FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

U. S. Department of Energy

Idaho Operations Office

Fiscal Year 2021 Consolidated Innovative Nuclear Research

Funding Opportunity Announcement:
DE-FOA-0002361

Announcement Type: Initial – September 3, 2020
Amendment 001- September 17, 2020

CFDA Number: 81.121

Informational Webinar: August 10-13, 2020
(Video links and presentations are available at www.neup.gov)

Issue Date: September 3, 2020

Letter of Intent (Mandatory only for NSUF Applications)
Due Date: September 16, 2020 at 7 p.m. ET

R&D/NSUF Pre-Applications (Mandatory)
Due Date: September 30, 2020 at 7:00 p.m. ET

NSUF Preliminary Statement of Work
Due Date: November 12, 2020 at 7:00 p.m. ET

NSUF Final Statement of Work
Due Date: January 22, 2021 at 7:00 p.m. ET

Full R&D Applications
Due Date: February 11, 2021 at 7:00 p.m. ET

Amendment 001

1. *Removes references to the DOE-ID resource page and replaces those references with information at neup.gov.*
2. *Removes note about an anticipated modification on September 17, 2020.*
3. *Note added that neup.gov's submission site will be available beginning on September 23, 2020 to accept pre-applications.*
4. *Restores links throughout the FOA to documents and informational resources available on neup.gov.*

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

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 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"; 3) Fill out the information in the "My Information" section.

NOTE: NEUP.gov's submission site will open to accept pre-applications on September 23, 2020. Access to the site will be restricted until that date.

Questions

Questions regarding the **content of the funding opportunity announcement** 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

NSUF Letters of Intent will be submitted to a Fedramp certified Box.com account. Submit an LOI at: https://inlbox.app.box.com/f/c973e8bcfce643feb4cacf5fc8890eec If the box.com upload is not successful, NSUF LOIs can be sent to neup@inl.gov.

Electronic applications and instructions are available at the NEUP 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.

NOTE: NEUP.gov's submission site will open to accept pre-applications on September 23, 2020. Access to the site will be restricted until that date.

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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)
DOE	Department of Energy
DUNS	Data Universal Numbering System
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
HTGCR	High-temperature Gas-cooled Reactor
ID	Identification
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
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
RPA	Request for Pre-applications
SAM	System for Award Management
SF	Standard Form
SMR	Small Modular Reactors
SOW	Statement of Work
URG	Under Represented Group
U.S.	United States

PART I – FUNDING OPPORTUNITY DESCRIPTIONS

A. STATEMENT OF OBJECTIVES

This Funding Opportunity Announcement (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's (DOE) Office of Nuclear Energy's (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.

All applications submitted under this FOA must demonstrate a strong tie to at least one of these three 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.

The 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, but 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 FOA are identified in Part IX, Appendices A-C, below. 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 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. NE funds research activities, through both competitive and direct mechanisms, as required to best meet the needs of 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 FOA addresses the competitive portion of NE's R&D portfolio, as executed through the Nuclear Energy University Program (NEUP), Nuclear Energy Enabling Technologies (NEET) Crosscutting Technology Development (CTD), and the Nuclear Science User Facilities (NSUF). NEUP utilizes up to 20% of funds appropriated to NE's R&D program for university-based infrastructure support and R&D in key NE program-related areas: Fuel Cycle Research and Development (FC R&D),

Reactor Concepts Research, Development and Demonstration (RC RD&D), and Nuclear Energy Advanced Modeling and Simulation (NEAMS). NEET CTD supports national laboratory and university-led crosscutting research. 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 FOA specifies many of NE's current and upcoming R&D priorities, NE reserves the right to respond to potential shifts in R&D priorities during Fiscal Year (FY) 2021 that may be driven by events, policy developments, or Congressional/budget direction. Further, NE reserves the right to fund all or part of an application to this FOA.

A.2 Major 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 conducts 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 scale, 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 conducts 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 Department of Energy’s (DOE) Office of Nuclear Energy’s (NE) 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 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 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 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 NE mission priorities and also tailored to align with NSUF capabilities.

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.

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 NE funded research programs.

Specifically, this FOA contains three separate funding opportunity areas defined as follows:

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

These funding opportunities 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 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 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 FOA, and the associated PS and MS work scopes contained in Part IX, Appendix A.

B.2 U.S. University-, National Laboratory-, or Industry-led PS R&D Projects

These funding opportunities are available to teams led by U.S. university, national laboratory, or U.S.-incorporated industry PIs. U.S. university or national laboratory PIs can apply as lead PI to any work scopes in Part IX, Appendix B. Proposed research projects in response to this area of the FOA should meet the objectives of the NEET CTD program, in the NSUF work scopes, the RC RD&D and FC R&D programs as described in the work scopes contained in Part IX, Appendix B of this FOA.

B.2.1 Note for Nuclear Science User Facilities 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), 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 C 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 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, national laboratory and industry PIs may apply for NSUF access with a joint request for R&D financial support as stated in the NSUF-1 work scope.
- 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, Appendix A & Appendix B, and applications must comply with the provisions of Part IX, Appendix C. **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.2.2 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.

The following items must be completed prior to 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 chemisty); and,
- Corrosion studies (at irradiation temperature and chemistry).
- 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 commitements 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: 2021 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 may apply for NSUF access only work scopes in response to this area of the FOA and the associated work scope contained in Part IX, Appendix B of this FOA, wherein only access to capabilities are sought to perform research in nuclear science.

Additional information on the NSUF process is included in Part IX, Appendix C.

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-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.

As described above, work scopes for the respective FOA areas may be found in the Part IX appendices to this 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 Program Supporting R&D Projects" R&D support and associated NSUF access and NSUF Access Only can be proposed in specific work scopes.

Table 1. FY 2021 Workscope Overview

Work Scope Code	Appendix	NSUF Access	Led by:			Work Scope Title
			University	National Laboratory	Industry	
RC-1.1	A	No	X			Development of Qualification/Acceptance Protocols for Additively Manufactured Metallic Components Under Elevated Temperature Cyclic Service
RC-1.2	A	No	X			Effects of Irradiation Induced Microstructure Change in Graphite
RC-2	A	No	X			Microreactor Cost Reduction and End-User Application Integration
RC-3	A	No	X			Liquid Metal-cooled Fast Reactor Technology Development and Demonstration to Support Deployment
RC-4.1	A	No	X			Heat Transfer Characterization in Horizontally Orientated Micro High Temperature Gas Reactors (HTGRs) under Pressurized Conduction Cooldown (PCC) Conditions
RC-4.2	A	No	X			High Temperature Gas Reactor Fission Product Source Term
RC-5	A	No	X			Pump Scaling Technology for Molten Salt Reactors
RC-6	A	No	X			Plant Modernization R&D Pathway: Improving Automation Use in Nuclear Power Plants
RC-7	A	No	X			Risk-Informed Systems Analysis R&D Pathway: Extension of Legacy PRA Tools to Accelerate Risk-Informed Applications for LWRS
RC-8	A	No	X			Materials Research Pathway: Characterization and Modeling of the High Fluence Effect on Reactor Pressure Vessel Steels
RC-9	A	No	X			Flexible Plant Operation and Generation Pathway: Development of Thermal and Electric Power Dispatch Simulation Tools
RC-10	A	No	X			Physical Security Pathway: Evaluation of Physical Phenomena Data Impact and Improvements
RC-11	A	No	X			Advanced Small Modular Reactor R&D
FC-1.1	A	No	X			Innovative Separations Chemistry for High-Value Used Fuels
FC-1.2	A	No	X			Nuclear Fuel Cycle Separations Chemistry
FC-1.3	A	No	X			Understanding, Predicting, and Optimizing the Physical Properties, Structure, and Dynamics of Molten Salts

Work Scope Code	Appendix	NSUF Access	Led by:			Work Scope Title
			University	National Laboratory	Industry	
FC-1.4	A	No	X			Understanding the Structure and Speciation of Molten Salt at the Atomic and Molecular Scale
FC-1.5	A	No	X			Advanced Salt Waste Forms
FC-2.1	A	No	X			Fuel-to-Coolant Thermomechanical Transport Behaviors Under Transient Conditions
FC-2.2	A	No	X			High Burnup LWR Fuel Rod Behavior Under Normal and Transient Conditions
FC-3	A	No	X			Materials Protection, Accounting and Control Technology
FC-4.1	A	Yes	X			Spent Fuel and Waste Disposition: Disposal
FC-4.2	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			Spent Fuel and Waste Disposition: Storage & Transportation
NEAMS-1	A	No	X			Advancing Material Modeling in System Analysis Module (SAM) Code
NEAMS-2	A	No	X			Corrosion Modeling for Molten-Salt-Facing Structural Components
NEAMS-3	A	No	X			Next Generation, High-Fidelity Pebble-Bed Simulation
NEAMS-4	A	No	X			Fundamentals of Multiphase Boiling Flow for High-Pressure, High-Void Conditions
NEAMS-5	A	No	X			Time-dependent Monte Carlo Simulation capability development
CT-1	A	No	X			Crosscutting Research-Cyber Security Research
CT-2	A	No	X			Integrated Energy Systems Design and Modeling
CT-3.1	A	No	X			Integrated Thermofluidic Experimentation and Modeling for TCR Core Components
CT-3.2	A	No	X			Materials Characterization of Additively Manufactured TCR Core Structural Materials
CT-4	A	No	X			Advanced and Small Modular Reactor Materials Accountancy and Physical Protection
CT-5	A	No	X			Nuclear Materials Discovery and Qualification Initiative R&D
MS-NE-1	A	No	X			Integral Benchmark Evaluations
MS-NE-2	A	No	X			Nuclear Data Needs for Nuclear Energy Applications

Work Scope Code	Appendix	NSUF Access	Led by:			Work Scope Title
			University	National Laboratory	Industry	
NEET-1	B	No	X	X		Advanced Methods for Manufacturing
NEET-2	B	No	X	X		Wireless Technology for Nuclear Instrumentation and Control Systems
NSUF-1.1	B	Yes	X	X	X	Testing of Advanced Materials for Sensors and Advanced Sensors for Nuclear Applications
NSUF-1.2	B	Yes	X	X	X	Irradiation Testing of Materials Produced by Innovative Manufacturing Techniques
NSUF-2.1	B	Yes			X	Core and Structural Materials
NSUF-2.2	B	Yes	X	X	X	High Performance Computing at Idaho National Laboratory

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 FOA areas are specified 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 $40 million in awards for this FOA area.

B.2 U.S. University- or National Laboratory-led PS R&D Projects

DOE currently estimates that it will fund approximately $3 million in awards for this FOA area.

B.2.1 Nuclear Science User Facilities Projects

DOE currently estimates that it will fund approximately $4 million in award value for this FOA area.

C. MAXIMUM AND MINIMUM AWARD SIZE

Maximum and minimum award sizes are identified for the four FOA areas below:

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

Ceiling (i.e., the maximum amount for an individual award made under this area):

- 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.

Floor (i.e., the minimum amount for an individual award made under this area): None.

C.2 U.S. University- or National Laboratory-led PS R&D Projects

Ceiling (i.e., the maximum amount for an individual award made under this area):

- PS: up to $1,000,000 (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 (i.e., the minimum amount for an individual award made under this announcement): None.

C.2.1 Nuclear Science User Facilities Projects

Ceiling (i.e., the maximum amount for an individual award made under this area): Irradiation/PIE Project: $4,000,000 NSUF Access Value (up to a 7-year project).

Floor (i.e., the minimum amount for an individual award made under this announcement): None.

D. EXPECTED NUMBER OF AWARDS

The number of awards for each of the four FOA areas is identified 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 40 awards under this area.

D.2 U.S. University- or National Laboratory-led PS R&D Projects

DOE anticipates making approximately 4 awards under this area.

D.2.1 Nuclear Science User Facilities Projects

DOE anticipates making approximately 10 awards under this area.

E. ANTICIPATED AWARD SIZE

The anticipated award size for each of the three FOA areas are identified 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/award for PS projects and up to $400,000/award for MS projects (except as explicitly stated in individual work scope areas).

E.2 U.S. University- or National Laboratory-led PS R&D Projects

DOE anticipates that R&D awards will be up to $1,000,000/award (except as explicitly stated in individual work scope areas).

E.2.1 Nuclear Science User Facilities Projects

DOE anticipates that award access value (funds not provided to the PI) should fall within the following ranges:

- 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.

F. PERIOD OF PERFORMANCE

DOE anticipates making awards for up to three years for each area 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 FOA by September 2021, funded projects shall begin no later than October 1, 2021. 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, 2021, 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 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 FOA.

PART III – ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

This FOA is open to U.S. universities, national laboratories, and industry.

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 FOA provides award opportunities to United States owned entities. United States means the several States, the District of Columbia, and all commonwealths, territories, and possessions of the United States.

United States-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[1];

(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 partnerships with industry, underrepresented groups, and MSI, which may receive funding support from the project. International partners are encouraged to participate; however, 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

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[1]Energy Policy Act of 1992

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 non-university collaborators, in composite, can have no more than 20% of the total funds provided by the government.

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 on the application form. **Any individuals that do not meet these criteria should not be listed as collaborators on the application.** The PI must certify that all collaborators are listed on the application form and have agreed to participate on the project.

Part IV, Section H outlines funding restrictions for this 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 (for PS or MS projects under NEET CTD), 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.

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.

[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.

2. U.S. Incorporated Foreign Entities

U.S. incorporated Foreign entities, whether for-profit or otherwise, are eligible to apply for funding under this 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 U.S., please refer to "Domestic Entities" above. For consortia incorporated in foreign countries, please refer to the requirements in "U.S. Incorporated Foreign Entities" 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 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, 2021.
    2. The PI has three or more R&D projects that will still be active after December 31, 2021 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, 2021 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.

- 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 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 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 200 for the applicable cost sharing guidance and Part VIII, Section H, 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 sharing 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 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: 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 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 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 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	$40,000,000	$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- or National Laboratory-led NEET CTD Projects	PS	Appendix B	$2,000,000	$1,000,000	Up to 3 years		
University-, National Laboratory, or Industry-led* NSUF Projects	PS	Appendix B	R&D: $1,000,000 NSUF: $4,000,000	Refer to maximum award size of the project funding and NSUF funding.	Refer to Part II, E.2.1		

***NSUF Projects that are led by industry are required to cost share the R&D request based on guidance in Part VIII, Section H .**

PART IV – APPLICATION AND SUBMISSION INFORMATION

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

A. ADDRESS TO REQUEST APPLICATION PACKAGE

Electronic applications and instructions are available at the NEUP 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.

Due to the COVID-19 pandemic, paper copies of the application package are unavailable. To request a copy of full application forms and materials, contact neup@inl.gov.

NOTE: NEUP.gov's submission site will open to accept pre-applications on September 23, 2020. Access to the site will be restricted until that date.

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".

C. NSUF Application Submittal Instructions

C.1 Letter of Intent

Letters of Intent are a requirement for projects needing NSUF access (NSUF-1 and NSUF-2 work scopes). Letters of Intent must be submitted by the date and time specified in Part IV, Section G.1.

C.1.1 Letter of Intent Submittal Instructions

Application forms and instructions are available at the NEUP 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 2021 NSUF Letter of Intent" and click on "Create New Application" for the type of application you are creating.

Letters of Intent 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;
- Applicable work scope:
  - NSUF-1 (have R&D funds available);
  - NSUF-2 for NSUF access only (no R&D funds available); and,
- A brief (<300 words) project description.

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 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: 2021 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-1 and NSUF-2 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 for pre-application requirements.

When completing the Pre-Application form via www.NEUP.gov, it is important that you link the Letter of Intent 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.

C.3 NSUF Preliminary Statement of Work

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

The Preliminary Statement of Work 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 Preliminary Statement of Work will be appended to the already submitted pre-application. To append the Statement of Work, 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; 4) Click "Attach File" on the "Post Submission Attachment" section and attach the Preliminary Statement of Work.

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

Name File: 2021 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 Statement of Work was appended correctly.

C.4 NSUF Final Statement of Work

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

The Final Statement of Work 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 Statement of Work 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 Statement of Work documents are submitted as an additional document to the already submitted NSUF pre-application. To append the Statement of Work, 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; 4) Click "Attach File" on the "Post Submission Attachment" section and attach the final Statement of Work.

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: 2021 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 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.

D. CONTENT AND FORM OF ALL PRE-APPLICATIONS

(Mandatory)

Pre-applications are a mandatory requirement for PS and/or MS and/or NSUF Projects (in Appendix B) 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.

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 Work Scope Identification (e.g., FC-1.1). The PI is responsible for selecting the appropriate work Scope, 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).
- 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).

3-page limit. Name File: 2021 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).

4-page limit. Name File: 2021 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: 2021 RPA DOE-NE Supported Publications "Insert ID #"

D.1.4 Principal Investigator Vitae

The lead PI 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: 2021 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 directly on the application form. **Any individuals that do not meet these criteria should not be listed as collaborators on the application.** The PI must certify that all collaborators are listed on the application form and have agreed to participate on the project.

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, integrity of R&D products and their usability by 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 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. **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-1 and NSUF-2 applications.** In order to ensure compliance throughout the application review process, applicants must state, during the NSUF pre-application and full application submission, 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 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: 2021 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: 2021 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: 2021 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 name of the applicant; 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 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.

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

Name File: 2021 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

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: 2021 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: 2021 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 on the online application.

NOTE: This does 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).

4-page limit, Name File: 2021 CFA Benefit of Collaboration "Insert ID#"

E.8 Capabilities

Provide information on the following, as applicable:

a. 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.

b. Adequate financial resources (if cost sharing).

c. Ability to comply with the required or proposed performance schedule, taking into consideration all existing commercial and governmental business commitments.

d. A satisfactory record of performance, integrity, and business ethics.

e. 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).

See the electronic application submission instructions for document guidance. This 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: 2021 CFA Capabilities “Insert ID #”

E.9 Budget Documents

E.9.1 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. 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).

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: 2021 CFA Budget "Insert ID #".xls

E.9.2 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: 2021 CFA Subaward Budget "Insert ID #".xls

E.9.3 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: 2021 CFA FWP "Insert ID #"

E.9.4 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.

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: 2021 CFA Budget Justification "Insert ID #"

E.10 Additional Attachments

E.10.1 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: 2021 CFA Current and Pending Support "Insert ID #"

E.10.2 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: 2021 CFA CMP "Insert ID #"

E.10.3 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 FOA.

Name File: 2021 CFA CO Authorization "Insert ID #"

E.10.4 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: 2021 CFA Site Location "Insert ID #"

E.10.5 Environmental Checklist

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

E.10.6 Disclosure of Lobbying Activities

If applicable, complete SF-LLL. Applicability: 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: 2021 CFA SF-LLL "Insert ID #"

E.10.7 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: 2021 CFA Cert & Assurances "Insert ID #"

E.10.8 Foreign Government Ownership Disclosure (Required for All Leads)

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

Name File: 2021 CFA Foreign Government Ownership Disclosure "Insert ID #"

Federal and Technical POCs for FY 2021 can be found at:
https://neup.inl.gov/SitePages/FY21_RD_Technical _Program_Contacts.aspx

Table 3 contains a summary of the required information for full application submittals.

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*	

Name of Document	Format	Required From	Signature Required
SF-424 (R&R) Subaward Budget (Total Fed + Non-Fed), if applicable	Form	University and Industry Collaborators*	
Budget for DOE National Laboratory Contractor or FFRDC, if applicable	PDF	National Laboratory Leads and Collaborators*	Yes
Budget Justification	PDF	University Leads and Collaborators*	
Current and Pending Support	PDF	All University and Industry Applicants	
Coordination and Management Plan	PDF	Lead Applicant	
Authorization for DOE/NNSA FFRDCs	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
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 Letter of Intent Due Date

(Mandatory for NSUF Projects)

LOIs for NSUF access are required by September 16, 2020, no later than 7:00 p.m. Eastern Time (ET). The LOI shall be submitted as required in Part IV, Section C.1.

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

(Mandatory)

Pre-applications are required by September 30, 2020, no later than 7:00 p.m. ET. The pre-application shall be submitted as required in Part IV, Section C.2 . 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 Statement of Work by November 12, 2020, 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 22, 2021, 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 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 11, 2021, 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

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

(b) (1) Any required FOA submittal, modification, or withdrawal received at the Government office designated in the FOA after the exact time specified for receipt of that submittal is “late” and will not be considered, unless it is received before award is made,

the Contracting Officer determines that accepting the late submittal would not unduly delay the FOA award process; and—

(i) It was transmitted through an electronic commerce method authorized by the 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 submittal; or

(ii) 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.

(2) 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.

(c) 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.

(d) 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 FOA, and urgent Government requirements preclude amendment of the 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 FOA, on the first work day on which normal Government processes resume.

(e) 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 200, as adopted and amended by 2 CFR 910. The cost principles for for-profit organizations are in 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 208-526-1602 or 208-526-8178 or send an email to NEUP@inl.gov.

J.2 Application Validity Timeframe

By submitting an application in response to this FOA applicants agree that their applications are valid for at least one year from the date set forth for receipt of applications to this 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 FOA areas unless specific requirements are identified.

A. CRITERIA

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

Selection of applying institutions invited to provide full applications shall be based on how well the pre-applications meet or exceed the technical and program relevancy and program priority evaluation criteria provided below, and as weighted as described in Table 4. All applications submitted under this FOA will be reviewed and scored as described below.

First, programmatic experts will assess each pre-application's program relevancy and program priority to R&D work scopes. Scores will be assigned according to the following program relevancy and program priority attributes:

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 that (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

- **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.

Note that the program relevancy score may be increased by up to 5 points based on evaluators' determination of the degree to which an application effectively partners with MSIs, international or industrial partners, and/or underrepresented groups.

Second, a separate technical expert/peer will assess each application on its technical merit. Reviewers will review the technical basis of the application, assigning it a merit category. Applications will then be judged as meeting all, most, or some expectations for that merit category.

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

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.

Applicants 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.

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

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 type of project, duration of project, experimental degree of complexity, types of samples, number of samples, needed 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. 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 that (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 FOA will be reviewed and scored as described in this FOA. A panel of programmatic experts will assess each full application's program relevancy/priority to 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 below.

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.1.1.

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 this criterion, 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, Letters of Intent and Full Applications)	Percentage of Program Relevancy/Priority Review Score

Criterion	
Relevancy	100%
Program Priority	Multiplier based on program priority rating
Diverse Partnerships	Up to 5 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 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 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.

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 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 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 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, 2021.

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 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 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 FOA the Applicant represents that:

(1) 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.

(2) 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:

a. ''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.''

b. The limitation above 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 provision listed in paragraph (a), 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 United States 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 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 contract with the DOE through the work authorization system as outlined in DOE O 412.1A, Admin Change 1. DOE O 481.1C., Work for Others, is not applicable. DOE national laboratories remain bound by the terms and conditions of their contract with DOE.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

B.1 Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR 200, as amended by 2 CFR 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 the System for Award Management (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 FOA. Primes and subawardees at all tiers must obtain Data Universal Numbering System (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 200, Appendix XII—*Award Term and Condition for Recipient Integrity and Performance Matters*, may also apply to any resultant award made under this 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 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 (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. 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 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.
- 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 apply:

  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). 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 are listed in the first bulleted section and DOE's responsibilities are listed in the second bulleted section:

- 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.

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 10/31/2021 for awardees in the above listed areas.

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

Questions regarding the content of this CINR FOA must be submitted to the Agency Contact listed in Part VII, Section B. Questions regarding work scopes may be submitted to the DOE federal and technical POCs listed in Appendices A, B, and C. 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. 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 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.

Interested parties are encouraged to ask questions as early in the FOA process as possible. Questions and comments concerning this 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 relating to the registration process, system requirements, how an application form works, or the submittal process, must be directed to NEUP@inl.gov.

B. AGENCY CONTACT

Name: Mr. 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. The Government will have certain statutory rights in an invention that is conceived or first actually reduced to practice under a DOE award. 42 U.S.C. 5908 provides that title to such inventions vests in the United States, except where 35 U.S.C. 202 provides otherwise for nonprofit organizations or small business firms. However, the Secretary of Energy may waive all or any part of the rights of the United States subject to certain conditions. (See "Notice of Right to Request Patent Waiver" in Section G below.)

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. NOTICE OF RIGHT TO REQUEST PATENT WAIVER

Applicants may request a waiver of all or any part of the rights of the United States in inventions conceived or first actually reduced to practice in performance of an agreement as a result of this announcement, in advance of or within thirty (30) days after the effective date of the award. Even if an advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver of the rights of the United States in identified inventions, i.e., individual inventions conceived or first actually reduced to practice in performance of the award. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784 at http://energy.gov/gc/services/technology-transfer-and-procurement/office-assistant-general-counsel-technology-transf-1 under the Patent Waivers.

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. Therefore, small businesses and non-profit organizations do not need to request a waiver.

H. 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 200 and 2 CFR 910 implement cost sharing requirements (see 2 CFR 200.306 and 2 CFR 910.130). The 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), 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 FOA will facilitate the identification of funding sources.

I. 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.

J. NO-COST TIME EXTENSIONS

Unilateral no-cost time extensions will NOT be permitted to awards made under this 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 and normally no later than three months before the original project end date.

No-cost time extensions on existing DOE-NE funded projects must be requested between October 1-April 15. Any request outside of this period will not be considered. 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. No-cost time extensions must be submitted prior to the deadline to NEUP@inl.gov.

K. 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 for which was included in the original application. Any request for the purchase of equipment exceeding $5k 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

L. 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: Accessing Nuclear Science User Facilities

Appendix D: 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: NUCLEAR REACTOR TECHNOLOGIES

RC-1: ADVANCED REACTOR MATERIALS

RC-1.1: DEVELOPMENT OF QUALIFICATION/ACCEPTANCE PROTOCOLS FOR ADDITIVELY MANUFACTURED METALLIC COMPONENTS UNDER ELEVATED TEMPERATURE CYCLIC SERVICE (FEDERAL POC – SUE LESICA & TECHNICAL POC – SAM SHAM) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Additive Manufacturing (AM) can allow the fabrication of more complex component geometries, with reduced number of fabrication steps, as compared to traditional fabrication processes. This would lead to increased design flexibility, shortened fabrication lead time and reduced construction costs. Future AM techniques could allow the reimagining of new material discovery, e.g., producing architected materials with performance and functionality that cannot be achieved using conventional manufacturing processes, hence could enable even more capable and compelling reactor designs. However, in order to leverage this new technology to support advanced reactor deployment, reactor components fabricated by AM must be licensable by the regulator.

There are two classes of AM technologies that are of particular interest to advanced reactor applications. They are Powder-Bed Fusion and Directed Energy Deposition. However, due to differences in powder attributes, fabrication environment, and processing parameters, different material microstructures and/or defects structure can result in the build volume for each of these AM methods. Since these characteristics will affect the structural performance, particularly for the elevated temperature environment of advanced reactor systems, the method to ascertain/demonstrate that final manufactured components meet or exceed the expected properties used in the design of the part, as required by the regulatory framework, is a key question to be addressed before the benefits of AM technology can be realized to support advanced reactor deployment. This will be particularly challenging as the design lifetimes for these advanced reactors can be 10, 20 or even 60 years.

The scope of this topic is to develop qualification/acceptance protocols to inspect, test and characterize the AM witness samples, and together with data from in-situ process monitoring of the AM processes, and possibly modeling and simulation techniques, to arrive at a reasonable assurance that the AM component would perform structurally as designed for the intended design lifetime in order to meet regulatory requirements. Understanding the relationship between microstructure, properties, and performance could be helpful to identifying key microstructural features to be characterized. Any mechanical properties testing would have to be practical for the protocols to be used to accept AM components. For example, test duration longer than 100 hours would be problematic. These advanced reactor components will be under elevated temperature cyclic service. Thus, mechanical properties of interest are tensile and creep properties (both strength and ductility), fatigue, and creep-fatigue.

The material of interest is 316H, an ASME Section III, Division 5 qualified Class A material. Assume a maximum operating temperature of 650C, a design lifetime of 100,000 h and some reasonable thermal transients to demonstrate the effectiveness of the developed qualification/acceptance protocols. The proposed work can be based on either Powder-Bed Fusion or Directed Energy Deposition method. While the use of AM materials is a necessity for the scope of this topic, the procurement of AM equipment is out of scope.

RC-1.2: EFFECTS OF IRRADIATION INDUCED MICROSTRUCTURE CHANGE IN GRAPHITE (FEDERAL POC – SUE LESICA & TECHNICAL POC – WILL WINDES) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Irradiated graphite nuclear reactor core component behavior is the result of a combination of atomic and crystallographic changes caused by neutron ballistic damage accumulating within the bulk graphite microstructure. [1,2] While significant progress at understanding and observing the crystallographic length-scale have been made recently, the effect on graphite behavior resulting from microstructural changes require more

investigation.[3] Research activities exploring the effect of microstructural changes (either irradiation, oxidation, and thermally induced) are sought to determine its contribution to the overall material property changes and graphite behavior. For this research, the focus should be on determining the underlying microstructural mechanisms responsible for the main mechanical graphite material property changes of interest; dimensional change-turnaround, strength, and elastic modulus. Thermal properties such as the coefficient of thermal expansion (CTE) and thermal conductivity are not of interest at this time.

All work (e.g., experiments and calculations) must be performed to NQA-1 standards. Data, experiments, and any calculations shall be submitted to the Idaho National Laboratory's NGNP Data Management and Analysis System (NDMAS).

[1] Steve Johns, et. al., "Experimental evidence for 'buckle, ruck and tuck' in neutron irradiated graphite", Carbon, Volume 159, 15 April 2020, Pages 119-121.
[2] A. Chartier, et. al., "Irradiation damage in nuclear graphite at the atomic scale", Carbon 133 (2018) 224-231.
[3] Cristian I. Contescu, et. al. "Development of mesopores in superfine grain graphite neutronirradiated at high fluence", Carbon 141 (2019) 663-675.

RC-2: MICROREACTOR COST REDUCTION AND END-USER APPLICATION INTEGRATION (FEDERAL POC – TOM SOWINSKI & TECHNICAL POC – JESS GEHIN) (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 they remain cost competitive 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:

- Readily deployable technologies and regimes that enable unattended and reliable operations
- Innovative use of existing advanced embedded sensors and instrumentation for remote online monitoring of microreactor operation and component conditions
- Reduction of fuel costs through more efficient use of fuel
- Alternatives for high cost microreactor components including core structures, heat exchangers, and power conversion systems
- Production approaches that enable standardization, efficient factory manufacturing and assembly, and mass-produced components leveraged from other technology fields.

Innovative proposals that could result in significant cost reductions, rather than incremental improvements, are encouraged. Proposals should include a clear description of the potential for the proposed scope to reduce microreactor energy production costs. Proposals are highly encouraged to leverage experimental capabilities being developed by the Microreactor Program that can support testing of integrated systems and components, particularly the use of the Microreactor Agile Non-Nuclear Experimental Testbed (MAGNET) at the Idaho National Laboratory (INL).

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In addition to cost reduction, the Microreactor Program is also seeking proposals for the development and experimental validation of technologies supporting the integration of end-user applications with microreactors. The Microreactor Program is developing a nuclear microreactor applications test bed to resolve technology gaps and perform R&D for improved integration of microreactors to end-user applications. This nuclear applications testbed, known as the Microreactor Applications Research, Validation and Evaluation (MARVEL) Project, includes the rapid development of a 100 kWth/20 kWe microreactor that is planned for availability in FY22 to provide a platform for end-user integration research.

MARVEL extends capabilities beyond those of the non-nuclear test bed (MAGNET) to provide a nuclear test platform that includes a full physics system representing actual operational features of a microreactor. Examples of envisioned potential end-user applications for integration with microreactor technologies includes:

- High performance computing and communication,
- HVAC,
- Energy storage,
- Water purification,
- Chemical processing.

Proposed research should focus on resolving microreactor-specific end-user application integration technological challenges (general development of end-user capabilities and technologies is not being sought in this area). Engagements with potential microreactor developers and end-users during proposal development is highly encouraged. Proposals are highly encouraged to leverage experimental capabilities, including MARVEL, being developed by the Microreactor Program.

More information on the Microreactor Program as well as MAGNET and MARVEL is available on the Microreactor Program Website: https://gain.inl.gov/SitePages/MicroreactorProgram.aspx.

RC-3: 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)

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 secure power source for our nation.

This work scope seeks proposals to develop instrumentation, control strategies, performance enhancing technologies, and experiments for the Mechanisms Engineering Test Loop (METL) facility for liquid metal (sodium or lead-cooled) fast reactors for potential utilization in advanced reactor concepts proposed by U.S. nuclear industry. Experiments that offer the potential for significant overall benefits to reactor capital or operating cost reductions are of interest.

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 should 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

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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 work areas 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), the detection of impurities in the coolant (i.e., improvement of plugging meters or oxygen sensors), alternative methods of leak detection, improved sensors for level measurement and other advanced sensors or instrumentation that improve the overall performance of the advanced reactor system.
2. *Components of 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.
5. *Thermal hydraulic testing in prototypic sodium environment* – A thermal hydraulic test loop could be used to acquire distributed temperature data in the cold and hot pools of a small scale sodium fast reactor during simulated nominal and protected/unprotected loss of flow accidents. This testing could allow for the articulation of the heated region in the core to allow for a parametric study of IHX/core outlet height difference and its effect on thermal stratification of sodium in the hot pool. Ultimately this data will be used for validating CFD and systems level code.
6. *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
7. *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
8. *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.
9. *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.

Though proposals are not limited to the example work areas above, applicants should indicate how their proposed work will support testing in the METL facility or monitoring the health of the METL facility or increasing the performance of the METL facility to support current DOE, national laboratory, and/or U.S. nuclear industry liquid metal-cooled fast reactor deployment and commercialization R&D initiatives. The proposals should also

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discuss how the technologies developed will ultimately benefit the advanced reactor industry.

See the following web site for more information on METL:

https://www.anl.gov/nse/mechanisms-engineering-test-loop-facility

RC-4: HIGH TEMPERATURE GAS REACTORS (HTGRS)

RC-4.1: HEAT TRANSFER CHARACTERIZATION IN HORIZONTALLY ORIENTATED MICRO HIGH TEMPERATURE GAS REACTORS (HTGRS) UNDER PRESSURIZED CONDUCTION COOLDOWN (PCC) CONDITIONS
(FEDERAL POC – DIANA LI & TECHNICAL POC – GERHARD STRYDOM)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

Experimental validation of High Temperature Gas-Cooled Reactors (HTGRs) is focused on providing code validation data for the simulation of HTGRs under normal operation and accident conditions. In general, heat transfer in HTGRs during normal operation is dominated by convective heat transfer, while radiation and conduction are the primary mechanisms during loss of forced helium flow (also known as Pressurized Conduction Cooldown (PCC) transients. Significant research has been performed on prismatic HTGR system response and heat flow during loss of convection scenarios (e.g., [1] and [2]), but all these studies assumed a reactor vessel and primary system that are orientated vertically. Based on recent requirements for very small (<10MWt) HTGR systems that can supply power or heat to remote locations, one design option is the modification of the standard vertical prismatic HTGRs orientation to a horizontal reactor layout.

In these modified HTGR systems, the helium coolant flow from the inlet to outlet plena is perpendicular to the gravity vector through the fuel block cooling channels during normal operation, which does not impact any of the main heat transfer paths or heat removal functions of the core significantly. However, when the forced helium flow terminates (e.g., after a blower trip), the change in orientation will influence the establishment of buoyancy-driven natural convection flow inside the core region and the reactor vessel, since the cold and hot plena are not located at the top and bottom of a vertical vessel anymore. Although the basic heat transfer phenomena are identical to the PCC phenomena in vertically-orientated designs, the location of the peak fuel temperature and the impact of helium cross-flows through the gaps between fuel blocks will be very dependent on the core and vessel orientation. The very small size of these micro HTGR designs (e.g., the vessel would approximately fit inside a standard shipping container, e.g., see [3] and [4]) could also lead to different time-scales for the onset of natural convection (if established at all), and the flow velocities could be smaller than in the larger traditional HTGR designs.

Proposals are requested to assess the heat transfer for prototypical conditions in a micro HTGR design for both normal operation and PCC conditions. The experimental envelope should cover the low-velocity flow regime that will establish in a helium-filled prismatic core at approximately 3-5 MPa. The standard Fort St. Vrain/MHTGR-350 fuel block design [5] and helium are preferred as the core geometry and working fluid, respectively, but other fluids and materials/geometries can be proposed if sufficiently motivated by scaling and equivalence analysis. If possible, a representative power and heat profile should be established at the start of the PCC event, e.g., with power peaked towards the cold inlet plenum (on the left side of a horizontal layout) and temperature peaked towards the hot outlet plenum (on the right side). The facility should be capable of operating up to 1200°C to cover most of the anticipated PCC temperature envelope for a period of 48 hours. The main Figures of Merit are the spatial variance in the peak "fuel" temperatures as a function of time and heat transfer rates from the core to the vessel through a typical cavity region. It is desirable to quantify the various contributions of radiation vs. convective heat transfer if practically possible.

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As an integral requirement of this call, it is requested that all measured data be produced with estimates of the uncertainties associated with the data.

Principal investigators are encouraged to consult with US-based HTGR vendors to refine the experiment design and test matrix (e.g., on scaling, representative flow regimes and equivalent working fluids and solids if helium and graphite will not be used). A literature review of previous experimental work performed for larger and vertically-orientated HTGRs would be expected from the successful application team to assess the differences that could result from the change in orientation and small physical size attributes.

All experiments must be performed to NQA-1 standards. Data, experiments, and calculations shall be submitted to the Idaho National Laboratory's NGNP Data Management and Analysis System (NDMAS). Assistance shall be provided by Idaho National Laboratory for NDMAS use and ensuring NQA-1 standards are properly established.

References:

[1] H. Wang, et al., "Computational fluid dynamics analysis of core bypass flow and crossflow in a prismatic very high temperature gas-cooled nuclear reactor based on a two-layer block model", *Nuclear Engineering and Design* 268 (2014) pp. 64–76.

[2] M. Kawaji, et al., "Experimental Investigation of Forced Convection and Natural Circulation Cooling of a VHTR Core under Normal Operation and Accident Scenarios", NEUP 15-8205 Final Project Report, The City College of New York, https://neup.inl.gov/SiteAssets/Final%20%20Reports/FY%202015/15-8205%20NEUP%20Final%20Report.pdf

[3] https://www.westinghousenuclear.com/new-plants/evinci-micro-reactor

[4] https://x-energy.com/reactors/xe-mobile

[5] OECD/NEA, "NEA Benchmark of the Modular High-Temperature Gas-Cooled Reactor-350 MW Core Design Volumes I and II", NEA/NSC/R(2017)4, February 2018.

RC-4.2: HIGH TEMPERATURE GAS REACTOR FISSION PRODUCT SOURCE TERM (FEDERAL POC – DIANA LI & TECHNICAL POC – PAUL DEMKOWICZ) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

An important area of study that is needed for the design, safety analysis, and licensing of TRISO-fueled, high-temperature reactors is the determination of fission product source terms in reactor configurations. This has not been extensively evaluated within the DOE Advanced Gas Reactor (AGR) Fuel Development and Qualification Program, in part because there has been insufficient reactor concept design information to determine the fission product behavior in the reactor coolant system. Phenomena such as fission product plateout, lift-off, washoff, and vaporization, as well as aerosol dynamics, are key in determining the behavior of circulating activity in a gas-cooled reactor coolant system and calculating total fission product release during reactor accidents. These behaviors can also be influenced significantly by changing conditions during reactor accidents, for example the introduction of water vapor into a gas-cooled reactor primary coolant circuit. Analogous phenomena relevant to molten-salt-cooled reactors will impact activity circulating in the coolant system in these reactor designs. Previous experiments designed to assess this behavior in gas-cooled reactors include the COMEDIE tests in the SILOE facility in France [1].

This call seeks proposals for small-scale experiments to assess radionuclide behavior in reactor coolant circuits. This can include experimental configurations that approximate reactor designs, accounting for coolant system components (e.g., loop, blower and fans, thermal gradients, etc.), and taking into consideration appropriate

scaling factors. Consideration of design-basis accident scenarios that can have significant impact on radionuclide transport is also critically important. Using the latest industry design information will be important, and therefore collaboration with reactor designers is expected to benefit the overall relevance of the proposal.
Note that there have been several DOE-sponsored, university-led projects performed previously on pebble dust generation and thermo-mechanical effects important for pebble bed design, and proposals should not repeat these previous projects' scope of work. References 2-4 give several examples of these past efforts. A successful proposal will detail how data will be obtained for source terms and how the PI will ensure there will not be repetition of work that was already performed. Reference 5 is a recently-published review of HTGR graphite research, and reference 6 provides additional background information relevant to source term validation experiment needs.
All experiments must be performed to NQA-1 standards. Data, experiments, and calculations shall be submitted to the Idaho National Laboratory's NGNP Data Management and Analysis System (NDMAS). Assistance shall be provided by Idaho National Laboratory for NDMAS use and ensuring NQA-1 standards are properly established.

References:
1. R. Acharya, D. Hanson, Fission Product Plateout/Liftoff/Washoff Test Plan, DOE-HTR-86111 Rev. 1, 1988
2. Akira Tokuhiro, "Experimental Study and Computational Simulations of Key Pebble Bed Thermo-mechanics Issues for Design and Safety," NEUP Project No. 09-810 Final Report, University of Idaho, https://www.osti.gov/servlets/purl/1157564,
3. Joshua Cogliati and Abder Ougouag, Pebble Bed Reactor Dust Production Model, HTR2008-58289, Proceedings of the 4th International Topical Meeting on High Temperature Reactor Technology https://www.researchgate.net/publication/255017160_Pebble_Bed_Reactor_Dust_Production_Model
4. S. Loyalka, A Research Program for Fission Product/Dust Transport in HTGRs, NEUP Project 11-2982 Final Report (2016) https://neup.inl.gov/SiteAssets/Final%20%20Reports/FY%202011/11-2982%20NEUP%20Final%20Report.pdf
5. Qi Sun, Wei Peng, Suyuan Yu, Kaiyuan Wang, A review of HTGR graphite dust transport research, Nuclear Engineering and Design 360 (2020) 110447
6. D. Hanson, Validation status of design methods for predicting source terms, Nuclear Engineering and Design 329 (2018) 60-72

RC-5: PUMP SCALING TECHNOLOGY FOR MOLTEN SALT REACTORS (FEDERAL POC – BRIAN ROBINSON & TECHNICAL POC – DAVID HOLCOMB) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $800,000)

Pumps for molten salt reactors are critical components for overall system reliability. However, liquid-fueled MSR pump designs must address unique materials and engineerinng challenges, including high temperature operation, radioactive fluids, complex chemistry that can influence corrosion rates, and limited access for inspection and maintenance.

Several features important to MSR pump development require development. These include 1) flanges that require repeated sealing along with thermal cycling for service conditions above 500 °C with low internal pressures, 2) bolting systems that address creep and relaxation, the potential for galling, and apply adequate sealing torque at both room temperature and operating temperature, and 3) differential thermal expansion of multi material systems that can result in reduced performance or leakage.

Evaluation of MSR pump requirements, examination of technology needs and gaps for MSR pumping systems, and preliminary engineering assessment of a representative pump design suitable for commercial MSR operation is requested.

Due to the relatively early stage of maturity of MSR and FHR facilities and significant resources required, establishing an NQA-1 program may not be feasible, however priority will be given to experiments that are

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performed to NQA-1 standards.

RC-6: PLANT MODERNIZATION R&D PATHWAY: IMPROVING AUTOMATION USE IN NUCLEAR POWER PLANTS

(FEDERAL POC – ALISON HAHN & TECHNICAL POC – CRAIG PRIMER)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

To improve efficiency and ensure safe, reliable operation, the U.S. nuclear industry is working to leverage automation as much as possible. To meaningfully implement automation, utilities' and regulators' concern over automation trustworthiness must be addressed. Automation transparency is key to its use in the nuclear industry, particularly with respect to how automated systems process information inputs, then make and convey decisions.

Research is sought to develop a methodology and provide the necessary evidence needed to verify automation technologies are explainable and trustworthy. This research needs to establish the technical bases and demonstrate automation technologies proposed for use in a nuclear power plant are operationally acceptable. Proposals should:

- Develop and demonstrate methods to ensure automation technologies being considered for deployment in commercial nuclear power plants are explainable and trustworthy.
- Develop and demonstrate the appropriate level of automation transparency to ensure automations reduces human workload, and improving overall system performance while maintaining the appropriate level of human situational awareness.

RC-7: RISK-INFORMED SYSTEMS ANALYSIS R&D PATHWAY: EXTENTION OF LEGACY PRA TOOLS TO ACCELERATE RISK-INFORMED APPLICATIONS FOR LWRS

(FEDERAL POC – ALISON HAHN & TECHNICAL POC – CURTIS SMITH)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

Probabilistic Risk Assessments (PRAs) for the nuclear power industry have provided tremendous benefit in the safe operation of the United States (US) fleet for decades. The insights obtained from the detailed models have provided perspective on everything from configuration control, maintenance, and the interaction of systems. Plant PRA models are also used extensively by both plant operators and regulatory personnel. For both stakeholders, PRA technology has been instrumental in demonstrating improvements in plant safety over time. As such, PRAs are now so ingrained in plant operation that the models used to generate insights and results are being asked to analyze aspects of the plant that could never have been envisioned by the first PRA practitioners. Increased demand on PRA models have led to an increased demand for computing power and for complex solution methods. As model complexity grows, so too does the memory allocations and processing power requirements. Trades offs can be made for a lack of computing resources and they almost always involve more time. This tradeoff is not ideal, as mentioned above, PRA models are now run in real time to evaluate changing plant conditions. Therefore, they must be capable of supporting real time analysis of unexpected equipment failure and support the understanding of configuration risk by plant operators who rely on the information to continue operating the plant safely. However, increased complexity means more time including analyzing combinations of events for dependency or criticality to quantification speed of multi-hazard models.

Additionally, as the complexity of plant PRA models has increased, the capability of non-PRA experts (in particular plant operators and management personnel) to understand the models, their insights, and use the information provided from them in an effective manner to support decision-making, has become increasingly difficult. This situation has become critical given the more prevalent use of the technology to support real time

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operational decisions at the plant as described above.

Technical issue areas to be considered for investigation include:

- Quantification Speed when Supporting Decision Making
- Integration of Multi-Hazard Models into Traditional PRAs
- Acceptance Criteria for Model Detail Required in Various Risk-Informed Applications
- Model Modification Simplification and Documentation Automation
- Improving Models for Time-Dependent Approximations

The research of this call will be to develop and apply new approaches to legacy PRA tools and methods that will reduce modeling or analysis time, reduce costs associated with application of PRA, or will provide clearer understanding of the PRA model and its resulting insights for decision making. The resulting tools and methods modifications will be created to provide analysis benefits to the current LWRs fleet of plants. Proposals that address analysis methodology development across multiple technical issues are strongly encouraged.

RC-8: MATERIALS RESEARCH PATHWAY: CHARACTERIZATION AND MODELING OF THE HIGH FLUENCE EFFECT ON REACTOR PRESSURE VESSEL STEELS
(FEDERAL POC – ALISON HAHN & 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, it is proposed to perform in-depth characterization and modeling of the effect of high fluence 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 effects of irradiation, such as the fluence and flux effects, and generation of models that could support life-extension licensing. Collaboration with industrial partners and national laboratories is also encouraged.

[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-9: FLEXIBLE PLANT OPERATION AND GENERATION PATHWAY: DEVELOPMENT OF THERMAL AND ELECTRIC POWER DISPATCH SIMULATION TOOLS
(FEDERAL POC – ALISON HAHN & TECHNICAL POC – TYLER WESTOVER)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)

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(UP TO 3 YEARS AND $800,000)

The Flexible Plant Operations and Generation Pathway is seeking to develop simulation capability to study the dispatch of thermal and electric power from existing nuclear reactors. The LWRS program has been developing full-scope simulators for pressurized water reactors (PWRs) to address a variety of technical subjects associated with extraction of a portion of the overall thermal energy from the power system for delivery to a closely coupled industry that will purchase this energy stream [1,2]. We wish to consider cased in which up to 50% of rated thermal power may be extracted from the main steam line without compromising plant operations. Boiling water reactors (BWRs) make up about one-third of the operating fleet. Extraction of thermal energy from a BWR for an industrial user is of interest, including addressing extraction of energy from different possible plant locations – such as the main steam system. The development of methods to extract thermal power from BWRs will need to address unique issues that are different from PWRs, including the design of the thermal power extraction and delivery systems and how to dynamically adjust the thermal energy used for power production versus the amount of power dispatched to the industrial user. It is imperative to develop an understanding of the interaction of these activities with plan operation.

Proposals that address methods for extracting 10-50% of the thermal energy from a generic or plant specific BWR are sought. Concepts should be modeled with a BWR reactor simulator (full-scope or partial) sufficient to address the dynamic extraction and delivery of thermal power via a secondary heat transfer loop. The secondary heat transport loop may be steam, a suitable synthetic oil, molten metal or salt, or a hot gas. The proposal should address the technical design, energy extraction and energy transport monitoring and controls, reactor operating safety impacts, and associated license modifications requirements. The simulators should evaluate the benefits of coupling with existing codes, such as VERA, which account for thermal behavior in the reactor core when actions to dispatch thermal energy may warrant an increase or decrease in the core heat rate. This effort will help inform the LWRS Program relative to pilot-scale demonstration tests to answer key research questions, including human factors issues, controls systems, and safety analysis that support reactor operating license modifications.

Suggestions for development of the BWR simulator tools include:

- Rancor Microworld simulators that are suitable for operator-in-the-loop and hardware-in-the-loop studies to investigate human factors issues associated with specific pilot-scale test capabilities
- High-fidelity, full-scope BWR simulators that include different BWR plant types coupled to different industrial plants, such as simplified hydrogen, fertilizer, petrochemical, or steel production plants.
- RELAP5-3D models of the coupled processes to verify system thermal-hydraulic performance predictions.

Studies should incorporate information that has already been released in technical reports by the Flexible Plant Operations and Generation Pathway in the LWRS Program (Refs). Project deliverables should include detailed descriptions of the thermal and electric power simulator tools as well as recommended design requirements and potential improvements that are relevant to specific simulators/applications.

References:

1. S. Hancock, A. Shigrekar, T. L. Westover, Incorporation of Thermal Hydraulic Models for Thermal Power Dispatch into a PWR Power Plant Simulator. INL/EXT-20-58766, June 2020.
2. T. L. Westover, S. Hancock, A. Shigrekar, Monitoring and Control Systems Technical Guidance for LWR Thermal Energy Delivery. INL/EXT-20-57577, February 2020.

RC-10: PHYSICAL SECURITY PATHWAY: EVALUATION OF PHYSICAL PHENOMENA DATA IMPACT AND IMPROVEMENTS

(FEDERAL POC – ALISON HAHN & TECHNICAL POC – F. MITCH MCCRORY)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)

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(UP TO 3 YEARS AND $800,000)

Physical security of nuclear power plants is an important aspect of maintaining a safe, secure, and reliable nuclear energy fleet. Physical security programs at U.S. nuclear sites grew to meet changes in their design-basis threat (DBT) in the early to mid-1980s. The events of September 11, 2001 saw more changes to the DBT and significant increases of physical security at nuclear power plant sites. As U.S nuclear power plants modernize their infrastructure and control systems and consider ways to enhance their physical-security postures to reduce security manpower while maintaining the required security effectiveness, an opportunity exists to apply advanced tools, methods, and automation that leverage these modern skillsets and their benefits. These include higher-fidelity models that reduce conservatisms in security models, leverage automation as a force multiplier, optimize security postures, and exploit advances in risk-informed methods to evaluate physical security to achieve needed postures.

The Light Water Reactor Sustainability Program Physical Security Pathway is soliciting research projects that will explore human reliability models that can be used in physical security modeling and simulation tools. During an adversary attack on facility, security and operations personnel are required to perform actions under significant stresses in order to prevent radiological sabotage. Potential models need to address the performance of operators and physical security personnel during the attack phase of a scenario and then human reliability of operators after a successful attack as they try to implement actions to prevent or mitigate a radiological release such as through the installation of FLEX equipment. Additionally, the models need to also include the human reliability of the adversary and response forces. This work should evaluate current human reliability models and explore/develop new methods for specific use in the above applications. The result of work needs to be a method that can be easily integrated into existing security modeling and simulation tools.

RC-11: ADVANCED SMALL MODULAR REACTOR R&D (FEDERAL POC – MELISSA BATES & 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

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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
  - diagnostic and prognostic instrumentation systems
  - remote manipulation technologies for maintenance and refueling
  - autonomous operation capabilities
  - advanced safeguards technology for multi-module plants
- *Diverse applications*: Technologies that facilitate utilization of SMRs for multiproduct (electricity and heat) applications, such as:
  - secondary system interface technologies
  - high-efficiency intermediary heat exchangers and steam isolation technologies
  - automated load-sensing and load-following technologies, such as rapid power and steam transition systems.

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.

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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: INNOVATIVE SEPARATIONS CHEMISTRY FOR HIGH-VALUE USED FUELS
(FEDERAL POC – CHRISTINA LEGGETT & TECHNICAL POC – TERRY TODD)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $400,000)

Many advanced reactor technologies, including micro-reactors, require the use of high-assay low-enriched uranium (HALEU) fuels that are significantly more enriched (up to 19.75% U-235) than conventional light water reactor fuels (up to 5% U-235). The UNF discharged from these advanced reactors will still contain a large quantity of valuable enriched U-235 that could prove economical to reuse. While the most heavily researched method of separating uranium, plutonium, and/or minor actinides from UNF is solvent extraction, other separations methods have been less studied, including selective oxidation, precipitation, and dry processes such as halogenation. Applications are sought that propose innovative or simplified methods of recovering uranium and other valuable actinides from a variety of used nuclear fuels that could contain HALEU.

FC-1.2: NUCLEAR FUEL CYCLE SEPARATIONS CHEMISTRY
(FEDERAL POC – CHRISTINA LEGGETT & TECHNICAL POC – TERRY TODD)
(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 separations processes and technologies for actinides and other valuable elements may provide additional economic benefits for UNF recycle. Applications are sought that propose innovative research on fundamental coordination chemistry, recovery of actinides and valuable elements from UNF, radiolysis in solvent extraction systems, and computational modeling of solvent extraction phenomena.

FC-1.3: UNDERSTANDING, PREDICTING, AND OPTIMIZING THE PHYSICAL PROPERTIES, STRUCTURE, AND DYNAMICS OF MOLTEN SALTS
(FEDERAL POC – CHRISTINA LEGGETT & TECHNICAL POC – MARK WILLIAMSON)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 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

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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-1.4: UNDERSTANDING THE STRUCTURE AND SPECIATION OF MOLTEN SALTS AT THE ATOMIC AND MOLECULAR SCALE
(FEDERAL POC – CHRISTINA LEGGETT & TECHNICAL POC – MARK WILLIAMSON)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $600,000)

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 are requested to take advantage of recent breakthroughs in advanced characterization tools and instrumentation methods to provide 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-1.5: ADVANCED SALT WASTE FORMS
(FEDERAL POC – KIMBERLY GRAY & TECHNICAL POC – WILLIAM EBERT)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $600,000)

Salt waste streams rich in alkali halides and/or alkaline earth halides may be generated from molten salt technologies. These salt waste streams contain fission products and actinides for potential recycle, and the waste must be treated to immobilize the radioactive components. Valuable Cl-37 can also be recovered from chloride salt waste streams that contain enriched Cl-37.

Proposals are requested for the following areas:

- New approaches for treating/partitioning chloride-based or fluoride-based salt streams for recycle of waste constituents (e.g., Cl, electrolyte salt) and methods for immobilizing the residual wastes in chemically durable waste forms.
- Waste form options for immobilizing chloride-based and/or fluoride-based salt streams in chemically durable forms.

The proposed effort should include the production of multiple, 20-gram monolithic waste form test samples that would be provided to the DOE National Laboratories for testing beginning no later than 12 months into the effort and continuing to the conclusion of the proposed effort. Samples of the proposed waste forms would be evaluated using the facilities and methods developed within the DOE National Laboratory complex.

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FC-2: ADVANCED FUELS

FC-2.1: FUEL-TO-COOLANT THERMOMECHANICAL TRANSPORT BEHAVIORS UNDER TRANSIENT CONDITIONS

(FEDERAL POC – FRANK GOLDNER & TECHNICAL POC – COLBY JENSEN)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

Nuclear fuel development and qualification emphasizes understanding performance across the full range of conditions the fuel will experience during application. In light water reactor (LWR) and many other reactor designs, fuel performance is intimately linked to the fuel-to-coolant (F2C) transport behaviors that define the external thermal-hydraulic boundary conditions. Power-cooling mismatch conditions experienced during operational and accident transients impose complex time-dependent phenomena that impact material performance. Inadequate characterization of these transient F2C transport behaviors (both qualitatively and analytically) often poses a challenge to predicting and/or explaining the associated material response. Modern multiphysics tools increasingly facilitate close coupling of fuel performance and thermal hydraulics codes to improve the opportunity to understand such interactions. Integral experiments at the Transient Reactor Test (TREAT) facility are being developed and performed to study these behaviors on irradiated nuclear fuels and support development/validation of modeling tools.

This call seeks proposals including experimental and/or modeling scopes that will extend current understanding and prediction of F2C transport behaviors, thermal and/or mechanical, during transient conditions relevant to nuclear fuel operations and safety. Proposals should focus on clear applications to near-term Accident Tolerant Fuels (ATF) concepts and high burnup fuel (>62 GWD/MTu). Proposals should show clear connectivity of separate effects experimental studies and modeling to integral behaviors (preferably in-pile integral experiments, planned or historical where applicable). Additionally, proposals are encouraged to consider coordinating findings with the NEAMS
program so that models can be incorporated into relevant tools. Transient conditions of particular interest include anticipated operational occurrences (AOO), reactivity-initiated accidents (RIA), and loss-of-coolant accidents (LOCA).

FC-2.2: HIGH BURNUP LWR FUEL ROD BEHAVIOR UNDER NORMAL AND TRANSIENT CONDITIONS

(FEDERAL POC – FRANK GOLDNER & TECHNICAL POC – NATHAN CAPPS)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

For economic reasons, the United States (U.S.) nuclear industry is renewing efforts to build a technical basis to extend peak rod average burnup limits above the current regulatory burnup limit of 62 GWd/MTU. The primary economic driver is to increase Pressurized Water Reactor cycle lengths to 24-month cycles to reduce the number of fresh fuel assemblies, outage times, and possibly reduce core design constraints. In order for U.S. nuclear utilities to leverage these economic efficiencies, the Nuclear Regulatory Commission (NRC) will likely require nuclear power plants (NPPs) to analyze a number of potential operational occurrences and their potential consequences with each new core design prior to resuming normal operation. Potential operational occurrences fall into three primary regimes: 1) normal operation, 2) anticipated operation occurrences (AOOs), and 3) design basis accidents (DBAs). Normal plant operation is an operating regime where the plant operates within specified operational limits until the end of the cycle, whereas, AOOs are events that result in the NPP deviating outside the normal operating regime. A key attribute of an AOO is that the occurrence should be expected, however, the occurrence of an AOO shall not result in a significant impact to the critical safety functions. The last potential operational occurrence is a DBA. From the fuel performance point-of-view, DBAs can be subdivided into two bounding categories: 1) loss of coolant accident (LOCA) and 2) reactivity insertion accident (RIA). Unlike AOOs, DBAs may result in fuel rod failure. The NRC imposes fundamental acceptance criteria to minimize

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radiological consequences to the public and on-site staff. Furthermore, safety criteria are typically linked to the fulfillment of other acceptance criteria related to reactor safety equipment designed to mitigate DBAs.

The objective of this call is to encourage proposals aimed to improve the ability to predict the fuel rod response and behavior at high burnup under normal and transient conditions. The primary focus should be to investigate those conditions that might be most limiting under normal and transient conditions, e.g. rod internal pressure and fission gas release, and evaluate potential test irradiation conditions that would eventually be conducted to provide data to fill the most critical gaps in predicting fuel performance (i.e. determine the required boundary conditions, determine which variables to isolate during the tests, etc.). Additionally, Accident Tolerant Fuels (ATFs) should be investigated in order to evaluate the additional safety margin in comparison to current Light Water Reactor Fuels. It is anticipated that novel experimental measurements and/or modeling approaches will be necessary to address this challenge. Proposals should consider how these methods and datasets will accelerate and emphasize the ability to inform the safety case. It is anticipated that proposals will not require new irradiation experiments. However, experiments not requiring irradiation and characterization of previously irradiated materials will be considered. Proposed experimental investigations may consider using surrogate materials, but the proposal must make a strong case as to why the information collected through use of surrogate material is applicable to the mechanisms governing the fuel response. Proposals should not aim to develop new safety criteria; they must rely on the existing safety criteria and support informing the safety case as well as future irradiation tests. Additionally, proposals are encouraged to consider coordinating findings with the NEAMS program so that models can be incorporated into relevant tools.

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.

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

PROGRAM SUPPORTING: FUEL CYCLE TECHNOLOGIES

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.

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 tuff. 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 aqueous speciation, multiphase barrier interactions, and surface sorption at elevated temperatures and geochemical conditions (e.g., high ionic strength) relevant to deep geologic disposal environments.
- Identification 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, state-of-the-art tools and methods for passive and active characterization and monitoring of engineered/natural system component properties and failure modes and their capability to isolate and contain waste.

FC-4.2: SPENT FUEL AND WASTE DISPOSITION: STORAGE & TRANSPORTATION (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 either concrete or metal overpacks. The U.S. Nuclear Regulatory Commission has identified key safety functional areas for storage, including retrievability, thermal performance, confinement, radiation protection, and subcriticality. It is important to demonstrate that these safety functions are met during extended storage and after transportation. Therefore, DOE is interested in developing innovative methods for interrogation of the DSC internal conditions to provide assurance that the safety functions continue to be met.
DOE invites proposals on developing innovative methods for periodic measurement/inspection of internal conditions within such DSC. Note that penetrations through the canister wall, which might result in leakage of

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the internal inert atmosphere, are not allowed. Options for performing interrogation of the internal conditions include:

1. All sensors and equipment are external to the canister.
2. Small sensors located inside the canister that send signals through the canister wall to equipment located external to the canister.

Options are complicated by the various conditions the DSC encounter, geometric and material limitations, and the internal conditions in which sensors/monitors would be required to perform. These internal conditions include:

- survive under water or in very dilute boric acid, during vacuum drying (pressures down to ~1 torr), temperatures up to 400°C, helium backfill pressures varying from ~0.8 atm to 8 atm, and radiation dose up to 500 Gy/hr.
- Internal sensors must be very small (preferably credit card size) and cannot interfere with the loading or retrievability of fuel assemblies, must be compatible with internal components (e.g., not result in corrosion, introduce organics, etc.) and must be self-powered or receive power externally without canister penetrations.

For external sensors and/or equipment, monitoring during storage (i.e., while the DSC is in an overpack) can be accomplished with instruments temporarily inserted into the very small annular space between the canister and the overpack via the inlet or outlet vents in the overpack.
It is envisioned that after transportation as the canister is being moved from the transportation cask to a new storage overpack, the geometric limitations for external equipment will be lessened, but dose and shielding requirements will still dictate equipment accessibility.
Research proposals are sought to develop sensor and monitoring technologies, including the power supply, through-wall signal transmission, and signal interpretation, for periodic inspection of DSC internal conditions, accounting for the conditions and requirements outlined above, with a focus on:

- Detection of helium leakage
- Monitoring internal pressure
- Detection of water (either as free or water vapor)
- Monitoring gas composition
    - Helium vs helium/air mixtures vs air
    - Xe or Kr release (to identify if cladding failures occur)
    - Hydrogen detection (to identify radiolysis or corrosion)
- Monitoring temperature profiles (mostly as a means for detecting loss of inert environment)
- Monitoring dose (mostly as a means for identifying any fuel relocation)

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

NEAMS-1: ADVANCING MATERIAL MODELING IN SYSTEM ANALYSIS MODULE (SAM) CODE

(FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – RUI HU)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $400,000)

The System Analysis Module (SAM) is a modern system analysis tool being developed under the support of the NEAMS program. It aims to provide fast-running, whole plant transient analyses capability with improved-fidelity for advanced non-LWR safety analysis. SAM utilizes an object-oriented application framework (MOOSE) and its underlying libraries to leverage modern advanced software environments and numerical methods. Although significant capabilities have been developed and implemented in SAM, specialized expertise in universities is sought to support the development of materials transport modeling capabilities for reactor safety assessment and source term evaluation.

Material performance under high temperature irradiative and corrosive environments remains a key challenge for advanced reactor applications. Materials transport of contamination species in the primary loop is of particular importance because of its crucial impacts on the safety and economics of reactor systems. There have been extensive studies on materials behaviors in reactor systems, but mostly at the local level and in very fine details. Capabilities for coolant-material interactions and the transport of fission products at system level are still lacking.

It is important to integrate computationally efficient yet accurate lumped parameter material models into system-level analysis code SAM. We are specifically interested in proposals that:

- Develop lumped parameter material models relevant to reactor safety assessments or source term evaluations.
- Develop system-level material transport models (such as production, transport, precipitation, and corrosion) and integrating those into SAM. Note that a general species transport modeling capability is already available in SAM, which can be leveraged in developing various material modeling capabilities.

Proposals on the specific topic of tritium transport in liquid-salt-cooled or fueled reactors are not sought for in this NEUP call, as that topic will be addressed through directed research under the NEAMS program to meet near-term industry needs.

NEAMS-2: CORROSION MODELING FOR MOLTEN-SALT-FACING STRUCTURAL COMPONENTS

(FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – BEN SPENCER)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $700,000)

Multiple advanced reactor designs are currently being developed that employ either fuel-bearing molten salts or non-fueled salts for a coolant. The corrosive nature of these salts imposes significant challenges to the structural integrity of the components interfacing with the salt. Robust modeling and simulation capabilities that can predict the evolution of corrosion in such components at scales of engineering relevance are essential for understanding the implications of design decisions on the service lives of such reactors.

Proposals are sought for projects that will develop capabilities for simulating the processes involved in corrosion in alloys relevant for these reactors. Models are needed to predict Cr depletion and material loss, accounting for the effects of radiation, stress state, and temperature. Physically realistic models of these processes at the mesoscale are essential, and there must be a clear path to allow the results of mesoscale simulations to be used to inform predictive engineering-scale models. Proposals that address any current capability gaps in this area are

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welcome. Examples of current needs include, but are not limited to: (1) improving the efficiency of current phase-field models to enable their use over larger length and time scales, (2) predicting the formation of He bubbles near the salt/metal interface, (3) quantifying the driving forces for chemical species transport at the salt/alloy interface, (4) predicting the effects of stress on reaction kinetics, and (5) the effects of pollution of the salt due to alloy corrosion on the performance of the salt.

While the primary emphasis of this call is in developing simulation tools, experimental studies can be included as part of a proposal, and are encouraged if they fill knowledge gaps and support development of simulation capability. Although experiments are permitted, the explicit outcome desired by this call is insight in to corrosion processes that ultimately inform predictive engineering-scale (Grizzly/Yellowjacket) analysis. There is flexibility with regard to the specific alloy, coolant, reactor type, and other conditions studied, but it is important that the results of the proposed study will be relevant to a reactor type that is currently under consideration for deployment. The work done in response to this call must be captured and made deployable as part of the NEAMS-supported tools. These include finite-element-based codes using the MOOSE platform (Grizzly and Yellowjacket), and spectral-solver-based codes currently developed with NEAMS (contact the TPOC for details).

NEAMS-3: NEXT GENERATION, HIGH-FIDELITY PEBBLE-BED SIMULATION (FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – JAVIER ORTENSI) (ELIGIBLE TO LEAD: UNIVERSITIES ONLY) (UP TO 3 YEARS AND $600,000)

Pebble bed reactors (PBRs) unite many advantages like robust fuel, strong negative temperature feedback, and small excess reactivity; they exist in two major variants: fluoride salt cooled high-temperature reactors (FHRs) and high-temperature gas cooled reactors (HTGRs). In both variants, pebbles move through the core while they are irradiated with the difference that FHRs are fueled from the bottom, while HTGRs are fueled from the top. At the outlet, pebbles are either recirculated or discarded depending on their burnup level. Recirculated pebbles mix with other pebbles and begin a new traversal through the core. Online refueling allows pebble-bed reactors to operate with very small excess reactivity. However, the mixing and recirculation of pebbles make the reactor more complicated to analyze.

We seek proposals which transcend the accuracy and fidelity of current models for pebble-bed reactor depletion. The call extends to both the equilibrium core (asymptotic state after long enough runtime) and the running-in phases (transient phase before reaching the equilibrium core). These new methods should address challenges with current models and allow for “reference calculations” which can benchmark lower-fidelity solutions. One major challenge to current PBR analysis is the creation of accurate multigroup cross sections during the depletion cycle. The spectrum a pebble of a certain burnup sees in the core does not only depend on where in the core it is, but also on the composition of the pebbles around it; these conditions constantly change making a traditional precomputing and tabulation approach infeasible. This challenge is in addition to the double heterogeneity and spectral "mixing" effects stemming from long mean free path that are common to HTGRs. Another challenge of pebble bed analysis is the reliance on homogenized pebble depletion models. The flow of pebbles is currently modeled as incompressible flow and single pebbles are not resolved. While this assumption is reasonable for engineering analysis of the reactor, its limitations are not well understood. This may pose issues during PBR licensing. Recently, more advanced radiation transport approaches like the pebble tracking transport (PTT) method in the NEAMS reactor physics code Griffin have been developed. PTT has not yet been extended to pebble depletion though.

This call is looking for proposals that fundamentally address the issues stated above using novel and unique computational approaches. It is desired that the developed capabilities are integrated into the NEAMS tool, Griffin. Using and developing the PTT method is a plus.

NEAMS-4: FUNDAMENTALS OF MULTIPHASE BOILING FLOW FOR HIGH-PRESSURE, HIGH-VOID CONDITIONS (FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – RUI HU)

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

(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $800,000)

The prediction of two-phase flow behavior is essential to the operational performance and safety of Light Water Reactors (LWRs) as well as the power generation systems in many non-LWR advanced reactor systems. Key parameters of interest are the void and pressure distribution over the range of boiling flow regimes that includes bubbly, slug, churn, and annular flow. Especially important is the film boiling behavior at which dry-out conditions occur that can lead to fuel failure (e.g. BWR critical power, especially under natural circulation conditions). A fundamental understanding of two-phase flow phenomena, including the measurement of high-resolution, high pedigree data, is therefore essential to advancing the predictive capabilities of two-phase flow simulation.
Proposals are sought to assist in characterizing flow boiling characteristics in high-pressure, high-void-fraction flow regimes relevant to the operation and safety of reactor systems. Key aspects include:

- High resolution, multi-phase thermal hydraulic testing for nuclear energy applications, including evaluation of surface effects, void fraction distributions and phasic velocities.
- Development of relevant closure models for prediction of slug, droplet and film phenomena in multi-phase computational fluid dynamics and subchannel analysis tools (such as Nek2P and CTF) .
- Establishment of a high-fidelity database for validation of high-void-fraction flow regime models and simulations.

The proposal should focus on one or more aspects of the following scope:

- Deliver high resolution experimental measurements of high void fraction flows of actual reactor coolants under conditions relevant to high pressure nuclear reactor systems, i.e. water-steam boiling flows at prototypic BWR pressures, flow rates and heat fluxes.
- Directly characterize time-evolving void distribution in flow channels with geometries relevant to nuclear applications, e.g., flow annulus or bundle pin lattice.
- Evaluate key mechanistic phenomena for development of closure models for multi-phase CFD, e.g., film thickness, film wave number, droplet entrainment and impingement phenomena, etc.
- Develop benchmark problem descriptions for each test facility and establish databases for the archive of experimental data from each test series.
- Demonstrate applicability of benchmarks through initial evaluations of selected test cases using current generation NEAMS boiling flow CFD closure modelscomputational tools (i.e. Nek2P and CTF) for two-phase flow simulations.

NEAMS-5: TIME-DEPENDENT MONTE CARLO SIMULATION CAPABILITY DEVELOPMENT

(FEDERAL POC – DAVE HENDERSON & TECHNICAL POC –MATT JESSEE)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $600,000)

Continuous-energy Monte Carlo is traditionally utilized to provide high-fidelity, high-resolution reference solution for reactor physics and radiation transport calculations which has generally been limited to steady-state calculations of critical core configurations and fixed-source fluence analysis. Challenges with time-dependent Monte Carlo analysis are well-known and include, for example, the need to achieve sufficient particle histories required for converged reaction rates for a given set of tally regions. For problems requiring isotopic depletion, Monte Carlo is coupled with deterministic depletion solvers which solves the isotopic transmutation equations based on the Monte Carlo computed reaction rates and flux distributions. For problems requiring delayed neutron modeling, Monte Carlo codes employ additional approaches for tracking prompt and delayed fission particles and simulating delayed neutrons over small time steps.

The focus of this NEUP will be the development of computationally efficient, robust Monte Carlo time-

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dependent capabilities that can serve as reference solutions for NEAMS-developed codes (Griffin and VERA) for a range of transient and depletion simulations. Such simulations would be characterized by different temporal discretization requirements, ranging from reactivity insertion transients (occurring over minutes), slowly-varying transients (occurring over days, such as Xenon transients), and reactor depletion (occurring over months). Proposals should focus on methods and algorithms that address the statistical nature of the Monte Carlo method via novel approaches for error control, hybrid approaches for efficient importance sampling, and/or acceleration approaches for performing multiphysics iterations. Comparisons against high fidelity neutronics codes such as Griffin or VERA or a brute force approach of large particle history reactor simulation with user-defined time-dependent reactor state conditions should be part of the proposal. Proposed capabilities must be able to be implemented in the Shift Monte Carlo code, and demonstration of the approach in/with Shift is preferred.

PROGRAM SUPPORTING: CROSSCUTTING TECHNOLOGIES

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 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.

Note that there is also cybersecurity-related content under CT-2: INTEGRATED ENERGY SYSTEMS DESIGN AND MODELING.

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

Advanced nuclear-renewable integrated energy systems (IES) are composed of one or more nuclear and renewable energy sources, industrial energy users, and energy storage systems. Various IES configurations are being evaluated for their economic benefit and technical feasibility within various geographic regions; systems may be “tightly coupled” within a single “energy park” type of configuration or may be loosely coupled within a grid balancing area.

Work scopes of interest for FY20 applications focus on the use of advanced (non-water cooled) reactors in IES. To date, large studies have been performed to assess the viability of direct thermal coupling between current LWR plants and several heat processes. New 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. Potential work scopes include:

(1) Deeper investigation and prioritization of process feasibility for advanced reactor thermal energy input, and how to effectively integrate these processes with candidate advanced reactor concepts, is key to performance optimization. In particular, aspects of interest for investigation include:

- Process design 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); and/or

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- Interface design (e.g., advanced heat exchangers, requirement for design of intermediate loops, impact to balance of plant, control systems) for prioritized coupled processes.

(2) Real time optimization of energy dispatch for a designed and deployed IES is the last step of an optimization process. This step is necessary to ensure the economic viability of the system operating within a grid balancing area to support multiple electric and non-electric energy users. In the future, the IES program expects to move in this direction by taking advantage of digital twins and artificial intelligence approaches. Applicants may contribute to the future development of the IES program by investigating algorithms for real time, online optimization of IES dispatch for economic performance optimization, with an emphasis on resolving the specific challenges of integrating nuclear power systems and their operations into such environments. This work scope includes a vast area of approaches, including:

- Prediction of grid demand and fluctuations in that demand as a function of numerous variables
- Real time update of IES control system predictive capability
- Large-scale data assimilation in real time.

(3) Leveraging the nuclear cybersecurity R&D that has so far focused on stand-alone nuclear plants that produce only electricity, develop IES-specific cyber-informed engineering approaches, architectures and/or design concepts. Proposals should emphasize cost-effective approaches to ensuring the security of these complex energy systems that require significant data exchange and control interactions among multiple coupled energy producers and users, potentially interfacing with multiple regulatory, safety and security frameworks.

CT-3: TRANFORMATIONAL CHALLENGE REACTOR R&D
(FEDERAL POC – TANSEL SELEKLER & TECHNICAL POC – KURT TERRANI)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $800,000)

The Transformational Challenge Reactor (TCR) was launched in FY 2019 to demonstrate application of advanced technologies for rapid production and testing of a nuclear reactor core. The central technology in the TCR demonstration program is additive manufacturing that is complemented with advanced design, materials, and data analytics thrusts.

The TCR program employs an agile design approach that is integrated with and iterates with manufacturing and testing. As the design evolves, the individual components of the core are continuously manufactured to assess production feasibility and provide articles for testing. The testing spans areas such as metrology, basic thermo-physical properties database development, mechanical testing, irradiation testing, and integral effects studies. The latter examines how core components fit together and behave under temperature and flow conditions.

CT-3.1: INTEGRATED THERMOFLUIDIC EXPERIMENTATION AND MODELING FOR TCR CORE COMPONENTS

This work scope seeks applications to provide experimental data on thermofluidic behavior of TCR core components. Application of a test facility at the university that can accomplish thermofluidic tests for additively manufactured TCR core components is sought. The objective is to enable measurement of validation grade thermofluidic data (such as local turbulence and mixing, velocity profiles, temperatures, heat transfer coefficients, pressure drops, loss coefficients etc.) for additively manufactured TCR components to benchmark high resolution computational fluid dynamics (CFD) models. Evaluating the impacts of manufacturing tolerances, surface roughness, fluid-structural interaction and differential thermal expansion are of specific interest. Testing parameters must be relevant to the operating and accident conditions of a He-cooled nuclear reactor. The use of He gas, or high-temperature testing, is not necessary if relevant data can be extracted from

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scaled and simpler flow test loops.

The TCR program will supply additively manufactured metallic or ceramic (non-fuel) specimens (20 cm × 20 cm × 100 cm or smaller) to be examined in this thermofluidic test facility. Description of a quality assurance plan needs to be presented in the application to ensure useful data is generated throughout the project.

CT-3.2: MATERIALS CHARACTERIZATION OF ADDITIVELY MANUFACTURED TCR CORE STRUCTURAL MATERIALS

This work scope seeks applications to provide experimental data on mechanical and microstructural properties of additively manufactured TCR core materials. The TCR program employs various additive manufacturing techniques to produce the constituents of a 3D-printed core with complex geometry. The following three material systems are the primary structural constituents of the TCR core:

- laser powder bed fusion derived 316L stainless steel
- laser powder bed fusion derived Inconel 718
- 3D printed (binderjet + infiltration) silicon carbide (SiC)

Once the materials are produced they undergo various examination to assess thermophysical properties, microstructure, and mechanical performance. Of critical importance is that the determined testing data is tagged and tracked back to a specific location in the additively build component. The location-specific in situ monitoring and post-manufacturing testing data are then collected and comprise the TCR database and feed its Digital Platform. The purpose of the digital platform is to use this centralized database and exploit artificial intelligence techniques to establish links between in situ monitoring and post-manufacturing testing datasets.

The activities performed under this work scope will utilize testing and characterization resources at universities to provide data on additively manufactured TCR core structural materials with a focus on mechanical and microstructural properties. Bulk additively-manufactured materials with reference fiducial markers will be supplied by the TCR program for these tests. The purpose of the fiducial markers is to facilitate location tracking in the test materials. Testing results need to accompany 3D location data (with at least 1 mm resolution) to be useful as input into the TCR digital platform. No specific testing is prescribed as any test data is a welcome addition to the TCR digital platform and may include basic mechanical testing, creep, fatigue, fracture, ion irradiation, etc. One, two, or all of the listed materials, and only those supplied by the TCR program, may be the subject of the testing. Description of a quality assurance program needs to be presented in the application to ensure useful data is generated throughout the project.

CT-4: ADVANCED AND SMALL MODULAR REACTOR MATERIALS ACCOUNTANCY AND PHYSICAL PROTECTION
(FEDERAL POC – WON YOON & TECHNICAL POC – BEN CIPITI)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 2 YEARS AND $400,000)

Advanced nuclear reactors, small modular reactors, and microreactors face challenges in meeting domestic materials control and accountability (MC&A) and physical protection system (PPS) requirements while still maintaining cost-effectiveness. New and novel approaches that may be used for process monitoring and MC&A for advanced reactors are needed to increase safeguards efficiency. This is particularly needed for reactors with more novel fuel types, such as liquid fueled and pebble bed designs. New and novel PPS approaches are also needed that can drastically reduce either up-front or operational security costs for the life of the reactor. Proposals should focus on regulatory needs and describe how the proposed work

PROGRAM SUPPORTING: CROSSCUTTING TECHNOLOGIES

addresses those needs for the advanced reactors.

Proposals focused on international safeguards and security requirements will not be considered for this area.

CT-5: NUCLEAR MATERIALS DISCOVERY AND QUALIFICATION INITIATIVE R&D
FEDERAL POC – TANSEL SELEKLER & TECHNICAL POC – ALLEN ROACH)
(ELIGIBLE TO LEAD: UNIVERSITIES ONLY)
(UP TO 3 YEARS AND $500,000)

The goal of the Nuclear Materials Discovery and Qualification Initiative (NMDQi) is to create the capability to achieve a rapid qualification paradigm for nuclear materials. Materials qualification is currently based on manufacturing processes; however, NMDQi aims to develop a microstructure-based qualification method that links structure and properties to facilitate the fabrication and qualification of novel materials. Applications are sought that focus on the analysis of representative volumes of material at the microstructure level and present well-documented and demonstrated methodologies to calculate macroscopic quantities of interest, such as yield strength, ultimate strength, or corrosion rates. This call focuses on developing data analytics frameworks that couple available datasets with modeling tools capable of predicting properties for broad qualification of classes of materials. Areas of interest include materials for core, cladding, structural materials and fuels for advanced reactors.

MISSION SUPPORTING: NUCLEAR ENERGY

MS-NE-1: INTEGRAL BENCHMARK EVALUATIONS (FEDERAL POC – DAVE HENDERSON & TECHNICAL POC – JOHN BESS) (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.

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.

Many nuclear data needs for NE may be found in the NEA Nuclear Data High Priority Request List (HPRL)

MISSION SUPPORTING: NUCLEAR ENERGY
(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. .

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

*Only Industry can lead in NSUF-2.1 work scopes

PROGRAM SUPPORTING: NUCLEAR ENERGY ENABLING TECHNOLOGIES (NEET)

NEET-1: ADVANCED METHODS FOR MANUFACTURING
(FEDERAL POC – DIRK CAIRNS-GALLIMORE & TECHNICAL POC – ISABELLA VAN ROOYEN)
(ELIGIBLE TO LEAD: UNIVERSITY OR NATIONAL LABORATORY)
(UP TO 3 YEARS AND $1,000,000)

The Advanced Methods for Manufacturing (AMM) program seeks applications for research and technology development to improve the methods by which nuclear equipment, components, and plants are manufactured, fabricated, and assembled. Applications should support the Department of Energy's (DOE) Office of Nuclear Energy's (NE) 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 goal of the program is to accelerate innovations reducing the cost and schedule of constructing new nuclear plants and make fabrication of nuclear power plant components faster, economically, and more reliable. The program seeks to encourage innovation that supports the "factory fabrication" and expeditious deployment of reactor technologies. Potential areas for exploration include:

1.1 MODULAR ADVANCED MANUFACTURING APPROACHES

Pre-fabrication and pre-assembly approaches for manufacturing technologies were used to construct previous nuclear power stations and can dramatically improve the competitiveness of new reactor designs. Further supporting the competitiveness of the U.S. nuclear basis, the AMM program sought proposals that can enhance the economics and flexibility of the advanced manufacturing technologies. The goal of this research area is to develop and mature manufacturing technologies that facilitate modular designs and the construction thereof. Proposals are sought for enhancement of the modular manufacturing technologies, including decreased necessity of field modifications. Emerging powder metallurgy techniques for fabricating nuclear components offer many benefits, including part consolidation, reduced requirements for field fabrication and welding, and the potential replacement of forging for pressure vessels.

1.2 NEW ADVANCED MANUFACTURING TECHNOLOGIES FOR QUALIFICATION AND CERTIFICATION TO ACCELERATE LICENSING

There are major opportunities for advanced manufacturing processes and digital workflows to develop and support validated qualification routes moving beyond code case approvals. Applications are sought for developing or utilizing enabling technologies through combinatorial fabrication-modeling and digital to allow designers, manufacturers, and the supply chain to enable increased data accuracy and accelerated qualification of a final product. Specific attention to lessons-learned from other industries as justification for the proposed approach(es), will be crucial for successful proposals. Developing new digital thread and digital twin visualization and planning technologies is also included. Proposals focusing on a specific aspect of a new qualification or licensing approach should clearly justify future integration for a complete strategy.

The most up-to-date information on active AMM projects can be found in the award summaries, technical review meetings and newsletters folders for the NEET AMM program on the NE website under NEET documents.

NEET-2: WIRELESS TECHNOLOGY FOR NUCLEAR INSTRUMENTATION AND CONTROL SYSTEMS
(FEDERAL POC – SUIBEL SCHUPPNER & TECHNICAL POC – CRAIG PRIMER)
(ELIGIBLE TO LEAD: UNIVERSITY OR NATIONAL LABORATORY)
(UP TO 3 YEARS AND $1,000,000)

The Advanced Sensors and Instrumentation program seeks applications to develop wireless instrumentation for

PROGRAM SUPPORTING: NUCLEAR ENERGY ENABLING TECHNOLOGIES (NEET)

nuclear applications, especially for advanced reactors. Currently, electrical cables are critical infrastructure necessary to operate a Nuclear Power Plant (NPP) effectively and safely. A typical NPP has more than 1,000 km of power, control, instrumentation and other cables within the plant and the cost of construction and maintenance is significant. When considering advanced control modes for future reactor concepts, including microreactors, cables performance degradation in radioactive environments becomes an important limiting factor.
Wireless technology is increasingly deployed for the improvement and cost optimization of several common industrial applications, for example the use of Radio-Frequency Identification (RFID) in the distribution and retail sector. Proposals should consider how technical solutions with proven performance in other applications, outside of the nuclear industry, could be adapted to improve the performance and cost-effectiveness of nuclear systems.

There are three tiers to the deployment of wireless technology in a nuclear system:

1. Generation and transmission of data from a system component (inside or outside the reactor vessel) to a receiving element within the nuclear containment structure;
2. Transmission of signal from inside to the outside of the containment;
3. Transmission of signal from outside containment to a control room or data cloud.

Proposals under this NEET-2 request shall address tier 1 only – data generation and transmission within the containment structure. Proposed technologies should seek to have as wide application as possible, including the potential to operate in harsh environment conditions present inside the reactor vessel. However, proposals addressing technical solutions applicable to ex-vessel components will be considered as long as they clearly specify the targeted applications and the intended operating conditions, including radiation.
Applicants should focus on the following:

- Develop wireless technology to measure and transmit data on system temperature, pressure, forces, acceleration, vibration, and the health of structural components. Multimodal sensors (i.e., capable of detecting two or more independent parameters simultaneously) or technologies applicable to more than one measurement type should be prioritized.
- Provide clear description of the impact of the proposed wireless technology on the system cost-effectiveness, including fabrication aspects and the integration with advanced control mode if applicable (i.e., supporting autonomous operation) by providing a cost-benefit analysis.

Applications should not include:

- Cyber security aspects related to wireless transmission. They should not be part of the proposal scope and won't be considered under this scope. They are mostly important for tier 2 and 3 (transmission to the control room or data cloud), which could fit better under the cyber program section of this solicitation.

The application should indicate whether and how the proposed technology is or may be applicable to multiple reactors or fuel cycle applications, i.e. crosscutting. Proposals should support the Department of Energy's (DOE) Office of Nuclear Energy's (NE) 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.

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

NSUF-1: NUCLEAR ENERGY-RELATED R&D SUPPORTED BY NUCLEAR SCIENCE USER FACILITIES CAPABILITIES

These workscopes 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. The focused topical areas are selected by NE's R&D programs (e.g. Nuclear Reactor Technologies, Fuel Cycle Technologies, and Nuclear Energy Enabling Technologies) with the explicit purpose to leverage the limited R&D funding available with access to NSUF capabilities. All applications submitted under these workscopes will be projects coupling R&D funding with NSUF access. Projects requiring "NSUF access only" (see NSUF-2 below) or "R&D funding only" must be submitted under other appropriate workscopes. Applications submitted under these workscopes 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 workscopes 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 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-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 indicate 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-1.1: TESTING OF ADVANCED MATERIALS FOR SENSORS AND ADVANCED SENSORS FOR NUCLEAR APPLICATIONS
(FEDERAL POC – SUIBEL SCHUPPNER & TECHNICAL POC – BRENDEN HEIDRICH)
(ELIGIBLE TO LEAD: UNIVERSITY, NATIONAL LABORATORY, OR INDUSTRY)
(REFER TO NSUF WORK SCOPE TIME PERIODS (PART II, SECTION E.2.1), UP TO $500,000)

Applications are sought for irradiation testing and post-irradiation examinations that support the development of advanced materials for sensors, and development of advanced sensors themselves to support NE's mission to enhance the long term viability and competitiveness of the existing fleet, to develop an advanced reactor pipeline, and to implement and maintain national strategic fuel cycle and supply chain infrastructure. This funding does not support research and development activities to develop materials or sensors, but rather the irradiation of sensors and materials that leads to rapid deployment and/or commercialization of sensor technologies as described below. Please review the recent competitive awards and programmatic work being performed in this area to ensure no duplication of effort: https://www.energy.gov/ne/advanced-sensors-and-instrumentation-asi-program-documents-resources.

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

1) Advanced Materials for Sensors: Successful irradiation testing and post irradiation examination of candidate materials proposed for advanced sensors applications will include: a description of the materials; irradiation and post irradiation examination needs; the role of the materials in new sensors, controls, communications or associated applications and a technology gap analysis to assess the impact of the proposed material in comparison with existing solutions.

2) Advanced Sensors: Successful irradiation and post irradiation examination of sensors and associated instrumentation will include: a description of the sensor and associated instrumentation and materials requiring irradiation and post irradiation examination; irradiation and post irradiation examination needs; the purpose and application of the developed sensor in nuclear energy systems and a technology gap analysis to assess the impact of the proposed technology in comparison with existing solutions.

NSUF-1.2: IRRADIATION TESTING OF MATERIALS PRODUCED BY INNOVATIVE MANUFACTURING TECHNIQUES
(FEDERAL POC – DIRK CAIRNS-GALLIMORE & TECHNICAL POC – ISABELLA VAN ROOYEN)
(ELIGIBLE TO LEAD: UNIVERSITY, NATIONAL LABORATORY, OR INDUSTRY)
(REFER TO NSUF WORK SCOPE TIME PERIODS (PART II, SECTION E.2.1), UP TO $500,000)

Products from advanced and innovative manufacturing, welding / joining, and surface modification and cladding techniques can be proposed for evaluation of irradiation effects on material performance in support of NE's mission to enhance the long term viability and competitiveness of the existing fleet, to develop an advanced reactor pipeline, and to implement and maintain national strategic fuel cycle and supply chain infrastructure. Proposals seeking technical knowledge and effects of fabrication parameters on irradiation behavior will be specifically of interest.

This funding does not support research and development activities to develop manufacturing and construction techniques, but rather evaluate the irradiation effects on material performance.

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: SEE SPECIFIC WORK SCOPES)
(REFER TO NSUF WORK SCOPE TIME PERIODS (PART II, SECTION E.2.1))

Applicants interested in utilizing Nuclear Science User Facilities (NSUF) capabilities only should submit "access only" applications under these workscopes. 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 workscopes 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

NUCLEAR SCIENCE USER FACILITIES (NSUF-2)

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-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 (ELIGIBLE TO LEAD: INDUSTRY ONLY)

This element is primarily focused on fundamental understanding of irradiation effects in core and structural materials such as material aging and degradation mechanisms (e.g. fatigue, embrittlement, void swelling, fracture toughness, IASCC processes and mitigation, and corrosion), as well as developing 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). Proposed projects may involve R&D in the areas of material irradiation performance and combined effects of irradiation and environment on materials. Proposals that advocate duplicating, even in part, previous or on-going NSUF supported irradiation studies will not be considered. 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. A complete list of NSUF awards made under the FY2017 to FY2020 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)

The Nuclear Science User Facility (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

NUCLEAR SCIENCE USER FACILITIES (NSUF-2)
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: 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

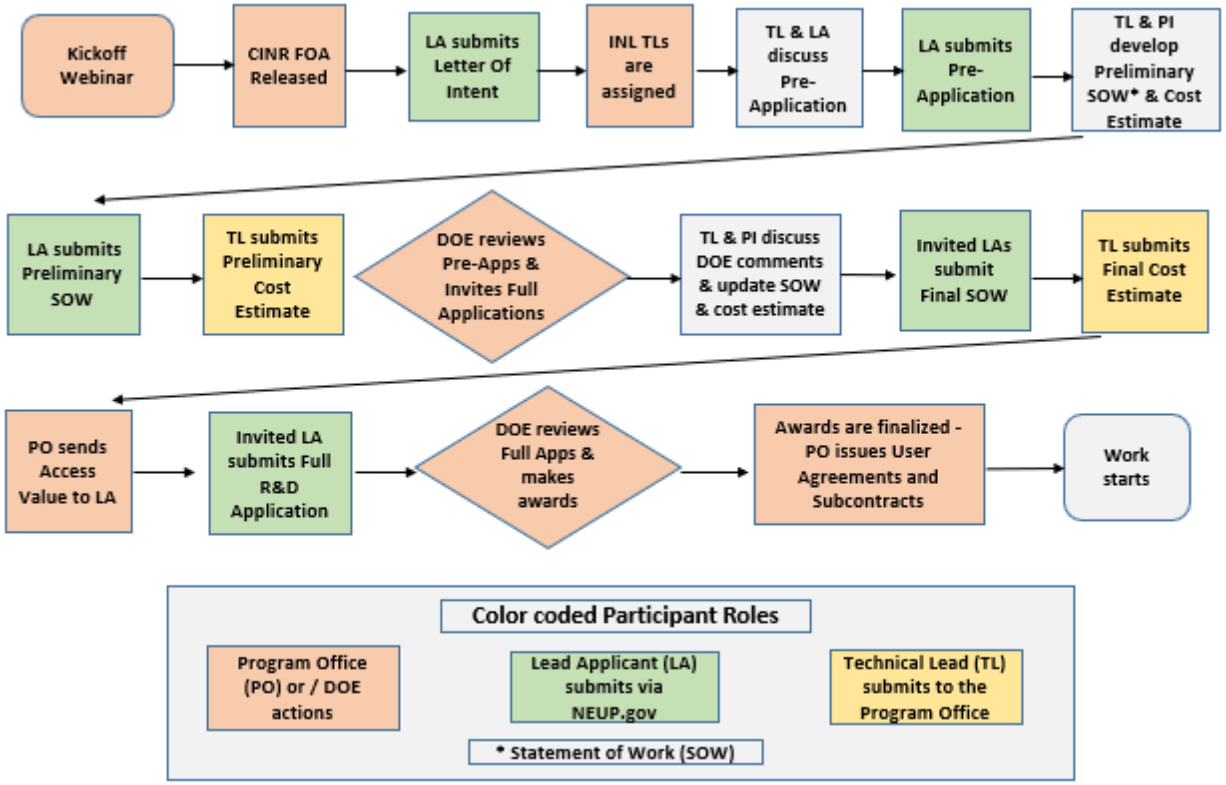
Irradiation of materials in test reactors requires additional rigor and quality assurance requirements beyond those described in other sections of this FOA. Specific requirements will depend on the reactor license, the irradiation vehicle design, and specimen constituents. NSUF Technical leads will assist 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 D: 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 C).**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 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 wishes to elect title to the Invention, a notice of election 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.**