with the provisions of Part IX, Appendix D of this CINR FOA.

Since NSUF projects involving reactor neutron irradiation and PIE combined may last up to seven years in duration, greater flexibility in the R&D funding distribution can be established in order to better accommodate the actual resource allocation requirements of the project.

Those applications requesting research support may request a project period of performance to spread the funding over the entire length of the project. The PIE phase of all NSUF projects is limited to three years in duration.

R&D funding shall not be utilized to directly supplement activities funded by NSUF.

The NSUF does not provide funding to the PI to support salaries, tuition, travel, or other costs typically supported via DOE-NE Program R&D funds.

B.2.1 NSUF Readiness

Applicants must demonstrate readiness for NSUF access, as described in Part I, Section B.1.2 of this CINR FOA.

B.3 U.S. University-led IRP Projects

IRPs comprise a significant element of DOE's innovative nuclear research objectives and represent the program directed (PD) component of the DOE-NE strategy to provide R&D solutions most directly relevant to the near-term, significant needs of the DOE-NE R&D programs. IRPs are significant projects within specific research areas. IRPs are intended to

develop a capability within each area to address specific needs, problems, or capability gaps identified and defined by DOE-NE. These projects are multidisciplinary and require multi-institutional partners. IRPs may include a combination of evaluation capability development, research program development, experimental work, and computer simulations. IRPs are intended to integrate several disciplinary skills in order to present solutions to complex systems design problems that cannot be addressed by a less comprehensive team.

Although a proposing team must be led by a lead university PI and include at least one additional university collaborator, the proposed project team may include multiple universities and non-university partners (e.g., industry/utility, minority-serving institutions (MSIs), historically black colleges and universities (HBCUs), national laboratories, and international partners).

Information on Minority Serving Institutions (MSI) can be found at: https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst-list-pg4.html. This information predominately covers institutions that have been awarded grants through the Department of Education and does not include all institutions that may meet the definition of an MSI. **This resource is not an exhaustive list of minority serving institutions.**

For purposes of identifying MSIs in DOE-NE's application system, DOE-NE is using a directory based off of 2020 U.S. Department of Education data compiled by Rutgers University's Center for MSIs which can be found here: https://cmsi.gse.rutgers.edu/content/msi-directory. This list is also not an exhaustive list of MSIs but will be used as a starting point for auto-identifying MSIs.

If applicants believes that their institution qualifies as an MSI and is not listed, please contact neup@inl.gov with an explanation for how the university meets the conditions of being considered an MSI.

U.S. university PIs are invited to propose research projects in response to this area of the CINR FOA and the associated PD work scopes contained in Part IX, Appendix C of this CINR FOA. As described above, work scopes for the respective CINR FOA areas may be found in the Part IX appendices to this CINR FOA as follows:

- Appendix A: "Work scopes for U.S. University-led Program and/or Mission Supporting R&D Projects." R&D support and associated NSUF access can only be proposed in specific work scopes.
- Appendix B: "Work scopes for U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF) Projects" NSUF Access Only can be proposed in specific work scopes.
- Appendix C: "Work scopes for U.S. University-led Program Directed Integrated Research Projects (IRP)."

Table 1. FY 2022 Work Scope Overview

Work Scope Code	Appendix	NSUF Access	Led by:			Work Scope Title
			University	National Laboratory	Industry	
FC-1.1	A	No	X			Nuclear Fuel Cycle Aqueous Separations Chemistry
FC-1.2	A	No	X			Understanding, Predicting, and Optimizing the Physical Properties, Structure, and Dynamics of Molten Salts
FC-1.3	A	No	X			Understanding the Structure and Speciation of Molten Salts at the Atomic and Molecular Scale
FC-1.4	A	No	X			Iron Phosphate Process: Evaluation of Processing Parameters on the Product Properties
FC-2.1	A	No	X			Next Generation LWR Fuels for SMR Applications
FC-2.2	A	No	X			Accident Tolerant Control Rods
FC-2.3	A	No	X			Accelerated Fuel Testing Method Development
FC-3	A	No	X			Materials Protection, Accounting and Control Technology
FC-4.1	A	No	X			Spent Fuel and Waste Disposition: Disposal
FC-4.2	A	No	X			Earthquake Response of Spent Nuclear Fuel in Dry Storage Facilities
FC-4.3	A	No	X			Experimental Validation of Particulate Deposition Mechanisms on Dry Storage Canisters
FC-5	A	No	X			Accelerated Fast Reactor Metal Fuel Cladding Material Development
RC-1.1	A	No	X			Improving Construction Cost and Schedule Outcomes
RC-1.2	A	No	X			Environmental Justice and Equity Considerations in Siting Energy or Industrial Facilities to Inform Advanced Nuclear Energy Siting
RC-1.3	A	No	X			Implementation Consideration for Alternative Applications of Advanced Nuclear Reactors
RC-2	A	No	X			Innovative Microreactor Solutions for End-User Applications
RC-3.1	A	No	X			Liquid Metal-Cooled Fast Reactor Technology Development and Demonstration to Support Deployment
RC-3.2	A	No	X			Experimental Validation of Fast Reactor Fuel Failure Modes
RC-4	A	No	X			High Temperature Gas Reactor Pebble Fuel Testing Development

RC-5	A	No	X			Materials Research Pathway: Characterization and Modeling of the High Fluence Effect and Thermal Aging on Reactor Pressure Vessel Steels
RC-6	A	No	X			Advanced Small Modular Reactor R&D
NEAMS-1	A	No	X			Improvement of Low-Order Transport Methods
NEAMS-2	A	No	X			Automated Optimization for Reactor Core Design
CT-1	A	No	X			Crosscutting Research-Cyber Security Research
CT-2	A	No	X			Integrated Energy Systems
CT-3.1	A	No	X			Multi-Material Systems
CT-3.2	A	No	X			Advanced Creep Mechanisms
CT-3.3	A	No	X			High Throughput Testing for Advanced Manufactured Materials
CT-4	A	No	X			Advanced and Small Modular Reactor Materials Accountancy and Physical Protection
CT-5	A	No	X			Advanced Sensors and Instrumentation
MS-NE-1	A	No	X			Integral Benchmark Evaluations
MS-NE-2	A	No	X			Nuclear Data Needs for Nuclear Energy Applications
NSUF-1	A	Yes	X			Core and Structural Materials and Nuclear Fuel Behavior and Advanced Nuclear Fuel Development
NSUF-2.1	B	Yes	X	X	X	Core and Structural Materials and Nuclear Fuel Behavior and Advanced Nuclear Fuel Development
NSUF-2.2	B	Yes	X	X	X	High Performance Computing at Idaho National Laboratory
IRP-FC-1	C	No	X			ATF Cladding Tests in the MITR Pressurized Water Loop
IRP-RC-1	C	No	X			Development of Enabling Fabrication Technology for Compact Heat Exchangers for Advanced Reactors
IRP-RC-2	C	No	X			High Temperature Reactor Graphite Core Waste Processing
IRP-RC-3	C	No	X			Developing the Technical Basis and Risk Assessment Tools for Flexible Plant Operation
IRP-NEAMS-1	C	No	X			Combined Experimental-Modeling Assessments of Impurities/Fission Products in Molten Salts and Fundamental Corrosion Mechanisms of Relevant Structural Alloys
IRP-MS-1*	C	No	X			Nuclear Energy Workforce Pipeline Gap Analysis
IRP-MS-2*	C	No	X			Consent-Based Siting

*University-led and collaboration with minority serving institutions (MSIs), historically black colleges and universities (HBCUs) or tribal colleges and universities (TCUs) is required.

Information on Minority Serving Institutions (MSI) can be found at: https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst-list-pg4.html. This information predominately covers

institutions that have been awarded grants through the Department of Education and does not include all institutions that may meet the definition of an MSI. **This resource is not an exhaustive list of minority serving institutions.**

For purposes of identifying MSIs in DOE-NE's application system, DOE-NE is using a directory based off of 2020 U.S. Department of Education data compiled by Rutgers University's Center for MSIs which can be found here: https://cmsi.gse.rutgers.edu/content/msi-directory. This list is also not an exhaustive list of MSIs but will be used as a starting point for auto-identifying MSIs.

If applicants believes that their institution qualifies as an MSI and is not listed, please contact neup@inl.gov with an explanation for how the university meets the conditions of being considered an MSI.

PART II – AWARD INFORMATION

A. TYPE OF AWARD INSTRUMENT

DOE anticipates awarding cooperative agreements under this CINR FOA, with the exception of awards to national laboratories, which will be funded through field work proposals (FWPs) and NSUF Access Awards which will be funded through an NSUF User Agreement.

B. ESTIMATED FUNDING

The estimated amounts identified for each of the CINR FOA areas are specified in Part II, Sections B.1-B.3 of this CINR FOA with ceilings and floors specified in Section C below. Funding for all awards is contingent upon the availability of funds appropriated by Congress for the purpose of this program.

B.1 U.S. University-led PS/MS R&D Projects

DOE currently estimates that it will fund approximately $46 million in awards for the U.S. University-led PS/MS R&D Projects CINR FOA area.

B.2 U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects

DOE currently estimates that it will fund approximately $3 million in award value for the U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects CINR FOA area.

B.3 U.S. University-led PD IRP Projects

DOE currently estimates that it will fund approximately $28 million in awards for the U.S. University-led PD IRP Projects CINR FOA area.

C. MAXIMUM AND MINIMUM AWARD SIZE

The ceiling (i.e., the maximum amount for an individual award made under each area) and floor (i.e., the minimum amount for an individual award made under each area) for each of the three CINR FOA areas are identified in Part II, Sections C.1-C.3 below:

C.1 U.S. University-led PS/MS R&D Projects

- Ceiling:

PS: up to $800,000 (3-year project), except as explicitly noted in individual work scopes.

MS: up to $400,000 (3-year project), except as explicitly noted in individual work scopes.

NSUF: up to $500,000 (up to 7-years) for R&D as noted in individual work scopes.

- Floor: None.

C.2 U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects

- Ceiling: Irradiation/PIE Project: $5,000,000 NSUF Access Value (up to a 7-year project).

- Floor: None.

C.3 U.S. University-led IRP Projects

- Ceiling: PD: up to $5,000,000 (3-year project), except as explicitly noted in individual work scopes.

- Floor: None.

D. EXPECTED NUMBER OF AWARDS

The number of awards for each of the three CINR FOA areas is identified in Part II, Sections D.1-3 of this CINR FOA below. The number of awards is dependent on the size of the awards. DOE reserves the right to make more or fewer (or even no awards) depending on funding availability and/or the quality of the applications.

D.1 U.S. University-led PS/MS R&D Projects

DOE anticipates making approximately 65 awards under the U.S. University-led PS/MS R&D Projects CINR FOA area.

D.2 U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects

DOE anticipates making approximately 3 awards under the U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects CINR FOA area.

D.3 U.S. University-led PD IRP Projects

DOE anticipates making approximately 8 awards under the U.S. University-led PD IRP Projects CINR FOA area.

E. ANTICIPATED AWARD SIZE

The anticipated award size for each of the three CINR FOA areas are identified in Part II Sections E.1-3 of this CINR FOA below. Amounts represent anticipated maximum per award.

E.1 U.S. University-led PS/MS R&D Projects

DOE anticipates that awards will be up to $800,000 per award for PS projects and up to $400,000 per award for MS projects (except as explicitly stated in individual work scope areas).

E.2 U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects

DOE anticipates that award access value (funds not provided to the PI) should fall within the following ranges for U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF-2) Access Projects CINR FOA areas:

Neutron Irradiation only: $500,000 to $3,500,000, typically up to 3 year duration.

Neutron Irradiation and PIE: $500,000 to $4,000,000, up to 7 year duration.

Synchrotron or Neutron Beamline or PIE only: $50,000 to $750,000, typically up to 3 year duration.

Ion or Gamma Irradiation only: $20,000 to $100,000, up to 3 year duration.

Ion or Gamma Irradiation and PIE: $50,000 to $250,000, up to 3 year duration.

E.3 U.S. University-led PD IRP Projects

DOE anticipates that awards will be up to $5,000,000 for the U.S. University-led PD IRP Projects CINR FOA areas, except as stated in individual work scopes.

F. PERIOD OF PERFORMANCE

DOE anticipates making awards for up to three years for each of the CINR FOA areas with the exception of awards involving NSUF access***, which may take up to seven years if neutron irradiation and PIE is requested.*** Assuming DOE makes awards under this CINR FOA by September 2022, funded projects shall begin no later than October 1, 2022. Proposing different start dates for the project and budget periods may make the application ineligible for award. If a different project start date, other than October 1, 2022, is absolutely necessary for the successful performance of the project, it must be fully documented and justified in the application for consideration by DOE.

G. TYPE OF APPLICATION

DOE will accept only new applications for each of the three CINR FOA areas defined in Part I, Section B of this FOA. Applications made to previous FOAs will not be considered. Previous applications can be resubmitted as a new application to this CINR FOA.

PART III – ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

This CINR FOA is open to U.S. universities, national laboratories, and industry. The application must originate from the lead institution. All lead PIs must have an active account in the NEUP.gov website submittal system.

Research consortiums may be composed of diverse institutions including academia, national laboratories, non-profit research institutes, industry/utilities, and international partners. Research teams should strive to achieve the synergies that arise when individuals with forefront expertise in different methodologies, technologies, disciplines, and areas of content knowledge approach a problem together, overcoming impasses by considering the issue from fresh angles and discovering novel solutions.

This CINR FOA provides award opportunities to U.S. owned entities. United States means the several States, the District of Columbia, and all commonwealths, territories, and possessions of the United States. U.S.-owned entity means an entity that is either -

(i) A United States-owned entity; or

(ii) Incorporated or organized under the laws of any State and has a parent company which is incorporated or organized under the laws of a country which -

(a) Affords to the United States-owned companies opportunities, comparable to those afforded to any other company, to participate in any joint venture similar to those authorized under the Act;

(b) Affords to United States-owned companies local investment opportunities comparable to those afforded to any other company; and

(c) Affords adequate and effective protection for the intellectual property rights of United States-owned companies.

DOE has restricted eligibility for award in accordance with 2 Code of Federal Regulation (CFR) 910.126(b). This eligibility restriction does not apply to subrecipients, subawards, vendors, or team members of the prime/lead applicant.

DOE-NE strongly encourages diversifying its research portfolio through effective teams and/or partnerships with MSIs, and HBCUs, and Tribal Colleges and Universities (TCUs) which may receive funding support from the project. While international partners are encouraged to participate, no U.S. government funding will be provided to entities incorporated outside of the United States or to a foreign government or any entity owned or controlled by a foreign government.

Foreign government ownership means direct ownership of the applicant entity, its parent organization (e.g., trust, holding company, corporation, etc.), and any and all other entities in the corporate structure regardless of the applicant entity’s place of incorporation and

operation. DOE-NE will evaluate the benefit and contribution of any such proposed partnerships as part of its program relevancy evaluation and scoring.

In Appendix A and Appendix C of this CINR FOA, non-university collaborators, in composite, can have no more than 20% of the total funds provided by the government. An employee with a joint appointment between a university and a DOE national laboratory can apply through the institute of higher education (IHE) if the institution pays his or her salary and provides his or her benefits.

A collaborator is an individual that makes a defined, material contribution that is critical to the success of the project and/or contributing to joint publications. Any individual appearing in the project summary, technical narrative, benefit of collaboration, coordination and management plan, or budget documents should be listed directly as collaborators on the application form. All collaborators must be added to the application form with complete information. **Any individuals that do not meet these criteria should not be listed as collaborators on the application.** Applicants must have the full consent of each collaborator prior to listing them on an application form.Part IV, Section H of this CINR FOA outlines funding restrictions for this CINR FOA.

1. Domestic Entities

For-profit entities, educational institutions, and nonprofits[1] that are incorporated (or otherwise formed) under the laws of a particular state or territory of the United States are eligible to apply for funding as a prime or subrecipient (only educational institutions may apply as a prime recipient for U.S. university-led PS, MS, and/or PD MS projects).

State, local, and tribal government entities are eligible to apply for funding as a subrecipient (for U.S. university-, national laboratory-, or industry-led PS and/or MS projects only).

DOE/National Nuclear Security Administration (NNSA) Federally Funded Research and Development Centers (FFRDCs) and DOE Government-Owned Government-Operated laboratories are eligible to apply for funding as a prime recipient under Appendix B, team member, or subrecipient. If an FFRDC is proposed as a team member or subrecipient, the requirements contained in Part III, Section C, apply.

Non-DOE/NNSA FFRDCs and non-DOE Government-Operated Government-Owned laboratories are eligible to apply for funding as a subrecipient but are not eligible to apply as a prime recipient.

[1] Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 2005, are not eligible to apply for funding.

Federal agencies and instrumentalities (other than DOE) are eligible to apply for funding as a subrecipient but are not eligible to apply as a prime recipient.

2. U.S. Incorporated Foreign Entities

U.S. incorporated foreign entities, whether for-profit or otherwise, are eligible to apply for funding under this CINR FOA as either a prime recipient or subrecipient subject to the requirements in 2 CFR 910.124.

3. Incorporated Consortia

Incorporated consortia, which may include domestic and/or foreign entities, are eligible to apply for funding as a prime recipient (U.S. university- or national laboratory-led PS and/or MS projects only) or subrecipient. For consortia incorporated (or otherwise formed) under the laws of a State or territory of the United States, please refer to "Domestic Entities" in Part III, Section A.2 above. For consortia incorporated in foreign countries, please refer to the requirements in "U.S. Incorporated Foreign Entities" Part III, Section A.2 above.

4. Unincorporated Consortia

Unincorporated consortia, which may include domestic and foreign entities, must designate one member of the consortium to serve as the prime recipient/consortium representative (U.S. university- or national laboratory-led PS and/or MS projects only). The prime recipient/consortium representative must be incorporated (or otherwise formed) under the laws of a State or territory of the U.S. The eligibility of the consortium will be determined by the eligibility of the prime recipient/consortium representative.

5. Application Restrictions

NOTE: Due to the COVID-19 pandemic, FY 2016-FY 2019 active projects will not be counted toward eligibility restrictions.

The following application restrictions apply to lead PIs:

Applicants are ineligible to apply to any area of this CINR FOA as a lead PI under any of the following circumstances:

1. The PI has a currently funded IRP that will be active after December 31, 2022.
2. The PI has three or more R&D and Distinguished Early Career Award (DE-FOA-0002556) projects that will still be active after December 31, 2022 excluding NSUF-2 projects and any NSUF project with a duration greater than 3 years.
3. The PI has a no-cost extension on any DOE-NE funded project (excluding Infrastructure) that will still be active beyond December 31, 2022, excluding extensions caused by NSUF.

U.S. university PIs may submit up to six pre-applications (three of those applications may be as lead PI).

A PI may have no more than one IRP or three R&D projects (excluding NSUF-2 projects and any NSUF project with a duration greater than 3 years) funded at any time, and may not submit more full applications than would be allowed by these restrictions.

PIs cannot submit the same application to multiple work scope areas, including NSUF-2.

Applications submitted in response to research requested by Appendix B are limited to three pre-applications per institution per work scope area, including NSUF-2.

For IRPs, an applicant is ineligible to submit an application as the PI if (s)he is designated as PI for more than one currently funded DOE-NE project that will be active beyond December 31, 2022.

If a PI chooses to submit an IRP to this CINR FOA, that PI is not allowed to submit R&D applications as the lead.

Access only requests for NSUF (NSUF-2) are not bound by these eligibility restrictions unless noted above.

NOTE: Procurement regulations require that applications submitted to this CINR FOA will be awarded to the applicant entity listed and will not be transferred pre-award to another institution if a lead PI changes institutions. Following the date set in this CINR FOA for receipt of applications, PIs that are moving from one institution to another during the CINR review time period are subject to the DOE-ID Changing Principal Investigator and Related Changes/Revisions Policy which is explained at www.NEUP.gov. Post award revision must adhere to the requirements of 2 CFR 200.308.

B. COST SHARING

For applications led by universities, cost sharing is not required, but may be proposed. If cost sharing is provided, see 2 CFR part 200 for the applicable cost sharing guidance and Part VIII, Section H of this CINR FOA below. Cost sharing is **NOT** a scored review criteria.

For applications led by all other entities (i.e., other than universities, nonprofit institutions/organizations, and FFRDCs), the provisions of the Energy Policy Act of 2005, Section 988, apply. Cost share of at least 20% of the total allowable costs of the project (i.e., the sum of the government share, including FFRDC contractor costs if applicable, and the recipient share of allowable costs equals the total allowable costs of the project) and must come from non-Federal sources, unless otherwise allowed by law. (See 2 CFR 200.29 for more information on the cost sharing requirements.)

Although the DOE/NNSA FFRDC contractor cost is not included in the total approved budget for the award, DOE will pay the DOE/NNSA FFRDC contractor portion of the effort under an existing DOE/NNSA contract. Recipient is not responsible for reporting on that portion of the total estimated cost that is paid directly to the DOE/NNSA FFRDC contractor.

By accepting federal funds under this award, you agree that you are liable for your percentage share of allowable project costs, even if the project is terminated early or is not funded to its completion. After award, failure to provide the cost share required may result in the subsequent recovery by DOE of some or all the funds provided under the award.

Cost sharing requirements do not apply to the value of the NSUF access.

C. OTHER ELIGIBILITY REQUIREMENTS

C.1 FFRDC Contractors

FFRDC contractors may be proposed as a lead institution (except as otherwise prohibited by this CINR FOA) or team member on another entity's application subject to the following guidelines:

Authorization for non-DOE/NNSA FFRDCs. The Federal agency sponsoring the FFRDC contractor must authorize in writing the use of the FFRDC contractor on the proposed project and this authorization must be submitted with the application. The use of an FFRDC contractor must be consistent with the contractor's authority under its award.

Authorization for DOE/NNSA FFRDCs. The cognizant contracting officer for the FFRDC must authorize in writing the use of a DOE/NNSA FFRDC contractor on the proposed project and this authorization must be submitted with the application. The following wording is acceptable for this authorization:

> "Authorization is granted for the Fill-in 1: [Name] Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complimentary to the missions of the laboratory, will not adversely impact execution of the DOE/NNSA assigned programs at the laboratory."

NOTE: The FFRDC's participation in the proposed project is subject to the terms and conditions of its management and operating (M&O) contract with DOE. Participants requiring access to the FFRDC facilities are subject to the FFRDC's policy and DOE regulations.

NOTE: If all FFRDC/non-FFRDC management has been notified of all submissions and acknowledgment of all participants are identified, individual Letters of Authorization may be submitted or submitted as blanket permission Identification of participants by name is to be included in the body or as a separate list.

NOTE: Letter of Authorization is not required for NSUF Technical Leads, unless the Technical Lead is designated as a collaborator on the application and is requesting R&D funding support under this CINR FOA.

- **Value/Funding**: The value of, and funding for, the FFRDC contractor portion of the work will not normally be included in the award to a successful applicant. Usually, DOE will fund a DOE FFRDC contractor through the DOE FWP system and other non-DOE FFRDC contractors through an interagency agreement with the sponsoring agency.
- **Cost Share**: On industry led applications, the applicant's cost share requirement will be based on the total cost of the project (excluding NSUF access value). FFRDC costs are included as part of the government cost share.
- **FFRDC Contractor Effort** (except for project(s) in support of NEET CTD and NSUF):
  - The scope of work to be performed by the FFRDC contractor may not be more significant than the scope of work to be performed by the prime applicant.

- The FFRDC contractor effort, in aggregate, shall not exceed 20% of the total estimated costs of the projects.

- **Responsibility**: The applicant, if successful, will be the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to, disputes and claims arising out of any agreement between the applicant and the FFRDC contractor.

Table 2 provides a summary of Parts II and III of this CINR FOA.

Table 2. Summary of Parts II and III.

		Applicable Work scope Appendix	Estimated Available Budget	Maximum Award Size	Project Duration	Cost Share	Collaboration
University-led NEUP Projects	PS	Appendix A	$46,000,000	$800,000	Up to 3 years	Permitted but not required	University, national laboratory, industry, and foreign collaborations are encouraged, but no U.S. funding can go to entities that are not incorporated in the U.S.
	MS			$400,000			
University-, National Laboratory, or Industry-led NSUF-2 Projects	PS	Appendix B	NSUF Access: $2,000,000*	No R&D Component	Refer to Part II, E.2.1		
University-led Integrated Research Projects-NEUP	PD	Appendix C	$28,000,000	$5,000,000	Up to 3 years, unless otherwise noted		

***NSUF Access will be used to support NSUF applications in NSUF-1 (Appendix A) and NSUF-2 (Appendix B) workscopes.**

PART IV – APPLICATION AND SUBMISSION INFORMATION

NOTE: The following requirements apply to all three areas defined in Part I, Section B. of this CINR FOA unless specific requirements are identified.

A. ADDRESS TO REQUEST APPLICATION PACKAGE

Electronic applications and instructions are available at the NEUP.gov website. To access these materials: (1) go to www.NEUP.gov; (2) select "Sign In" from the top right hand corner of the screen; (3) enter your user credentials; (4) select "Applications" from the menu; and (5) click on "Create New Application" for the type of application you are creating. Apply at: www.NEUP.gov.

Paper copies of the application package may be requested at:

INR Integration Office
Attn: Drew Thomas
PO Box 1625 MS 3730
Idaho Falls, ID. 83415
Telephone: 208-526-1602
Fax: 208-526-1844

B. DOCUMENT FORMAT REQUIREMENTS

All non-budget documentation (use templates where provided) is to be prepared using standard 8.5" × 11" paper with 1-inch margins (top, bottom, left, right), using a font size no smaller than Times New Roman 11 point. This is a requirement for all pages included in the document, (i.e., table of contents, references, etc.). The preferred file format is Adobe Portable Document Format (PDF) for all documents except for spreadsheets. All spreadsheets are to be uploaded in Excel file format to the online application. Do **NOT** lock any cells in the spreadsheet.

Applicants must comply with all pertinent page limitations. Any text (including references and data tables) in a document that does not adhere to the requirements listed above (except graphics, graphs, charts, and equations) will be removed from the document and will not be reviewed. DOE reserves the right to dismiss applications that violate formatting requirements. Signature blocks must be signed by the designated official.

Documents should be saved using the document naming suggestion at the bottom of each document description. The tracking ID will automatically be generated by the application system and can be found at the top of the application form under "Tracking ID."

DOE reserves the right to dismiss applications which it deems, after initial review, to lack enough detail for reviewers to adequately judge technical merit. Applications submitted with corrupted, incomplete, or incorrect files may be dismissed without further review.

C. NSUF Application Submittal Instructions

C.1 Letter of Intent (LOI)

LOIs are a requirement for projects needing NSUF access. LOIs must be submitted by the date and time specified in Part IV, Section G.1.

C.1.1 LOI Submittal Instructions

Application forms and instructions are available at the NEUP.gov website. To access these materials: (1) go to www.NEUP.gov; (2) select "Login" from the top right hand corner of the screen; (3) enter your user credentials; (4) select "Applications" from the menu; and (5) find "FY 2022 NSUF Letter of Intent" and click on "Create New Application" for the type of application you are creating.

LOIs are to include the following:

- Title of project;
- Identification of NSUF Technical Lead(s), if known;
- Identification of NSUF facilities;
- Proposing PI and associated institution, if known;
- Applicable work scope:
  - NSUF-1 (have R&D funds available); and
  - NSUF-2 for NSUF access only (no R&D funds available); and
- A brief (<300 words) project description covering only the NSUF scope of the project.

- Points of contact (POCs) for the NSUF facilities, as well as facility descriptions, are provided on the NSUF website at NSUF.inl.gov/Page/Partners. NSUF Partner Institution contacts are also the Technical Leads. Idaho National Laboratory (INL) Technical Leads are assigned by the NSUF Program Office. For assistance in identifying a NSUF Technical Lead or facility POC, please contact NSUF staff members listed on the website.

2-page limit. Name File: 2022 LOI "Insert ID #"

C.1.2 Agreement Requirements

Access to NSUF capabilities will require agreement and final signature to the User Agreement (copy provided in Appendix D). **The terms and conditions of the User Agreement are non-negotiable and failure to accept the terms and conditions of the User Agreement will terminate processing and review of NSUF applications.** In order to ensure compliance throughout the application review process, applicants must indicate in the LOI that the User Agreement has been read, understood, and the terms and conditions are accepted. Further, submission of a pre-application and a full application indicates the applicant will comply and agree to the terms and conditions of the User Agreement. Upon award of an NSUF supported project, the User Agreement must be signed before activities will begin on the project. An applicant cannot submit an LOI without checking the "I Agree" checkbox. Failure to sign the non-negotiable User Agreement within 30 days of receipt of the User Agreement may result in cancellation of an awarded project.

C.2 Pre-Application

Refer to Part IV, Section D of this CINR FOA for pre-application requirements.

When completing the Pre-Application form via www.NEUP.gov, it is important that you link the LOI to the Pre-Application to retain the same tracking identification number. To link the LOI and pre-application, you must select your application from the pre-application drop-down list. Doing this assigns the same tracking identification number to the Pre-Application that is used for the LOI. The pre-application must be submitted from the same user account that the LOI was submitted under. **Do not start a new pre-application.**

NOTE: A summary of readiness is required in the pre-applications in accordance with Part I, Section B.2.2 of this CINR FOA.

C.3 NSUF Preliminary Statement of Work (Prelim SOW)

NSUF applicants are required to provide a Prelim SOW in support of their NSUF pre-application. The Prelim SOW must be submitted at NEUP.gov using the provided Statement of Work Template.

The Prelim SOW is necessary to inform the NSUF feasibility review and determine a preliminary value (cost) for NSUF access. The document is not used for the merit or readiness reviews. The Prelim SOW will be appended to the already submitted pre-application. To append the Prelim SOW: 1) Find the submitted pre-application in the "My Applications" section of the submission website; 2) Open the submitted pre-application by using the 'pencil' icon; 3) Scroll to the bottom of the application form; and 4) Click "Attach File" on the "Post Submission Attachment" section and attach the Prelim SOW.

Any submissions uploaded or altered after the deadline outlined in the CINR FOA will be disregarded. Do not make changes to the Prelim SOW after the submission deadline, as the upload timestamp is used to confirm timely submission:

Name File: 2022 Prelim SOW "Insert ID #"

NOTE: Do not resubmit the pre-application. A timestamp will appear in the "File Upload Date" area, which is confirmation that the Prelim SOW was appended correctly.

C.4 NSUF Final Statement of Work (Final SOW)

If an NSUF applicant is invited to submit a full application, a Final SOW is required, prior to the submittal of their full application. Final SOW documents are submitted at NEUP.gov using the provided Statement of Work Template.

The Final SOW is necessary to complete the NSUF feasibility review and determine a value (cost) for NSUF access. The document is not used for the merit or readiness reviews. The Final SOW is not included in the technical peer review. Technical details that will inform a peer reviewer must be included in the 15-page technical narrative.

Final SOW documents are submitted as an additional document to the already submitted NSUF pre-application. To append the Final SOW: 1) find the submitted pre-application in the "My Applications" section of the submission website; 2) Open the submitted pre-application by using the 'pencil' icon; 3) Scroll to the bottom of the application form; and 4) Click "Attach File" on the "Post Submission Attachment" section and attach the Final SOW.

NOTE: Do not resubmit the pre-application. A timestamp will appear in the "File Upload Date" area, which is confirmation that the Statement of Work was appended correctly:

Name File: 2022 FinalSOW "Insert ID #"

NOTE: Preliminary and final cost estimates for NSUF access are prepared and submitted by the NSUF Technical Lead(s) supporting the application.

C.5 Full Application

Refer to Part IV, Section E of this CINR FOA for full application requirements.

NOTE: A detailed summary of readiness is required in the full application in accordance with Part I, Section B.2.2 of this CINR FOA.

D. CONTENT AND FORM OF ALL PRE-APPLICATIONS (Mandatory except for IRPs)

Pre-applications are a mandatory requirement for PS and/or MS and/or NSUF Projects (in Appendix B of this CINR FOA) for U.S. University-, National Laboratory-, or Industry-led projects.. Pre-applications must be submitted by the date and time specified in Part IV, Section G.2 of this CINR FOA.

The PI and named collaborators identified in the pre-application may not be changed in the full application without adequate justification and consent of the Contracting Officer.

The following information shall be provided for all pre-applications:

D.1.1 Pre-application Narrative

Applicant shall provide a narrative that addresses the specific information below:

- Title of project.
- Technical Workscope Identification (e.g., FC-1.1). The PI is responsible for selecting the appropriate workscope, and this area may not be changed between the pre-application and full application.
- Name of Project Director/PI(s) and associated organization(s).
- A summary of the proposed project, including a description of the project and a clear explanation of its importance and relevance to the objectives.
- Major deliverables and outcomes the R&D will produce.

- Estimated cost of project (not including value of NSUF access).
- Timeframe for execution of proposed project (specify the time period for R&D, one-, two-, or three-year period or up to seven years for NSUF).
- Specific facilities and equipment access requirements (NSUF only).
- Source, scope, and duration of R&D funding (i.e., support for the PI) associated with request for NSUF Access Only (NSUF-2 only).
- A clear and concise summary of the readiness of the project for NSUF access (as described in Part I, Section B.2.1 of this CINR FOA).
- Proprietary data, such as chemical composition or physical properties of a material, that the applicant wishes to protect during the irradiation or PIE phase of the project. This may negatively impact the selection of the project (NSUF-1 and NSUF-2 only).
    - 5-page limit. Name File: 2022 Pre-Application Narrative "Insert ID #"

D.1.2 Benefit of Collaboration

Applicant shall provide a narrative that includes an explanation of the contribution that will be made by the collaborating organizations and/or facilities to be utilized. It may contain brief biographies of staff and descriptions of the facilities wherein the research will be conducted. Please indicate within this section whether the application has benefit or influence on other ongoing or proposed NE R&D projects (e.g., modeling and simulation in one application and effect validation in a separate application).

- This document is required, unless the application only has a single prinicipal investigator.

- 4-page limit. Name File: 2022 RPA Benefit of Collaboration "Insert ID #"

D.1.3 Publications

Applications must include a list of publications that resulted from previous DOE-NE (NEUP, NEET, NSUF) funded projects. A reference to the project that supported each publication should be included. If the PI has not led a DOE-NE (NEUP, NEET, NSUF) project, this document is not required.

- No page limit. Name File: 2022 RPA DOE-NE Supported Publications "Insert ID #"

D.1.4 Principal Investigator Vitae

The lead PI shall provide a brief curriculum vitae (CV) that lists the following:

Contact information.

Education and Training: Provide institution, major/area, degree, and year for undergraduate, graduate, and postdoctoral training.

Research and Professional Experience: Beginning with the current position list, in chronological order (newest to oldest), professional/academic positions with a brief description.

Publications: Provide a list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically.

Patents, copyrights, and software systems developed may be provided in addition to or substituted for publications.

Synergistic Activities: List no more than five professional and scholarly activities related to the effort proposed.

- 2-page limit. Name File: 2022 RPA "Last Name of Individual" "Insert ID #"

D.1.5 Collaborators

A collaborator is an individual that makes a defined, material contribution that is critical to the success of the project and/or contributing to joint publications. Any individual appearing in the project summary, technical narrative, benefit of collaboration, coordination and management plan, or budget documents should be listed as a collaborator directly on the application form. The applicant must have the full consent of all collaborators prior to submitting application. **Any individuals that do not meet these criteria should not be listed as collaborators on the application.**

D.1.6 Agreement Requirements

Institutions will be expected to follow quality assurance (QA) principles and requirements in conducting R&D activities. If the application is successful, the integrity of R&D products and their usability by DOE-NE is predicated on meeting QA requirements, as they apply to a specific scope of work and associated deliverables. Further, each institution serving as a team member to the proposed project shall be identified in the pre-application, with their commitment made to collaborate in the CINR FOA process.

If applicable, access to NSUF capabilities will require agreement and final signature to the User Agreement (copy provided in Part IX, Appendix D of this CINR FOA). **The terms and conditions of the User Agreement are non-negotiable and failure to accept the terms and conditions of the User Agreement will terminate processing and review of NSUF applications.** In order to ensure compliance throughout the application review process, applicants must state, during the NSUF pre-application and full application submission processes, that the User Agreement has been read, understood, and the terms and conditions are accepted. Further, submission of a NSUF pre-application and a full application indicates the applicant will comply and agree to the terms and conditions of the User Agreement. Upon award of an NSUF supported project, the User Agreement must be signed before activities will begin on the project. Failure to sign the non-negotiable User Agreement within 30 days of receipt of the User Agreement may result in cancellation of an awarded project.

E. CONTENT AND FORM OF ALL FULL APPLICATIONS

Applicants must provide all information requested. Forms and optional templates may be used to provide the information in accordance with the instructions below. Files that are attached must be in PDF format, unless otherwise specified in this announcement. Optional document templates can be found on the NEUP.gov website by clicking the 'Documents' button at the bottom of the front page (https://neup.inl.gov/SitePages/Related_Documents.aspx).

You must save the full application before a tracking ID number will be generated.

E.1 Conflict-of-Interest (COI) Acknowledgement (Checkbox)

COI may exist due to previous efforts performed by the applicant or assistance provided in program direction and other mission related activities. Check the appropriate box on the application signifying whether a potential COI exists. If a COI has been identified (for the lead PI or a collaborator, including national laboratories), a file that explains the conflict must be attached, which includes a statement on how the potential conflict will be avoided, neutralized, or mitigated. This document must be attached, even if the conflict appears to be insignificant. If no COI exists, check the box and proceed.

Name File: 2022 CFA COI "Insert ID #"

E.2 SF-424 Research and Related (R&R)

Applicants shall complete the SF-424, R&R form, available at www.NEUP.gov and upload a completed PDF copy of the form with the application.

Name File: 2022 CFA SF424RR "Insert ID #"

E.3 R&R Other Project Information

Applicants shall complete items 1–6 on the R&R Other Project Information form available at www.NEUP.gov, and upload a completed PDF copy of the form. Items 7-12 will be completed in the application form and do not need to be completed here.

Name File: 2022 CFA R&R Other Project Information "Insert ID #"

E.4 Project Summary/Abstract

(Use Provided Template on Application Site)

The project summary/abstract must contain a summary of the proposed activity, suitable for dissemination to the public. It should be a self-contained document that identifies the following: the name of the applicant; the name of the project director/PI(s); the project title; a list of major deliverables; the scope and objectives of the project; a description of the project, including major tasks (phases, planned approach, etc.) and methods to be employed; the potential impact of the project (i.e., benefits, outcomes); and the names of major participants (for collaborative projects). This document must not include any proprietary or sensitive business information as DOE-NE may make it available to the public after awards are made.

- 2-page limit for IRPs. (Appendix C Template)
- 1-page limit for R&D. (Appendix A Template) (Appendix B Template)

Name File: 2022 CFA Technical Abstract "Insert ID #"

E.5 Project Narrative

Applicant shall provide a written narrative addressing the strategy to execute R&D that supports the specified Technical Work Scope. The documentation provided shall include the items specified below:

- Application title.
- Final Technical Work Scope Identification (FC-1.1, RC-1, etc.).
- Project Objectives: Provide a clear, concise statement of specific objectives/aims of the proposed project.
- Proposed scope description.
- Logical path to accomplishing scope, including descriptions of tasks. This section will provide a clear, concise statement of the specific objectives/aims of the proposed project. This section should be formatted to address each of the merit review criterion and sub-criterion listed in Part V, Section A. Provide sufficient information so that reviewers will be able to evaluate the application in accordance with these merit review criteria. **DOE has the right to evaluate and consider only those applications that separately address each of the merit review criteria**.
- Relevance and Outcomes/Impacts: This section will explain the program relevance/priority of the effort to the objectives in the program announcement and the expected outcomes and/or impacts.
- Schedule: Define timelines for executing the specified work scope, including all important activities or phases of the project. Successful applicants must use this schedule when reporting project progress.
- Milestones and deliverables.
- Type/Description of facilities that will be used to execute the scope (if applicable).
- The roles and responsibilities of each partnering organization in the execution of the work scope. Describe the role and work to be performed by each participant/investigator, the business arrangements between the applicant and participants, and how the various efforts will be integrated and managed.
- Unique challenges to accomplishing the work and planned mitigations.
- Information, data, plans, or drawings necessary to explain the details of the application.
- Source, scope, and duration of R&D funding (i.e. support for the PI) associated with request for NSUF Access Only (NSUF-2 only).
- A stand-alone detailed description of the readiness of the project for NSUF access (as described in Part I, Section B.2.1) (NSUF-1 and NSUF-2 only)

- Proprietary data, such as chemical composition or physical properties of a material, that the applicant wishes to protect during the irradiation or PIE phase of the project. This may negatively impact the selection of the project (NSUF-1 and NSUF-2 only).

Page limits include cover page, table of contents, charts, graphs, maps, photographs, tables, references and other pictorial presentations while complying with the document format instructions in Part IV, Section B. **Evaluators will not review pages above the specified limit.**

- All R&D Projects: 10-pages
- All NSUF Projects: 15-pages
- All IRP Projects: 50-pages

Do not include any internet addresses (URLs) that provide information necessary to review the application; information contained in these sites will not be reviewed.

Name File: 2022 CFA Technical Narrative "Insert ID #"

E.6 Vitae (Technical Expertise and Qualifications)

Applicant shall name all teaming partners by name and organization, as well as their proposed roles and responsibilities. For collaborators (including senior key person), who will contribute in a substantial, measurable way to the project (including for subrecipients and consultants), the applicant shall provide a brief vitae that lists the following:

Contact information.

Education and Training: Provide institution, major/area, degree, and year for undergraduate, graduate, and postdoctoral training.

Research and Professional Experience: Beginning with the current position list, in chronological order (newest to oldest), professional/academic positions with a brief description.

Publications: Provide a list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically.

Patents, copyrights, and software systems developed may be provided in addition to or substituted for publications.

Synergistic Activities: List no more than five professional and scholarly activities related to the effort proposed.

2-page limit

Name File: 2022 CFA "Last Name of Individual" "Insert ID #"

Technical expertise and qualifications are to be provided for individual participants, whether or not the participant is receiving funding or not (including consultants or national laboratory personnel). All participants making a defined, material contribution that is critical to the success of the project must be listed as collaborators on the online application. Applicants must have the full consent of all collaborators prior to submitting the application.

NOTE: The above criteria do not include NSUF support staff.

E.7 Benefit of Collaboration

The applicant shall provide a narrative that includes an explanation of the contribution that will be made by the collaborating organizations and/or facilities to be utilized. Please indicate within this section whether the application has benefit or influence on other ongoing or proposed NE R&D projects (e.g., modeling and simulation in one application and effect validation in a separate application).

- This document is required, unless the application only has a single prinicipal investigator.
- 4-page limit

Name File: 2022 CFA Benefit of Collaboration "Insert ID#"

E.8 Capabilities

Provide information on the following, as applicable:

- Infrastructure Requirements: The applicant shall identify the infrastructure (e.g., facilities, equipment, instrumentation, and other resources) required to execute the proposed scope of work, including their location, availability, capabilities, and how they will be used in the project. Describe the non-labor (e.g., facilities, equipment, and instrumentation) resources that are available and accessible to the applicant and are required to execute the scope of work. Describe any unique equipment and facilities that are needed, are accessible, and will be used to execute the scope of work. Discuss the adequacy of these resources and identify any gaps and how these will be addressed.
- Adequate financial resources (if cost sharing).
- Ability to comply with the required or proposed performance schedule, taking into consideration all existing commercial and governmental business commitments.
- A satisfactory record of performance, integrity, and business ethics.
- Necessary organization, experience, accounting and operational controls, or the ability to obtain them (including, as appropriate, such elements as property control systems, quality assurance measures, and safety programs).

This CINR FOA allows the applicant to propose the purchase of any needed equipment to conduct the proposed work. If equipment purchases are proposed, describe comparable equipment, if any, already at the institution and explain why it cannot be used.

2-page limit

Name File: 2022 CFA Capabilities "Insert ID #"

E.9 Letters of Support (IRPs, MS-NE-1 and MS-NE-2 scopes only), if applicable

A letter of support from non-federal, non-academic partners (industry/utility, international) is recommended to describe the level and type of support (e.g., financial or in-kind contributions) contemplated for the project. Letters of support must be on company stationery and signed by an authorized company official.

For R&D full applications, Letters of Support should be uploaded to the 'Budget Justification' area.

Name File: 2022 CFA Letter of Support "Insert ID #"

E.10 Budget Documents

E.10.1 R&R Lead Budget Form: (TOTAL FED & NON-FED) (Required for all lead institutions, not required for NSUF-2 applications)

Complete the Research and Related Budget (Total Fed & Non-Fed) form in accordance with the following instructions contained in Part IV, Section E.

A separate budget must be completed for each year of requested support. The form will generate a cumulative budget for the total project period. Complete all the mandatory information on the form. Funds may be requested under any of the categories listed as long as the item and amount are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions in this announcement (see Part IV, Section I of this CINR FOA).

NOTE: Successful applicants may be requested to participate in an annual program review meeting and should budget travel accordingly.

NOTE: Do **NOT** lock the cells when saving this document. Applications containing budget forms with **locked cells** may not be evaluated further.

Name File: 2022 CFA Budget "Insert ID #".xls

E.10.2 R&R Subaward Budget Form: (TOTAL FED & NON-FED) (Required for University and Industry collaborators, not required for NSUF-2 applications)

Budgets for subrecipients, other than DOE FFRDC Contractors. Applicant must provide a separate cumulative SF-424 budget for each subrecipient that is expected to perform work estimated to be more than $250,000 or 50% of the total work effort (whichever is less). Use up to 10 letters of the subrecipient institution's name as the file name.

NOTE: Do **NOT** lock the cells when saving this document. Applications containing budget forms with LOCKED CELLS may not be evaluated further.

Name File: 2022 CFA Subaward Budget "Insert ID #".xls

E.10.3 Budget for DOE/NNSA Federally Funded Research and Development Center (FFRDC) Contractor (Required for National Laboratory participants, not required for NSUF-2 applications)

If a DOE/NNSA FFRDC contractor is applying, it must provide a DOE Field Work Proposal in accordance with the requirements in DOE Order 412.1A, Administrative (Admin) Change 1, Work Authorization System dated 05/21/2014. FWPs can be obtained from respective laboratory financial administrators.

FFRDCs are permitted to propose costs in accordance with their established DOE contracts (e.g., overhead, fees, etc.).

Name File: 2022 CFA FWP "Insert ID #"

E.10.4 Budget Justification (Required for all university and industry participants, not required for NSUF-2 applications)

The Budget Justification Supporting Documentation is available at NEUP.gov. Provide the required supporting information for all costs required to accomplish the project, including the following costs: labor; equipment; domestic and foreign travel; participant/trainees; material and supplies; publication; consultant services; automated data processing/computer services; subaward/consortium/contractual; equipment or facility rental/user fees; alterations and renovations; and indirect cost type. Provide any other information you wish to submit to justify the budget request.

A budget justification is required for the lead applicant and all sub-awardees. The justification can be combined into one document or submitted as separate files.

Foreign travel must be included in the budget justification request. Any foreign travel not added to the budget justification will not be approved upon issuance of the cooperative agreement.

If cost sharing is required or voluntarily proposed, provide an explanation of the source, nature, amount, and availability of any proposed cost sharing.

- Third Parties Contributing to Cost Sharing Information (if applicable):

  A letter from each third party (i.e., a party other than the organization submitting the application) contributing to the cost share, at the time the application is submitted. The letter must state that the third party is committed to providing a specific minimum dollar amount of cost sharing. Submitting the letters with the application provides assurance that the letters of commitment have been signed.

  In an appendix to the Budget Justification, the following information for each third party contributing to cost sharing must be identified: (1) the name of the organization; (2) the proposed dollar amount to be provided; (3) the amount as a percentage of the total project cost; and (4) the proposed cost sharing - cash, services, or property. Successful applicants must provide the signed letters of commitment outlined in Part IV. Section F,

Submissions from Successful Applicants. This appendix will not count in the project narrative page limit.

Name File: 2022 CFA Budget Justification "Insert ID #"

E.11 Additional Attachments

E.11.1 Current and Pending Support

(Required for all University and Industry Applicants)

As requested by the submission form, PI(s), subrecipients, and other senior/key persons for ongoing and pending applications shall identify all federal funding sources by agency source, project name, monetary amount (total award amounts for entire project period, including indirect costs), and length of term, person-months per year to be devoted to the project by the senior/key persons that are pending or currently in place for the university PI or collaborators within the past five years.

Name File: 2022 CFA Current and Pending Support "Insert ID #"

E.11.2 Coordination and Management Plan

Multiple PIs (multiple individuals i.e. Lead PI, Co-PI, etc.): The applicant, whether a single organization or team/partnership/consortium, must state whether the project will include multiple PIs. This decision is solely the responsibility of the applicant. If multiple PIs will be designated, the application must identify the Contact PI/Project Coordinator and provide a "Coordination and Management Plan" that describes the organization structure of the project as it pertains to the designation of multiple PIs. This plan should, at a minimum, include:

- Process for making decisions on scientific/technical direction;
- Publications;
- Intellectual property issues;
- Communication plans;
- Procedures for resolving conflicts; and,
- PIs' roles and administrative, technical, and scientific responsibilities for the project.

Name File: 2022 CFA CMP "Insert ID #"

E.11.3 Letter of Authorization for DOE/NNSA FFRDCs (Required for all national laboratory participants listed on the application regardless of funding level or tier)

The cognizant contracting officer for the FFRDC must authorize in writing the use of DOE/NNSA FFRDC and non-DOE/NNSA FFRDC contractors on the proposed project, and this authorization must be submitted with the application. The following wording is acceptable for this authorization.

> "Authorization is granted for the Fill-in 1: [Name] Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complimentary to the missions of the

laboratory, will not adversely impact execution of the DOE/NNSA assigned programs at the laboratory, and will not place the laboratory in direct competition with the domestic private sector."

NOTE: Individual Letters of Authorization may be submitted, if all FFRDC/non-FFRDC management has been notified of all submissions, and all participants are identified, may be submitted as a blanket permission. Identification of participants by name is to be included in the body or as a separate list.

NOTE: Letter of Authorization is not required for NSUF Technical Leads unless the Technical Lead is requesting R&D funding support under this CINR FOA.

Name File: 2022 CFA CO Authorization "Insert ID #"

E.11.4 Project/Performance Site Location(s)

Indicate lead and collaborating site(s) where R&D work will be performed. Note the Project/Performance Site Congressional District is entered in the format of the 2-digit state code, following by the 3-digit Congressional district code (e.g., AA-001).

Name File: 2022 CFA Site Location "Insert ID #"

E.11.5 Environmental Checklist

An environmental checklist will be required at the time of award negotiations. If selected for award negotiations please fill out the Environmental Checklist.

E.11.6 Data Management Plan (DMP)

A Data Management Plan (DMP) will be required within 90 days of award notification that:

1. Should describe whether and how data generated in the course of the proposed research will be shared and preserved. If the plan is not to share and/or preserve certain data, then the plan must explain the basis of the decision (for example, cost/benefit considerations, other parameters of feasibility, scientific appropriateness, or limitations discussed in #4). At a minimum, DMPs must describe how data sharing and preservation will enable validation of results, or how results could be validated if data are not shared or preserved.
2. Should provide a plan for making all research data displayed in publications resulting from the proposed research open, machine-readable, and digitally accessible to the public at the time of publication. This includes data that are displayed in charts, figures, images, etc. In addition, the underlying digital research data used to generate the displayed data should be made as accessible as possible to the public in accordance with the principles stated above. This requirement could be met by including the data as supplementary information to the published article, or through other means. The published article should indicate how these data can be accessed.
3. Should consult and reference available information about data management resources to be used in the course of the proposed research. In particular, DMPs that explicitly

or implicitly commit data management resources at a facility beyond what is conventionally made available to approved users should be accompanied by written approval from that facility.

4. DMPs must protect confidentiality, personal privacy, Personally Identifiable Information, and U.S. national, homeland, and economic security; recognize proprietary interests, business confidential information, and intellectual property rights; avoid significant negative impact on innovation, and U.S. competitiveness; and otherwise be consistent with all applicable laws, regulations, and DOE orders and policies. There is no requirement to share proprietary data.

E.11.7 Disclosure of Lobbying Activities

Applicants must complete and attach the SF-LLL. If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the grant/cooperative agreement, you must complete and submit Standard Form - LLL, "Disclosure Form to Report Lobbying," which is available at the application site document library.

Name File: 2022 CFA SF-LLL “Insert ID #”

E.11.8 Certifications and Assurances

(Required for All University Leads) (Not required for NSUF-2 applications)

Applicants must complete and attach the Certifications and Assurances form found on the DOE Financial Assistance Forms Page at: http://energy.gov/management/downloads/certifications-and-assurances-use-sf-424.

Name File: 2022 CFA Cert & Assurances “Insert ID #”

E.11.9 Foreign Government Ownership Disclosure (Required for All Leads)

Applicants must complete and attach the Foreign Government Ownership Disclosure template.

Name File: 2022 CFA Foreign Government Ownership Disclosure “Insert ID #”

Table 3. Summary of Full Application Required Information.

Name of Document	Format	Required From	Signature Required
Conflict-of-Interest	Checkbox	Affirmed by Lead Applicant for all Participants	
SF-424 (R&R)	Form	Lead Applicant	Yes
Research and Related Other Project Information	Form	Lead Applicant	
Project Summary/Abstract	PDF	Lead Applicant	
Project Narrative	PDF	Lead Applicant	
Other Attachments			
Vitae - Technical Expertise and Qualifications (2 pages each)	PDF	All Leads and Collaborators	
Benefits of Collaborations (4 pages)	PDF	Lead Applicant	
Capabilities (2 pages)	PDF	Lead Applicant	
SF-424 (R&R) Lead Budget Form (Total Fed + Non-Fed)	Form	All Lead Applicants*	
SF-424 (R&R) Subaward Budget (Total Fed + Non-Fed), if applicable	Form	Collaborators who meet minimum requirements (work estimated to be $250,000 or more or 50% of the total work effort, whichever is less)*	
Budget for DOE National Laboratory Contractor or FFRDC, if applicable	PDF	National Laboratory Leads and Collaborators*	Yes
Budget Justification	PDF	University Leads	
Subaward Budget Justification, if applicable	PDF	Collaborators who meet minimum requirements (work estimated to be $250,000 or more or 50% of the total work effort, whichever is less) *	
Current and Pending Support, if applicable	PDF	All University and Industry Applicants	
Coordination and Management Plan	PDF	Lead Applicant	
Authorization for DOE/NNSA FFRDCs, if applicable	PDF	National Laboratory Applicants (including non-funded collaborators)	Yes
Project/Performance Site Location	PDF	All sites performing work	
SF-LLL Disclosure of Lobbying Activities	PDF	Lead Applicant	Yes
Certifications and Assurances	Form	University Leads*	Yes

Name of Document	Format	Required From	Signature Required
Foreign Government Ownership Disclosure	PDF	University and Industry Leads	

***Not required for NSUF-2 Access Only applications. The applicant will need to upload a document that states "Not required for NSUF-2 application" in these upload fields.**

F. SUBMISSION FROM SUCCESSFUL APPLICANTS

If selected for award, DOE reserves the right to request additional or clarifying information for any reason deemed necessary including but not limited to, the following:

Indirect cost information

Other budget information

Name and phone number of the Designated Responsible Employee for compliance with national policies prohibiting discrimination (*See* 10 CFR Part 1040.5);

Representation of Limited Rights Data and Restricted Software, if applicable; and

Commitment Letter from Third Parties Contributing to Cost Sharing, if applicable.

Environmental Checklist

G. SUBMISSION DATES AND TIMES

G.1 NSUF LOI Due Date

(Mandatory for NSUF Projects)

LOIs for NSUF access are required by September 9, 2021, no later than 7:00 p.m. Eastern Time (ET). The LOI shall be submitted as required in Part IV, Section C.1 of this CINR FOA.

G.2 R&D/NSUF Pre-Application Due Date

(Mandatory except for IRPs)

Pre-applications are required by September 22, 2021, no later than 7:00 p.m. ET. The pre-application shall be submitted as required in Part IV, Section C.2 of this CINR FOA. Applicants who fail to submit a pre-application will be determined non-responsive and ineligible for a comprehensive merit review.

G.3 NSUF Preliminary Statement of Work Due Date

Applicants requesting NSUF access must submit a Preliminary SOW by November 10, 2021, no later than 7:00 p.m. ET. The preliminary SOW shall be submitted as required in Part IV, Section C.3. Applicants who fail to submit a preliminary SOW will be determined non-responsive and ineligible for further consideration.

G.4 NSUF Final Statement of Work Due Date

Applicants requesting NSUF access must submit a Final Statement of Work by January 20, 2022, no later than 7:00 p.m. ET. The final SOW shall be submitted as required in Part IV, Section C.4. Applicants who fail to submit a final SOW will be determined non-responsive and ineligible for further consideration.

G.5 Integrated Research Projects (IRP) Due Date

IRPs must be received by February 9, 2022 no later than 7:00 p.m. ET. Applicants are encouraged to transmit their applications well before the deadline. Applications received after the deadline will not be reviewed or considered for award.

G.6 Full R&D/NSUF Application Due Date

Full R&D/NSUF applications (including program concurrence for applicable NSUF projects, see Part I, B.2.2) must be received by February 9, 2022, no later than 7:00 p.m. ET. Applicants are encouraged to transmit their applications well before the deadline. Applications received after the deadline will not be reviewed or considered for award.

G.7 Late Submissions, Modifications, and Withdrawals of Pre-Applications, Applications, and NSUF Statement of Work

Applicants are responsible for submitting any/all required submissions specified in this CINR FOA, including LOIs, applications, statements of work and any modifications or withdrawals thereto, so as to reach the Government office designated in the CINR FOA by the date/time specified in the CINR FOA.

Any required CINR FOA submittal, modification, or withdrawal received at the Government office designated in the CINR FOA after the exact time specified for receipt of that submittal is “late” and will not be considered, except for the following:

- The application is received before award is made;
- The Contracting Officer determines that accepting the late submittal would not unduly delay the FOA award process;
- The application was transmitted through an electronic commerce method authorized by the CINR FOA and received at the initial point of entry to the Government infrastructure not later than 5:00 p.m. one working day prior to the date specified for receipt of the sumittal; or there is acceptable evidence to establish that it was received at the Government installation, designated for receipt of the submittal, and was under the Government’s control prior to the time set for receipt of the required submittal;
- A late modification of an otherwise successful submittal or application that makes its terms more favorable to the Government will be considered at any time it is received and may be accepted.

- Acceptable evidence to establish the time of receipt at the Government installation includes the time/date stamp of that installation on the required electronic submission, other documentary evidence of receipt maintained by the installation, or oral testimony or statements of Government personnel.

- If an emergency or unanticipated event interrupts normal Government processes such that the required submittal cannot be received at the Government office designated for receipt of the submittal by the exact time specified in the CINR FOA, and urgent Government requirements preclude amendment of the CINR FOA, the time specified for receipt of the required submittal will be deemed to be extended to the same time of day, as specified in the CINR FOA, on the first work day on which normal Government processes resume.

Applications and other submittals may be withdrawn by written notice (sent electronically to NEUP@inl.gov) received at any time before the exact time set for receipt of that submittal. A required submittal may be withdrawn in person by an applicant or its authorized representative, if, before the exact time set for receipt of that submittal, the identity of the person requesting withdrawal is established and the person signs a receipt for the submittal.

If electronic applications cannot be submitted, applicants can contact:

INR Integration Office
Attn: Drew Thomas
PO Box 1625 MS 3730
Idaho Falls, Idaho. 83415

Telephone: 208-526-1602
Fax: 208-526-1844

H. INTERGOVERNMENTAL REVIEW

This program is not subject to Executive Order 12372, “Intergovernmental Review of Federal Programs.”

I. FUNDING RESTRICTIONS

Funding for all awards is contingent upon the availability of funds appropriated by Congress for the purpose of this program in current and future fiscal years.

I.1 Cost Principles

Costs must be allowable, allocable, and reasonable in accordance with the applicable Federal cost principles referenced in 2 CFR part 200, as adopted and amended by 2 CFR part 910. The cost principles for for-profit organizations are in FAR Part 31.

NOTE: For for-profit organizations, 2 CFR 910.352 incorporates the cost principles located at the Federal Acquisition Regulation (FAR) Part 31.

I.2 Pre-Award Costs

Recipients may charge to an award, resulting from this announcement pre-award costs that were incurred within the ninety (90) calendar day period immediately preceding the effective date of the award, if the costs are allowable in accordance with the applicable Federal cost principles. Recipients must obtain the prior approval of the contracting officer for any pre-award costs that are for periods greater than this 90-day calendar period.

Pre-award costs are incurred at the applicant's risk. DOE is under no obligation to reimburse such costs if for any reason the applicant does not receive an award or if the award is made for a lesser amount than the applicant expected.

J. OTHER SUBMISSION AND REGISTRATION REQUIREMENTS

J.1 Where to Submit

NOTE: Submit applications through www.NEUP.gov to be considered for award.

Submit electronic applications through the "Applications" function at www.NEUP.gov. For problems with completing the registration process or submitting your application, call Drew Thomas at 208-526-1602 or Anna Podgorney at 208-526-2123 or send an email to NEUP@inl.gov.

J.2 Application Validity Timeframe

By submitting an application in response to this CINR FOA applicants agree that their applications are valid for at least one year from the date set forth for receipt of applications to this CINR FOA. DOE reserves the right (with concurrence of the applicant) to use the submitted application(s) to make additional awards for up to a one year, even after DOE's initial selection announcement has occurred.

PART V – APPLICATION REVIEW INFORMATION

NOTE: The following requirements apply to all CINR FOA areas unless specific requirements are identified.

A. CRITERIA

A.1 Pre-application Review (PS, MS, and NSUF)

At the pre-application review stage, DOE will invite selected applicants to provide full applications, based on how well the pre-applications meet or exceed the technical and program relevancy and program priority evaluation criteria, provided below in Part V, Sections A.1 of this CINR FOA, and weighted as described in Table 4 of Section A.5.2 of this CINR FOA.

All pre-applications as described in Part IV, Section C.2 submitted under this CINR FOA will be reviewed and scored as described below in Part V, Section A of this CINR FOA.

A.1.1 Pre-Application Initial Review Criteria of Pre-Applications

Prior to a comprehensive merit evaluation, DOE will perform an initial review to determine the following: (1) the applicant is eligible for an award; (2) the information required by the announcement has been submitted; and (3) all mandatory requirements are satisfied. Only applications meeting these pre-application initial review criteria will be considered during the pre-application technical review process.

A.1.2 Relevancy Attributes

Following the pre-application intital review, programmatic experts will assess those application that have met the pre-application initial review criteria for program relevancy and program priority to R&D work scopes. Scores will be assigned according to the following program relevancy and program priority attributes found in Part V, Section A.1.2-A.1.3:

- **High Relevance:** The project is fully supportive of, and has significant, easily recognized and demonstrable ties to mission and relevant work scope area. The project builds on synergies with ongoing direct- or competitively-funded projects or meets a critical mission need. The project focuses on critical knowledge gaps where limited work is currently being performed.
- **Moderate Relevance:** The project is supportive of, and has significant, recognized and demonstrable ties to mission and relevant work scope area. The project recognizes synergies with ongoing direct- or competitively-funded projects and identifies areas for improvement to current, or recently completed, work. The project has ties to knowledge gaps where limited work is currently being performed.
- **Some Relevance:** The project is somewhat supportive of, and has some ties to mission and relevant work scope area. The project recognizes ongoing direct- or competitively-funded projects and identifies limited improvements to current work. The project addresses some knowledge gaps, although there is a moderate amount of work currently being performed in the area.

- **Low Relevance:** The project is minimally supportive of, and has limited ties to mission and relevant work scope area. The project does not recognize ongoing work and does not identify areas for improvement to current, or recently completed work. Substantial work is currently being performed in the area to address knowledge gaps.
- **No Relevance:** The project is not supportive of mission or the relevant work scope area.

A.1.3 Program Priority

Application relevancy scores from the technical evaluation will be weighted in consideration of program priority, which is established and influenced by factors such as balance of portfolio, funding constraints, and anticipated program needs. The categories for program priority are listed below:

- **High Program Priority:** The project is critical to program objectives and/or the work scope area, and will provide unique results that can be effectively integrated with other currently funded work (direct and/or competitively funded).
- **Moderate Program Priority:** The project is important to program objectives and/or the work scope area, and will provide complementary results to currently funded work (direct and/or competitively funded).
- **Low Program Priority:** The project is somewhat important to program objectives and/or the work scope area, but results may be duplicative of currently funded work (direct and/or competitively funded) or unnecessary for current program objectives.
- **No Program Priority:** The project is not important to program objectives and/or the work scope area. The project may also be duplicative of ongoing R&D efforts.

A separate technical expert/peer will then assess each application on its technical merit. Reviewers will review the technical basis of the application, assigning it a merit category as described belowin Part V, Section A.1.4 of this CINR FOA. During this technical review, applications will then be judged as meeting all, most, or some expectations for that merit category.

A.1.4 Merit Categories

- **High Merit:** The project unquestionably advances the technical state of knowledge and understanding of the mission or relevant work scope area, and is creative and based largely on original concepts. The scope can be executed fully in the facilities available.
- **Moderate Merit:** The project advances the technical state of knowledge and understanding of the mission or relevant work scope area, and is based on some established concepts, although several creative and original concepts are presented. The scope may be executed fully in the facilities available.
- **Some Merit:** The project incrementally advances the technical state of knowledge and understanding of the mission or relevant work scope area, and is based predominately on established concepts, with some creative, original concepts. The scope may be difficult to execute fully in the facilities available.

- **Low Merit:** The project recognizes the technical state of knowledge and understanding of the mission or relevant work scope area, and is only marginally creative and contains few original concepts. The scope will require resources not named in the project, or will require additional facilities or resources to execute.
- **No Merit:** The project does not advance or recognize the technical state of knowledge and understanding of the mission or relevant work scope area, and is not creative or original. The scope cannot be executed fully in the facilities available.

The individual scores determined by evaluating each application against the above criteria, will then be weighted as defined in Table 4 to determine an overall evaluation score for each application.

After considering the overall evaluation scores, available funding, and the other selection factors (see Part V, Section A.7 of this CINR FOA) as needed, DOE will make a final determination of applicants, who will be invited to provide full applications.

Applicants, other than NSUF pre-application, who are not specifically invited to submit full applications may still do so at their own risk. There is no guarantee uninvited full applications will receive a full review; however, all full applications will be re-reviewed for program relevancy/priority. Only those uninvited full applications scored as "High Relevance" and at least "Moderate Program Priority" will be forwarded for technical peer review during the evaluation phase for full applications described below in Part V, Section A.4.

NSUF pre-applications that do not receive an invitation to submit are not permitted to submit a full application.

A.1.5 Diverse Team Review

Up to 10 points may be contributed to the average program relevancy score during the merit review process based on the degree to which an application is led by or effectively partners with MSIs, HBCUs, and/or TCUs. (For a directory of MSIs, please visit: https://cmsi.gse.rutgers.edu/content/msi-directory)

NOTE: Diverse teamings and partnerships are not required for projects to be evaluated as unquestionably relevant; however, diverse teamings and partnerships will increase the relevance score by up to 10 points, not to exceed the maximum available relevancy points, based on the project meeting one of the following criteria: (1) the project has a substantive contribution by MSIs, HBCUs, and/or TCUs as lead or collaborator; (2) the project has a demonstrable contribution by MSIs, HBCUs and/or TCUs as lead or collaborator; or (3) the project has some relevant partnership with MSIs, HBCUs, and/or TCUs as lead or collaborator.

A.2 Feasibility Review (NSUF Projects Only)

The feasibility review is a very important part of the NSUF pre-application review process. Many factors will be taken into account as part of the feasibility review including the following: type of project; duration of project; experimental degree of complexity; types of

samples; number of samples; need for shipping and containment; potential needed capability or facility enhancement or upgrade; project schedule, and cost.

In order to ensure that a pre-application and eventual application is submitted with the highest possible degree of feasibility, it is imperative that potential proposers establish contact with an NSUF Technical Lead at the earliest possible time. The NSUF Technical Lead will have knowledge of and direct access to the facility or facilities where the work will be performed. It is intended that the Technical Lead should be an integral collaborator on the project and contribute strongly to the application preparation. The Technical Lead will provide guidance in establishing the scope of the project in negotiation with the facility to produce a cost estimate. Should the project be awarded, the Technical Lead will be the primary POC to best ensure the project is performed on schedule and within budget.

Applications deemed not feasible or high risk by the NSUF Program Office will not be considered.

A.3 Readiness Review (NSUF Projects Only)

Prior to final selection, pre-applications and full applications for NSUF access will be reviewed by the NSUF Program Office to verify the project is ready for NSUF access, as discussed in Part 1, Section B.2.2 of this CINR FOA. Pre-applications and full applications deemed not ready for NSUF access will not be considered.

A.4 Initial Review Criteria of Full Applications

Prior to a comprehensive merit evaluation, DOE will perform an initial review to determine: (1) the applicant is eligible for an award; (2) the named applicant, PI(s) and collaborators have not changed from the pre-application to the full application or, if they have, DOE's Contracting Officer has provided signed approval; (3) the information required by the announcement has been submitted; and (4) all mandatory requirements are satisfied. Only applications meeting these initial review criteria will be considered during the merit review and award selection decision.

A.5 PS/MS/NSUF R&D Merit Review Criteria: Full Applications

Selection will be made in accordance with the review criteria identified for each area and the program policy factors (other selection factors) listed in Part V, Section A.7 of this FOA. The criteria for the respective FOA areas are identified below along with the relative importance of each criterion or sub-criterion, if applicable. All applications will be point scored and ranked. Applications must be fully responsive to each of the following criteria.

Review of full applications shall be based on how well the applications meet or exceed the technical and program relevancy/priority evaluation criteria provided below and as weighted as described in Table 4. All invited full applications submitted under this CINR FOA will be reviewed and scored as described in this CINR FOA. A panel of programmatic experts will assess each full application's program relevancy/priority to DOE-NE's R&D mission and work scope area, and multiple technical peer reviewers will evaluate the project for technical merit. Effective partnerships will be incorporated into the program relevancy/priority evaluation, as described in Part V, Section A.1.5.

A.5.1 Program Relevancy/Priority Attributes

Same criteria used for PS/MS/NSUF pre-application evaluation phase applies to full applications. See Part V, Section A.1.1of this CINR FOA.

A.5.2 Technical Merit Attributes

Applications will be subjected to formal merit review and will be evaluated against the following criteria.

- **Criterion 1 – Advances the State of Knowledge and Understanding and Addresses Gaps in Nuclear Science and Engineering Research**: The technical merit of the proposed R&D project will be evaluated, including the extent to which the project advances the state of knowledge and understanding and addresses gaps in nuclear science and engineering research. Evaluation will consider how important the proposed project is to advancing knowledge and understanding within the area selected and how well the proposed project advances, discovers, or explores creative, original, or potentially transformative concepts.
- **Criterion 2 – Technical Quality of the Proposed R&D Project**: DOE will evaluate the overall quality/acceptability of the proposed R&D project. In evaluating this criterion, DOE may consider the (1) merit, feasibility, and realism of the proposed methodology and approach to the project; (2) schedule, including sequence of project tasks, principle milestones, and times for each task; (3) planned assignment of responsibilities; (4) proposed project efficiencies; and (5) technical expertise available to the applicant in carrying out the project.
- **Criterion 3 – Applicant Team Capabilities, Risks, and Experience**: The extent to which the applicant team provides objective evidence that it has the resources and abilities to successfully complete the R&D project in a technically defensible manner will be evaluated. Current activities, working with industry, relevance and depth of the organization's experience and capabilities, past performance, together with that of the PI, and the adequacy of the requested resources and their supporting justification will all be evaluated as they relate to the likely successful completion of the R&D objectives.

  In evaluating criterion 3, DOE will consider the extent to which the application demonstrates the following:

  - That the capabilities and qualifications of engineering and scientific personnel, PI, and other key contributors are such that they can successfully accomplish the technical scope of the proposed project;
  - That the applicant or respective team members have demonstrated successful experience/past performance, knowledge, and understanding of the business and regulatory requirements for projects of similar size, scope, and complexity in achieving project technical success on time with no significant, unresolved safety and quality issues;
  - The applicant team's identification of, and work with industry, to gain industry perspective and technical knowledge important to project decisions, and how the applicant will work with industry to best achieve the objectives of this FOA and the project.

Table 4. PS/MS R&D and NSUF Access Only Pre-applications and Full Applications - Weighting of Evaluation Scores.

Criterion	
Technical Application – Peer Review	Percentage of Peer Review Score
Pre-Applications	
Technical Merit Category	100%
Full Applications	
Criterion 1: Advances the State of Scientific Knowledge and Understanding and Addresses Gaps in Nuclear Science and Engineering Research	35%
Criterion 2: Technical Quality of the Proposed R&D Project	35%
Criterion 3: Applicant Team Capabilities, Risks, and Experience	30%
Peer Review Score	Sum of ratings x weights
Program Relevance/Priority[1] (Separate Review Process, Used for Pre-Applications, LOIs and Full Applications)	Percentage of Program Relevancy/Priority Review Score
Relevancy	100%
Program Priority	Multiplier based on program priority rating
Diverse Team Review	Up to 10 points, not to exceed the maximum relevancy points available.
Program Relevancy/Priority Score	Sum of ratings[2] x program priority multiplier
Weighting	Weighted Score Ratio (Technical : Relevancy) Program Supporting: 65:35 Mission Supporting: 80:20 NSUF Access Only: 65:35

[1] Supports Program Relevance: This element will be scored by the Program Offices, not by peer review.
[2] Total program relevancy/priority points cannot exceed 100% of points available from the program relevancy/priority criteria.

A.6 Program Directed (PD) Integrated Research Projects (IRP) Merit Review for Full Application

Selection for the PD IRP for U.S. university-led projects will be based on the following relevancy and technical merit attributes and criteria and sub-criteria in Part V, Section A.6.1-A.6.3. The criteria are equally important. Review of full applications shall be based on how well the applications meet or exceed the technical and program relevancy/priority evaluation criteria provided below, and as weighted as described in Table 5.

A.6.1 Relevancy Attributes

- **Program Factors:** Relation of the proposed project to the core research activities within the DOE programs

- **Resource Factors:** The degree to which award of the project optimizes use of the proposed resources to achieve project goals

- **Collaboration Factors:** Potential for developing synergies between the proposed IRP and other DOE research activities

A.6.2 Technical Merit Attributes

- **Criterion 1 – Scientific and/or Technical Merit of the Project:** The scientific and technical merit of the proposed IRP will be evaluated, including the extent to which the project advances the state of scientific knowledge and understanding relative to the IRP and addresses key scientific challenges and shifts in research directions towards promising developments. Evaluations will consider how important the proposed project presents a balanced and comprehensive program of research that, as needed, supports experimental, theoretical, and computational efforts and develops new approaches in these areas.

- **Criterion 2 – Appropriateness of the Proposed Method or Approach:** The appropriateness of the proposed IRP method or approach will be evaluated, including risk posed by the approach, as well as the extent to which the strategy and plan for the development and operation of the proposed IRP identifies an acceptable approach involving senior/key personnel, the means for achieving integration on the IRP, and plans for leadership and guidance for the scientific and technical direction. DOE shall consider whether the applicant presents a comprehensive management plan for a world-class program that encourages research—including high-risk, high-reward—as well as synergisms among investigators. The organization structure should delineate the roles and responsibilities of senior/key personnel and describes the means of providing external oversight and guidance for scientific and technical direction and approval of the research program. Additionally, DOE will also consider the following:

    - The applicant’s plans (if any) for education, outreach, and training in the proposed IRP are appropriate and, if needed, described as part of the scope.

    - Appropriateness and reasonableness of applicant’s plans (if any) for external collaborations and partnerships.

    - The roles and intellectual contributions of the IRP lead PI, other investigator(s), and each senior/key person.

    - Maximizing the use of other available facilities and existing equipment.

    - Relation to existing and planned research programs at the host or collaborator institution.

- **Criterion 3 – Applicant Team Capabilities, Risks, and Experience:** DOE will evaluate the extent to which the applicant team provides objective evidence that it has, or can obtain the professional resources and abilities to successfully complete the

IRP project in a technically defensible manner. Current activities, relevance, and depth of the organization's experience and capabilities, together with that of the PI, will be evaluated as it relates to the likely successful completion of the IRP. Risk posed by the applicant team will be evaluated. In evaluating this criterion, DOE will consider the extent to which the application demonstrates the following**:**

- Maximizing the use of other available facilities and existing equipment.
- The proposed access to existing research space, instrumentation, and facilities at the host institutions and its partners are likely to meet the needs of the proposed IRP;
- There is adequate access to experimental and computational capabilities as needed to ensure successful completion of the proposed research;
- The lead institution and the senior/key personnel for the IRP have proven records of success in project, program, and personnel management for projects of comparable magnitude;
- The plan for recruiting any additional scientific and technical personnel including new senior staff, students, and post-docs is reasonable and appropriate;
- The IRP leadership has the capability to communicate effectively with scientists of all required disciplines;
- The IRP lead PI and senior/key personnel will be adequately involved in the proposed IRP, particularly taking into account their potential involvement in other major projects.

A.6.3 Diverse Team Review

Up to 10 points may be contributed to the average program relevancy score during the merit review process based on the degree to which an application is led by or effectively partners with MSIs, HBCUs, and/or TCUs. (For a directory of MSIs, please visit: https://cmsi.gse.rutgers.edu/content/msi-directory)

NOTE: Diverse teamings and partnerships are not required for projects to be evaluated as unquestionably relevant; however, diverse teamings and partnerships will increase the relevance score by up to 10 points, not to exceed the maximum available relevancy points, based on the project meeting one of the following criteria: (1) the project has a substantive contribution by MSIs, HBCUs, and/or TCUs as lead or collaborator; (2) the project has a demonstrable contribution by MSIs, HBCUs and/TCUs as lead or collaborator; or (3) the project has some relevant partnership with MSIs, HBCUs, and/or TCUs as lead or collaborator.

Table 5. PD IRP Full Applications - Weighting of Evaluation Scores.

Criterion	
Technical Application – Peer Review	Percentage of Peer Review Score

Criterion	
Criterion 1: Scientific and/or Technical Merit of the Project	35%
Criterion 2: Appropriateness of the Proposed Method or Approach	35%
Criterion 3: Applicant Team Capabilities, Risks, and Experience	30%
Peer Review Score	Sum of ratings x weights
Relevance[1] (Separate Review Process)	Percentage of Relevancy Review Score
Program Factors	40%
Resource Factors	40%
Collaboration Factors	20%
Diverse Team Review	Up to 10 points, not to exceed the maximum relevancy points available.
Relevancy Score	Sum of ratings[2] x weights
Weighting	Weighted Score Ratio (Peer : Relevancy) PD: 50:50
[1] Supports Program Relevance: This element will be scored by the Federal Program and Technical Integration Offices, not by peer review. [2] Total relevancy points cannot exceed 100% of points available from the relevancy criteria.	

A.7 Other Selection Factors

Program Policy Factors. The Selection Official may consider the following program policy factors in the selection process:

- Degree to which proposed project optimizes/balances/maximizes use of available DOE funding to achieve DOE program goals and objectives, including how those R&D and IRP projects support DOE research. It may also include research portfolio diversity, geographic distribution and/or how the projects support other complementary efforts that, when taken together, will best achieve program research goals and objectives;
- Application selection may optimize appropriate mix of projects to best achieve DOE research goals objectives;
- Cost/Budget considerations, including availability of funding;
- Extent that the applicant has awards in progress, or not completed, from DOE, from a previous year's FOA, or has existing no cost extensions;
- Demonstrated ability of the applicant to successfully complete projects (including relevant prior projects) and do so within budget and within the specified timeframe of the award;

- Applicability across multiple reactor technologies, including future design types. Proposed cost share that exceeds minimum required amounts on the part of the applicant may be given preferential consideration;
- Potential to enhance U.S. nuclear infrastructure may be given preferential consideration;
- Consistent and conformant work proposed in the application with current Office of Nuclear Energy Congressional appropriations.
- Foreign government ownership, if any, of the applicant, the applicant's parent companies, or any entity owned or controlled by a foreign government, may be considered in making the award;
- Applications that have national security concerns;
- Whether the entity is located in an urban and economically distressed area including a Qualified Opportunity Zone (QOZ) or the proposed project will occur in a QOZ or otherwise advance the goals of QOZ. The goals include spurring economic development and job creation in distressed communities throughout the United States.
- Whether the proposed project may directly or indirectly benefit disadvantaged communities or exhibits team member diversity, with participants including but not limited to those from Minority Serving Institutions (e.g. Historically Black Colleges and Universities (HBCUs) /Other Minority Institutions (OMIs)), Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses, Veteran Owned Businesses, or members within disadvantaged communities.

Any of the above factors may be independently considered by the Selection Official in determining the optimum mix of applications that will be selected for support. These factors, while not indicators of the application's merit, may be essential to the process of selecting the application(s) that, individually or collectively, will best achieve the program objectives. Such factors are often beyond the control of the applicant. **Applicants should recognize that some very good applications might not receive an award because of program priorities and available funding.** Therefore, the above factors may be used by the Selection Official to assist in determining which applications shall receive DOE funding support.

For applications requesting R&D support with NSUF access, DOE reserves the right to decouple the R&D element from the NSUF access element and consider either portion for a provisional award, dependent on confirmation from the applicant that the portion selected for award can be executed independently.

B. SUMMARY OF THE REVIEW AND SELECTION PROCESS

B.1 PS/MS/NSUF Pre-applications

Pre-application projects will be evaluated against the technical and program relevancy/priority criteria described in this CINR FOA. This technical and program evaluation process will produce a list of recommended projects for each work scope. DOE will consider the overall evaluation results and subjective programmatic factors to select a final set of invited projects to provide a full application.

NOTE: Applicants not requesting NSUF access who do not receive a formal invitation from DOE to submit full applications in response to the pre-application review process may still do so at their own risk. There is no guarantee uninvited full applications will receive a full review; however, all full applications received will be re-reviewed for program relevancy/priority. Only uninvited full applications scored as "High Relevance" and at least "Moderate Program Priority" will receive a technical peer review during the evaluation phase for full applications.

NOTE: Applicants requesting NSUF access who are not specifically invited by DOE to submit full applications will NOT be allowed to submit full applications. Due to resource limitations within the NSUF, the feasibility review, a critical element of NSUF access, will continue only for applications that are specifically invited. An uninvited NSUF application without a complete NSUF feasibility review is incomplete, and cannot be re-reviewed for program relevancy/priority.

B.2 PS/MS/NSUF Full Applications

Multiple peer reviewers will independently evaluate the applications in accordance with the technical review evaluation criteria described in this CINR FOA. Also, DOE will complete a program relevancy/priority review process in accordance with the criteria described above. These results will be weighted in accordance with the ratio described above. DOE will consider the overall evaluation results and subjective programmatic factors to ultimately recommend a final set of applications for approval by the Selection Official.

B.3 IRP Full Applications

Multiple technical experts independently evaluate the applications in accordance with the review criteria and weighted as described above. Also, DOE will complete a program/relevancy review process in accordance with the criteria described above. Following individual review, reviewers meet as a panel for final recommendation to DOE. DOE will consider the overall evaluation results and subjective programmatic factors to ultimately recommend applications for approval by the Selection Official.

Due to the expected complexity of these projects, DOE may require clarification on the contents of application(s) and an opportunity to ask questions regarding the proposed project. As part of the evaluation and selection process for any review cycle, DOE may elect to do pre-selection clarifications. These pre-selection clarifications, if done, will be used for the purposes of clarifying the applications, not supplementing the applications. Use of such pre-selection clarifications neither obligates DOE to make an award nor to use a clarification process for successive review cycles.

B.4 Reporting of Matters Related to Recipient Integrity and Performance

DOE, prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold, is required to review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM (currently FAPIIS) (see 41 U.S.C. § 2313).

The applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM. The applicant may comment on any information about itself

that a Federal awarding agency previously entered that is currently in the designated integrity and performance system accessible through SAM.

DOE will consider any written comments by the applicant, in addition to the other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.205 - Federal awarding agency review of risk posed by applicants.

C. ANTICIPATED NOTICE OF SELECTION

DOE anticipates making selection announcements no later than July 31, 2022.

PART VI – AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

A.1 Notice of Selection

DOE will notify applicants selected for award. This notice of selection is not an authorization to begin performance. (See Part IV, Section I.2 of this CINR FOA with respect to the allowability of pre-award costs.) Organizations whose applications have not been selected will be advised as promptly as possible. This notice will explain why the application was not selected.

A notice of Federal award, signed by the DOE Contracting Officer, is the authorizing award document for any cooperative agreements awarded as a result of this CINR FOA. A post-selection/pre-award process will occur prior to issuing the actual award. This process includes such activities as a responsibility review/review of risk posed by the selected applicant, a technical and budget review of the selected applicant's proposed budget, etc. Once approved, the actual award notice will be provided by DOE to the recipient by electronic means.

A.2 Nondisclosure and Confidentiality Agreements Representations

In submitting an application in response to this CINR FOA the Applicant represents that:

- It does not and will not require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contractors from lawfully reporting waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.

- It does not and will not use any Federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:

  ‘‘These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive Orders and statutory provisions are incorporated into this agreement and are controlling.’’

- The limitation and representations above in Part VI, Section A.2 of this CINR FOA shall not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

Notwithstanding the limitation and representations listed Part VI, Section A.2 of this CINR FOA above, a nondisclosure or confidentiality policy form or agreement that is to be executed by a

person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States Government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not disclose any classified information received in the course of such activity, unless specifically authorized to do so by the U.S. Government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosures to Congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

A.3 Notice of Award

An assistance agreement issued by the Contracting Officer is the authorizing award document (excludes NSUF access only awards). It normally includes, either as an attachment or by reference, the following: (1) special terms and conditions; (2) applicable program regulations, if any; (3) application as approved by DOE; (4) DOE assistance regulations at 2 CFR part 200, as amended by 2 CFR part 910; (5) National Policy Assurances to be incorporated as award terms; (6) Budget Summary; and (7) Federal Assistance Reporting Checklist, which identifies the reporting requirements.

If award is made to a DOE national laboratory, it will be made against their existing prime M&O contract with DOE through the work authorization system as outlined in DOE O 412.1A, Admin Change 1. DOE national laboratories remain bound by the terms and conditions of their contract with DOE. DOE O 481.1C., Work for Others, is not applicable.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

B.1 Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR part 200, as amended by 2 CFR part 910 (See: http://ecfr.gov). Grants and cooperative agreements made to universities, non-profits, and other entities subject to Title 2 CFR are subject to the Research Terms and Conditions located on the National Science Foundation website at http://www.nsf.gov/bfa/dias/policy/rtc/index.jsp.

B.1.1 DUNS and SAM Requirements

Additional administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR, part 25 (see http://www.ecfr.gov/cgi-bin/ECFR?page=browse). Prime awardees must be registered in SAM before submitting an application, and must continue to maintain a SAM registration with current information at all times during which it has an active Federal award or an application or plan under consideration by DOE under this CINR FOA. Primes and subawardees at all tiers must obtain a DUNS numbers and provide the DUNS to the prime awardee before the subaward can be issued. The prime will provide this valid unique entity identifier in its application. DOE may not make a Federal award to an applicant until the applicant has complied with all applicable unique entity identifier and SAM requirements and, if an applicant has not fully complied with the requirements by the time DOE is ready to make the award, DOE may determine that the applicant is not qualified to receive an award and use that determination as a basis for making an award to another applicant.

B.1.2 Subaward and Executive Reporting

Additional administrative requirements necessary for DOE grants and cooperative agreements to comply with the Federal Funding and Transparency Act of 2006 (FFATA) are contained in 2 CFR, part 170 (see http://www.ecfr.gov/cgi-bin/ECFR?page=browse). Prime awardees must register with the new FFATA Subaward Reporting System (FSRS) database and report the required data on their first tier subawardees. Prime awardees must report the executive compensation for their own executives as part of their registration profile in the SAM.

B.2 Special Terms and Conditions and National Policy Requirements

The DOE special terms and conditions for use in most grants and cooperative agreements are located at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under "Award Terms".

If the Federal share of any Federal award may include more than $500,000 over the period of performance, post award reporting requirements reflected in 2 CFR part 200, Appendix XII—*Award Term and Condition for Recipient Integrity and Performance Matters*, may also apply to any resultant award made under this CINR FOA.

The National Policy assurances to be incorporated as award terms are located at http://www.nsf.gov/bfa/dias/policy/rtc/appc.pdf and at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under Award Terms.

Quality Assurance (QA) to be incorporated as award terms (applicable to educational institutions only). While DOE will normally rely on the institution's quality assurance (QA) system, below are general guidelines that those systems should adhere to, as applicable, for the type of work being done. No separate deliverable is required by this provision, unless the institution's existing QA systems are not compliant with these guidelines, or in the case that the institution identifies that the work to be performed has any special or unique QA requirements. The DOE has the right of access to the university facilities and records for surveillance or inspection. Any surveillance or inspections will be coordinated with the PI.

- **Test Planning, Implementation, and Documentation (Research Planning)**
    - Test methods and characteristics shall be planned and documented, and the approaches and procedures recorded and evaluated. Characteristics to be tested and test methods shall be specified. The test results shall be documented and their conformance to acceptance criteria evaluated.
    - Documentation shall be developed to ensure replication of the work. The researcher/developer shall document work methods and results in a complete and accurate manner. The level of documentation shall be sufficient to withstand a successful peer review. Protocols on generation and safeguarding of data and process development from research shall be developed for consistency of R&D work.
    - Laboratory notebooks shall be controlled by a university documented procedure/process. Also, the process for development of intellectual property

documentation shall be controlled under university document control procedures/processes.

- If the university identifies any special or unique QA requirements for Test Planning, Implementation, and Documentation, the university shall submit a Test Plan/Research Plan to the funding organization for review and concurrence prior to use.

Equipment Calibration and Documentation

The researcher shall specify the requirements of accuracy, precision, and repeatability of measuring and test equipment (M&TE). Depending upon the need for accuracy, precision, and repeatability of M&TE used in research, standard university documented procedures shall be implemented. During the process development stage, and for all R&D support activities, M&TE shall be controlled. The degree of control shall be dependent on the application of the measurement. The university shall have available calibration records documenting instrument calibration to a national standard.

Procurement Document Control

University documented procurement document control procedures/processes shall be implemented, if results of initial research work are expected in the next stage of work, and if the pedigree of materials being used could influence the usefulness of the research work results. Procurement document specifications shall be controlled. For development and support activities, the level of procurement document control shall be applied to support a design basis, i.e., engineering design system criteria. If procurement document control requirements apply, the university shall have a documented procedure/process for control of suspect/counterfeit items (S/CI), and have available for submission for DOE review material pedigree records.

Training and Personnel Qualification

Personnel performing research activities shall be trained per university documented requirements to ensure work is being conducted properly to prevent rework or the production of unacceptable data. The university shall have available—for submission for DOE review—personnel training records.

Records

In many cases, the notebook or journal of the researcher is the QA record. These documents shall be controlled in accordance with university documented procedure/process, e.g., maintain notebook as a controlled document, maintain copies of critical pages or access-controlled filing when not in use to preserve process repeatability and the QA record. Electronic media may be used to record data and shall be subject to documented administrative controls for handling and storage of data. Work activity records shall be maintained by the university and available for DOE review, upon request, within sixty (60) days of completion of the work scope.

Data Acquisition/Collection and Analysis

When gathering data, the researcher shall ensure that the systems and subsystems of the experiment are operating properly. Software systems used to collect data and operate the experiment requires verification that it meets functional requirements prior to collection of actual data. Data anomalies require investigation. When performing data analysis, define the

following: (1) assumptions and the methods used; (2) the results obtained so that independent qualified experts can evaluate how data was interpreted;(3) methods used to identify and minimize measurement uncertainty; (4) the analytical models used; and (5) whether the R&D results have been documented adequately and can be validated.

Peer Review

Peer reviews shall be performed in accordance with peer review best practices as described in Part V of this CINR FOA. The peer reviews shall be documented and maintained by the university. Peer review documentation and results shall be provided to DOE.

B.3 Intellectual Property Provisions

The standard DOE financial assistance intellectual property provisions applicable to the various types of recipients are located at http://energy.gov/gc/standard-intellectual-property-ip-provisions-financial-assistance-awards.

B.4 Lobby Restrictions

By accepting funds under this award, the applicant agree that none of the funds obligated on the award shall be expended, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. § 1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

B.5 Corporate Felony Conviction and Federal Tax Liability Representations

In submitting an application in response to this CINR FOA the applicant represents that:

- It is not a corporation that has been convicted (or had an officer or agent of such corporation acting on behalf of the corporation convicted) of a felony criminal violation under any Federal law within the preceding 24 months; and
- It is not a corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

For purposes of these representations the following definitions applies:

- A corporation includes any entity that has filed articles of incorporation in any of the 50 states, the District of Columbia, or the various territories of the United States (but not foreign corporations); and
- It includes both for-profit and non-profit organizations.

B.6 Statement of Substantial Involvement

DOE anticipates having substantial involvement during the project period, through technical assistance, advice, intervention, integration with other awardees performing related activities, and technical transfer activities. The recipient's responsibilities and DOE's responsibilities are listed in Part VI, Section B.6 below:

Recipient's Responsibilities. The recipient is responsible for:

- Complying with all award requirements, including performing the activities supported by this award, including providing the required personnel, facilities, equipment, supplies and services;
- Defining approaches and plans as may be required by this award, submitting the plans to DOE for review, and incorporating DOE's comments;
- Managing and conducting the project activities, including coordinating with DOE management and operating (M&O) contractor(s) as required and as proposed in the recipient's project plan on activities performed under the M&O contract(s) that are related to the project;
- Attending annual program review meetings and reporting project status, if requested by the program;
- Submitting technical reports as stated in the Federal Assistance Reporting Checklist, and incorporating DOE comments
- Completing reporting requirements as outlined in the instructions provided in the awards Attachment B "Federal Assistance Reporting Checklist and Instructions" including:
    - **DOE-NE Program Information Collection System (PICS:NE):** NE CINR R&D award PIs are required to complete reporting requirements as outlined in the instructions provided in the awards Attachment B "Federal Assistance Reporting Checklist and Instructions". Information provided in required award reporting will be utilized to populate PICS:NE (PICS:NE data entry will be done by DOE using information provided by the PI). PIs may be asked by the DOE PICS:NE representative for additional information during the initial work package setup process to accurately document the project plan, as well as through the award's project period to populate information in PICS:NE. PIs may be requested to provide additional assistance for clarification purposes in assuring accuracy of the information being entered into PICS:NE;
    - **DOE-NE Program Accrual Information:** DOE policy requires the monthly tracking of uncosted obligations on financial assistance awards in the DOE accounting system to assist DOE in accomplishing more accurate project management and to more accurately recognize Department liabilities to the recipient. DOE personnel do this internally by subtracting paid costs and any costs accrued (yet to be paid incurred costs of the recipient) from the amounts obligated on the financial assistance award. In accomplishing this, DOE may request the recipient provide additional cost accrual information to accurately estimate/document the accrual in the DOE accounting system. If such information is needed, it will typically be done on awards over $1M and DOE will normally do this using an e-mail to the recipient requesting the recipient identify the dollar value of work it has performed each month but not yet invoiced (or done a Treasury system draw on) as of month end. Recipients will cooperate with DOE in providing the needed cost accrual information.

- **DOE Responsibilities.** DOE is responsible for the following items, which may be revised depending on the project:
    - Reviewing in a timely manner project plans, including technology transfer plans, and redirecting the work effort if the plans do not address critical programmatic issues;
    - Conducting annual program review meetings to ensure adequate progress and that the work accomplishes the program and project activities. Redirecting work or shifting work emphasis, if needed;
    - Promoting and facilitating technology transfer activities, including disseminating program results through presentations and publications; and
    - Serving as scientific/technical liaison between awardees and other program or industry staff.

NOTE: There are limitations on recipient and DOE responsibilities and authorities in the performance of the project activities. Performance of the project activities must be within the scope of the Statement of Objectives, the terms and conditions of the Cooperative Agreement, and the funding and schedule constraints.

C. REPORTING

Reporting requirements are identified on the Federal Assistance Reporting Checklist, DOE F 4600.2, attached to the award agreement. A sample checklist is available at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under Award Forms.

NOTE: The DOE F 4600.2 identifies in box 4.E "Other Reporting", a checkbox titled "Other (see special instructions)". For NEUP and NEET/NSUF awards, the other box is checked and the following is requested.

NOTE: A new award may be delayed due to delinquent reporting, including delinquent final reports for past awards.

Work Package Template (one time submission) – Completed and submitted by the PI to assist DOE with populating general award information in the PICS:NE system. The template is due no later than 10/31/2022 for awardees in the above listed areas. The Work Package should contain milestones that are appropriate, meaningful and measurable, over the life of the project.

Quad Chart (quarterly submission) – The chart is completed and submitted by the PI to provide DOE-NE program managers and technical leads with a quick "snap-shot" look at R&D progress.

Research Performance Progress Report Template (quarterly submission) – The DOE F 4600.2 identifies in box 4.A "Management Reporting", a checkbox titled "Research Performance Progress Report (RPPR)(RD&D Projects)". The PI will complete and submit this template, which asks for information that satisfies the RPPR.

PART VII – QUESTIONS/AGENCY CONTACTS

A. QUESTIONS

Interested parties are encouraged to ask questions as early in the CINR FOA process as possible. Questions and comments concerning this CINR FOA shall be submitted not later than five (5) business days prior to the application due date. Questions submitted after that date may not allow the Government sufficient time to respond.

Questions regarding the content of this CINR FOA must be submitted to the Agency Contact listed in Part VII, Section B of this CINR FOA. Questions regarding work scopes may be submitted to the DOE federal and technical POCs listed in Appendices A, B, and C of this CINR FOA. Applicants can communicate directly with the Federal and Technical Point of Contact until full applications are submitted regarding work scopes and technical questions. Questions pertaining to items such as application processes, eligibility, or application document requirements should be directed to NEUP@inl.gov.

Questions relating to the registration process, system requirements, how an application form works, or the submittal process, must be directed to NEUP@inl.gov.

PIs are not allowed to contact Federal or Technical Points of Contact after the full application due date. Answers to submitted questions submitted containing information about the CINR FOA or the FOA process that would be necessary for the preparation of applications will be posted to www.NEUP.gov as soon as practical. Information provided to a potential applicant in response to its request will not be disclosed if doing so would reveal the potential applicant's confidential business strategy and/or is otherwise protected. DOE will try to respond to a question within three (3) business days, unless a similar question and answer have already been posted on the website.

B. AGENCY CONTACT

Name: Andrew Ford
E-mail: fordaj@id.doe.gov

C. INFORMATIONAL WEBINAR

DOE holds a webinar each year to discuss the structure and execution of this FOA, including major updates from previous years, including work scopes. Applicants can watch and participate in the live webinars and submit questions, through the GoToWebinar interface, to be answered in real time. Registration information and webinar presentations are available on www.NEUP.gov for review by applicants.

PART VIII – OTHER INFORMATION

A. MODIFICATIONS

Notices of any modifications to this announcement will be posted on www.FedConnect.net and www.Grants.gov and will also be posted as a courtesy on www.NEUP.gov. It is recommended that the website is checked frequently at www.NEUP.gov to ensure you receive timely notice of any modifications or other announcements.

B. GOVERNMENT RIGHT TO REJECT OR NEGOTIATE

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

C. COMMITMENT OF PUBLIC FUNDS

The Contracting Officer is the only individual, who can make awards or commit the Government to the expenditure of public funds. A commitment by anyone other than the Contracting Officer, either explicit or implied, is invalid.

Funding for all awards is contingent upon the availability of funds appropriated by Congress for the purpose of this program.

D. PROPRIETARY APPLICATION INFORMATION

Patentable ideas, trade secrets, proprietary or confidential commercial or financial information, disclosure of which may harm the applicant, should be included in an application only when such information is necessary to convey an understanding of the proposed project. The use and disclosure of such data may be restricted, provided the applicant includes the following legend on the first page of the project narrative and specifies the pages of the application which are to be restricted:

> "The data contained in pages [Insert pages] of this application have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award. This restriction does not limit the government's right to use or disclose data obtained without restriction from any source, including the applicant."

To protect such data, each line or paragraph on the pages containing such data must be specifically identified and marked with a legend similar to the following:

> "The following contains proprietary information that (name of applicant) requests not be released to persons outside the Government, except for purposes of review and evaluation."

E. EVALUATION AND ADMINISTRATION BY NON-FEDERAL PERSONNEL

In conducting the merit review evaluation, the Government may seek the advice of qualified non-Federal personnel as reviewers. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The applicant, by submitting an application, consents to the use of non-Federal reviewers/administrators. Non-Federal reviewers must sign COI and non-disclosure agreements prior to reviewing an application. Non-Federal personnel conducting administrative activities must sign a non-disclosure agreement.

F. INTELLECTUAL PROPERTY DEVELOPED UNDER THIS PROGRAM

Patent Rights. Domestic small businesses and domestic nonprofit organizations will receive the patent rights clause at 37 CFR 401.14, i.e., the implementation of the Bayh-Dole Act. This clause permits domestic small business and domestic non-profit organizations to retain title to subject inventions.

Class Patent Waiver. For applicant's that are not domestic small businesses or nonprofit organizations, the Office Nuclear Energy (NE) Class Patent Waiver W(C) 2020-002 may be applicable to an award made under this announcement. The class patent waiver will provide applicants, not subject to the Bayh-Dole Act, the option to retain title to their own inventions, subject to the same government retained rights identified in the Act above. To receive the class waiver, an applicant, must agree to provide statutory minimum cost share required under the award and agree to substantially manufacture technology created under the award in the U.S., or provide other economic benefits to the U.S. in accordance with the U.S. Competitiveness provision set forth in the above-referenced class patent waiver.

Rights in Technical Data. Normally, the Government has unlimited rights in technical data created under a DOE agreement. Delivery or third-party licensing of proprietary software or data developed solely at private expense will not normally be required except as specifically negotiated in a particular agreement to satisfy DOE's own needs or to insure the commercialization of technology developed under a DOE agreement.

Special Protected Data Statutes. This program is covered by a special protected data statute. These special protected data statutes apply to only those applicants who cost share. The provisions of the statute provide for the protection from public disclosure, for a period of up to five (5) years from the development of the information, of data that would be a trade secret, or commercial or financial information that is privileged or confidential, if the information had been obtained from a non-Federal party. Generally, the provision entitled, Rights in Data - Programs Covered Under Special Protected Data Statutes (Item 4 under 2 CFR 910, Appendix A to Subpart D), would apply to an award made under this announcement. This provision will identify data or categories of data first produced in the performance of the award that will be made available to the public, notwithstanding the statutory authority to withhold data from public dissemination, and will also identify data that will be recognized by the parties as protected data.

G. UNDERSTANDING COST SHARING REQUIREMENTS

(Cost sharing is not required for universities and FFRDCs)

Department-wide cost sharing requirements are established by Section 988 of the Energy Policy Act of 2005. The DOE Financial Assistance Rules at 2 CFR part 200 and 2 CFR part 910 implement cost sharing requirements (see 2 CFR 200.306 and 2 CFR 910.130). The CINR FOA requires a minimum of 20% cost sharing by awardees, except for applications led by U.S. non-profit educational institutions/universities. The applicant's cost share requirement will be based on the total cost of the project. FFRDC costs are included as part of government cost share.

In accordance with section 988 (d) of the Energy Policy Act of 2005, Calculation of Amount, when calculating the amount of the non-Federal contribution, the Government:

1. May include the following costs as allowable in accordance with the applicable cost principles:
    a. Cash.
    b. Personnel costs.
    c. The value of a service, other resource, or third party in-kind contribution determined in accordance with the applicable circular of the Office of Management and Budget [**Note**: In-kind contributions, like any other cost, need to be incurred during the award project period, e.g., cannot give credit for costs incurred prior to the award, including prior development costs, unless otherwise authorized by the applicable cost principles].
    d. Indirect costs or facilities and administrative costs.
    e. Any funds received under the power program of the Tennessee Valley Authority (except to the extent that such funds are made available under an annual appropriation act).

Shall not include:

a. Revenues or royalties from the prospective operation of an activity beyond the time considered in the award.
b. Proceeds from the prospective sale of an asset of an activity.
c. Other appropriated Federal funds.

The terms and conditions of the cooperative agreement will include appropriate provisions on allowable costs.

The Federal share shall not be required to be repaid as a condition of award. Royalties should not be used to repay or recover the Federal share, but may be used as a reward for technology transfer activities.

Cost share is often confused with some form of cost matching. The key to understanding how cost share works is to understand the base from which the cost share percentage is calculated. Cost share percentage is a percentage of the total allowable costs of the project. Note that it is NOT a percentage of the DOE funds, but rather the entire project, including all awardee funds, DOE funds, and all FFRDC requirements.

When determining the cost share requirement in dollars, it is first necessary to determine the entire project cost. Initially, no consideration would be given as to where the funds would come from. An applicant would determine that a certain cost (e.g., hours, travel, supplies, etc.) would be needed to complete the project as proposed in the application. Once the project cost is

determined, an applicant can then calculate the cost share requirement by multiplying the cost share percentage by the project cost. The resulting dollar figure would be the dollar requirement that the applicant must provide as cost share.

Below are several examples of how the cost share amount would be calculated:

Example 1

The applicant determines that the following budget requirements are needed to carry out the work described in its application to DOE:

Direct Labor	$100,000
Travel	$3,000
Equipment	$17,000
Supplies	$10,000
Subcontract	$20,000
Total Project Cost	**$150,000**

A cost share requirement of 20% was specified in the funding announcement.
Cost Share = (cost share percentage) × (***total project cost***)
Cost Share = (20%) × ($150,000)
Cost Share = $30,000

The applicant must now identify $30,000 of $150,000 as Cost Share.
The applicant would then request DOE funding in the amount of $120,000.

DOE Share = $120,000 **Awardee Share = $30,000**

Example 2

The applicant determines that the following budget requirements are needed to carry out the work described in its application to DOE:

Direct	$200,000
Labor	$10,000
Travel	$20,000
Equipment	$10,000
Supplies	$60,000
Total Project	**$300,000**

A cost share requirement of 20% was specified in the funding announcement.

Cost Share = (cost share percentage) × (total project cost)
Cost Share = (20%) × ($300,000)
Cost Share = $60,000

The applicant must now identify $60,000 of $300,000 as Cost Share. DOE would pay $60,000 directly to the FFRDC. The applicant would then request DOE funding in the amount of $180,000.

DOE Share = $180,000 (funds to Awardee) + $60,000 (FFRDC) = $240,000

Awardee Share = $60,000

NOTE: FFRDC funds are paid directly to the FFRDC by DOE. The work provided by the FFRDC is still considered part of the total project cost; therefore, it is included in the base from which the awardee cost share is calculated.

In all cases, the applicant must specify the individual costs that make up each part of the total project cost and indicate whether DOE or non-DOE funds will be used to cover the cost.

The budget from **Example 1** might look something like the following:

		DOE	**Non-DOE**
Direct Labor	$100,000	$70,000	$30,000
Travel	$3,000	$3,000	$0
Equipment	$17,000	$17,000	$0
Supplies	$10,000	$10,000	$0
Subcontract	$20,000	$20,000	$0
Total Project Cost	**$150,000**	**$120,000**	**$30,000**

The application forms in this CINR FOA will facilitate the identification of funding sources.

H. NOTICE REGARDING ELIGIBLE/INELIGIBLE ACTIVITIES

Eligible activities under this program include those which describe and promote the understanding of scientific and technical aspects of specific energy technologies, but not those that encourage or support political activities such as the collection and dissemination of information related to potential, planned, or pending legislation.

I. NO-COST TIME EXTENSIONS

Unilateral no-cost time extensions will NOT be permitted to awards made under this CINR FOA. All no-cost time extensions must provide adequate justification and receive approval from the Contracting Officer. No-cost time extensions should be requested as soon as the need is identified within the last year of the award.

A request for a no-cost time extension on existing DOE-NE funded projects must only be made between October 1 - April 15. Any request outside of this period will need to be substantially justified and receive approval from the Contracting Officer. One no-cost time extension request may be granted for up to 12 months, pending review and approval. No more than one no cost

time extension will be allowed on any DOE-NE funded project. No-cost time extensions should be submitted only during the period of October 1 – April 15 to NEUP@inl.gov.

J. REBUDGET REQUEST

Any rebudget request where the cumulative amount of such change is expected to exceed 10 percent of the total budget as last approved by the Federal awarding agency must be requested in writing (see 2 CFR 200.308). The request must include a detailed budget justification, and an updated budget in the same format that was used in the original application. Any request for the purchase of equipment exceeding $5,000 must be requested in writing to include a valid quote, and justification for purchase.

Budget forms can be found at: https://www.energy.gov/management/downloads/sf-424-research-and-related-budget-rr

K. CONFERENCE SPENDING

The recipient shall not expend any funds on a conference not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded that would defray the cost to the United States government of a conference held by any executive branch department, agency, board, commission, or office for which the cost to the United States government would otherwise exceed $20,000, thereby circumventing the required notification by the head of any such executive branch department, agency, board, commission, or office to the inspector general (or senior ethics official for any entity without an inspector general), of the date, location, and number of employees attending such conference.

PART IX – APPENDICES/REFERENCE MATERIAL

Appendix A: Work Scopes for U.S. University-led Program and/or Mission Supporting R&D Projects

Appendix B: Work Scopes for U.S. University-, National Laboratory-, or Industry-led Program and/or Mission Supporting R&D Projects

Appendix C: Work Scopes for U.S. University-led Integrated Research Project (IRP) R&D

Appendix D: Accessing Nuclear Science User Facilities

Appendix E: Draft Nuclear Science User Facilities User Agreement

Appendix A: Work Scopes for U.S. University-led Program and/or Mission Supporting R&D Projects

PROGRAM SUPPORTING: FUEL CYCLE TECHNOLOGIES

FC-1: MATERIAL RECOVERY AND WASTE FORM DEVELOPMENT

The Material Recovery and Waste Form Development program supports innovative methods to recover valuable elements from used nuclear fuel (UNF) and manage the resulting wastes. The program employs a science-based approach to foster innovative and transformational technology solutions and applies unique nuclear fuel cycle chemistry expertise and technical capabilities to a broad range of civil nuclear energy applications. These chemical technologies, when combined with advanced reactors and their fuels, form the basis of advanced fuel cycles for sustainable and potentially growing nuclear power in the U.S.

FC-1.1: NUCLEAR FUEL CYCLE AQUEOUS SEPARATIONS CHEMISTRY (FEDERAL POC – STEPHEN KUNG & TECHNICAL POC – KEN MARSDEN) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 2 YEARS AND $400,000)

Chemical separation of actinides is employed in nearly every stage of the nuclear fuel cycle, from mining to reprocessing, as well as in other areas such as isotope production. While these separations typically focus on uranium and plutonium recycling, several other valuable isotopes could be recovered. Advanced aqueous separations processes and technologies for actinides and other valuable elements may provide additional economic benefits for UNF recycle. Innovative research to better understand the fundamental coordination chemistry, recovery of valuable materials from used nuclear fuel, radiolysis in solvent extraction systems, and computational modeling of solvent extraction phenomena are especially encouraged.

FC-1.2: UNDERSTANDING, PREDICTING, AND OPTIMIZING THE PHYSICAL PROPERTIES, STRUCTURE, AND DYNAMICS OF MOLTEN SALTS (FEDERAL POC – STEPHEN KUNG & TECHNICAL POC – KEN MARSDEN) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $400,000)

Molten salts find applications in advanced nuclear technologies as electrolytes for pyroprocessing and as fuel solvents and coolants for advanced reactors. Thermodynamic models are needed to predict critical salt characteristics such as melting points, heat capacities, free energies for potential corrosion reactions, and solubilities of fission and corrosion products as a function of temperature and composition. The atomic composition and redox potential of the salt may change with time as a result of fission product formation and material irradiation. Applications are requested to better understand, predict, and optimize the physical properties and thermochemical behavior of molten salts. The goal is to develop and use first-principles molecular dynamics simulations and computational electronic structure methods to extend the limited experimental data sets to cover a broader range of chemical evolution and environments. Innovative approaches to (1) apply molecular dynamics simulations to predict thermophysical and transport properties; (2) build multi-component models for prediction of phase diagrams; and (3) develop advanced models to guide experimental efforts to manipulate molten salt thermophysical properties are especially encouraged.

FC-1.3: UNDERSTANDING THE STRUCTURE AND SPECIATION OF MOLTEN SALTS AT THE ATOMIC AND MOLECULAR SCALE (FEDERAL POC – STEPHEN KUNG & TECHNICAL POC – KEN MARSDEN) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 2 YEARS AND $400,000)

To understand the effects of structure and dynamics of molten salts on their physical and chemical properties—such as viscosity, solubility, volatility, and thermal conductivity—it is necessary to determine the speciation of salt components as well as the local and intermediate structures at operationally relevant temperatures. Real-time spectroscopic and electrochemical methods can be used to monitor key chemical species in solution. Applications

PROGRAM SUPPORTING: FUEL CYCLE TECHNOLOGIES

are requested to take advantage of recent breakthroughs in advanced characterization tools and instrumentation methods to provide fundamental information at the atomic and molecular scale. The goals are to determine the local structure and bonding of chemical species in salt solutions and to develop innovative real-time analytical methods for microscopic and macroscopic property measurements. Innovative approaches to (1) determine salt molecular structure using scattering and spectroscopic methods, (2) develop novel electrochemistry and spectroscopy methods for in-situ monitoring and predictive modeling, and (3) develop a molten salt optical basicity scale to determine corrosivity and solubility of actinides are especially encouraged.

FC-1.4: IRON PHOSPHATE PROCESS: EVALUATION OF PROCESSING PARAMETERS ON THE PRODUCT PROPERTIES
(FEDERAL POC – KIMBERLY GRAY & TECHNICAL POC – WILLIAM EBERT)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $400,000)

The Material Recovery and Waste Form Development program is currently developing a phosphate-based process for salt waste forms. The goals are to enable recycling chlorine and to generate chemically durable iron phosphate glass wastes. In the baseline process, ammonium dihydrogen phosphate is reacted with the salts in air to evolve ammonium chloride which can be captured for recycle. The resulting product in the crucible is a non-durable phosphate product containing oxides of the salt cations. The solid is remelted with added iron oxide to improve the chemical durability. Improved understanding of the chemical processing, including materials development, will further enhance the throughput of waste form production. Proposals with an innovative approach are requested to (1) characterize and verify preferred phosphate precursor selection to improve processing rate, dechlorination efficiency, and chemical durability of the products; (2) identify advanced crucible material that is compatible with the chemical process; (3) characterize and evaluate the waste products properties, such as crystalline phase assemblage and residual glass phase composition; and (4) utilize and advanced process to enable efficient recovering of recycled chlorine.

FC-2: ADVANCED FUELS

FC-2.1: NEXT GENERATION LWR FUELS FOR SMR APPLICATIONS
(FEDERAL POC – FRANK GOLDNER & TECHNICAL POC – NICOLAS WOOLSTENHULME)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

The unique operating environment of modern small modular light water reactors creates an opportunity for novel fuel designs that have been optimized for this particular environment. For example, significant changes in design basis accident scenarios, cycle length, or power density are likely to impact the limiting operating and/or safety design limits. Proposals are sought that identify and evaluate candidate advanced SMR fuel designs or optimization of current fuel designs that can benefit from the Accident Tolerant Fuel program current candidates. Research should address relevant fuel performance considerations (under both normal operation and off-normal conditions) as well as system level fuel cycle considerations (enrichment through disposition) or assessment of specific performance limiting phenomena. Collaboration with commercial SMR developers and/or fuel developers is strongly encouraged.

FC-2.2: ACCIDENT TOLERANT CONTROL RODS
(FEDERAL POC – FRANK GOLDNER & TECHNICAL POC – MIKE TODOSOW)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

Proposals are sought to assess the neutronic, and thermo-mechanical performance attributes of potential advanced materials and/or designs for BWR and PWR control rods that retain/enhance the poisoning effects/requirements

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(worth – individual and bank, etc.) while maintaining structural integrity/functionality (e.g., ability to insert/ withdraw) during normal operation and accident conditions (temperatures, cooling, etc.). Also, materials and associated studies may be considered that address the retention of the structural integrity/geometry of the core which depends on the ability of components such as guide tubes, grid spacers, core support plate, etc. to retain "functionality" during normal operation and accident conditions. Consultation with existing DOE-NE ATF related programs in this area is encouraged/desirable.

FC-2.3: ACCELERATED FUEL TESTING METHOD DEVELOPMENT (FEDERAL POC – KEN KELLAR & TECHNICAL POC – DAN WACHS) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Proposals are sought to enhance nuclear fuel research approaches that integrate experimental results that span large time, spatial, and system complexity scales. Limitations in the ability to quantitatively assess the effectiveness of bridging the interpretation of test results across these scales often forces developers, operators, and regulators to apply unnecessarily large factors of safety during implementation. For example, full-scale tests that ideally capture all aspects of an event (i.e. a design basis or severe accident) cannot be reasonably simulated experimentally (due to facility constraints or overall cost), thus engineering and safety criteria must be conservatively applied to account for distortions or uncertainties that arise due to experimental or analytical simplifications made during a 'simulated' event. A variety of 'scaling' methods have been established to enhance development and licensing of nuclear technology in this environment. These methods, which typically rely on functional integration of modeling and simulation with separate effects and integral effects tests, have been demonstrated to significantly reduce the cost and time associated with nuclear system development and licensing (nuclear reactor system performance demonstration, in particular, have developed and utilized these methods to support licensing for generations). However, the building blocks necessary to fully implement these techniques for nuclear fuel performance have only become available in roughly the last decade, including mechanistic fuel behavior modeling, high fidelity material property characterization through advanced PIE, and in-situ measurement of time-dependent irradiated fuel behavior. Proposals are sought to investigate the application of scaling methodologies to nuclear fuel testing with emphasis on using existing experimental data and fuel performance/reactor system codes as the foundation for method development.

FC-3: MATERIALS PROTECTION, ACCOUNTING AND CONTROL TECHNOLOGY (FEDERAL POC – MIKE REIM & TECHNICAL POC – MIKE BROWNE) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 2 YEARS AND $400,000)

The Materials Protection, Accounting and Control Technology (MPACT) program seeks to develop and demonstrate the application of technologies and data integration and analysis tools to enable U.S. domestic nuclear materials management and safeguards for emerging nuclear fuel cycles. Specifically, MPACT develops tools that 1) enable the integration of safeguards and security features into the design and operation of nuclear fuel cycles, and 2) fill nuclear material accounting and control technology gaps for nuclear fuel cycles. Nuclear fuel cycle technologies of interest to MPACT include processes such as fuel fabrication, used nuclear fuel recycling, hold up in bulk nuclear material facilities, used nuclear fuel short and long-term storage, and nuclear processes waste and disposition.

Applications are requested to develop innovative materials control and accounting technologies and tools to increase the accuracy, reliability, and efficiency of nuclear materials quantification, nuclear material tracking capability in nuclear fuel cycle facilities and processes, and process monitoring tools.

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FC-4: SPENT FUEL AND WASTE DISPOSITION

FC-4.1: SPENT FUEL AND WASTE DISPOSITION: DISPOSAL (FEDERAL POC – JOHN ORCHARD & TECHNICAL POC – DAVID SASSANI) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Assessments of nuclear waste disposal options start with waste package failure and waste form degradation and consequent mobilization of radionuclides, reactive transport through the near field environment (waste package and engineered barriers), and transport into and through the geosphere. Science, engineering, and technology improvements may advance our understanding of waste isolation in generic deep geologic environments and will facilitate the characterization of the natural system and the design of an effective engineered barrier system for a demonstrable safe total system performance of a disposal system. DOE is required to provide reasonable assurance that the disposal system isolates the waste over long timescales, such that engineered and natural systems work together to prevent or delay migration of waste components to the accessible environment.

Mined geologic repository projects and ongoing generic disposal system investigations generate business and R&D opportunities that focus on current technologies. DOE invites proposals:

- Involving novel material development, testing methods, and modeling concept and capability enhancements that support the program efforts to design, develop, and characterize the barrier systems and performance (i.e., to assess the safety of a nuclear waste repository).
- Addressing applications of state-of-the-art uncertainty quantification and sensitivity analysis approaches to coupled-process modeling and performance assessment which contribute to a better assurance of barrier system performance and the optimization of repository performance.
- Reducing uncertainties in data and in models currently used in geologic repository performance assessment programs.
- Incorporating advances in artificial intelligence (AI) and machine learning (ML) in research activities supporting repository performance studies.

Research proposals are sought to support the development of materials, modeling tools, and data relevant to permanent disposal of spent nuclear fuel and high-level radioactive waste for a variety of generic mined disposal concepts in clay/shale, salt, crystalline rock, and unsaturated alluvium media. Key university research contributions for the disposal portion of this activity may include one or more of the following:

- Improved understanding of waste package failure modes and material degradation processes (i.e. corrosion) for heat generating waste containers/packages considering direct interactions with canister and buffer materials in a repository environment leading to the development of improved models (including uncertainties) to represent the waste container/package long term performance.
- New concepts or approaches for alleviating potential post-closure criticality concerns related to the disposal of high capacity waste packages. Development of models and experimental approaches for including burn-up credit in the assessment of the potential for criticality assessment for spent nuclear fuel permanently disposed in dual- purpose canisters that are designed and licensed for storage and transportation only.
- Development of pertinent data and relevant understanding of source terms (including aqueous speciation, multiphase barrier interactions, surface sorption and especially irreversible radionuclide uptake processes) at elevated temperatures and geochemical conditions (e.g., high ionic strength) relevant to deep geologic disposal environments.
- Development and assessment of innovative and novel buffer materials, new methods and tools for multi-scale integration of relevant repository characterization data (including hydrological, thermal, transport, mechanical, and chemical properties), new approaches for imaging and characterization of low permeability materials or fractured media, state-of-the-art tools and methods for passive and active

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characterization and monitoring of engineered/natural system component properties and failure modes and their capability to isolate and contain waste.

- Novel data analytics and high-performance computing methods for multi-scale data fusion and integration, process model coupling, uncertainty quantification and automation and optimization of field monitoring.

FC-4.2: EARTHQUAKE RESPONSE OF SPENT NUCLEAR FUEL IN DRY STORAGE FACILITIES (FEDERAL POC – JOHN ORCHARD & TECHNICAL POC – DAVID SASSANI) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Currently, spent nuclear fuel (SNF) is stored in onsite independent spent-fuel storage facilities (ISFISIs) at seventy-three (73) nuclear power plants (NPPs). Currently, only three NPPs do not have on-site dry storage. However, they consider building on-site ISFSIs in the near future. Because the SNF will be stored longer than planned, there is a desire to obtain data on the behavior of the SNF during representative earthquakes. To address this, the Spent Fuel Waste Disposition (SFWD) program is planning to conduct an earthquake shake table test. The goal of this test is to quantify the strains and accelerations on surrogate fuel assembly hardware and cladding during the earthquakes representative of the range of seismotectonic and other conditions that any site in the Western or Central Eastern US might entail. This will allow for determining potential damage that different earthquakes could inflict on spent nuclear fuel rods while SNF is in dry storage at the on-site ISFISIs. The representative earthquakes will cover a range of site conditions: hard-rock, soft-rock, and soil (shallow and deep soil conditions).

Testing will take place at the recently reconfigured six-degree-of-freedom Large High-Performance Outdoor Shaking Table of the University of California, San Diego (LHPOST6) in summer of 2022. Two dry storage configurations will be tested: (i) a generic vertical storage overpack (VSO) and (ii) a NUHOM horizontal storage module (HSM). In both cases, the NUHOM 32 PTH2 canister, loaded with three (3) surrogate fuel assemblies and twenty-nine (29) dummy assemblies, will be placed inside the VSO and the HSM. The surrogate assemblies consist of an actual assembly hardware – skeleton and nozzles. Instead of the actual fuel rods, zircalloy tubes filled with lead pellets will be used. The dummy assemblies are concrete masses with the same weigh as the surrogate assemblies. The total weight of the test units in either configuration is greater than 300,000 lbs. Up to one hundred (100) tests will be performed on each dry storage system. The surrogate assemblies will be instrumented with a dense array of accelerometers, displacement transducers, and strain gauges. High-definition cameras will be installed at multiple locations. The accelerometers will be installed at some dummy assemblies, on the basket, on the canister, and on VSO and HSM. Dynamic inclinometers will be installed on the VSO and HSM. A number of sensors is expected to range between one to three-hundred (100 to 300).

Research proposals are sought to develop innovative techniques to demonstrate that the stresses and strains on all structural components are within allowables, based on the data collected during the shake tests. The proposed study will need to develop new data analysis methods and new numerical modeling methods and methodologies to study and interpret the data. The shake test data set will provide a validation opportunity for novel numerical models and methods. The proposed study should consider the differences between the as-tested shake table configuration and the real-world SNF dry storage configuration, which will be influenced by soil-structure interaction effects that the shake table configuration will not include. The applicants may select to use either existing or in house developed software and may choose to develop their own models of the system and its elements – fuel assembly, canister, and dry storage overpack/module (VSO or HSM). The analysis should be able to quantify the responses of spent fuel in the vertical and horizontal storage configurations to the different seismic events. The transfer functions should be calculated between all the elements of the storage system – assemblies, basket, canister, and VSO/HSM. If sliding and/or rocking occurs during the tests, the analysis should explain the cause of the sliding and rocking and should quantify the impacts on the surrogate spent fuel assemblies. The proposal must demonstrate that the large volume of data analyzed will support the development of high-fidelity computational models. Demonstrated experience analyzing large sets of seismic experimental data, as well as conducting large shake table experiments is needed to analyze the data correctly, assess risk, and provide recommendations for mitigating risk. For example, it could be discovered that the shake table was not able to

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reproduce some ground motion inputs. In this case, the shake table simulations might be required to understand what factors were responsible for this, as well as an additional shake table test might be needed to close the gaps in the analysis. Direct experience with using large shake tables is an advantage for understanding the specifics of the data.

The work has to be documented in the form of an annual report at the end of each project year and in the form of the final report at the end of the study. The annual reports have to provide the detailed description of the work performed. They should include the description of the original data, data processing technique, data analysis methods, models (if used), and data analysis and modeling results. The supporting data analysis and modeling files should be submitted separately. The final report should provide the summary of the work performed, major results, conclusions, and suggestions regarding the potential future work.

During the course of work, quarterly (virtual) meetings are expected to take place between the PI and TPOC to discuss any emergent issues, like performance variances, technical approach, data discrepancies, and other. It is expected that this work will result in a number of publications. Before the publications are submitted to a conference or a journal, they have to be reviewed by the program to ensure accuracy and the proper use of the program data and funding.

FC-4.3: EXPERIMENTAL VALIDATION OF PARTICULATE DEPOSITION MECHANISMS ON DRY STORAGE CANISTERS
(FEDERAL POC – JOHN ORCHARD & TECHNICAL POC – DAVID SASSANI)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

Spent nuclear fuel (SNF) will continue to be stored, typically in dry cask storage systems, until a determination on final disposition is made. Over 90% of dry cask storage systems in the United States are welded dry storage canisters (DSC), typically on the order of 5/8-inch thick (Type 304 or 316) stainless steel, emplaced in ventilated concrete or steel overpacks. Approximately 1/3 of the canisters are stored in horizontal ventilated overpacks (i.e, NUHOMS systems by Orano) with the remainder in vertical ventilated overpacks (e.g., designs by Holtec International or NAC International). The potential for stress corrosion cracking (SCC) of the canisters over extended periods is a concern for DOE and the nuclear industry. One potential mechanism that could facilitate SCC is deliquescence of salts that are deposited on the canister surface.

DOE is planning for a Canister Deposition Field Demonstration where three electrically-heated canisters with heat loads of 0, 10, and 40 kW are placed in a ventilated overpack. Ambient air containing particulates and deliquesced salt aerosols of various sizes and compositions, dependent on the geographic location of the storage systems, will enter the inlet vents, be warmed as heat is transferred from the hot canisters, and exit the outlet vents via natural convection. During this process, particulates and aerosols may deposit on the canister. DOE will periodically analyze the canister surfaces to measure the concentration of particulates in various locations. To apply the lessons learned to different locations and to inform the testing intervals, a deposition model is being developed [1,2]. The model will include the following physical phenomena: aerosol droplet evaporation, Brownian Diffusion, Aerodynamic Deposition, Gravitational Settling, Thermophoresis, Turbophoresis, Saffman Lift, Diffusiophoresis, Stefan Flow, and Electrophoresis. DOE is seeking laboratory- and small-scale experimental validation of these ten particulate deposition and resuspension mechanisms on these dry storage canisters under the following conditions relevant to dry storage.

- Horizontal and vertical canister configurations
- Ambient air conditions for both coastal and inland locations
- Canister surface temperatures from ambient up to 200°C
- Air flow rates through the overpack (around the canister) of 0.1-8 kg/s
- Particle/aerosol droplet sizes in the range of <100 nm to tens of microns [3,4]

The desired outcome of the work is deposition/resuspension rates as a function of time and each of the relevant conditions. In particular, tests looking at the separate as well as combined effects of the physical phenomena

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identified are necessary. It is expected that some phenomena will be more important than others under different conditions. These results will help calibrate the DOE model.

During the course of the work, quarterly (virtual) meetings are expected to take place where the principal investigator from each institution and the assigned national laboratory technical points of contact (TPOC) will discuss any emergent issues, technical approaches, results, data discrepancies and suggested path forward. In addition to the required quarterly, annual, and final reports, which need to include sufficient detail of all parameters and outcomes, publication in peer-reviewed journals is encouraged. Such publications should be reviewed by the TPOC prior to submittal.

References:
[1] Jensen et al. *Preliminary Deposition Modeling: For Determining the Deposition of Corrosive Contaminants on SNF Canisters.* PNNL-2960. January 24, 2020.
[2] Jensen et al. *Status Update: Deposition Modeling for SNF Canister CISCC.* PNNL-30793. December 18, 2020.
[3] Tyree, C. A., Hellion, V. M., Alexandrova, O. A., & Allen, J. O. (2007). Foam droplets generated from natural and artificial seawaters. *Journal of Geophysical Research: Atmospheres*, 112(D12).
[4] Schaller et al., *FY20 Status Report: SNF Interim Storage Canister Corrosion and Surface Environment Investigations*. SAND20-12663 R, November 11, 2020.

FC-5: ACCELERATED FAST REACTOR METAL FUEL CLADDING MATERIAL DEVELOPMENT (FEDERAL POC – KEN KELLAR & TECHNICAL POC – TBD) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Applications are sought to support enhancement of reference cladding designs or development of new cladding concepts for increasingly extreme conditions such as very high dose (up to 300-400 dpa) and temperature (up to 700ºC). At present, the leading cladding designs consist of ferritic martensitic steels such as HT9 or T91 and Oxide Dispersion Strengthened (ODS) steels such as 14YWT. However, proposals to investigation other novel concepts will be considered. Proposed studies should focus on one of the critical aspects of cladding performance that prevent the particular concept from advancing to a higher technical readiness level. This could include, for example, investigation of irradiation performance, fabrication technology, or composite concepts (e.g. coatings or liners). Proposals as sought that recognize the gaps to be overcome, and do not propose activities that will prove feasibility in comparison to existing cladding concepts, will not be accepted. A knowledge of the present program plan for fast reactor cladding development is recommended.

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RC-1: NATIONAL REACTOR INNOVATION CENTER (NRIC)

RC-1.1: IMPROVING CONSTRUCTION COST AND SCHEDULE OUTCOMES (FEDERAL POC – JANELLE EDDINS & TECHNICAL POC – ASHLEY FINAN) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Various studies of nuclear energy economics have identified the major role of construction costs and schedule risks in driving up the costs of nuclear power plants. (e.g. *The Future of Nuclear Energy in a Carbon-Constrained World*, Massachusetts Institute of Technology 2018; *The ETI Nuclear Cost Drivers Project: Summary Report*, Energy Technologies Institute (ETI), 2018; *Advanced Nuclear Technology: Economic-Based Research and Development Roadmap for Nuclear Power Plant Construction*, Electric Power Research Institute (EPRI), 2019.) Through its Advanced Construction Technology Initiative, the National Reactor Innovation Center seeks to develop and demonstrate technologies, processes, and approaches that would mitigate construction risks and improve construction outcomes through improved project management, advanced technologies, manufacturing approaches, and/or supply chain improvements.

Proposals are sought that identify, evaluate and/or develop methods, processes, or technologies that can significantly improve advanced nuclear construction cost and schedule outcomes by addressing key challenges identified in literature or projects. These could include approaches to project management, digital engineering, open architecture design, construction technologies, manufacturing approaches, etc.

RC-1.2: ENVIRONMENTAL JUSTICE AND EQUITY CONSIDERATIONS IN SITING ENERGY OR INDUSTRIAL FACILITIES TO INFORM ADVANCED NUCLEAR ENERGY SITING (FEDERAL POC – JANELLE EDDINS & TECHNICAL POC – ASHLEY FINAN) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

The National Reactor Innovation Center (NRIC) is charged with accelerating the demonstration and deployment of advanced nuclear reactors. Successful demonstration and deployment at scale will hinge on positive benefits to communities hosting those projects. Evaluating and achieving this entails a sociotechnical approach to deployment that includes in-depth consideration of technology, geography, economics, politics, social issues, and historical context. Areas of interest include quantitative and analytical approaches to evaluating equity and justice impacts of siting decisions, case studies of historical or contemporary analogous projects and analyses of success and failure, and social-science led studies of related topics important to advanced nuclear deployment in the United States and/or globally. If non-nuclear case studies are selected, the application should clearly state how the proposed studies are relevant to, and can inform the approach for, the siting of advanced nuclear technologies.

Aspects to consider include:
- Environmental Justice throughout the nuclear fuel cycle
- Distribution of nuclear costs and benefits across communities
- Capacity building for Tribal communities
- How to better connect with the renewable energy R&D spectrum
- The role of advanced nuclear energy in industrial planning and public works programs
- Special needs of rural and remote Americans
- Supply chain
- Knowledge transfer across generations
- Other fuel cycle impacts

This effort can draw on a multitude of academic disciplines, including:

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- Law, policy, and regulatory structures
- Psychology, sociology, and other social sciences
- Risk and perception
- The arts and humanities
- The visual display of technical information
- Finance and tax
- Education

This announcement is intentionally broad, to encourage a large number and wide variety of responses. NRIC encourages eligible applicants to think expansively and seek out multidisciplinary partners in their responses.

For investigators applying to this workscope, incremental funding is potentially available through participation in the Department of Energy's interactions with the Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) Nuclear Education, Skills and Technology (NEST) program. NEST ties together university research projects across multiple countries to provide students a fuller professional experience as they pursue their degree. NEST funds are provided to allow travel for students to interact with colleagues in other NEST countries in accordance with NEST program rules. Applications submitted to this work-scope do not require NEST participation. Access to NEST funds do require investigators to agree to participate in NEST. Investigators must clearly indicate in their application if they are willing to join as a NEST project or not.

NOTE: Anticipated budget requirements for NEST participation must not be included in an application submitted to this workscope. NEST funding received by successful applicants will not be included or tracked as part of the overall project budget and not subject to inclusion in project financial reporting. Additionally, participation in NEST will not be a factor considered in the review of applications.

RC-1.3: IMPLEMENTATION CONSIDERATION FOR ALTERNATIVE APPLICATIONS OF ADVANCED NUCLEAR REACTORS
(FEDERAL POC – JANELLE EDDINS & TECHNICAL POC – ASHLEY FINAN)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $400,000)

New large electrical loads pose a number of challenges to the U.S. electric power grid that could potentially be addressed through alternative application of microreactors or small advanced reactors. These challenges include congestion caused by insufficient transmission capacity, power quality, reliability, and the need to provide high but variable power levels. In addition, it is possible to site new smaller reactors near thermal loads, or on large ships, to reduce the consumption of fossil fuels and related emissions. Some of these applications include electric vehicle charging stations, electrolyzers for hydrogen stations, data centers, maritime shipping, district heating, synthetic fuel production, or other industrial processes. Areas of interest include: techno-economic analysis; technical interface considerations and regulatory analysis; details on reactor type, size, variability of loads, thermal and electrical output capacity; startup and shutdown requirements under planned and unplanned conditions; site requirements such as containment function, methods and capacity to transfer heat to the environment in various operating conditions, access, and physical security boundaries, operator and security staff. Proposals are sought that identify high value opportunities for advanced nuclear reactors to provide a dedicated supply of heat and/or electricity when compared to current power sources. Applications should address alternative markets that are not currently being extensively studied by other DOE-sponsored projects.

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RC-2: INNOVATIVE MICROREACTOR SOLUTIONS FOR END-USER APPLICATIONS (FEDERAL POC – DIANA LI & TECHNICAL POC – JOHN JACKSON) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Microreactors represent an innovative class of nuclear reactors characterized by their simplicity of design, small footprints, inherent, and passive safety features, factory fabrication and assembly, highly integrated and transportable systems, and ability to provide energy for both electricity and process heat production. Microreactors are currently envisioned for deployment in remote areas and/or for unique applications that currently have high energy costs or challenges related to energy infrastructure. Many microreactor concepts under development in the United States anticipate commercial deployment within the next decade. Broad deployment of microreactors will require cost competitiveness with other available sources of energy. This work scope seeks the development of technologies that advance the future deployment of microreactors by improving their economic competitiveness and enabling their integration into end-user applications for broad deployment and use. In the area of improving economic competitiveness, approaches for reducing microreactor construction, operation, and maintenance costs are of particular interest. Suggested areas of research include, but are not limited to:

- Microreactor designs with transformative economic reduction potential.
- Readily deployable control technologies and regimes that enable unattended and reliable operations.
- Moderator, reflector and fuel concept technologies that enable efficient and economic fuel use.
- Advanced heat transfer and/or power conversion technologies and storage systems.
- Production approaches that enable standardization, efficient factory manufacturing and assembly, and mass-produced components leveraged from other technology fields.
- Improved ability to support non-electric applications such as process heat, etc.
- Enhanced reliability and high-capacity factors, resilience against disruptions.
- Minimization of on-site construction in remote applications.
- Compatibility with local microgrids supporting facility operations.
- Ability to scale to meet changing loads over time, at multiple voltage outputs.

Innovative proposals for (i) reactor designs and/or (ii) technology solutions, that could result in significant cost reductions, rather than incremental improvements, is desired. For example, significant cost reductions notionally relates to a Levelized Cost Of Electricity, LCOE, < $200/MWh. Proposals should include a clear description of the potential for the proposed scope to reduce microreactor energy production costs. To meet the overall cost reduction objective, the following guidelines are provided. These guidelines are not requirements, rather performance targets, that may have the potential to ultimately achieve economically feasible designs.

	Units	**Preferred**	**Limit**
Net Power	MW_{th}	1.0 - 30	< 50
Staff	FTE/MW	0.5-1.5	< 3
Enrichment	%U235	<10	< 19.75
Burnup	MWd/kgU	>10	No less than 5
Specific Power	kWe/kgU	>5	No less than 2.5

More information on the Microreactor Program is available on the Microreactor Program Website: https://gain.inl.gov/SitePages/MicroreactorProgram.aspx.

RC-3: LIQUID METAL-COOLED FAST REACTORS (LMFRS)

The Department of Energy, National Laboratories, and U.S. nuclear industry are aggressively working to revive, revitalize, and expand U.S. nuclear energy capacity. Advanced non-light water reactors such as liquid metal-cooled fast reactor concepts offer the potential for significant improvements to safety, economics, and environmental performance to help sustain and expand the availability of nuclear power as a clean, reliable, and

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secure power source for our nation.

RC-3.1: LIQUID METAL-COOLED FAST REACTOR TECHNOLOGY DEVELOPMENT AND DEMONSTRATION TO SUPPORT DEPLOYMENT
(FEDERAL POC – BRIAN ROBINSON & TECHNICAL POC – CHRIS GRANDY)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

This work scope seeks proposals for experiments and technologies that can either support potential utilization in fast reactor concepts proposed by U.S. nuclear industry and ultimately be demonstrated in the Mechanisms Engineering Test Loop (METL) facility, or increases the capability of the Mechanisms Engineering Test Loop (METL) Facility. Example activities could include development of: instrumentation, control strategies, performance enhancing technologies, and experiments for the METL facility for liquid metal (sodium or lead-cooled) fast reactors. Proposals that offer the potential for significant overall benefits to reactor capital or operating cost reductions are of interest. Development of test articles and testing in METL is preferred though not mandatory.

METL is an intermediate sodium test facility designed to test small to intermediate-scale components and systems in order to develop advanced liquid metal technologies. Testing different components in METL is essential for the future of advanced fast reactors as it could provide invaluable performance data and reduce the risk of failures during plant operation.

METL also provides development opportunities for younger scientists, engineers, and designers who will ultimately lead the advancement of U.S. liquid metal technologies. The hands-on experience with METL, both successes and perceived failures; will ultimately lead to better liquid metal technology programs that can support the commercialization of advanced reactors.

Examples of potentially beneficial technologies and experimental areas that support fast reactors and can be tested in METL and/or improve the capability of METL include:

1. *Advanced sensors and instrumentation* – Advanced fast reactors contain sensors and instrumentation for monitoring the condition of the plant. Sometimes these components are required to work while immersed in the primary coolant. This category includes but is not limited to, sensors for the rapid detection of hydrogen presence in sodium (which is indicative of a leak), alternative methods of leak detection, and other advanced sensors or instrumentation that improve the overall performance of the advanced reactor system.
2. *Components for an advanced fuel handling system* – Fuel handling systems are used for the insertion and removal of core assemblies located within the reactor vessel. Undoubtedly, these components are essential to the successful operation of fast reactors. For liquid metal applications, fuel handling systems need to work inside the primary vessel and typically penetrate through the cover gas of the primary system. As a result, fuel handling systems must address issues associated with ‘sodium-frost’ buildup.
3. *Mechanisms for self-actuated control and shutdown systems* – These components have been conceived by various designers to provide added defense-in-depth for reducing the consequences of beyond-design-basis accidents. These self-actuated control and shutdown mechanisms include devices such as curie-point magnets and fusible linkages.
4. *In-service inspection and repair technologies* – These systems include visualization sensors for immersed coolant applications and technologies for the welding and repair of structures in contact with the primary coolant.

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5. *Health Monitoring of METL systems and components* - Development of sensors and prognostic techniques for deployment that can monitor and quantify materials degradation in liquid metal-cooled fast reactor primary systems. Of interest are technologies that are able to detect degradation early, can survive in typical liquid metal-cooled fast reactor environments over extended periods of time, and can be embedded in/on structural materials to enable structural health monitoring (e.g., nondestructive examination techniques, remote or automated inspection techniques including visualization in optically opaque coolants). Consideration should be given to deployment issues that may arise, such as powering the sensor and data exfiltration needs.
6. *Development of test articles for testing in the Mechanisms Engineering Test Laboratory (METL) sodium loop facility* - The test articles should consider demonstration of innovative fast reactor sub-components (sensors, seals, mechanisms, etc.) or validation of key fast reactor behaviors (e.g., thermal striping) under prototypic or near prototypic conditions.
7. *Performance improvement technologies for METL* – Technologies for improving the performance of liquid metal test loops potentially include rugged high temperature resistance heating systems, improved insulation technology, improved sodium leak detection and identification technologies, vessel support technologies that reduce heat losses, improved clamp on flow meters, thermal monitoring, etc.
8. *Human Machine Interface Technology* – Technologies for improving the ability of operators to understand what is happening inside the sodium environment. One example would be the ability to provide a refueling system operator to see in-vessel refueling in a virtual environment during in-vessel refueling.

The proposals should also discuss how the technologies developed will ultimately benefit the advanced reactor industry or provide additional capability for the METL facility.

See the following web site for more information on METL:
https://www.anl.gov/nse/mechanisms-engineering-test-loop-facility

RC-3.2: EXPERIMENTAL VALIDATION OF FAST REACTOR FUEL FAILURE MODES (FEDERAL POC – BRIAN ROBINSON & TECHNICAL POC – TANJU SOFU) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

The objective of this call is to solicit proposals for university-led experiments to test the impact of cladding failure in fast reactor fuel assemblies for validation of fuel damage propagation models. The idea is to find out, under the prototypical accident conditions (with both full and reduced flow), what happens when the cladding fails and accumulated fission gas is released into the coolant channel. This subject was studied in 1970s for normal operation conditions in Sodium-cooled Fast Reactors [J.B. van Erp *et. al.*, *Nuclear Engineering and Design*, **31**, 128-150 (1974)]. However, it has not been studied yet for accident conditions or for Lead-cooled Fast Reactors. Moreover, new generation of higher quality data sets is needed to further develop and validate the new, more mechanistic physical models [A. Karahan *et.al.*, *Trans. Amer. Nucl. Soc.*, **123**, 627-630, November 16-19, 2020].

The proposed tests should aim to assess the depth of gas jet penetration, including its impact in the immediate and neighboring coolant channels in terms of potential flow stagnation or reversal. The behavior in both subsonic and sonic jet flow conditions should be studied since typically fission gas jet is initially sonic flow. The impact of degraded heat transfer conditions due to fission gas jet impingement on neighboring fuel pins is also of high interest. Understanding of the fission gas jet penetration and impingement is important for assessment of stochastic fuel damage propagation potential during the postulated accidents including the key phenomena and factors that may increase that potential.

Transient overpower scenarios (where the fuel pin linear heat rate can be significantly higher compared to the nominal conditions) and loss of flow scenarios (where the coolant flow rate can be reduced to natural circulation levels) are of special interest. It is desired (but not required) to have an axial length and coolant channel pressure

distribution that is comparable to the typical fast reactor conditions and to study the solid fuel particles or molten fuel droplets entrained by the fission gas and deposited to the coolant channel and neighbor clad surface. Experiments with the liquid metal coolants (sodium and lead) would be desirable but other surrogate coolants (even water) will be acceptable if appropriate scalability of the tested configurations for the liquid-metal coolants is demonstrated.

RC-4: HIGH TEMPERATURE REACTOR PEBBLE FUEL TESTING DEVELOPMENT (FEDERAL POC – DYLAN PREVOST & TECHNICAL POC – WILL WINDES) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $700,000)

The microstructure and material properties of fuel pebbles from pebble bed high-temperature reactor designs are unique; a graphite and carbonized resin matrix material holding the fuel particles and a thin unfueled shell of matrix material providing structural strength and protection from degradation. While several standardized tests are available for structural nuclear graphite there are no approved test standards available for the pebbles even though they serve many similar functions in protecting the fuel particles (i.e., structural strength, oxidation resistance, molten salt protection, wear resistance, etc.). A comprehensive test methodology, incorporating "best practices" for testing these unique materials must be developed and verified. This would include consideration of past and present pebble testing practices, modeling to validate the consistency of the proposed test methods, and experimental verification of the testing method. This work scope is applicable to all advanced reactors relying on TRISO fuel in pebble form.

Specific areas of research contained within this proposal call include:

a) Literature review to determine past and current testing practices in mechanical testing, chemical attack (oxidation), abrasion/erosion (dust entrained He gas and molten salt), and wear (static and rolling friction).
b) A modest modeling effort to verify the optimal test practices for test methods.
c) A testing program to validate the various testing methods.

The end product from this effort will be a series of test protocols in mechanical, chemical, and wear testing of fuel pebbles. The focus is to eventually produce internationally approved test standards based upon the data and best practices developed from this research and development activity.

RC-5: MATERIALS RESEARCH PATHWAY: CHARACTERIZATION AND MODELING OF THE HIGH FLUENCE EFFECT AND THERMAL AGING ON REACTOR PRESSURE VESSEL STEELS (FEDERAL POC – SUE LESICA & TECHNICAL POC – TOM ROSSEEL) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Reactor pressure vessel (RPV) steels undergo significant changes in microstructure and associated mechanical properties, especially fracture toughness, when exposed to neutron irradiation and elevated temperatures; these changes represent a serious safety concern for light-water reactor life-extension. The changes are a complex function of the combination of the irradiation conditions and the alloy composition and processing path. Due to the long-periods associated with life-extension, a rigorous quantitative understanding and prediction of RPV behavior is still an open challenge. For example, the U.S. NRC Regulatory Guide 1.99 rev.2 for predicting the radiation embrittlement of RPV steels is shown to underpredict the transition temperature shift for RPV steels after high fluence irradiation under certain conditions. Moreover, recent research [1] has demonstrated that current models (EONY and ASTM E900) also underpredict ΔT in the US RPV fleet at high fluence.

Therefore, proposals are sought to perform in-depth characterization and modeling of the effect of high fluence and thermal aging on RPV steels to improve new reduced order models. This may include characterization and

modeling of microstructure and mechanical properties, including precipitate type, formation mechanisms and evolution, alterations in dislocation density and structure, both increases in yield stress and the ductile to brittle transition temperature, and couplings between these phenomena. Approaches that integrate novel characterization methods, advanced physical and data-centric modeling approaches, and rigorous validation are of particular interest. Proposals should include the effects of irradiation, such as the fluence and flux effects, potential for thermal aging at long term exposure, and generation of models that could support life-extension licensing. Collaboration with industrial partners, national laboratories, or the NSUF materials library for accessing RPV steels at different irradiation conditions is also encouraged.

References:
[1] G. R. Odette, T. Yamamoto, T. J. Williams, R. K. Nanstad and C. A. English, The History and Status of Reactor Pressure Vessel Steel Ductile to Brittle Transition Shift Prediction Models, J. Nucl. Mater. , 525, 1 December 2019, 151863.

RC-6: ADVANCED SMALL MODULAR REACTOR R&D (FEDERAL POC – REBECCA ONUSCHAK & TECHNICAL POC – DAN INGERSOLL) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

The DOE's Advanced Small Modular Reactor (SMR) Research and Development (R&D) Program supports technology development efforts for domestic SMR designs that can provide safe, affordable and resilient power generation options to meet the nation's economic, energy security and environmental goals. SMRs are nuclear power plants that are smaller in size (approximately 50 to 300 megawatts electric) than current generation base load plants (typically greater than 1,000 megawatts electric). These smaller, compact designs consist of major components and modules that can be factory-fabricated and transported to a nuclear power site by truck, rail, or barge. The Department is currently working with industry, the national laboratories and academia to advance the development, certification, licensing, and siting of domestic SMR designs, and to reduce technical, economic, and regulatory barriers to their deployment. DOE's work is primarily focused on domestic deployment of SMRs. This solicitation under the NEUP is seeking applications that can develop technologies to support the accelerated development and deployment of domestic SMR designs, improve operational efficiencies, and facilitate or enable diverse application of SMRs to additional energy markets.

This work scope seeks applications that propose to develop technologies, capabilities and methodologies specific to SMR characteristics and environments that would help to improve their deployment, operations, and overall utility in meeting domestic and international market needs. Applications can support a broad range of SMR technologies (i.e., light-water, gas, liquid-metal and molten-salt cooled designs), and should offer specific safety, safeguards, operational, and economic efficiency improvements for this class of reactor designs. Applicants should focus on areas that address the niche characteristics of SMRs, such as the simplified designs, operational flexibility, multi-unit deployment, potential for fleet-level deployment, potential for added design robustness and resiliency, and other key aspects. Examples of technology development areas where applications are sought include, but are not limited to, the following:

- *Design advancements*: Technologies that enable innovative design solutions that can function in specific SMR environments, such as:
    - compact components for primary and secondary systems
    - primary system penetration technologies
    - fail-safe valve technologies
    - robust on-line sensors, instrumentation and monitoring systems
    - technologies that enhance design resilience
- *Operational advancements*: Technologies that improve the efficiency (reduce cost, schedules, and/or staffing requirements) for SMR operations, such as:
    - remote inspection technologies
    - on-line maintenance technologies

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- diagnostic and prognostic instrumentation systems
- remote manipulation technologies for maintenance and refueling
- autonomous operation capabilities

For investigators applying to this work scope, incremental funding is potentially available through participation in the Department of Energy's interactions with the Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) Nuclear Education, Skills and Technology (NEST) program. NEST ties together university research projects across multiple countries to provide students a fuller professional experience as they pursue their degree. NEST funds are provided to allow travel for students to interact with colleagues in other NEST countries in accordance with NEST program rules. Applications submitted to this work-scope do not require NEST participation. Access to NEST funds do require investigators to agree to participate in NEST. Investigators must clearly indicate in their application if they are willing to join as a NEST project or not.

NOTE: Anticipated budget requirements for NEST participation must not be included in an application submitted to this work scope. NEST funding received by successful applicants will not be included or tracked as part of the overall project budget and not subject to inclusion in project financial reporting. Additionally, participation in NEST will not be a factor considered in the review of applications.

Specifically not of interest are microreactor applications or technologies, and concepts that benefit nuclear reactors broadly without addressing features or benefits specific to SMRs, either for a specific reactor concept or as a class.

PROGRAM SUPPORTING: NUCLEAR ENERGY ADVANCED MODELING AND SIMULATION (NEAMS)

NEAMS-1: IMPROVEMENT OF LOW-ORDER TRANSPORT METHODS (FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – MATT JESSEE) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $600,000)

Computationally efficient low order transport models such as those based on diffusion theory or SPN methods are important to advanced transient reactor multiphysics simulation. Such simulations are characterized by tight coupling between neutronics, thermal-hydraulics, structural and fuel performance codes and seek to resolve the local power behavior within a reactor. Modeling of feedback effects within the context of multigroup nuclear cross section data provided as input to reactor simulation codes, such as the NEAMS Griffin code, are therefore critical to the accurate prediction of transient local power that are important to operational and safety limits. Past approaches such as the use of spectral homogenization factors, designed to preserve reaction rates and discontinuity factors, designed to preserve surface neutron currents, have been used as part of low order transport models to assure consistency between cross section homogenized and continuous energy heterogeneous transport solutions (i.e. Monte Carlo simulation results).

Applications under this scope should focus on the development of low order transport methods to replicate Monte Carlo results applicable over a wide range feedback mechanisms including, but not limited to, changes in fuel temperature, coolant density, control material configurations, and structural geometry. Of particular interest is the effect and modeling of isotopic depletion history on the creation of multigroup cross section libraries applicable to advanced reactor multiphysics simulation analysis. Applications should provide detailed discussion of the methods and model proposed including the process for generation of nuclear cross section data applicable to a wide range of feedback mechanisms and depletion histories, and the application of the method and benchmark against continuous energy Monte Carlo depletion. Applicants should demonstrate knowledge of previously awarded work in related areas, such as multigroup cross section generation methods.

Note: This call is focused on methods for improvement of low order transport method itself in the framework of multiphysics simulation. This is in contrast to the previous call that focused specifically on multigroup cross section generation methodologies applied to existing methods.

NEAMS-2: AUTOMATED OPTIMIZATION FOR REACTOR CORE DESIGN (FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – FANDE KONG) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 2 YEARS AND $400,000)

Reactor core design involves the simultaneous optimization of multiple design parameters, including coolant flow rate, power, fuel loading patterns, burnable poison placement, material selection, and control mechanisms. These parameters must be balanced to create a reactor that is efficient, safe, and cost-effective. Large numbers of parameters and multiple interacting and competing effects can lead to costly, prolonged design times with many design/test iterations. High-fidelity modeling and simulation provides an opportunity to reduce design time through fast, accurate, actionable feedback during design iterations. However, there are still limits to the number of iterations and design ideas a core design team can consider.

Robust automated optimization for reactor designs would offer an opportunity to accelerate the design, manufacture, licensing and operation of nuclear reactors. Robust design would enable integrated workflows to allow for more rapid design iterations that focus on both the economic, safety, and performance aspects of the system. Such automation would be informed by the product cycle, resulting in reduced development time and cost, as well as incorporate safety by design that would accelerate licensing.
Applications are sought for methods development in robust, automated optimization of reactor designs that integrate multiphysics simulation capabilities with engineering design processes for development of safe, efficiently manufacturable nuclear reactors. Application areas of interest include: control rod/blade/drum shape

PROGRAM SUPPORTING: NUCLEAR ENERGY ADVANCED MODELING AND SIMULATION (NEAMS)
and operation, fuel shape, coolant channel shape, and core configuration. Use of existing NEAMS tools is preferred, such as BISON, Griffin, SAM, Pronghorn, Nek5000, and Grizzly. It is suggested that the proposed work builds on existing capabilities within MOOSE, such as automatic differentiation, displaced mesh, stochastic tools, and inverse solvers. The final goal of the study is to enable an automated optimization platform for MOOSE-based codes to better address nuclear energy design challenges.

PROGRAM SUPPORTING: NUCLEAR ENERGY ENABLING TECHNOLOGIES CROSSCUTTING TECHNOLOGIES (NEET CTD)

CT-1: CROSSCUTTING RESEARCH-CYBER SECURITY RESEARCH
(FEDERAL POC – REBECCA ONUSCHAK & TECHNICAL POC – LON DAWSON)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

The DOE-NE Cyber Security program seeks to perform R&D in technologies that support and enable digital solutions for the U.S. nuclear sector. The Cyber Security program focuses on risk management tools and technologies to manage cyber risk related to digital assets; secure architectures for instrumentation and control (I&C) solutions; supply chain risk management solutions; and cyber security modeling and simulation tool development.

The U.S. nuclear industry is developing many advanced reactor concepts including small modular reactors, micro reactors, and advanced alternatives to light water reactors. Many of these technologies will require different secure I&C solutions to enable their intended missions. Proposals are sought for research and development to enable secure communication solutions for future reactor technologies, specific to safety- and security-related sensors and/or controls. Areas of interest include cybersecurity research that enables advanced reactor control concepts including the potential for remote reactor operations. Compelling proposals should include aspects of:

1. Secure communications for control and monitoring systems to enable remote and autonomous operations;
2. Secure communications to support expanded use of data for operational decision making.

Specifically not of interest are general-purpose attack scenario models or intrusion detection tools for plant operations.

CT-2: INTEGRATED ENERGY SYSTEMS
(FEDERAL POC – JASON MARCINKOSKI & TECHNICAL POC – SHANNON BRAGG-SITTON)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

A nuclear-renewable-fossil integrated energy system would leverage multiple energy resources, producing both thermal and electrical energy with zero or low-emission, to flexibly and reliably meet electrical grid demand, while also supporting the heat and electricity demands of other coupled energy users. Coupled non-grid energy users may utilize multiple feedstocks to support industrial processes and water purification, or to produce energy carriers (e.g., hydrogen) that will be utilized for mobility and other downstream processes.

Various IES configurations are currently being evaluated for their economic benefit and technical feasibility within various geographic regions as key options to reduce the emission of CO_2 and other greenhouse gases across all energy use sectors. Work scopes of interest for FY22 applications focus on the use of advanced (non-water cooled) reactors in IES, which may be coupled with renewable generation resources or with fossil-based generation with carbon capture. To date, large studies have been performed to assess the viability of direct thermal coupling between current LWR plants and several heat processes, with several of these studies progressing to demonstration at existing fleet nuclear plants. Emerging advanced reactor designs offer new opportunities for non-electric processes that would take advantage of the different heat profiles and secondary side ramp rates available for these advanced designs.

IES performance optimization requires efficient integration of energy users with candidate advanced reactors, utilizing all energy types as needed. Recognizing that many processes could benefit from the high-quality heat, reliable electricity, and dispatchability provided by nuclear systems, energy use processes should be prioritized

PROGRAM SUPPORTING: NUCLEAR ENERGY ENABLING TECHNOLOGIES CROSSCUTTING TECHNOLOGIES (NEET CTD)

based on technical and economic feasibility for coupling with advanced reactors. Some processes may also benefit from use of the radiation produced as a result of nuclear system options. Aspects of interest for investigation include:

- Process design (energy user) as it pertains to nuclear system integration (e.g., potential for radiation-assisted processes, modification of the process design to better match the nuclear system)
- Direct utilization of decay heat (e.g., from used fuel assemblies) to support production of consumer products, where processes may include direct production of commodities or production of "tailored" isotopes that could be employed in small-scale or portable systems for specialized applications.

Each area of interest proposed should include Nuclear plant-process interface design (e.g., advanced heat exchangers, design of intermediate loops, impact to balance of plant operation, control systems, utilization of rejected "waste" heat) for prioritized coupled energy use processes.

CT-3: ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGIES (AMMT)

CT-3.1: MULTI-MATERIAL SYSTEMS
(FEDERAL POC – DIRK CAIRNS-GALLIMORE & TECHNICAL POC – ISABELLA VAN ROOYEN)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $500,000)

With the demand of new advanced reactor technologies economics under diverse and extreme environments, the application envelope of material and product systems are drastically expanded from the current qualified material portfolio and manufacturing processes. Specifically, flexibility in material systems for multiple reactor systems, which no single material can satisfy comprehensively, resulting in either long development processes, or multiple material systems to be developed.

Multiple cladding and coating technologies have been proposed and evaluated for specific reactor systems to overcome economic and performance challenges. To enhance economics and robustness of designs by minimizing mechanical transitions or weldments of dissimilar materials, gradient structures are an engineering methodology to minimize the complexity and number of manufacturing and assembly operations. Furthermore, functional graded materials are considered for multiple surface functions for specific benefits as environmental and thermal protection (e.g., increased corrosion resistance, wear resistance, thermal resistance).

For this call, an integrated approach is sought for an agnostic gradient material verification methodology in terms of interface and residual stress requirements. Proposals will be required to validate these approaches with dissimilar metallic materials, composite materials and metallic-ceramic material systems fabricated by at least two advanced manufacturing processes for comparative purposes. All proposals need to include a substantive gap-analysis on earlier research and current standards, modeling and simulation activities, the use of digital twins, accelerated testing and characterization for proof of concepts. Proposals should include a detailed justification for the material and manufacturing process choices that will be used for the proof of concept research.

This research is aiming to aid the deployment of advanced reactor technology in the foreseeing future; therefore, industry partnership is required.

PROGRAM SUPPORTING: NUCLEAR ENERGY ENABLING TECHNOLOGIES CROSSCUTTING TECHNOLOGIES (NEET CTD)

CT-3.2: ADVANCED CREEP MECHANISMS
(FEDERAL POC – DIRK CAIRNS-GALLIMORE & TECHNICAL POC – ROBERT ROACH)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $500,000)

Deployment of advanced reactor concepts requires materials that can withstand extreme environments involving radiation, high temperatures, and non-aqueous corrosion. Innovative materials design, manufacture, and testing is required to accelerate the development and qualification of materials that meet these criteria. For this call, a new approach to the nuclear material design cycle is desired with a focus on transformational materials design, advanced additive manufacturing, and accelerated materials testing. We request proposals to develop novel approaches to assess time-dependent phenomena relevant to reactor licensing and operation on a reduced timeline such that the accelerated test results will correlate to the results of non-accelerated testing with high fidelity.

One of the traditional and significant challenges facing fission reactor materials is creep, and creep is selected as the case study for this proposal call. Today, material selection and long-term creep surveillance are the most common solutions to manage the challenge of creep, but this approach is impractical for the timely deployment of new materials. Material designs and manufacturing involving the incorporation of functional small-scale material structures provides an exceptional opportunity to develop a flexible methodology for clarifying creep mechanisms under specific conditions, such as irradiation or in a corrosive environment. These functional small-scale material structures can range from lattice structures to unique metamaterials. This call specifically encourages the submission of proposals using advanced additive manufacturing to build functional small-scale structures and graded features with *in-situ* mechanical testing and *in-situ* or *ex-situ* microscopy to understand fundamental creep deformation mechanisms of a given metallic structural material. Proposals that include modeling, simulation, and/or machine learning to overcome the traditional surface-to-bulk constraints limiting sample specimen sizes and to interpret experimental data are highly encouraged. Methods developed by proposals, e.g., characterization techniques, should be ones that can be deployed in irradiation environments such as hot cells. Proposals for this call should aim to develop a framework for accelerated assessment of time-dependent behaviors that can be extended to multiple material systems.

CT-3.3: HIGH THROUGHPUT TESTING FOR ADVANCED MANUFACTURED MATERIALS
(FEDERAL POC – DIRK CAIRNS-GALLIMORE & TECHNICAL POC – BEN BETZLER)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $500,000)

Additive manufacturing techniques can yield large amounts of location-specific in situ data that are stored in a digital thread for a given part or component. A corresponding manufacturing digital platform uses artificial intelligence techniques to establish links between characteristics within these digital threads and post-manufacturing testing datasets. It is critically important that these testing datasets be tracked to specific locations in the additively manufactured components. The artificial intelligence techniques employed benefit from large high-quality data sets that can be used for training and validation. Generating testing data for a variety of material properties is critical for developing and demonstrating a digital platform informed approach to component certification.

This call focuses on the development and application of novel high throughput thermophysical or mechanical property testing techniques that can yield spatial data with at least 1 mm resolution for additive manufactured builds. Proposals should include detailed description of the proposed measurement technique(s) and the methods to store and track spatially resolved data. The choice of material and additive manufacturing process should be appropriately justified. Description of a quality assurance program needs to be presented in the application to ensure useful data is generated throughout the project.

PROGRAM SUPPORTING: NUCLEAR ENERGY ENABLING TECHNOLOGIES CROSSCUTTING TECHNOLOGIES (NEET CTD)

CT-4: ADVANCED AND SMALL MODULAR REACTOR MATERIALS ACCOUNTANCY AND PHYSICAL PROTECTION

(FEDERAL POC – ALISON HAHN & TECHNICAL POC – BEN CIPITI)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $400,000)

Advanced nuclear reactors, small modular reactors, and microreactors are pushing the boundaries on the integration of safeguards and security with safety and cybersecurity. The move toward smaller plant designs, compact and modular construction, and potentially remote operations raise new challenges in safeguards and security and also present new opportunities for Safeguards, Security, and Safety by Design (3SBD). New approaches for 3SBD are needed, focused on domestic material control and accounting (MC&A) and physical protection system (PPS) requirements for construction in the U.S. Increasingly, the tie to safety systems will be important for full PPS analysis. Proposals should focus on regulatory requirements with attention to new rulemaking activities that support advanced reactor licensing.

Proposals that focus on sodium fast reactors, pebble bed reactors, and microreactors will be given higher priority. Proposals focused on international safeguards and security requirements will not be considered for this area.

CT-5: ADVANCED SENSORS AND INSTRUMENTATION

FEDERAL POC – DANIEL NICHOLS & TECHNICAL POC – PATTRICK CALDERONI)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

The Advanced Sensors and Instrumentation (ASI) program seeks applications to develop dynamic measurement systems for structural health monitoring of advanced reactors. Advanced reactors of interest are those defined in section A.2.2 Reactor Concepts Research, Development and Demonstration (RC RD&D) Program and related items in Appendix A. The proposal should demonstrate an adequate level of knowledge of the targeted application.

In alignment with the crosscutting nature of ASI activities, the proposal should seek to develop technologies that are applicable to multiple reactor concepts and can operate in a broad range of conditions. Proposals can target one or more plant systems and components, including the reactor core, the reactor vessel and other in-vessel components, primary and secondary cooling circuits in order to define the range of expected operating conditions, including temperature, pressure, radiation field and limitations in terms of material compatibility. The proposal should clearly identify the application, the target operating range and the criteria that will be used to assess the proposed technology feasibility. The potential impact of the technology should be discussed in relation to its benefit in terms of reduction of operating and maintenance cost or increased functionality/efficiency.

The outcome of the proposed work should be the feasibility demonstration in laboratory settings (i.e., demonstration in a neutron environment is not required) of a complete measurement system, including and not limited to sensing elements, hardware and software tools for interrogation, data acquisition system and data analytics. The use of technologies leading to high data throughput and the integration of advanced tools for data analysis compatibility with integration in real time control systems is highly encouraged.

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MS-NE-1: INTEGRAL BENCHMARK EVALUATIONS
(FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – MARGARET MARSHALL)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $400,000)

The International Reactor Physics Experiment Evaluation Project (IRPhEP) and International Criticality Safety Benchmark Evaluation Project (ICSBEP) are recognized world-class programs that have provided quality assured (peer-reviewed) integral benchmark specifications for thousands of experiments. The Project produces two annually updated Organization for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) Handbooks that are among the most frequently quoted references in the nuclear industry. Applications are sought, within the scope of these two projects, to provide complete benchmark evaluations of existing experimental data that would be included in IRPhEP and ICSBEP handbooks, and would support current and future R&D activities. Applicants should demonstrate knowledge of existing work through awards (NE, SC, and others) and other DOE-funded work.

The IRPhEP and ICSBEP Handbooks are the collaborative efforts of nearly 500 scientists from 24 countries to compile new and legacy experimental data generated worldwide. Without careful data evaluation, peer review, and formal documentation, legacy data are in jeopardy of being lost and reproducing those experiments would incur an enormous and unnecessary cost. The handbooks are used worldwide by specialists in reactor safety and design, criticality safety, nuclear data, and analytical methods development to perform necessary validations of computational models. Proposed benchmark evaluations should be of existing experimental data. Measurements of interest include critical, subcritical, buckling, spectral characteristics, reactivity effects, reactivity coefficients, kinetics, reaction-rate and power distributions, and other miscellaneous types of neutron and gamma transport measurements. A growing area of interest includes evaluation of transient and/or multiphysics benchmark experiment data for light water reactor systems, such as PWRs and BWRs.

All evaluations must be completed according to the requirements, including peer review, in the IRPhEP and the ICSBEP. DOE currently invests tens of millions of dollars each year to develop the next generation of nuclear engineering modeling & simulation tools. These tools need ad-hoc evaluated and quality-assured experimental data for validation purposes and, consequently, benchmark evaluations in support of DOE programs such as, but not limited to, TREAT, LWRS, FCT, ART, and NE's Advanced Modeling and Simulation Program (which combines application of computational capabilities from the NEAMS ToolKit and the VERA suite developed by the Energy Innovation Hub for Reactor M&S) are of particular interest to this call. Proposals must clearly identify and demonstrate the importance of the proposed work to deployment or operation of a reactor (e.g. letter of support or impact from industry). Proposals should demonstrate knowledge of existing benchmark handbook validation content similar to their proposed work and clearly identify gaps in existing data that the proposed work will address.

MS-NE-2: NUCLEAR DATA NEEDS FOR NUCLEAR ENERGY APPLICATIONS
(FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – MATT JESSEE)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $400,000)

The Evaluated Nuclear Data File (ENDF) maintained by the National Nuclear Data Program (NNDC) at Brookhaven National Laboratory (BNL) provides the most reliable and commonly used nuclear data for nuclear energy applications. However, a close and critical examination of the existing nuclear data often finds that it is inadequate for current and emerging applications.

Proposals are sought that address nuclear data needs in NE mission areas, provided that these needs are clearly demonstrated to be a limiting factor in nuclear fuel and reactor design, analysis, safety, and licensing calculations. Use of sensitivity and uncertainty analysis methods in proposed efforts is encouraged to demonstrate these needs.

MISSION SUPPORTING: NUCLEAR ENERGY

Many nuclear data needs for NE may be found in the NEA Nuclear Data High Priority Request List (HPRL) (https://www.oecd-nea.org/dbdata/hprl/, which includes a broad spectrum of needs encompassing light water reactors (LWRs) as well as sodium fast reactors. Other emerging needs not yet listed on the HPRL include continued investigations of thermal scattering data in high-temperature graphite, thermal scattering data for fluorine-based molten salt reactors, and chlorine reactions for fast spectrum molten salt reactors. Additional nuclear data needs that meet documented needs for industry and DOE-NE missions are also encouraged especially as aligned with the Gateway for Accelerated Innovation in Nuclear (GAIN), Nuclear Energy Advanced Modeling and Simulation (NEAMS), Advanced Reactor Technologies (ART), Fuel Cycle Research and Development (FCR&D), Transient Test Reactor (TREAT), Light Water Reactor Sustainability (LWRS) and others.

Proposals are sought that provide relevant improvements in nuclear data that address one or more stated needs by developing and demonstrating the enhancements through the entire nuclear data pipeline, from 1) new nuclear data measurements; 2) evaluation in the appropriate format (e.g. ENDF); 3) inclusion of nuclear data covariances; 4) processing into usable forms for application codes; 5) confirmation of improved predictions and uncertainties through application studies and validation; and 6) deployment through the National Nuclear Data Center at BNL for inclusion by external users in quality-assured design, analysis, safety, and licensing calculations. Proposals must clearly identify and demonstrate the importance of the proposed work to deployment or operation of a reactor (e.g. letter of support or impact from industry) and collaborations with industry are specifically encouraged for this reason. Applicants should demonstrate knowledge of existing work through awards (NE, SC, and others) and other DOE-funded work.

PROGRAM SUPPORTING: NUCLEAR SCIENCE USER FACILITIES (NSUF-1)

NUCLEAR ENERGY-RELATED R&D SUPPORTED BY NUCLEAR SCIENCE USER FACILITIES CAPABILITIES

These work scopes solicit applications for nuclear energy related research projects focused on the topical areas described below. It is intended that these focused topical areas will change with each future CINR FOA. In this CINR FOA, for the first time, NSUF will provide up to $800,000 in direct funding to the university PIs over the course of the projects to support their research directly associated with the proposed irradiation and/or post irradiation examinations including compilation and interpretation of results in addition to the access to NSUF capabilities. All applications submitted under these work scopes will be projects coupling funding with NSUF access. Projects requiring "NSUF access only" (see NSUF-2 below) or "funding only" must be submitted under other appropriate work scopes. Applications submitted under these work scopes must support the Department of Energy Office of Nuclear Energy mission. Capabilities available through the NSUF can be found on the website at NSUF.inl.gov.

The Office of Nuclear Energy (NE) supports the Department of Energy's HPC4 Materials (High Performance Computing for Materials) initiative to accelerate "…industry discovery, design, and development of materials for severe environments by enabling access to computational capabilities and expertise in the DOE laboratories." NE's high-performance computing capabilities include Sawtooth, Lemhi, and Falcon at the Idaho National Laboratory. More information on NSUF computational resources can be found at hpc.inl.gov. NE is seeking applications for the development of innovative materials or material concepts for the extreme operating and accident environments expected in advanced reactor and fuel cycle technologies using the high-performance computing capabilities at the INL.

Experiments with x-ray synchrotron radiation may be proposed in applicable work scopes below. The NSUF has access to beam time at the X-ray Powder Diffraction beamline at NSLS-II.

NOTE: Access to NSUF capabilities will require agreement and final signature to the User Agreement (copy provided in Part IX, Appendix E).**The terms and conditions of the User Agreement are non-negotiable, and failure to accept the terms and conditions of the User Agreement will terminate processing and review of the NSUF-1 and NSUF-2 applications.** In order to ensure compliance throughout the application review process, applicants must indicate in the Letter of Intent (LOI) and full application submission that the User Agreement has been read, understood, and the terms and conditions are accepted. Further, submission of a pre-application and a full application indicates the applicant will comply with and agree to the terms and conditions of the User Agreement. Upon award of an NSUF supported project, the User Agreement must be signed before activities will begin on the project. Failure to sign the non-negotiable User Agreement within 30 days of receipt of the User Agreement may result in cancellation of an awarded project.

NSUF-1: CORE AND STRUCTURAL MATERIALS AND NUCLEAR FUEL BEHAVIOR AND ADVANCED NUCLEAR FUEL DEVELOPMENT
(FEDERAL POC – TANSEL SELEKLER & TECHNICAL POC – RORY KENNEDY)
(R&D FUNDED THROUGH NSUF)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 7 YEARS, $800,000)
(NSUF READINESS REQUIREMENTS APPLY)

This element is focused on fundamental understanding of irradiation effects in core and structural materials and the behavior of nuclear fuels (including cladding) in reactor and research into advanced nuclear fuels and improving the performance of current fuels. For the core and structural materials aspect of the work scope, areas of interest include material aging and degradation mechanisms (e.g. fatigue, embrittlement, void swelling, fracture toughness, IASCC processes and mitigation, and corrosion), testing alternate and/or radiation resistant materials for application in current and future fission reactors, and materials from alternate or advanced manufacturing techniques (including welding and joining). For the nuclear fuels aspect of the work scope, areas of interest include the physics and

PROGRAM SUPPORTING: NUCLEAR SCIENCE USER FACILITIES (NSUF-1)
chemistry of nuclear fuels, irradiation and thermal effects on microstructure development and the effects on, for example, thermophysical and thermomechanical properties as well as chemical interactions. Proposed projects may involve research in the areas of fuels and materials irradiation performance and combined effects of irradiation and environment on fuels and materials. Programs of work on common place conventionally and additively manufactured materials such as 304 SS and 316 SS, 718 Inconel, uncoated Zirconium alloys, and SiC and SiC-SiC composites that have been the target of previous NSUF awards are not requested. Advanced fuel types extend to fast spectrum transmutation systems, coated particle fuels for high-temperature reactor systems, robust fuels for light water reactors including accident tolerant fuels, and fuel for small modular, micro-, and other advanced reactor concept. Activities should be aimed at irradiation experiments (neutron steady state or transient, ion, and gamma) and post irradiation examination that investigate fundamental aspects of fuel performance such as radiation damage, amorphization, fuel restructuring, species diffusion and migration, and fission product behavior. Separate effects testing focused on validation of specific modeling and simulation issues is encouraged. Proposals that advocate duplicating previous or on-going NSUF supported irradiation studies will not be considered. A complete list of NSUF awards made under CINR funding opportunities can be found under the R&D flag on the website NEUP.inl.gov. Projects whose relevancy is based solely or primarily on fusion energy needs will not be considered. Applications coupling experimental methods with modeling and simulation are highly encouraged.

Appendix B: Work Scopes for U.S. University-, National Laboratory-, or Industry-led Nuclear Science User Facilities (NSUF) Projects

NUCLEAR SCIENCE USER FACILITIES (NSUF-2)

NSUF-2: NUCLEAR SCIENCE USER FACILITIES ACCESS ONLY (FEDERAL POC – TANSEL SELEKLER & TECHNICAL POC – RORY KENNEDY) (ELIGIBLE TO LEAD: UNIVERSITY, NATIONAL LABORATORY, OR INDUSTRY)

Applicants interested in utilizing Nuclear Science User Facilities (NSUF) capabilities only should submit "access only" applications under these work scopes. Applications must support the Department of Energy Office of Nuclear Energy's mission. Capabilities available through the NSUF can be found on the website at NSUF.inl.gov.

The Office of Nuclear Energy (NE) supports the Department of Energy's HPC4 Materials (High Performance Computing for Materials) initiative to accelerate "…industry discovery, design, and development of materials for severe environments by enabling access to computational capabilities and expertise in the DOE laboratories." NE's high-performance computing capabilities include Sawtooth, Lemhi, and Falcon at Idaho National Laboratory. More information on computational resources available through the NSUF can be found at NSUF.inl.gov. NE is seeking applications for the development of innovative materials or material concepts for the extreme operating environments expected in advanced reactor and fuel cycle technologies using the high-performance computing capabilities at the INL.

Experiments with x-ray synchrotron radiation may be proposed in applicable work scopes below. The NSUF has access to beam time at the X-ray Powder Diffraction beamline at NSLS-II.

NOTE: Access to NSUF capabilities will require agreement and final signature to the User Agreement (copy provided in Part IX, Appendix E).**The terms and conditions of the User Agreement are non-negotiable, and failure to accept the terms and conditions of the User Agreement will terminate processing and review of the NSUF-1 and NSUF-2 applications.** In order to ensure compliance throughout the application review process, applicants must indicate in the Letter of Intent (LOI) and full application submission that the User Agreement has been read, understood, and the terms and conditions are accepted. Further, submission of a pre-application and a full application indicates the applicant will comply with and agree to the terms and conditions of the User Agreement. Upon award of an NSUF supported project, the User Agreement must be signed before activities will begin on the project. Failure to sign the non-negotiable User Agreement within 30 days of receipt of the User Agreement may result in cancellation of an awarded project.

NSUF-2.1: CORE AND STRUCTURAL MATERIALS AND NUCLEAR FUEL BEHAVIOR AND ADVANCED NUCLEAR FUEL DEVELOPMENT (ELIGIBLE TO LEAD: UNIVERSITY, NATIONAL LABORATORY, OR INDUSTRY) (UP TO 7 YEARS) (NSUF READINESS REQUIREMENTS APPLY)

This element is focused on fundamental understanding of irradiation effects in core and structural materials and the behavior of nuclear fuels (including cladding) in reactor and research into advanced nuclear fuels and improving the performance of current fuels. For the core and structural materials aspect of the work scope, areas of interest include material aging and degradation mechanisms (e.g. fatigue, embrittlement, void swelling, fracture toughness, IASCC processes and mitigation, and corrosion), testing alternate and/or radiation resistant materials for application in current and future fission reactors, and materials from alternate or advanced manufacturing techniques (including welding and joining). For the nuclear fuels aspect of the work scope, areas of interest include the physics and chemistry of nuclear fuels, irradiation and thermal effects on microstructure development and the effects on, for example, thermophysical and thermomechanical properties as well as chemical interactions. Proposed projects may involve research in the areas of fuels and materials irradiation performance and combined effects of irradiation and environment on fuels and materials. Programs of work on common place conventionally and additively manufactured materials such as 304 SS and 316 SS, 718 Inconel, uncoated Zirconium alloys, and SiC and SiC-SiC composites that have been the target of previous NSUF awards are not requested. Advanced fuel types extend to fast spectrum transmutation systems, coated particle fuels for high-temperature reactor systems, robust fuels for light water reactors including accident tolerant fuels, and fuel for small modular, micro-, and other advanced reactor

NUCLEAR SCIENCE USER FACILITIES (NSUF-2)

concept. Activities should be aimed at irradiation experiments (neutron steady state or transient, ion, and gamma) and post irradiation examination that investigate fundamental aspects of fuel performance such as radiation damage, amorphization, fuel restructuring, species diffusion and migration, and fission product behavior. Separate effects testing focused on validation of specific modeling and simulation issues is encouraged. Proposals that advocate duplicating previous or on-going NSUF supported irradiation studies will not be considered. A complete list of NSUF awards made under CINR funding opportunities can be found under the R&D flag on the website NEUP.inl.gov. Projects whose relevancy is based solely or primarily on fusion energy needs will not be considered. Applications coupling experimental methods with modeling and simulation are highly encouraged.

NSUF-2.2: HIGH PERFORMANCE COMPUTING AT IDAHO NATIONAL LABORATORY (LIMITED TO 3 YEARS) (ELIGIBLE TO LEAD: UNIVERSITY, NATIONAL LABORATORY, AND INDUSTRY) (NSUF READINESS REQUIREMENTS APPLY)

The Nuclear Science User Facilities (NSUF) High-Performance Computing (HPC) resources offered through **Idaho National Laboratory** provide scientific computing capabilities to support advanced modeling and simulation. Applications may address a wide range of research activities, including performance of materials in harsh environments (including the effects of irradiation and high temperatures), performance of existing light water and advanced nuclear reactors, and multiscale multiphysics analysis of nuclear fuel performance.

Current HPC capabilities include:

- **Sawtooth**: INL's newest supercomputer operates with a LINPACK rating of 5.6 petaflops and is ranked #37 on the November 2019 TOP500 list. The HPE SGI 8600 system comprises 99,792 cores with 403 TB of memory. The system also includes dedicated GPU capability.
- **Lemhi**: A Dell 6420-based system operating on an OmniPath fat tree network. It contains 20,160 cores and 94 total terabytes of memory. Lemhi is rated at 1 petaflop and ranked #427 on the November 2018 TOP500 list.
- **Falcon**: A SGI ICE-X distributed memory system comprised of 34,992 cores, with each node containing dual Xeon E5-2695 v4 processors. It is rated at 1.1 petaflops and includes 121 TB of memory.

HPC support includes access to INL HPC systems, assistance with system login and running code, basic HPC training, and software support and expertise as requested. Software includes an assortment of tools in the areas of: Computer Aided Engineering, Chemistry, Code Development, Data Manipulation, Math, MPI, Neutronics and Transport, Numerical Libraries, Programming, and Visualization. Access to HPC resources through this FOA does not provide licenses to software. INL MOOSE-based tools are available subject to license approval. Use of DOE-developed software from the NEAMS programs is encouraged.

Appendix C: Work Scopes for U.S. University-led Integrated Research Project (IRP) R&D

PROGRAM DIRECTED: FUEL CYCLE TECHNOLOGIES

IRP-FC-1: ATF CLADDING TESTS IN THE MITR PRESSURIZED WATER LOOP (FEDERAL POC – FRANK GOLDNER & TECHNICAL POC – NICK WOOLSTENHULME) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 4 YEARS AND $5,000,000)

Proposals are sought to study the behavior of Accident Tolerant Fuel (ATF) claddings in a prototypic LWR irradiation coolant loop environment. A variety of cladding concepts, including coated cladding, FeCrAl, and SiC, are being developed under DOE's ATF program to enhance overall fuel performance during both steady state and transient conditions. This is primarily accomplished by design modifications that mitigate degradation mechanisms that are active under irradiation (i.e. corrosion, hydrogen pickup, cladding creep, effects of coating defects, etc.). Investigation of these behaviors requires subjecting cladding materials to prototypic thermal, hydraulic, chemical, and nuclear environments. Proposals should identify experimental and analytical research studies to explore a relevant research topic in this area. Through Directed University R&D from the AFC program, the integrated research project team will have access to a pressurized water loop installed in the MIT Reactor associated irradiation test design and engineering support, and limited PIE (constrained by the duration of the project). This loop can be operated in modes that represent desired conditions for BWR and/or PWR environments and provides the opportunity for utilizing novel in-situ instruments. The in-pile studies should be complemented by out-of-pile experiments as well as modeling and simulation activities. It is also highly encouraged to demonstrate relevance to the industrial ATF programs.

PROGRAM DIRECTED: NUCLEAR REACTOR TECHNOLOGIES

IRP-RC-1: DEVELOPMENT OF ENABLING FABRICATION TECHNOLOGY FOR COMPACT HEAT EXCHANGERS FOR ADVANCED REACTORS (FEDERAL POC – SUE LESICA & TECHNICAL POC – SAM SHAM) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $4,000,000)

Compact heat exchangers (CHXs) offer the potential for significant improvement in efficiency and reduction in cost for advanced reactors systems. Their use is appropriate with all coolants currently being investigated for such systems by advanced reactor developers (gas, liquid metals & molten salt) as well as for both supercritical CO_2 for advanced energy conversion systems and even water for small modular or large integrated PWRs.

Microchannel CHXs fabricated by the diffusion bonding of multiple layers of etched stainless steel sheets, e.g., 316L, have been successfully commercialized for applications in petrochemical processing and other applications. Efforts to apply this technology to fabrication of nuclear components for operations at 750°C or above from high temperature alloys have proven to be challenging. Specifically, the properties critical for high temperature reactor operations such as creep and cyclic properties of multi-layer stacks of diffusion bonded Alloy 800H or Alloy 617 produced to date have been significantly degraded compared to their wrought counterparts and failure tends to occur at the bond-lines with limited ductility.

Proposals are sought for an integrated research project (IRP) that will determine the scientific basis of process/property relationships for successful diffusion bonding of high temperature alloys that are qualified or being qualified for nuclear construction in Section III Division 5 of the ASME Boiler and Pressure Vessel Code. Improvement of creep, fatigue, and creep-fatigue properties to near-wrought values is one goal of the IRP. Along with demonstration of improved properties, it is desired that a predictive capability be developed that will dramatically decrease the iterative development of processing pathways for additional high temperature alloys of interest.

Currently, tensile properties and microstructural characterization of diffusion-bonded interfaces are used to judge success of diffusion bonding process development. These characteristics have not generally been shown to predict the long-term creep and cyclic properties that are critical to success of bonding for the extended high-temperature

operation of nuclear components. A final goal of this IRP is to develop acceptance criteria for diffusion bonding processes that adequately reflect the performance metrics for nuclear applications for incorporation in nuclear codes and standards.

Validation of the acceptance criteria will need to be demonstrated by the testing of a diffusion-bonded structural component under creep and cyclic loading. The test article will need to be fabricated using the optimized diffusion bonding process developed as part of the IRP and incorporate microchannels typical of a CHX, but it can be a simplified component for testing, if desired. The results of the testing will be to provide evidence of the improved bonding technique and the appropriateness of the acceptance criteria.

Establishing an IRP to investigate the issues described above would significantly augment the existing ART programmatic content and address a recognized need in a very useful manner. The university community has well established strengths that directly address the topics identified (structure-properties relations, characterization, materials joining, process modeling, high temperature material behaviors, mechanical properties testing, etc.) and, in conjunction with industry and Federally Funded Research and Development Centers (FFRDCs), could form a powerful team that could make a great deal of progress towards resolving these issues in a three-year period.

IRP-RC-2: HIGH TEMPERATURE REACTOR GRAPHITE CORE WASTE PROCESSING (FEDERAL POC – DIANA LI & TECHNICAL POC – WILL WINDES) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $3,000,000)

Issues surrounding waste disposal of TRISO fuel and core structural graphite are of importance for both past as well as new High Temperature Reactor (HTR) designs. As part of the license application for these new designs the applicant must consider the potential waste generated and all disposal options. Due to the relatively low power density for graphite core HTR designs one of the main issues is waste minimization or volume reduction of the large amount of graphite core components. This includes both fueled components (prismatic fuel elements and pebbles) and unfueled, structural graphite components which constitute ~80% of the solid core volume in either design. Secondly, the physical form and robust nature of the fuel form (either large prismatic blocks or fuel pebbles) requires special handling and storage considerations different from traditional LWR fuel waste practices. Third, molten salt HTR designs have the added complexity of dealing with the molten salt effects. Research and development in the specific areas of graphite handling, core decommissioning, waste storage, waste minimization, and core disposal for all graphite-core HTR designs are of interest.

This research will explore the options available for graphite-based waste reduction and disposal. Areas of interest for this proposal include:

a) Previous waste research and regulatory rules: Emphasis on the technical (engineering) aspects of waste reduction, fuel recovery, consolidation, and disposal will be primary but the regulatory issues surrounding carbon waste must be considered as well. It may be that regulatory issues may drive the waste technology in specific directions and this should be considered during development of these waste technologies. Considerable effort and success has previously been achieved both domestically and internationally in these specific waste areas. Extensive progress was achieved in previous DOE waste programs for the Fort St. Vrain and Peach Bottom graphite core reactors (INL's Graphite Fuel and Spent Nuclear Fuel programs in the late 1980s and 1990s). These domestic technologies should be investigated thoroughly. Additionally, graphite core designs are the primary nuclear reactor designs for many countries (the U.K., specifically) and they have made considerable progress in all areas of waste management. Specifically, waste reduction technology, carbon capture, and core dismantling for the Magnox and AGR designs should be carefully researched for potential solutions to the current graphite waste issues. Finally, it is expected that international technologies and regulatory practices will be considered within this scope due to their considerable experience in graphite and carbon waste.
b) Waste reduction of the graphite components: The obvious method for waste volume reduction for graphite components is oxidizing the solid carbon material. While graphite readily oxidizes under high temperature (>600C) and flowing oxygen conditions it is not a trivial exercise, especially for the amount of graphite

waste anticipated and already in storage. Full scale (large) furnaces capable of handling and oxidizing large irradiated components, the capture of activated impurities after oxidation, and eventually the capture of the carbon itself to reduce the carbon footprint from the process make this an engineering challenge. The treatment of fueled components may require completely different technologies than the unfueled components.

c) Molten salt contamination issues: Designs using molten salt coolant will make waste storage and minimization technologies even more challenging. This is specifically true if the design uses fueled molten salt coolant. The technical and regulatory issues surrounding molten salt contaminated graphite components will require special attention (mixed waste storage and treatment).

The end product from this research effort will be regulatory informed methods for handling irradiated graphite and waste volume reduction methods addressing the fundamental issues of processing large components, and activated material capture.

IRP-RC-3: DEVELOPING THE TECHNICAL BASIS AND RISK ASSESSMENT TOOLS FOR FLEXIBLE PLANT OPERATION
(FEDERAL POC – JASON MARCINKOSKI & BILL WALSH & TECHNICAL POC – RICHARD BOARDMAN & SVETLANA LAWRENCE)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 5 YEARS AND $4,000,000)

With the buildup of variable power generation in the United States many nuclear power plants are considering more flexible approaches to plant operations where thermal and electrical power are dispatched to non-grid applications that are physically connected to the nuclear power plant. Flexible plant operation and generation will employ technologies new to the commercial nuclear power industry, requiring new operating concepts and supporting technologies to continue to achieve safe and reliable operations. Control interfaces that combine current analog data and control systems with modern digital data and controls systems may be needed. Extension of legacy probabilistic risk assessment tools that provide perspective on everything from configuration control, maintenance, and interaction of the systems, requires revision of plant simulators. Specifically, the capabilities of the plant simulators should be extended to include real-time analysis of multi-hazards in order to support licensee assessment of operating conditions, conduct operator training, and pursue any necessary license amendments Flexible operation of nuclear power plants may increase the wear on critical unit operations, necessitating increased health monitoring and preventative maintenance. Additionally, intelligent design of the instruments, data transmission and process and control signals must incorporate cyber security. This new paradigm may involve continuous communication with the grid balancing authority in order to dynamically apportion energy between the electricity grid and storage or a second user of the thermal energy or electrical power. The IEEE 2030 standards development approach recognizes the interactive nature of power plant interconnections with the grid including communications and information technologies that establish a smart grid.

The Light Water Reactor Sustainability Program Pathways for Flexible Plant Operations and Generation, Plant Modernization, and Risk-Informed Systems Analysis are soliciting research projects that accelerate the development of control systems, data collection, processing and system diagnostics, and computational tools that enable existing LWR power plants to be efficiently and safely integrated with process applications and that allow nuclear power plants to provide ancillary services to the grid. Potential work scopes may include:

(1) Controls systems that are capable of rapidly apportioning thermal and electrical power to support electricity grids technical services while optimizing plant revenue through energy arbitrage. In particular, aspects of interest for research and development include:
   - Design and testing of new operator task panels with human factors that ensure reliable human performance and efficient hybrid operations.
   - Development of IEEE-2030 standards and protocol for grid-to-plant data links that enable nuclear plant operators to directly communicate with regional transmission and balancing authorities, thus

PROGRAM DIRECTED: NUCLEAR REACTOR TECHNOLOGIES

allowing the nuclear plant to participate in capacity markets by providing spinning or non-spinning reserves or frequency regulation.

(2) General or plant specific LWR simulators or other computational tools that can be used to help design, test, and optimize dynamic thermal energy extraction and delivery and electricity dispatch. Activities that consider the following operation scenarios are sought:
- Full-scope simulators that can be used to optimize thermal energy extraction within the operating basis of the nuclear plant license.
- Reduced order models of the integrated systems that can be used to accelerate the development of human factors.
- Computational models that are tied to actual physical unit operations that represent new energy delivery components that can credibly support probabilistic risk assessments (PRAs) addressing the risks of potential upsets in operating conditions and loss of load situations that are introduced by specific integrated plant designs and hybrid operation conditions.

(3) Extension of legacy probabilistic tools to include new initiating events introduced by new grid-to-plant process controls and plant-to-hybrid process controls coupling. Activities that consider the following operation scenarios are sought:
- Hybrid plants that flexibly apportion power to the grid and thermal energy and power to a hydrogen production plant
- Hybrid operations that store thermal energy for power arbitrage on the grid- where power dynamics of power transmission are included in potential loss of load events
- Modes of heat rejection relevant to rapid transients in the new heat extraction and delivery system; for example, failure of control values, sudden disruption in the heat transport line to the external thermal energy application, or a rapid change is heat demand by the external application

(4) Development and demonstration of operating concepts using smart valve flow controllers, smart instrumentation, data links, and data analytics for hybrid plant operations. Activities that consider the following operation scenarios are sought:
- Approaches that combine conventional analog instruments and controls with modern digital instruments and controls for rapid thermal and electrical power dispatch to an external user
- Design and testing of smart valves and valve alignments in thermal flow loops with multiple parallel outputs/inputs for plants that serve multiple processes for systems that enable rapid thermal extraction and dispatch based on operator-supervised automatic control systems
- Data management and analytics that enable operators to track system state conditions and that can be used to automatically adjust process conditions with human cognition and supervision
- Instrumentation and data analytics that perform component health monitoring
- Approaches that provide inherent cyber security and systems reliability based on total state awareness

PROGRAM DIRECTED: NUCLEAR ENERGY ADVANCED MODELING AND SIMULATION

IRP-NEAMS-1: COMBINED EXPERIMENTAL-MODELING ASSESSMENTS OF IMPURITIES/FISSION PRODUCTS IN MOLTEN SALTS AND FUNDAMENTAL CORROSION MECHANISMS OF RELEVANT STRUCTURAL ALLOYS
(FEDERAL POC – BRIAN ROBINSON & TECHNICAL POC – CHRIS STANEK)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $3,000,000)

During operation of a Molten Salt Reactor (MSR) impurities are present in the salt and furthermore fission products are formed thus affecting the thermophysical properties, corrosion kinetics of structural materials, as well as reactor

PROGRAM DIRECTED: NUCLEAR ENERGY ADVANCED MODELING AND SIMULATION

operations. Proposal are sought to study the impact of halide salt impurities on reactor performance based on experimental and computational methods.

There are several specific topics of interest. First, proposals are sought that address the impact of low impurity concentration on burnup calculations. Specific examples include the impact of low concentrations of impurities on temperature, spectrum and cross-section uncertainties, and reactor operation. Experiments aimed at the identification of specific isotopes are expected be a useful complement to the modeling research. A second topic of interest is salt property alteration with impurity concentrations to ultimately provide recommendations for the allowable concentrations for oxygen, hydroxide, etc. to ensure sound MSR operation, with a focus on heat transfer and containment corrosion. For example, oxide/hydroxide impurities accelerate corrosion rates of halide salt melts in contact with stainless steel and nickel-based alloys. These recommendations generated through the R&D performed should include allowable impurity concentration of the fresh salt melt as well as allowable impurity/fission product concentration during MSR operation.

Vital to the development of impurity limits and guidelines is a better understanding of corrosion mechanisms of austenitic stainless steels, ferritic/martensitic stainless steel, and nickel-based alloys in fluoride and chloride salt melts at 650° C to 750° C. It is currently believed that the corrosion of stainless steel and nickel-based alloys in contact with halide salt melts is derived by the leaching of chromium from the alloy matrix and the formation of stable chromium fluoride or chromium chlorides at the salt-containment interface. The depletion of chromium may weaken the steel structure to further enhance corrosion rates. Overall, corrosion rates of stainless steel and nickel-based alloys could be, as a simplified approach, derived by chromium-self diffusion from the alloy matrices to the surface and the ultimate formation of stable chromium halides. However, overall chromium self-diffusion is a result of matrix and grain-boundary diffusion and their specific ratio is dependent on temperature as well as on microstructure (e.g., phases, precipitates, grain sizes, texture, defects). The proposal should therefore address these and any additional factors to derive an approach for modeling chromium diffusion, and subsequently corrosion of austenitic stainless steels (e.g., Alloy 316H and Alloy 709), ferritic/martensitic stainless steels (e.g., HT9, T91) and nickel-based alloys (e.g., Hastelloy N and Haynes 244). This research will provide a fundamental theoretical and experimental basis for enhancing the current knowledge on corrosion of austenitic stainless steels (fcc) vs. ferritic/martensitic stainless steel (bcc), vs. the more expensive nickel-based alloys in contact with halide salt melts at temperatures applicable to MSR operation.

Proposals are sought that employ integrated experiments and modeling/simulation to address the above problems. Proposals should rely on NEAMS software or at a minimum provide a clear path for model developed in to NEAMS codes.

Since this research is aimed at the deployment of MSR technology, industry partnership is required.

PROGRAM DIRECTED: MISSION SUPPORTING (MS)

IRP-MS-1: NUCLEAR ENERGY WORKFORCE PIPELINE GAP ANALYSIS
(FEDERAL POC – JENNA PAYNE & TECHNICAL POC – DREW THOMAS)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(COLLABORATION REQUIREMENT: MINORITY SERVING INSTITUTIONS (MSIS), HISTORICALLY BLACK COLLEGES AND UNIVERSITIES (HBCUS) AND/OR TRIBAL COLLEGES AND UNIVERSITIES (TCUS))
(UP TO 3 YEARS AND $3,000,000)

Background

The nuclear energy industry is broad and is anticipated to change rapidly because of the emergence of micro- and advanced reactor concepts. DOE-NE anticipates that some of these concepts will be demonstrated by the end of the decade. The existing disconnect between the availability of and growing demand for skilled workers presents a

PROGRAM DIRECTED: MISSION SUPPORTING (MS)

critical opportunity for our nation to educate, train, and retain more scientists and engineers to establish economic leadership and maintain global competitiveness.

A comprehensive understanding of the nuclear energy workforce landscape is needed to address workforce needs in the existing light water reactor fleet, and to develop, construct, operate, and maintain advanced reactors as their design fully matures. A reliable source of technicians, operators, and engineers will help ensure continued safe and reliable operation of the nuclear powered electrical generating stations in the years to come. A workforce pipeline that is inclusive of the existing light water reactor fleet, advanced reactor development, advanced reactor construction, operation, and maintenance, and other aspects of the nuclear fuel cycle will be critical to training the next generation of nuclear energy professionals.

IRP Goals and Objectives

Applications are sought to identify existing and future gaps in the nuclear energy workforce. This gap analysis should explore all aspects of the U.S. nuclear fuel cycle and should be inclusive of labor pools associated with uranium supply, enrichment and fuel fabrication, fission reactors, recycling, interim storage, and final disposal.

Applications would provide DOE-NE with a comprehensive nuclear energy workforce development plan to address identified gaps, challenges, needed resources, and opportunities to create these pipelines.

Successful teams will be made up of not only nuclear energy experts, but also those from social science disciplines, including sociology, political science, psychology, economics, education and business and management.

IRP-MS-2: CONSENT-BASED SITING
(FEDERAL POC – ALISA TRUNZO & TECHNICAL POC – ROB HOWARD)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(COLLABORATION REQUIREMENT: MINORITY SERVING INSTITUTIONS (MSIS), HISTORICALLY BLACK COLLEGES AND UNIVERSITIES (HBCUS) AND/OR TRIBAL COLLEGES AND UNIVERSITIES (TCUS))
(UP TO 3 YEARS AND $3,000,000)

Background:

The Department of Energy is developing a phased, adaptive, and consent-based approach to siting and implementing a comprehensive integrated waste management and disposal system for spent nuclear fuel (SNF) and high-level radioactive waste (HLW). A consent-based siting process must put people and communities first, promote community well-being, build in environmental justice and equity, ensure fair treatment, and reduce barriers to meaningful participation. The Department will initially focus on consent-based siting of one or more consolidated interim storage facilities.

The Department's draft consent-based siting process design principles include, among other things:

• *Environmental Justice* – The process will pursue fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income. The process will also embrace environmental justice principles, and comply with federal requirements and guidance on these issues.
• *Informed Participation* – Consent is not meaningful unless it is informed. This means sharing information and resources to communities as needed to enable effective participation and provide for informed decision-making.
• *Equal Treatment and Full Consideration of Impacts* – The siting process will be conducted in a manner that is considerate of parties who are or may reasonably be affected, identifies and shares information about potential impacts, and makes explicit the role of fairness and equity considerations in its decision-making.

Potential Integrated Research Project Scope of Work:

PROGRAM DIRECTED: MISSION SUPPORTING (MS)

Provide scholarly research to support the Department of Energy in integrating principles of environmental justice and equity into the consent-based siting process and the waste management system as a whole; ensuring that the implementation of consent-based siting processes offer fair treatment and meaningful involvement; and removing barriers to meaningful participation for groups and communities who have not historically been well-represented in these conversations. The research should include:

- Developing programmatic goals and metrics to evaluate success with incorporating environmental justice values into the consent-based siting program
- Identifying practices and approaches to ensure environmental paternalism is avoided in the cooperation and consultation process
- Identifying ways that sensitivities of environmental justice communities are readily recognized and addressed
- Identifying and analyzing successful and unsuccessful cases of consent-based siting, including suggestions for corrective actions and improvements

In addition to scholarly research, provide the Department of Energy with support in facilitating actual engagement with communities. This includes planning and preparation for engagement by identifying effective ways to collaborate and facilitate mutual learning on issues that may impact community well-being, as well as being available to communities as resources to assist in articulating and advocating for community well-being.

Successful teams will be made up of not only nuclear energy experts, but also those from social science disciplines, including sociology, political science, psychology, economics, education and business and management, and other relevant fields.

https://www.energy.gov/sites/prod/files/2016/12/f34/Summary%20of%20Public%20Input%20Report%20FINAL.pdf

https://www.energy.gov/sites/prod/files/2017/01/f34/Draft%20Consent-Based%20Siting%20Process%20and%20Siting%20Considerations.pdf

Appendix D: Accessing Nuclear Science User Facilities

As previously described in this document, the NSUF provides access, at no cost to the user, to DOE, University, and Industry facilities. Access to these facilities includes the support of the technical staff at each facility to ensure that the applicant is able to successfully complete their research. Requesting NSUF access funding is more complex than requesting R&D funding through this FOA. Figure D-1 depicts the process for requesting NSUF access from the perspective of the Lead Applicant. Note that NSUF Rapid Turnaround Experiments (RTEs) are not part of this FOA, for information on RTEs see NSUF.inl.gov/. A list of NSUF work scopes can be found on the work scope index on Table 1.

Unlike the other work scopes in this FOA, the applicant will not be able to provide cost information without the involvement of the NSUF facilities and staff. The effort to develop a firm cost estimate requires effort on the applicant's part, as well as the NSUF facilities and staff and must be started at the earliest possible date in order to have the information available for inclusion in the full application. In order to get this process started, the applicant may need to contact the NSUF Program Office to identify the NSUF technical lead(s), (points of contact for NSUF partner institutions are the Technical Leads listed on NSUF.inl.gov/Page/Partners. INL Technical Leads are assigned by the NSUF Program Office). The applicant is required to submit a NSUF Letter of Intent and pre-application to apply for the FOA. The applicant will work with the NSUF Technical Lead(s) to prepare the LOI and pre-application. If invited to submit a full application, the applicant and NSUF Technical Lead(s) will work together to develop the application and define the scope of the application and estimate the cost.

For all applications, the NSUF Technical Lead(s) will work with the applicant to define the scope in the form of a Statement of Work (SOW). A Preliminary SOW will be submitted as a "post submission document" in the pre-application. If invited to submit a full application, a Final SOW will be submitted prior to the full application as a "post submission document" attachment in the pre-application. At a minimum, the SOW will include the following (as applicable):

- Facilities and equipment required to conduct the experiment,
- Specific requirements for specimen acquisition (e.g., material location, material condition, and fabrication or preparation requirements),
- Specific requirements for irradiation or beam-time (e.g., neutron or beam energy spectrum, target temperature, flux and fluence [or burn-up/dpa] for each specimen, in-pile instrumentation, etc.) including a detailed test matrix; and,
- Specific requirements for post-irradiation examination (PIE) of each specimen (e.g., visual examination, dimensional examinations, tensile testing, radiography, microscopy, etc.) including a detailed test matrix.

The Preliminary and Final SOW (Statement of Work Template) will be utilized by the NSUF facility technical staff to develop an execution plan and cost.. Execution Plan details may be included in the final SOW at the discretion of the NSUF Technical Lead and typically addresses the following elements (as applicable):

- Concept for the irradiation device including fabrication and assembly plans;
- Irradiation position and duration;

- Experiment shipping;
- Disassembling and cataloging the experiment;
- Specimen preparation and shipping;
- Specimen examination details;
- Waste disposal; and,
- Resource loaded schedule.

After award announcement, several steps will be required prior to initiation of work. The successful applicant's institution will be required to sign a Non-Proprietary User Agreement with Battelle Energy Alliance. Appendix D contains the standard User Agreement. **The User Agreement is not negotiable.** The SOW will be an appendix in the User Agreement in order to bind the PI to the SOW and to define the NSUF policies applicable to the scope of work. A subcontract(s) or work authorization(s), with a total value equal to the previously developed cost estimate, will be placed with NSUF institutions performing the work defined in the SOW and experiment execution plan.

NSUF Quality Assurance Requirements

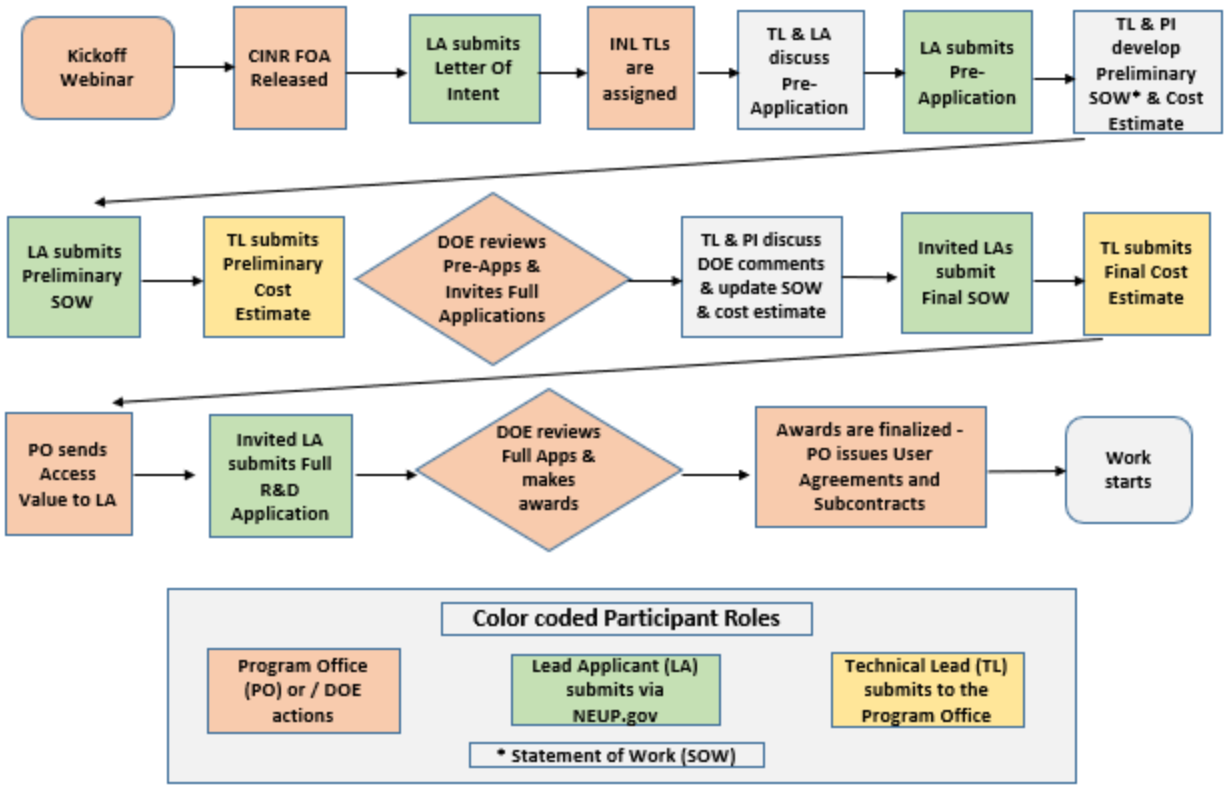
Irradiation of materials in test reactors requires additional rigor and quality assurance requirements beyond those described in other sections of this FOA. Specific requirements will depend on the reactor license, the irradiation vehicle design, and specimen constituents. NSUF Technical leads will assist the PI in understanding the specific requirements early in the process.

Budget Development for NSUF Applications

Applicants need to ensure that the following cost elements are covered within the R&D budget for NSUF-1 work scopes in this FOA or via another fund source for NSUF-2 work scopes:

- Travel costs to NSUF facilities for facility access training, technical meetings, examinations, experiment loading, etc.;
- Applicant salary support;
- Graduate student support;
- Post-doctoral or other researcher support; and,
- Materials and supplies support at the PI's work location.

- Figure D-1. Process for NSUF applications.



Appendix E: Draft Nuclear Science User Facilities User Agreement

NOTE: Access to NSUF capabilities will require agreement and final signature to the User Agreement (copy provided in Part IX, Appendix D).**The terms and conditions of the User Agreement are non-negotiable, and failure to accept the terms and conditions of the User Agreement will terminate processing and review of the NSUF applications.** In order to ensure compliance throughout the application review process, applicants must indicate in the LOI and full application submission that the User Agreement has been read, understood, and the terms and conditions are accepted. Further, submission of a pre- application and a full application indicates the applicant will comply with and agree to the terms and conditions of the User Agreement. Upon award of an NSUF supported project, the User Agreement must be signed before activities will begin on the project.

Failure to sign the non-negotiable User Agreement within 30 days of receipt of the User Agreement may result in cancellation of an awarded project.

NOTE: For Public Institutions residing in the State of Colorado, a version of the User Agreement, compliant with Colorado statute, is available. Contact the NSUF program office for more information.

Non-Proprietary User Agreement

User Facility Agreement No. xxxxx BETWEEN

BATTELLE ENERGY ALLIANCE, LLC

(" CONTRACTOR")
Operator of The Idaho National Laboratory (hereinafter "Laboratory") under U.S. Department of Energy (DOE) Contract No. DE-AC07-05ID14517

AND

XXXXXXXXXXXXXXXXX

("USER")

(Collectively, "the Parties")

The obligations of the above-identified DOE Contractor may be transferred to and shall apply to any successor in interest to said Contractor continuing the operation of the DOE Non-Proprietary User Facility involved in this User Agreement.

ARTICLE I. FACILITIES AND SCOPE OF WORK

Subject to the terms and conditions of this Agreement, CONTRACTOR will make available to employees, consultants and representatives of USER (hereinafter called "Participants") certain Laboratory Non-Proprietary User facilities, which may include equipment, services, information and other material, with or without Laboratory scientist collaboration, for purposes as described in the attached Scope of Work and in accordance with the attached Funding Statement, both of which are incorporated by this reference and are made a part of this Agreement. Amendments to the attached Scope of Work and Funding Statement may be submitted by USER for identifying facilities and purposes during the term of this Agreement (see Article II). Such amendments will be considered to be part of this Agreement upon written acceptance by CONTRACTOR. The attached Scope of Work sets forth a specific project, including deliverables, to be performed pursuant to this

Agreement. The Scope of Work and abstracts thereof, shall not be considered proprietary information and shall be publicly releasable. The Parties agree that an initial abstract of the work to be performed shall be deliverable under this Agreement.

ARTICLE II. TERM OF THE AGREEMENT

This Agreement shall have a term of X years from the effective date. The term of this Agreement shall be effective as of the date on which it is signed by the last of the Parties.

ARTICLE III: COST

Each Party will bear its own costs and expenses associated with this Agreement unless otherwise agreed to by the Parties or as may otherwise be agreed to by the User and DOE.

ARTICLE IV: ADMISSION REQUIREMENTS

USERs and Participants are subject to the administrative and technical supervision and control of CONTRACTOR; and will comply with all applicable rules of CONTRACTOR and DOE with regard to admission to and use of the User facility, including safety, operating and health-physics procedures, environment protection, access to information, hours of work, and conduct. Participants shall execute any and all documents required by CONTRACTOR acknowledging and agreeing to comply with such applicable rules of CONTRACTOR. Participants will not be considered employees of CONTRACTOR for any purpose.

ARTICLE V: PROPERTY AND MATERIALS***

USER may be permitted by Contractor to furnish equipment, tooling, test apparatus, or materials necessary to assist in the performance of its experiment(s) at the USER facility. Such items shall remain the property of USER, except as otherwise provided in this Article. Unless the Parties otherwise agree, all such property furnished by USER or equipment and test apparatus provided by USER will be removed by USER within sixty (60) days of termination or expiration of this Agreement or will be disposed of as directed by USER at User's expense. Any equipment that becomes integrated into the facility shall be the property of the Government. USER acknowledges that any material supplied by USER may be damaged, consumed or lost. USER will return facilities and equipment utilized in their original condition except for normal wear and tear.

CONTRACTOR shall have no responsibility for USER's property in CONTRACTOR's possession other than loss or damage caused by willful misconduct or gross negligence of CONTRACTOR or its employees.

Personal property produced or acquired during the course of this Agreement shall be disposed of as directed by the owner at the owner's expense.

USER represents that it owns and has full authority to transfer ownership and title to any materials it supplies for the purpose of irradiation under this Agreement and that said materials are free of any liens, claims of ownership, or other liabilities. Transfer of materials for irradiation and/or examination under this Agreement, shall constitute a transfer of title of said materials from User to DOE upon delivery of the materials at the Nuclear Science User Facility (NSUF) unless otherwise specified.

After the material has been irradiated, transferred to an examination facility and extracted from the encapsulation and/or holders, the USER will be notified by the CONTRACTOR that the irradiated material is available for examination. The USER will have exclusive research rights to the irradiated material for a period of three (3) years from the date of notification. After the three (3) years, DOE and CONTRACTOR have full discretion to make the irradiated material available to the general research community, maintain possession, transfer possession, or dispose of the irradiated material. DOE may transfer title to the material at its discretion.

ARTICLE VI: SCHEDULING***

USER understands that CONTRACTOR will have sole responsibility and discretion for allocating and scheduling usage of the User Facilities and equipment needed for or involved under this Agreement.

ARTICLE VII: INDEMNITY AND LIABILITY***

A. Personnel Relationships - USER shall be responsible for the acts or omissions of Participants.

B. Product Liability - To the extent permitted by US and US State law, if USER utilizes the work derived from this Agreement in the making, using, or selling of a product, process or service, then USER hereby agrees to hold harmless and indemnify CONTRACTOR and the United States Government, their officers, agents and employees from any and all liability, claims, damages, costs and expenses, including attorney fees, for injury to or death of persons, or damage to or destruction of property, as a result of or arising out of such utilization of the work by or on behalf of USER, its assignees or licensees.

C. General Indemnity - To the extent permitted by US and US State law, USER hereby agrees to indemnify and hold harmless CONTRACTOR and the United States Government, their officers, agents and employees from any and all liability, claims, damages, costs and expenses, including attorney fees, for injury to or death of persons, or damage to or destruction of property, to the extent such liability, claims, or damages is caused by or contributed to the negligence or intentional misconduct of USER or its employees or representatives during the performance of the work under this Agreement.

D. Patent and Copyright Indemnity—Limited - *To the extent permitted by US and US State law, USER shall fully indemnify the Government and CONTRACTOR and their officers, agents, and employees for infringement of any United States patent or copyright arising out of any acts*

required or directed or performed by USER under the Agreement to the extent such acts are not normally performed at the facility.

E. The liability and indemnity provisions in paragraphs B, C and D above shall not apply unless USER shall have been informed as soon as practicable by CONTRACTOR or the Government of the suit or action alleging such infringement, and such indemnity shall not apply to a claimed infringement that is settled without the consent of USER unless required by a court of competent jurisdiction.

F. General Disclaimer -

THE GOVERNMENT AND CONTRACTOR MAKE NO EXPRESS OR IMPLIED WARRANTY AS TO THE CONDITIONS OF THE USER FACILITY FURNISHED HEREUNDER. IN ADDITION, THE GOVERNMENT, CONTRACTOR AND USER MAKE NO EXPRESS OR IMPLIED WARRANTY AS TO THE RESEARCH OR ANY INTELLECTUAL PROPERTY, GENERATED INFORMATION, OR PRODUCT MADE OR DEVELOPED UNDER THIS AGREEMENT, OR THE OWNERSHIP, MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE OF THE RESEARCH OR RESULTING PRODUCT; THAT THE GOODS, SERVICES, MATERIALS, PRODUCTS, PROCESSES, INFORMATION, OR DATA TO BE FURNISHED HEREUNDER WILL ACCOMPLISH INTENDED RESULTS OR ARE SAFE FOR ANY PURPOSE INCLUDING THE INTENDED PURPOSE; OR THAT ANY OF THE ABOVE WILL NOT INTERFERE WITH PRIVATELY OWNED

RIGHTS OF OTHERS. THE GOVERNMENT, CONTRACTOR AND/OR USER SHALL NOT BE LIABLE FOR SPECIAL, CONSEQUENTIAL, OR INCIDENTAL DAMAGES ATTRIBUTED TO USE OF SUCH FACILITIES, RESEARCH OR RESULTING PRODUCT, INTELLECTUAL PROPERTY, GENERATED INFORMATION, OR PRODUCT MADE OR DELIVERED UNDER THIS AGREEMENT.

ARTICLE VIII: PATENT RIGHTS***

A. Definitions

1. “Subject Invention” means any invention or discovery conceived or first actually reduced to practice in the course of or under this Agreement.

2. "USER Invention" means any Subject Invention of USER.

3. “CONTRACTOR Invention” means any Subject Invention of CONTRACTOR.

4. "Patent Counsel" means the DOE Counsel for Intellectual Property assisting the DOE Contracting activity.

B. Subject Inventions

CONTRACTOR and USER agree to disclose their Subject Inventions, which includes any inventions of their Participants, to each other, concurrent with

reporting such Subject Inventions to DOE.

C. CONTRACTOR's Rights

Except as provided below in the case of joint inventions, CONTRACTOR Inventions will be governed by the provisions of CONTRACTOR'S Prime Contract for operation of the User facility.

D. USER's Rights

Subject to the provisions herein, USER may elect title to any USER Invention and in any resulting patent secured by USER within one year of reporting the subject invention to DOE. The USER shall file a US patent application within a reasonable period of time. Where appropriate, the filing of patent applications by USER is subject to DOE security regulations and requirements.

E. Joint Inventions

For Subject Inventions conceived or first actually reduced to practice under this Agreement that are joint Subject Inventions made by CONTRACTOR and USER, each Party shall have the option to elect and retain title to its undivided rights in such joint Subject Inventions.

F. Rights of Government

1. USER agrees to timely assign to the Government, if requested, the entire right, title, and interest in any country to each USER Invention where USER:

a. Does not elect to retain such rights; or

b. Fails to timely have a patent application filed in that country on the USER Invention or decides not to continue prosecution or not to pay the maintenance fees covering the Invention; or

c. At any time, no longer desires to retain title.

2. USER shall provide the Government a copy of any application filed by USER promptly after such application is filed, including its serial number and filing date.

3. USER hereby grants to the Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States the USER Invention made under said project throughout the world.

4. USER acknowledges that the DOE has certain March-in Rights to any USER Inventions elected by the USER in accordance with 48 C.F.R. 27.304-1(g) and that the USER is subject to the requirements with respect to preference for U.S. industry pursuant to 35 U.S.C. § 204 to any USER Inventions elected by the USER.

5. The USER agrees to include, within the specification of any U.S. patent applications and any patent issuing thereon covering a USER Invention, the following statement: “The Government has rights in this invention pursuant to a USER Agreement (specify number) between (USER name) and (CONTRACTOR Name), which manages and operates (name of Laboratory) for the US Department of Energy.”
6. USER agrees to submit on request periodic reports to DOE no more frequently than annually on the utilization of USER Inventions or on efforts to obtain such utilization that are being made by USER or its licensees or assignees.
7. Facilities License: USER agrees to and does hereby grant to the Government a nonexclusive, nontransferable, irrevocable, paid-up license in and to any inventions or discoveries, regardless of when conceived or actually reduced to practice or acquired by USER, which are incorporated in the User Facility as a result of this Agreement to such an extent that the facility is not restored to the condition existing prior to the Agreement (1) to practice or to have practiced by or for the Government at the facility, and (2) to transfer such licenses with the transfer of that facility. The acceptance or exercise by the Government of the aforesaid rights and license shall not prevent the Government at any time from contesting the enforceability, validity or scope of, or title to, any rights or patents herein licensed.

G. Invention Report and Election

USER shall furnish the Patent Counsel a written report concerning each USER Invention within six months after conception or first actual reduction to practice, whichever occurs first. If USER wished to elect title to the Invention, a notice should be submitted with the report or within one year of such date of reporting.

ARTICLE IX: RIGHTS IN TECHNICAL DATA***

A. Definitions:

1. "Technical Data" means recorded information regardless of form or characteristic, of a scientific or technical nature. Technical Data as used herein does not include financial reports, costs analyses, and other information incidental to Agreement administration.
2. "Proprietary Data" means Technical Data which embody trade secrets developed at private expense, outside of this agreement, such as design procedures or techniques, chemical composition of materials, or manufacturing methods, processes, or treatments, including minor modifications thereof, provided that such data:
   - **a.** Are not generally known or available from other sources without obligation concerning their confidentiality.
   - **b.** Have not been made available by the owner to others without obligation concerning their confidentiality
   - **c.** Are not already available to the CONTRACTOR or the Government without obligation concerning their confidentiality.
   - **d.** Are marked as “Proprietary Data.”
3. "Unlimited Rights" means right to use, duplicate, or disclose Technical Data, in whole or in part, in any manner and for any purpose whatsoever, and to permit others to do so.

B. Allocation of Rights

1. The Government shall have Unlimited Rights in Technical Data first produced or specifically used in the performance of this Agreement except as otherwise provided in this Agreement.
2. USER shall have the right to use for its private purposes, subject to patent, security or other provisions of this Agreement, Technical Data it first produces in the performance of this Agreement provided the data delivery requirements of this Agreement have been met as of the date of the private use of such data; and Technical Data first produced by CONTRACTOR, if any, under this Agreement. USER agrees that to the extent it receives or is given access to Proprietary Data or other technical, business or financial data in the form of recorded information from DOE or a DOE contractor or subcontractor, USER shall treat such data in accordance with any restrictive legend contained thereon, unless use is specifically authorized by prior written approval of the Contracting Officer.

C. Deliverables

1. USER agrees to furnish to DOE or CONTRACTOR those data, if any, which are (a) specified to be delivered in Appendices, (b) essential to the performance of work by CONTRACTOR personnel or (c) necessary for the health and safety of such personnel in the performance of the work. Any data furnished to DOE or CONTRACTOR shall be deemed to have been delivered

with unlimited rights unless marked as "Proprietary Data" of USER.

2. Upon completion or termination of the project, USER agrees to deliver to DOE and CONTRACTOR a nonproprietary report describing the work performed under this Agreement.

D. Legal Notice

The following legal notice shall be affixed to each report or publication resulting from this Agreement which may be distributed by USER:

DISCLAIMER NOTICE

This document was prepared by __ as a result of the use of facilities provided through the U.S. Department of Energy (DOE) Nuclear Science User Facilities program, which is managed by Battelle Energy Alliance, LLC, acting under Contract No.DE-AC-07-05ID14517. Neither Battelle Energy Alliance, LLC, DOE, the U.S. Government, nor any government contractors, nor other persons and facilities performing work under this Agreement or acting on behalf of any of the above: (a) make any warranty or representation, express or implied, with respect to the information contained in this document; or (b) assume any liabilities with respect to the use of, or damages resulting from the use of any information contained in the document.

E. Copyrighted Material

1. USER agrees to, and does hereby grant to the Government, and to its officers, agents, servants and employees acting within the scope of their duties:

a. A royalty-free, nonexclusive, irrevocable license to reproduce, translate, publish, use, and dispose of and to authorize others so to do, all copyrightable material first produced or composed in the performance of this Agreement by USER, its employees or any individual or concern specifically employed or assigned to originate and prepare such material; and

b. A license as aforesaid under any and all copyrighted or copyrightable works not first produced or composed by USER in the performance of this Agreement but which are incorporated in the material furnished or delivered under the Agreement, provided that such license shall be only to the extent USER now has, or prior to completion or final settlement of the Agreement may acquire, the right to grant such license without becoming liable to pay compensation to others solely because of such grant.

2. USER agrees that it will not knowingly include any copyrightable material furnished or delivered under this Agreement without a license as provided for in subparagraph 1(b) hereof, or without the consent of the copyright owner, unless it obtains specific written approval of the Contracting Officer for the inclusion of such copyrighted materials.

F. Disclosure of Proprietary Data

In the absence of a properly executed and effective non disclosure agreement between USER and CONTRACTOR, the USER shall not bring Proprietary Data into the USER facility except at USER's own risk and any such data, regardless how it is marked, shall be deemed Technical Data and shall be treated according to this article of this Agreement.

ARTICLE X: LABORATORY SITE ACCESS, SAFETY AND HEALTH***

As a precondition to using CONTRACTOR facilities, Participants must complete all CONTRACTOR Site Access documents and requirements. USER and participant shall take all reasonable precautions in activities carried out under this Agreement to protect the safety and health of others and to protect the environment. Participants must comply with all applicable safety, health, access to information, security and environmental regulations and the requirements of the Department and CONTRACTOR, including the specific requirements of the User Facility covered by this Agreement. In the event that USER or Participant fails to comply with said regulations and requirements, CONTRACTOR may, without prejudice to any other legal or contractual rights, issue and order stopping all or any part of USER's activities at the User Facility.

Article XI: PERSONNEL RELATIONSHIPS***

Participants will remain employees or representatives of the USER at all times during their participation in the work under this Agreement, and shall not be considered employees of CONTRACTOR or DOE for any purpose. Participants shall be subject to the administrative and technical supervision and control of CONTRACTOR during and in connection with the Participant's activities under this Agreement.

ARTICLE XII: EXPORT CONTROLS***

USER acknowledges that the export of goods or Technical Data may require some form of export control license from the U.S. Government and that failure to obtain such export control license may result in criminal liability under the laws of the United States.

ARTICLE XIII: PUBLICATIONS***

A. USER and CONTRACTOR will provide each other copies of articles of any publication of information generated pursuant to this Agreement for review and comment fourteen (14) days prior to publication.

B. USER will not use the name of CONTRACTOR or the United States Government or their employees in any promotional activity, such as advertisements, with reference to any product or service resulting from this Agreement, without prior written approval of the Government and CONTRACTOR.

ARTICLE XIV: DISPUTES***

The parties will attempt to jointly resolve all disputes arising under this agreement. If the parties are unable to jointly resolve a dispute within a reasonable period of time, either party may

contact the laboratory's Technology Transfer Ombudsman (TTO) to provide assistance. The TTO may work directly to resolve the dispute or, upon mutual agreement of the parties, contact a third party neutral mediator to assist the parties in coming to a resolution. The costs of the mediator's services will be shared equally by the parties. In the event that an agreement is not reached with the aid of the ombudsman or mediator, the parties may agree to have the dispute addressed by neutral evaluation. The decision rendered by the neutral evaluator shall be nonbinding on the parties, and any costs incurred there from shall be divided equally between the parties. Upon mutual agreement, the parties may request a final decision by the DOE Contracting Officer. Absent resolution, either party may seek relief in a court of competent jurisdiction.

ARTICLE XV: CONFLICT OF TERMS***

This Agreement constitutes the primary document which governs the work described in the attached Appendices. In the event of any conflict between the terms of this document and any other document issued by either Party, the terms of this document shall prevail.

ARTICLE XVI: TERMINATION***

Either Party may terminate this Agreement for any reason at any time by giving not less than thirty (30) days prior written notice to the other Party. Notice will be deemed made as of the day of receipt. The obligations of any clause of this Agreement, which by their nature extend beyond its termination, shall remain in full force and effect until fulfilled.

BATTELLE ENERGY ALLIANCE, LLC (CONTRACTOR):

BY: _____
Signature

NAME: _____
Printed

TITLE: Deputy Laboratory Director, Science & Technology

DATE: _____

User's Formal Name (USER):

BY: _____
Signature

NAME: _____
Printed

TITLE: _____

DATE: _____

ADDRESS: _____

TELEPHONE: _____

User Principal Investigator Acknowledgment

I, XXXXXXXX, have read and hereby acknowledge the above terms and conditions.

BY: _____
Signature

TITLE: _____

DATE: _____

ADDRESS: _____

TELEPHONE: _____

***** Any changes to the *** or substantive changes to the non *** provisions will require formal written approval by DOE.**