FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

U. S. Department of Energy

Idaho Operations Office

Fiscal Year 2015 Consolidated Innovative Nuclear Research

Funding Opportunity Announcement:
DE-FOA-0001129

Announcement Type: Initial: 8/18/2014
AMENDMENT 000001 (9/4/2014)
AMENDMENT 000002 (10/1/2014)
AMENDMENT 000003 (11/05/2014)
AMENDMENT 000004 (12/08/2014)

CFDA Number: 81.121

Informational Webinar: August 12-14, 2014
(Video links and presentations will be made available at www.neup.gov)

Issue Date: August 18, 2014

Letter of Intent (Mandatory only for NSUF Applications)
Due Date: September 11, 2014 at 8:00 PM ET

Pre-Application (Mandatory except for IRPs)
Due Date: October 2, 2014 at 8:00 PM ET

Full Application
Due Date: February 19, 2015 at 8:00 PM ET

AMENDMENT 000001 - The purpose of this modification is to update the Technical Point of Contact (TPOC) for two workscopes included in this funding opportunity announcement. Jeremy Busby is being replaced by Sam Sham as the TPOC for workscope RC-3, and J. Blair Briggs is being replace by Gilles Youinou as the TPOC for workscope MS-NE-1.

AMENDMENT 000002 – The purpose of this modification is to clarify the application restrictions regarding IRP submissions in Part III, A, 5. An additional paragraph has been added stating "*For IRPs, an applicant is ineligible to submit an application as the PI if (s)he is designated as PI for more than one currently funded DOE-NE project that will still be active beyond December 31, 2015*. Eligibility Flowchart"

AMENDMENT 000003 – The purpose of this modification is to update the title only of workscope RC-1 to "Experimental Validation of Gas-Cooled Reactor Simulations". Also, to update the TPOC for workscope FC-6 from Sheng Dai to Phillip Britt, the Federal POC on MS-NEET-1 from Bradley Williams to Rob Versluis, and the Federal POC on MS-FC-1 from Andy Griffith to David Henderson. Additionally, clarification was added to Part II, Section F regarding the expected start date for successful applications. Specifically, the following sentences were added at the end stating, "Assuming DOE makes awards under this FOA by September 2015, successful applications shall begin no later than October 1, 2015; additionally, each successive budget period within the project period of performance should begin on October 1st of each year during the overall project period of performance. 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, 2015, is absolutely necessary for the successful performance of the project, it must be fully documented and justified in the application for consideration by DOE."

AMENDMENT 000004 – The purpose of the modification is to clarify the eligibility restrictions in Part III. A. 5 so it applies to all PIs. Specifically, the first paragraph now reads "PIs with a currently funded IRP; who have three or more R&D projects that will still be active after December 31, 2015; or who have a no-cost extension (NCE) on any DOE-NE funded project (excluding Infrastructure) which will still be active beyond December 31, 2015, are ineligible to apply to any area of this FOA as a lead PI, but are eligible to participate as a collaborator." This is to include NCE requests and limit of projects to also apply to national laboratory and industry participants. In addition we have updated the Federal POC of the MS-NE-1 workscope (pg. 65) from Trevor Cook to Rob Versluis and to also change the Agency Contact (PartVII. B.) from Aaron Gravelle to Shawn Tinsley.

Table of Contents

List of Acronyms

ARC – Advanced Reactor Concepts
ATR – Advanced Test Reactor
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
DPA – Displacements per atom
DUNS – Data Universal Numbering System
EPAct – Energy Policy Act of 2005
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
GOGO – Government Owned/Government Operated
GSI – General Scientific Infrastructure
ICHMI – Instrumentation, Control, Human, Machine Interface
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
NE – Office of Nuclear Energy
NEAMS – Nuclear Energy Advanced Modeling and Simulation
NEET – Nuclear Energy Enabling Technologies
NEUP – Nuclear Energy University Programs
NGNP – Next Generation Nuclear Plant Demonstration Project
NSUF – National Scientific User Facility
NNSA – National Nuclear Security Administration

NPPs – Nuclear Power Plants
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
RPS – Radioisotope Power Systems
RPV – Reactor Pressure Vessel
RTE – Rapid Turnaround Experiment
SAM – System for Award Management
SBIR – Small Business Innovation Research
SF – Standard Form
SMR – Small Modular Reactors
SOW – Statement of Work
STTR – Small Business Technology Transfer
TAC – Total Allowable Costs
U.S. – United States
TIO – Technical Integration Office
TMI-2 – Three Mile Island Unit 2

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".

1. Background and Objectives

The Department of Energy's (DOE) Office of Nuclear Energy (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 advanced reactors and fuel cycle concepts while maximizing the impact of DOE resources.

NE strives to promote integrated and collaborative research conducted by national laboratory, university, industry, and international partners under the direction of NE's programs. 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 Programs (NEUP), Nuclear Energy Enabling Technologies Crosscutting Technology Development (NEET CTD), and Advanced Test Reactor National Scientific User Facility (ATR NSUF). NEUP utilizes up to 20 percent 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-, university- and industry-led crosscutting research. By establishing the NSUF in 2007, DOE-NE opened up the world of 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. In addition to the consolidation of the NSUF Call for Applications (CFA) for access to capabilities, NEUP or NEET CTD projects requiring irradiation testing and/or post irradiation examination (PIE) may include no-cost access to NSUF capabilities through a single application response to this FOA.

NE reserves the right to respond to potential shifts in R&D priorities during FY 2015 that may be driven by events, policy developments, or Congressional/budget direction. NE will factor such considerations into decisions related to the timing and scale of award announcements associated with this FOA.

2. Major NE-Funded Research Programs

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 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 nuclear wastes have been fully implemented. Additionally, it is desired that advanced nuclear fuel and 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 burnup 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 results of the evaluation to stakeholders.

Reactor Concepts Research, Development and Demonstration (RC RD&D) Program. The mission of the RC RD&D program is to develop new and advanced reactor designs and technologies that broaden the applicability, improve the competitiveness, and ensure the lasting contribution toward meeting our Nation's energy and environmental challenges. Research activities are designed to address the technical, cost, safety, and security issues associated with various reactor concepts. The four technical areas are Light Water Reactor Sustainability (LWRS), Small Modular Reactors (SMR), Advanced (Non-Light Water) Reactor Concepts (ARC) and Advanced Small Modular Reactors (Adv SMRs). In addition, R&D for the manufacturing of radioisotope power systems for national security and space exploration missions is supported through the Space and Defense Infrastructure Program.

Nuclear Energy Advanced Modeling and Simulation (NEAMS) Program. The mission of the NEAMS program is to create modern computer simulation codes and methods that give the user state-of-the-art physics models that can take advantage of powerful multi-processing computers in order to better understand the behavior of nuclear reactor and fuel systems during normal operations and/or transient events. In particular, NEAMS is aimed at creating an advanced mechanistic toolkit that is applicable to a wide range of reactor designs for use by industry, academia, and the national laboratories. The NEAMS Toolkit will help engineers and scientists form new insights into the safety and economics of current and next generation reactor and fuel systems. It will provide much higher fidelity than current methods and incorporate well-defined and validated prediction capabilities.

This will be achieved by employing advanced software environments and modern high-performance computers to create a set of engineering-level codes in which fuels and materials continuum properties are informed by first-principles modeling of materials at the atomistic and meso-scale. A set of simulation tools will be developed that promote interoperability of codes with respect to spatial meshing, materials and fuels models, and achieve a common "look and feel" for setting up problems and displaying results. The toolset to be developed aims to achieve scalability in terms of computing power and the types and couplings of the physics that dominates the system behavior.

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, improving its competitiveness and promoting 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. The knowledge generated through these activities will allow NE to address key challenges affecting nuclear reactor and fuel cycle deployment with a focus on cross-cutting innovative technologies.

Advanced Test Reactor National Scientific User Facility (NSUF). DOE-NE funds access to world-class capabilities to facilitate the advancement of nuclear science and technology. This mission is supported by providing cost-free access to state-of-the-art experimental irradiation testing and PIE facilities as well as technical assistance including the design and analysis of reactor experiments. NSUF and its partner facilities represent a prototype laboratory for the future. 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 leads. 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 no-cost access to equipment and staff at Idaho National Laboratory, the Center for Advanced Energy Studies' Microscopy and Characterization Suite (MaCS) and designated capabilities at the following partner facilities:

- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Illinois Institute of Technology
- Massachusetts Institute of Technology
- North Carolina State University
- University of California, Berkeley
- University of Michigan

- University of Nevada, Las Vegas
- University of Wisconsin, Madison
- Westinghouse Materials Center for Excellence

Part I, Section C.4 of this FOA describes application options for projects requiring NSUF capabilities. Applicants may request R&D support and NSUF no-cost access in a "joint" NSUF R&D project. Applicants may also request just NSUF no-cost access in a NSUF Access Only project.

NSUF Sample Library - The NSUF sample library is a cataloged collection of irradiated materials and is a critical component of the NSUF. The library was established to reduce costs and take advantage of new ideas and future analysis techniques and equipment. Researchers are encouraged to use the sample library materials to develop research concepts. The catalog of available materials is available under the "User Resources" tab located at https://atrnsuf.inl.gov/default.aspx?enc=WmcQS2jsT4P1vYd9vnRLlcdPHLQHTshFnS6MJNvpZDMmGO5eF+Ig4kH+bSAp2x3dc9nN/Dl7wiOFJzCtavcs4HrSvmKHY89V8TnLvI55a3NMVdvBOtkFHK8reHG6epqW. In order to continue the expansion of the sample library, the NSUF Program Office may recommend irradiating a larger number of samples than required for the proposed research. These samples will be added to the sample library. In addition, all specimens remaining after three years of PIE will be moved into the sample library. Principal Investigators (PIs) of all future awarded applications to study non-generic or non-standard specimens added to the library from previous awarded irradiation tests will be put in contact with the PI(s) of the project that produced the non-generic or non-standard specimens for potential collaboration.

The NSUF capabilities are described in detail at https://atrnsuf.inl.gov/.

B. RELATED COLLABORATIVE OPPORTUNITIES

Utilization of acquired equipment and infrastructure, as a result of other collaborative opportunities, may enhance an R&D project. Therefore, opportunities exist to leverage equipment and infrastructure capabilities as outlined below.

Scientific Infrastructure Support for Consolidated Innovative Nuclear Research (Infrastructure).
DOE-NE funds university research reactor upgrades and general scientific infrastructure (GSI) support as part of a separate FOA (DE-FOA-0001130). The Infrastructure FOA seeks applications from U.S. universities and national laboratories to support equipment and infrastructure needs. NE is facilitating the ability of university researchers to coordinate and enhance their proposed R&D applications in response to this CINR FOA with equipment and infrastructure applications made in response to the Infrastructure FOA, as appropriate and as described below.

University researchers may submit a separate application to DE-FOA-0001130 to request related equipment. Applications submitted through this joint mechanism will be reviewed and ranked according to the criteria and processes described in the respective FOA. As funding permits,

applications selected by both review processes will be funded. Both applications must be successful for either to be considered for award.

C. FUNDING OPPORTUNITIES

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

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

1. **U.S. University-led Program and/or Mission Supporting 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 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 must also support the NE mission. MS R&D activities could also produce breakthroughs in nuclear technology or could including 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 workscopes contained in Appendix A of this FOA.

2. **U.S. University-, National Laboratory-, or Industry-led Program and/or Mission Supporting R&D Projects** – These funding opportunities are available to teams led by either U.S. university, national laboratory, or U.S.-incorporated industry PIs, who are invited to propose research projects in response to this area of the FOA that meet the objectives of the NEET CTD Program as identified by the above general PS and MS definitions and the specific PS and MS research objectives described in the workscopes contained in Appendix B of this FOA.

3. **U.S. University-led Integrated Research Project (IRP) R&D** – IRPs comprise a significant element of DOE's innovative nuclear research objectives and represent the PD component of the NE strategy to provide R&D solutions most directly relevant to the near-term, significant needs of the NE R&D programs. IRPs are significant projects within specific research areas. IRPs are intended to develop a capability within each area to address specific needs, problems, or capability gaps identified and defined by NE. These projects are multidisciplinary and require multi-institutional partners. IRPs may include a combination of evaluation capability development, research program development, experimental work, and computer simulations. IRPs are intended to integrate several disciplinary skills in order to present solutions to complex systems design problems that cannot be addressed by a less comprehensive team.

Although a proposing team must be led by a lead university PI and include at least one additional university collaborator, the proposed project team may include multiple universities and non-university partners (e.g., industry/utility, minority-serving institution (MSI), national laboratory, underrepresented group, and international). U.S. university PIs are invited to propose research projects in response to this area of the FOA and the associated PD workscopes contained in Appendix C of this FOA.

4. **Advanced Test Reactor National Scientific User Facility Access Only Projects** – NSUF access project applications will require a Letter of Intent (LOI) in addition to the pre-application and eventual full application. NSUF project applications will also require a feasibility review in addition to the relevancy and technical reviews. Very important aspects of NSUF applications are described in Appendix F 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 https://atrnsuf.inl.gov/.

   The NSUF does not provide funding to the proposing researcher to support salaries, tuition, travel, etc. Those seeking joint NSUF-supported access to capabilities as well as PS and/or MS R&D research funding should refer to item 4a. of this Section.

   All awarded NSUF access projects will be fully funded for the entire duration of the project. NSUF access project attributes:

   - 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 applicable sections of this FOA (see summary in item 4a. below)
   - U.S. universities, national laboratory and industry PIs may apply for only NSUF access without a joint request for R&D financial support (see summary in item 4b. below)

   4a. *Joint NSUF Access and PS/MS R&D Projects* – Joint NSUF Access and PS/MS R&D projects involve both a request for funding for a PS or MS R&D proposal in response to areas 1 and/or 2 above and the associated workscopes contained in either Appendix A or B of this FOA, as well as a request for NSUF access in response to this area of the FOA and in accordance with the provisions of Appendix F. Since NSUF projects involving reactor neutron irradiation 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 PS or MS R&D research support, though limited to a total of three years of funding, may request a project period of performance to spread the funding over the entire length of the project. For irradiation only, PIE only, and beamline applications, a standard continuous funding profile should remain adequate.

   4b. *NSUF Access Only Projects* – Projects not requiring R&D financial support may apply for NSUF access only projects in response to this area of the FOA and the

associated workscopes contained in Appendix D of this FOA, wherein only no-cost access to capabilities are sought to perform research in nuclear science.

Additional information on the NSUF process is included in Appendix F.

As described above, workscopes for the respective FOA areas may be found in the appendices to this FOA as follows:

- Appendix A: "Workscopes for U.S. University-led Program and/or Mission Supporting R&D Projects" – University Lead; project proposals may request either R&D support only or R&D support and associated NSUF access
- Appendix B: "Workscopes for U.S. University-, National Laboratory-, or Industry-led Program and/or Mission Supporting R&D Projects" – University, National Laboratory, or Industry Lead; project proposals may request either R&D support only or R&D support and associated NSUF access
- Appendix C: "Workscopes for U.S. University-led Integrated Research Project (IRP) R&D" – University Lead; project proposals may request R&D support only
- Appendix D: "Workscopes for Advanced Test Reactor National Scientific User Facility Access Only Projects" - University, National Laboratory, or Industry Lead; project proposals may request NSUF access only

DOE has significant interest in leveraging multiple needs to the extent possible. Accordingly, Appendix E provides a description of key data needs for validating advanced modeling and simulation tools being developed by NE. Researchers should evaluate their applications in light of these data needs and highlight any potential for capturing key data.

Note: Access to the Intermediate Voltage Electron Microscope (IVEM) facility at ANL is not guaranteed beyond September 30, 2015.

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 (see Part VI, Section B.6).

The NSUF award and access process is described in Appendix F.

B. ESTIMATED FUNDING

The estimated amounts identified for each of the four FOA areas is contingent upon Congressional appropriations and is subject to change.

1. **U.S. University-led Program and/or Mission Supporting R&D Projects**

DOE currently estimates that it will fund approximately $27.5 million in awards for this FOA area.

2. **U.S. University-, National Laboratory-, or Industry-led Program and/or Mission Supporting R&D Projects**

DOE currently estimates that it will fund approximately $12 million in awards for this FOA area.

3. **U.S. University-led Integrated Research Project (IRP) R&D**

DOE currently estimates that it will fund approximately $13 million in awards for this FOA area.

4. **Advanced Test Reactor National Scientific User Facility Access Only Projects**

DOE currently estimates that it will fund approximately $3.7 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:

1. **U.S. University-led Program and/or Mission Supporting R&D Projects**

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

Program Supporting: up to $800,000 (3-year project), except as explicitly noted in individual workscopes.

Mission Supporting: up to $400,000 (3-year project).

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

None.

2. **U.S. University-, National Laboratory-, or Industry-led Program and/or Mission Supporting R&D Projects**

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

Program Supporting: up to $1,000,000 (3-year project), except as explicitly noted in individual workscopes.

Mission Supporting: up to $500,000 (3-year project).

Floor (i.e., the minimum amount for an individual award made under this announcement):

None.

3. U.S. University-led Integrated Research Project (IRP) R&D

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

Program Directed: up to $4,000,000 (3-year project), except as explicitly noted in individual workscopes

Floor (i.e., the minimum amount for an individual award made under this announcement):

None.

4. Advanced Test Reactor National Scientific User Facility Access Only Projects

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

Full Irradiation/PIE Project: $3.7M 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.

1. U.S. University-led Program and/or Mission Supporting R&D Projects

DOE anticipates making up to approximately 40 awards under this area.

2. U.S. University-, National Laboratory-, or Industry-led Program and/or Mission Supporting R&D Projects

DOE anticipates making up to 15 awards under this area.

3. U.S. University-led Integrated Research Project (IRP) R&D

DOE anticipates making 4 awards under this area (1 award per IRP workscope).

4. Advanced Test Reactor National Scientific User Facility Access Only Projects

DOE anticipates making 6 awards under this area.

E. ANTICIPATED AWARD SIZE

The anticipated award size for each of the four FOA areas are identified below. (Amounts represent anticipated maximum per award.)

1. U.S. University-led Program and/or Mission Supporting 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 workscope areas).

2. U.S. University-, National Laboratory-, or Industry-led Program and/or Mission Supporting 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 workscope areas).

3. U.S. University-led Integrated Research Project (IRP) R&D

DOE anticipates that awards will be up to $3,000,000 or $4,000,000 per project as stated in the individual workscope).

4. Advanced Test Reactor National Scientific User Facility Access Only Projects

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

Irradiation only: $500K to $1.0M
Full Irradiation /PIE: $500K to $3.0M
PIE only: $50K to $500K
Beamline: $100K to $200K

F. PERIOD OF PERFORMANCE

DOE anticipates making awards for up to 3 years for each area with the exception of NSUF full irradiation/PIE projects that may take up to 7 years. Assuming DOE makes awards under this FOA by September 2015, successful applications shall begin no later than October 1, 2015; additionally, each successive budget period within the project period of performance should begin on October 1st of each year during the overall project period of performance. 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, 2015, 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 four areas defined in Part I, Section A.2.C. of 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.

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 U.S. DOE-NE will evaluate any such proposed partnerships as part of its program relevancy evaluation and scoring. The following link provides the current list of MSI: http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html.

No more than 20 percent of the total funds provided by the government to a university (excluding NEET CTD) can go to a non-university collaborator.

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 projects).

[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.

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-Operated Government-Owned laboratories (GOGOs) 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 GOGOs 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.

2. **U.S. Incorporated Foreign Entities (for projects under NEET CTD or NSUF)**

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 following:

Other than as provided in the "Individuals" or "Domestic Entities" sections above, all prime recipients (U.S. university-, national laboratory-, or industry-led PS and/or MS projects only) receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a state or territory of the United States. If a foreign entity applies for funding as a prime recipient, it must designate in the full application a subsidiary or affiliate incorporated (or otherwise formed) under the laws of a state or territory of the United States to be the prime recipient. The full application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate.

3. **Incorporated Consortia (for projects under NEET CTD or NSUF)**

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

4. **Unincorporated Consortia (for projects under NEET CTD or NSUF)**

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-, national laboratory-, or industry-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 United States. The eligibility of the consortium will be determined by the eligibility of the prime recipient/consortium representative.

5. **Application Restrictions**

PIs with a currently funded IRP; who have three or more R&D projects that will still be active after December 31, 2015; or who have a no-cost extension (NCE) on any DOE-NE funded project (excluding Infrastructure) which will still be active beyond December 31, 2015, are ineligible to apply to any area of this FOA as a lead PI, but are eligible to participate as a collaborator.

An academic PI cannot be included in more than six pre-applications with no more than three applications as the primary PI. Additionally, a PI may have no more than one IRP or three R&D projects funded at any time, and may therefore not submit more full applications than would be allowed by these restrictions should these applications be selected for funding. Further, applications submitted in response to PS and/or MS research requested by the NEET CTD are limited to three pre-applications per entity per objective area. If an academic PI is designated as the lead, these submissions will count toward the above overall university researcher limitation of being associated with no more than six pre-applications total in response to all areas of this FOA, with no more than three of those associations being as the lead PI.

For IRPs, an applicant is ineligible to submit an application as the PI if (s)he is designated as PI for more than one currently funded DOE-NE project that will still be active beyond December 31, 2015. Eligibility Flowchart

Applications requesting NSUF access and R&D support will be evaluated on a case-by-case basis with respect to these eligibility requirements.

Access Only requests for NSUF are not bound by these eligibility restrictions.

B. COST SHARING

For applications led by universities, cost sharing is encouraged, but not required. If cost sharing is provided, see 10 CFR 600 for the applicable cost sharing guidance and Part VIII, Section H below.

For applications led by all other entities (i.e. other than universities and FFRDCs), the provisions of the Energy Policy Act of 2005, Section 988, a cost share of at least 20% of the total allowable costs (TAC) 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 TAC of the project) and must come from non-Federal sources unless otherwise allowed by law. (See 10 CFR 600.30 for

more information on the cost sharing requirements.)

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

C. OTHER ELIGIBILITY REQUIREMENTS

FFRDC Contractors

FFRDC contractors may be proposed as a lead institution 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 a 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: Letter of authorization not required for NSUF Technical Leads unless the Technical Lead 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 field work proposal system and other FFRDC contractors through an interagency agreement with the sponsoring agency.
- *Cost Share.* 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 1. Summary of Parts II and III.

		Applicable Workscope Appendix	Estimated Available Budget	Maximum Award Size	Project Duration	Optional Tie to GSI	Optional Tie to NSUF	Collaboration
University-led NEUP Projects (Area 1)	**Program Supporting**	Appendix A	$27,500,000	$800,000	Up to 3 years	Yes	Yes	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.
	Mission Supporting			$400,000				
University-, National Laboratory-, or Industry-led NEET CTD Projects (Area 2)	**Program Supporting**	Appendix B	$12,000,000	$1,000,000	Up to 3 years	Yes (if led by a university)	Yes	
	Mission Supporting			$500,000				
University-led Integrated Research Projects - NEUP (Area 3)	**Program Directed**	Appendix C	$13,000,000	$4,000,000	Up to 3 years	No	No	
Joint NSUF / NEUP (or) NEET CTD R&D Projects (Area 4a)	**Program Supporting**	Appendices A & B		Refer to maximum award size of the project funding and NSUF funding.	Up to 7 years	Yes		
	Mission Supporting							
NSUF Access Only (Area 4b)		Appendix D	$3.7M	$3.7M	Up to 7 years	No		N/A

PART IV - APPLICATION AND SUBMISSION INFORMATION

Note: The following requirements apply to all four areas defined in Part I, Section A.2.C. of this FOA unless specific requirements are identified.

A. ADDRESS TO REQUEST APPLICATION PACKAGE

Application forms and instructions are available at the NEUP website. To access these materials, 1) go to http://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) click on "Create New Application" for the type of application you are creating.

Apply at http://www.NEUP.gov.

B. LETTER OF INTENT AND PRE-APPLICATION

1. Letter of Intent (Mandatory for NSUF Projects Only)

LOIs must be submitted by the date and time specified in Part IV, Section E.1. Pre-applications for NSUF projects will not be accepted without submittal of a LOI by the due date.

All NSUF applications must be 1) initiated with a LOI and 2) generated in close collaboration with a Technical Lead from the NSUF facility to define scope and feasibility of the project. Awarded NSUF projects are to be fully funded for the entire duration of the project; thus, where applicable, a firm cost estimate must be prepared for the NSUF portion of the project in addition to the required budget for the PS or MS R&D funding. Since the cost estimate for the NSUF provided workscope to be included in the full application must be obtained from the particular NSUF facility or facilities where the work is to be performed, the application must be generated in close collaboration with a Technical Lead from the NSUF facility wherein the scope and feasibility of the project are established. The scope of work and the cost estimate are important considerations during the feasibility review (outlined in Part V, Section A.2). It is imperative that all potential proposers establish immediate contact with a Technical Lead when preparing the pre-application to produce the most accurate feasibility result. **Pre-applications will not be accepted without submission of a LOI identifying the Technical Lead and NSUF facility to be used by the date and time specified in Part IV, Section E.1.**

In addition to the NSUF Technical Lead, LOIs should include the following:

- Title of the project
- Proposing and associated institution
- Co-PIs and associated institutions
- Type of project (full irradiation/PIE, irradiation-only, PIE-only, or beamline)
- Type of R&D support requested (NSUF Facility Access Only, Program Supporting and NSUF, Mission Supporting and NSUF)
- 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 https://atrnsuf.inl.gov/. For assistance in identifying a NSUF Technical Lead or facility POC, please contact NSUF staff members listed on the website.

LOI Submittal Instructions

Application forms and instructions are available at the NEUP website. To access these materials, 1) go to http://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 2015 NSUF Letter of Intent” and click on “Create New Application” for the type of

application you are creating.

LOIs are to be prepared using standard 8.5" X 11" paper with 1-inch margins (top, bottom, left, right), using a font size no smaller than Times New Roman 11 point.

2-page limit. Name File: 2015 LOI "Insert ID #"

2. Pre-applications (Mandatory except for IRPs)

Pre-applications are a mandatory requirement for Program and/or Mission Supporting and/or NSUF Projects (Appendix D) for U.S. university-, national laboratory-, or industry-led projects. Pre-applications are not required for Program Directed IRPs. Pre-applications must be submitted by the date and time specified in Part IV, Section E.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.

Pre-applications are to be prepared using standard 8.5" X 11" paper with 1-inch margins (top, bottom, left, right), using a font size no smaller than Times New Roman 11 point.

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

a. **Pre-application Narrative**

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

- Title of project.
- Technical Workscope Identification (e.g. FC-1.1). The PI is responsible for selecting the appropriate workscope, and this area may not be changed between the pre-application and full application.
- Name of Project Director/PI(s) and associated organization(s).
- A summary of the proposed project, including a description of the project and a clear explanation of its importance and relevance to the objectives.
- Major deliverables and outcomes the R&D will produce.
- Estimated cost of project (not including value of NSUF access).
- Timeframe for execution of proposed project (specify if the R&D is for a one-, two-, or three-year period or up to seven years for NSUF).
- Specific facilities and equipment access requirements (NSUF only).

3-page limit. Name File: 2015 RPA Narrative "Insert ID #"

b. **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 can contain brief biographies of staff and descriptions of the facilities wherein the research will be conducted. Please indicate within this section if 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).

2-page limit. Name File: 2015 RPA Benefit of Collaboration "Insert ID #"

3. Agreement Requirements

Each institution serving as a team member to the proposed project must be identified in the pre-application, with their commitment made to collaborate in the FOA process.

C. CONTENT AND FORM OF APPLICATION: PS, MS, PD, AND NSUF FULL APPLICATIONS

Applicants must complete the mandatory forms and any applicable optional forms (e.g., Disclosure of Lobbying Activities (SF-LLL)) in accordance with the instructions on the forms and the additional instructions below. Files that are attached to the forms must be in Adobe Portable Document Format (PDF) unless otherwise specified in this announcement.

Note: The review process for full applications (PS/MS R&D) is a semi-blind process. Please be sure to review the requirements below carefully as non-compliant applications may be excluded from review.

1. Point of Contact (POC) Information Sheet

This form should be completed identifying key personnel and points of contact regarding the application should it be selected for award. This includes key business office personnel.

Name File: 2014 CFA POC "Insert ID #.pdf

2. SF 424 (R&R)

Applicants shall complete the SF424 (R&R) form available at www.NEUP.gov and upload a completed PDF copy of the form with the application.

Name File: 2015 CFA SF424RR "Insert ID #.pdf"

3. RESEARCH AND RELATED Other Project Information

Applicants shall complete items 1 – 6 on the Research and Related Other Project Information form available at www.NEUP.gov and upload a completed PDF copy of the form as well as

complete the NEUP application form (items listed below).

Name File: 2015 CFA R&R Other Project Information "Insert ID #.pdf"

4. Project Summary/Abstract (Use Provided Template)

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; the objectives of the project; a description of the project, including 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.

The project summary/abstract is to be prepared using standard 8.5" X 11" paper with 1-inch margins (top, bottom, left, right), using a font size no smaller than Times New Roman 11 point.

2-page limit. Name File: 2015 CFA Technical Abstract "Insert ID #.pdf"

5. Project Narrative

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

- Application title.
- Final Technical Workscope Identification (FC-1.1, RC-1, etc.).
- 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.
- 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 workscope.
- 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

workscope.

- Unique challenges to accomplishing the work and planned mitigations.
- Information, data, plans, or drawings necessary to explain the details of the application.

Note: References are included in the page limits.

The R&D technical narrative (Program/Mission Supporting and R&D application requesting NSUF access) shall NOT include the following information:

- Cost and pricing information.
- Identification, by individual name or name of institution, of any teaming partner or lead institution. Examples of acceptable ways of referring to partners will be posted on the NEUP website.
- Official name or title of facilities used to execute scope. Describe the facility by function and/or technical attributes such as an accelerator, a test reactor, etc.

Note: For applications requesting NSUF access, NSUF facilities may be named.

10-page limit for Program/Mission Supporting and NSUF Access Only; 15-page limit for R&D applications requesting NSUF access; 50-page limit for Program Directed IRPs.

Name File: 2015 CFA Technical Narrative "Insert ID #.pdf"

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 the PI and collaborators, the applicant shall provide a brief vita that lists the following:

- Contact information.
- Education and Training: Undergraduate, graduate, and postdoctoral training. Provide institution, major/area, degree, and year.
- Research and Professional Experience: Beginning with the current position list, in chronological order, 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 5 professional and scholarly activities related to the effort proposed.

2-page limit for each. Name File: 2015 CFA "Last Name of Individual" "Insert ID #.pdf"

Technical expertise and qualifications are to be provided for a maximum of five individual participants, whether to receive funding or not (including consultants or national laboratory personnel). All participants performing work on the project must be listed on the application form but do not need to be represented in this section. This would typically not include the NSUF support staff.

7. Benefit of Collaborations

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. It can contain brief biographies of staff and descriptions of the facilities wherein the research will be conducted. Please indicate within this section if 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).

2-page limit for Program Supporting, Mission Supporting, and NSUF projects; 4-page limit for Program Directed IRPs. Name file: 2015 CFA Benefits of Collaboration "Insert ID#.pdf"

8. Capabilities

Infrastructure Requirements: In a separate document, the applicant shall identify the infrastructure (e.g., facilities, equipment, and instrumentation) required to execute the proposed scope of work. 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.

> **Note: Access to the Intermediate Voltage Electron Microscope (IVEM) facility at ANL is not guaranteed beyond September 30, 2015.**

If the applicant is requesting funds through the GSI FOA (DE-FOA-0001130) to support this research, provide summary detail of the request here.

See the electronic application submission form for document guidance. This FOA allows the applicant to propose the purchase of any needed equipment to conduct the proposed work.

2-page limit. Name file: 2015 CFA Capabilities "Insert ID#.pdf"

9. Letters of Support (Program Directed IRPs only)

IRPs are expected to foster and encourage robust interaction with collaborators to accomplish the scope of R&D defined by this FOA. Applicants are encouraged to provide information regarding their plans to create a research environment that promotes diverse collaboration, when appropriate, to enable organizational cognizance of international capabilities, industry/utility readiness, technology transfer, and assisting the transition of developed technologies to industrial development.

A letter of support from non-Federal partners (e.g., industry, utility, international) is required to describe the level and type of support contemplated for the project.

The applicant shall include letters of support on company stationery and be signed by an appropriate company official.

Name File: 2015 CFA Letter of Support "Insert ID#.pdf"

10. Budget Documents

- **Research and Related Budget (TOTAL FED & NON-FED)**

  Complete the Research and Related Budget (Total Fed & Non-Fed) form in accordance with the instructions on the form (Activate Help Mode to see instructions) and the following instructions. You must complete a separate budget for each year of support requested. The form will generate a cumulative budget for the total project period. You must complete all the mandatory information on the form before the NEXT PERIOD button is activated. You may request funds 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 G.).

  Name File: 2015 CFA Budget "Insert ID #xls"

- **R&R Subaward Budget Form (TOTAL FED & NON-FED)**

  Budgets for subrecipients, other than DOE FFRDC Contractors. Applicant must provide a separate cumulative R&R budget for each subrecipient that is expected to perform work estimated to be more than $100,000 or 50 percent of the total work effort (whichever is less). Use up to 10 letters of the subrecipient institution's name as the file name.

  Name File: 2015 CFA Subaward Budget "Insert ID #xls"

- **Budget for DOE/NNSA Federally Funded Research and Development Center (FFRDC) Contractor, If Applicable**

  If a DOE/NNSA FFRDC contractor is to perform a portion of the work, applicant must provide a DOE Field Work Proposal (FWP) in accordance with the requirements in DOE Order 412.1 Work Authorization System. This Order and the DOE Field Work Proposal form are available at http://energy.gov/management/office-management/operationalmanagement/financial-assistance/financial-assistance-forms.

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

  Name File: 2015 CFA FWP "Insert ID #.pdf"

- **Budget Justification**

  Provide the required supporting information for all costs required to accomplish the project, including the following costs (See R&R instructions): 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 your budget request. Attach a single budget justification file for the entire project period in Field K. The file automatically carries over to each budget year.

  Name File: 2015 CFA Budget Justification "Insert ID #.pdf"

11. Additional Attachments

- **Current and Pending Support (not required by national laboratory applicants)**

  As requested by the submission form, applicant shall identify all federal funding sources by agency source, project name, monetary amount, and length of term that are pending or currently in place for the university PI or collaborators within the past five years.

  Name File: 2015 CFA Current and Pending Support "Insert ID #.pdf"

- **Data Validation Needs**

  Researchers should evaluate their applications in light of the data needs for verification and validation of modeling and simulation tools identified in Appendix E and highlight any potential for capturing key data.

Name File: 2015 CFA Data Validation "Insert ID #.pdf"

- **Environmental Checklist**

  Applicants must complete the environmental checklist available at www.NEUP.gov. The environmental checklist will not include the NSUF capabilities.

  Name File: 2015 CFA Env "Insert ID #.pdf"

- **Conflict-of-Interest Statement**

  Conflicts of interest may exist due to previous efforts performed by the Labs or assistance provided in program direction and other mission related activities. Accordingly, each applicant (or subapplicant) that is a national laboratory or DOE/NNSA and/or non-DOE FFRDC must identify any potential conflicts of interest; fully explain the conflict, whether you feel it is significant or not, along with your rationale; and how you will avoid, neutralize, or mitigate the potential conflict.

  Name File: 2015 CFA COI "Insert ID #.pdf"

- **Authorization for DOE/NNSA FFRDCs**

  (Required for national laboratories, DOE/NNSA and non-DOE FFRDC applicants and subrecipients.)

  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, and will not place the laboratory in direct competition with the domestic private sector."

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

  Name File: 2015 CFA CO Authorization "Insert ID #.pdf

- **DISCLOSURE OF LOBBYING ACTIVITIES (SF-LLL)**

  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 SF-LLL, "Disclosure Form to Report Lobbying."

Name File: 2015 CFA SF-LLL "Insert ID #.pdf"

- **Certifications and Assurances (University Applicants Only)**

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

  File Name: 2014 CFA Cert & Assurances "Insert ID #.pdf"

Federal and Technical POCs for FY 2015 can be found at https://inlportal.inl.gov/portal/server.pt/community/neup_home/600/FY15_R&D_Technical_Points_of_Contact and https://inlportal.inl.gov/portal/server.pt/community/neup_home/600/FY15_IRP_Technical_Points_of_Contact.

Table 2. Summary of Full Application Required Forms/Files.

Name of Document	Format	File Name
POC Information Sheet	Form	2014 CFA POC "Insert ID #.pdf
SF424 (R&R)	Form	2015 CFA SF424RR "Insert ID #.pdf"
Research and Related Other Project Information	Form	2015 CFA R&R Other Project Information "Insert ID #.pdf"
Project Summary/Abstract	PDF	2015 CFA Technical Abstract "Insert ID #.pdf"
Project Narrative	PDF	2015 CFA Technical Narrative "Insert ID#.pdf"
Other Attachments	PDF	See Below
Vitae - Technical Expertise and Qualifications (2 pages each)	PDF	2015 CFA "Last Name" "Insert ID #.pdf"
Capabilities (2 pages)	PDF	2015 CFA Capabilities "Insert ID#.pdf"
Benefits of Collaborations (PS/MS/NSUF - 2 pages; PD - 4 pages)	PDF	2015 CFA Benefits of Collaboration "Insert ID#.pdf"
Letters of Support (Program Directed IRPs only)	PDF	2015 CFA Letter of Support "Insert ID#.pdf"
Current and Pending Support	PDF	2015 CFA Current and Pending Support "Insert ID#.pdf"

Name of Document	Format	File Name
Data Validation Needs	PDF	2015 CFA Data Validation "Insert ID #.pdf"
Environmental Checklist	PDF	2015 CFA Env "Insert ID #.pdf"
Conflict-of-Interest Statement, applicable to National Laboratories, DOE and Non-DOE FFRDC applicants and subapplicants	PDF	2015 CFA COI "Insert ID #.pdf"
Authorization for DOE/NNSA FFRDCs	PDF	2015 CFA CO Authorization "Insert ID #.pdf"
Research and Related Budget (Total Fed + Non-Fed)	Form	2015 CFA Budget "Insert ID #xls"
R&R Subaward Budget (Total Fed + Non-Fed), if applicable	Form	2015 CFA Subaward Budget "Insert ID #.pdf"
Budget for DOE National Laboratory Contractor or FFRDC, if applicable	PDF	2015 CFA FWP "Insert ID #.pdf"
Budget Justification	PDF	2015 CFA Budget Justification "Insert ID #xls"
SF-LLL Disclosure of Lobbying Activities, if applicable	Form	2015 CFA SF-LLL "Insert ID #.pdf"
Certifications and Assurances	Form	2015 CFA Cert & Assurances "Insert ID #.pdf"

D. 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 complying with national policies prohibiting discrimination (See 10 CFR Part 1040.5).
- Representation of Limited Rights Data and Restricted Software, if applicable.
- Commitment Letter from Third Parties Contributing to Cost Sharing, if applicable.

E. SUBMISSION DATES AND TIMES

1. Letter of Intent Due Date (Mandatory for NSUF Projects)

LOIs for NSUF access are required by September 11, 2014 at 8:00 p.m. Eastern Time (ET). The LOI shall be submitted as required in Part IV, Section B.1.

2. Pre-Application Due Date

Applicants must submit a pre-application by October 2, 2014 at 8:00 p.m. ET. The pre-application shall be submitted as required in Part IV, Section B.2. Applicants who fail to submit a pre-application will be determined non-responsive and ineligible for a comprehensive merit review.

3. Full Application Due Date

Full applications must be received by February 19, 2015, not later than 8:00 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.

F. INTERGOVERNMENTAL REVIEW

This program is not subject to Executive Order 12372 – Intergovernmental Review of Federal Programs.

G. FUNDING RESTRICTIONS

Funding for all awards and future budget periods is contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority.

Cost Principles. Costs must be allowable, allocable, and reasonable in accordance with the applicable Federal cost principles referenced in 10 CFR 600. The cost principles for "for profit" organizations are in FAR Part 31.

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 referenced in 10 CFR 600. 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.

H. OTHER SUBMISSION AND REGISTRATION REQUIREMENTS

1. Where to Submit

Note: Applications must be submitted through www.NEUP.gov to be considered for award.

Submit electronic applications through the "Applications" function at www.NEUP.gov. If you have problems completing the registration process or submitting your application, call 208-526-1507 or send an email to NEUP@inl.gov.

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 valid time-frame, 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

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 3. All applications submitted under this FOA will be reviewed and scored as described below.

First, a panel of programmatic experts will assess each pre-application's program relevancy and program priority to NE's R&D Program/Mission/NSUF workscopes. Scores will be assigned according to the following program relevancy and program priority attributes:

Relevancy Attributes:

- **High Relevance:** The project is fully supportive of, and has significant, easily recognized and demonstrable ties to, the NE mission and the relevant workscope 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, the NE mission and the relevant workscope 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, the NE mission and the relevant workscope 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, the NE mission and the relevant workscope 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 the NE mission or the relevant workscope area.

Program Priority:

Application relevancy scores 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**
- **Moderate Program Priority**
- **Low Program Priority**
- **No Program Priority**

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.

Merit Categories:

- **High Merit:** The project unquestionably advances the technical state of knowledge

and understanding of the NE mission or relevant workscope area, and is creative and based largely on original concepts. The scope can be executed fully in the facilities available within the proposed budget.

- **Moderate Merit:** The project advances the technical state of knowledge and understanding of the NE mission or relevant workscope 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 within the proposed budget.
- **Some Merit:** The project incrementally advances the technical state of knowledge and understanding of the NE mission or relevant workscope 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 within the proposed budget.
- **Low Merit:** The project recognizes the technical state of knowledge and understanding of the NE mission or relevant workscope 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 funding to execute.
- **No Merit:** The project does not advance or recognize the technical state of knowledge and understanding of the NE mission or relevant workscope area, and is not creative or original. The scope cannot be executed fully in the facilities available within the proposed budget.

The individual scores determined by evaluating each application against the above criteria will then be weighted as defined in Table 3 to determine an overall evaluation score for each application.

After considering the overall evaluation scores, available funding, and the other selection factors (see Part V, Section A.6) as needed, NE will make a final determination of applicants who will be invited to provide full applications. 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.

2. Feasibility Review (NSUF Projects Only)

The feasibility review is a very important part of the NSUF 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 by the NSUF Program Office will not be considered.

3. Initial Review Criteria of Full Application

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 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 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.

4. 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 listed in Item 6. 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 3. 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 workscope area and multiple technical peer reviewers will evaluate the project for technical merit. Effective partnerships will be incorporated into the program relevancy/priority evaluation.

Program Relevancy/Priority Attributes:

Same criteria used for PS/MS/NSUF pre-application evaluation phase. See Part V, Section A.1.

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 Scientific 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 scientific 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) resources available to the applicant in carrying out the project.

Criterion 3 – Applicant Team Capabilities, Experience, and Resources

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, relevance and depth of the organization's experience and capabilities, 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 within budget and on time with no significant 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 3. 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	
Merit Category	100%
Full Applications	
Scientific and Technical Merit	35%
Technical Quality of the Proposed R&D Project	35%
Team Capabilities, Experience, and Budget	30%
Peer Review Score	Sum of ratings x weights
Program Relevance/Priority[1] (Separate Review Process, Used for Both Pre-Applications and Full Applications)	**Percentage of Program Relevancy/Priority Review Score**
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 (Peer : Relevancy)** **Program Supporting: 65:35** **Mission Supporting: 80:20** **NSUF Access Only: 80:20**

[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.

5. Program Directed Merit Review – Full Application

Selection for the Program Directed IRP for U.S. university-led projects will be based on the following criteria and sub-criteria. The criteria are equally important.

Relevancy Attributes:

- **Program Factors:** Relation of the proposed project to the core research activities within the DOE-NE programs.
- **Cost Factors:** The degree to which award of the proposed project optimizes use of the available DOE funding to achieve NE program goals.
- **Collaboration Factors:** Potential for developing synergies between the proposed IRP and other DOE-NE research activities
- **Diverse Partnerships:** The degree to which MSIs, international and/or industry partners, and/or underrepresented groups, if any, contribute to the project's ability to support the relevant program element or overall NE mission.

  Note: Effective partnerships are not required for projects to be evaluated as unquestionably relevant, but effective partnerships will increase the relevance score by 1 to 5 points, not to exceed the maximum available relevancy points, based on meeting one of the following criteria: the project has 1) a substantive contribution by an industrial, international, underrepresented group, or MSI as lead or collaborator; 2) a demonstrable contribution by an industrial, international, underrepresented group, or MSI as lead or collaborator; or 3) some relevant partnership with an industrial, international, underrepresented group, or MSI as lead or collaborator.

Technical Merit Attributes:

Criterion 1 - Scientific and/or Technical Merit of the Project

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

Criterion 2 - Appropriateness of the Proposed Method or Approach

The appropriateness of the proposed IRP method or approach will be evaluated, including the extent to which the strategy and plan for the development and operation of the proposed IRP identifies an approach involving several senior/key personnel, the means for achieving integration on the IRP, and plans for leadership and guidance for the scientific and technical

direction. DOE shall consider whether the applicant presents a comprehensive management plan for a world-class program that encourages research—including high-risk, high-reward—as well as synergisms among investigators, thus demonstrating that the whole is substantially greater than the sum of the individual parts. The organization structure should delineate the roles and responsibilities of senior/key personnel and describes the means of providing external oversight and guidance for scientific and technical direction and approval of the research program. Additionally, DOE will also consider the following:

- The applicant's plans (if any) for education, outreach, and training in the proposed IRP are appropriate and, if needed, described as part of the scope.
- Appropriateness and reasonableness of applicant's plans (if any) for external collaborations and partnerships.
- The roles and intellectual contributions of the IRP lead PI, other investigator(s), and each senior/key person.
- Maximizing the use of other available facilities and existing equipment.
- Relation to existing and planned research programs at the host or collaborator institution.

Criterion 3 – Applicant Team Capabilities and Experience

The extent to which the applicant team provides objective evidence that it has, or can obtain, the professional resources and abilities to successfully complete the IRP project in a technically defensible manner. Current activities, relevance and depth of the organization's experience and capabilities, together with that of the PI, will be evaluated as it relates to the likely successful completion of the IRP. In evaluating this criterion, DOE will consider the extent to which the application demonstrates the following:

- The applicant's senior/key personnel have a proven record of research in the disciplines needed for success in the project.
- The proposed access to existing research space, instrumentation, and facilities at the host institutions and its partners are likely to meet the needs of the proposed IRP.
- There is adequate access to experimental and computational capabilities as needed to ensure successful completion of the proposed research.
- The lead institution and the senior/key personnel for the IRP have proven records of success in project, program, and personnel management for projects of comparable magnitude.
- The plan for recruiting any additional scientific and technical personnel including new senior staff, students, and postdocs is reasonable and appropriate.
- The IRP leadership has the capability to communicate effectively with scientists of all required disciplines.

- The IRP lead PI and senior/key personnel will be adequately involved in the proposed IRP, particularly taking into account their potential involvement in other major projects.

Criterion 4 - Reasonableness and Appropriateness of the Proposed Resources

The proposed budget will be evaluated to determine the reasonableness and appropriateness of requested resources from a technical perspective. DOE will consider whether the 1) requested funding aligns with the project description; 2) proposed costs are reasonable for the planned scientific program; 3) costs for existing and new equipment and instrumentation are realistic; and 4) all subawards, travel, student costs, and other ancillary expenses are adequately justified and estimated.

Table 4. PD IRP R&D Full Applications - Weighting of Evaluation Scores.

Criterion	
Technical Application – Peer Review	**Percentage of Peer Review Score**
Scientific and Technical Merit	25%
Appropriateness of the Proposed Method or Approach	25%
Applicant Team Capabilities and Experience	25%
Reasonableness and Appropriateness of the Proposed Budget	25%
Peer Review Score	Sum of ratings x weights
Relevance[1] (Separate Review Process)	**Percentage of Relevancy Review Score**
Program Factors	40%
Cost Factors	40%
Collaboration Factors	20%
Partnership Relevance	Up to 5 points, not to exceed the maximum relevancy points available.
Relevancy Score	Sum of ratings[2] x weights
Weighting	**Weighted Score Ratio (Peer : Relevancy) Program Directed 50:50**

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

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/maximizes use of available DOE-NE funding to achieve DOE program goals and objectives. This includes how those R&D and IRP projects support DOE-NE research; it may also include research portfolio diversity and/or how the projects support other complementary efforts which, when taken together, will best achieve program research goals and objectives.
- Application selection may optimize appropriate mix of projects to best achieve DOE-NE research goals objectives.
- Program Relevance and Priority to agency's programmatic needs.
- Cost/Budget considerations, including cost reasonableness of the proposed cost elements to achieve the proposed objectives, and availability of funding.
- The demonstrated ability of the applicant to complete projects in the specified timeframe. This includes the extent that applicant has awards in progress, or not completed, from DOE, from a previous year's FOA, or has existing no cost extensions.
- Past performance considerations including the type of project/work previously performed and how successful the applicant was at performing the project/work.
- Underrepresented groups and MSIs that submit a competitive application.
- Extent or degree to which projects provide a balanced programmatic effort and a variety of research capabilities among various sizes and kinds of organizations as well as their geographic distribution.
- NSUF availability/feasibility.

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.

B. SUMMARY OF THE REVIEW AND SELECTION PROCESS

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 peer and program evaluation process will produce a list of recommended projects for each workscope provided in Appendices A through D. DOE-NE will consider the overall evaluation results and subjective programmatic factors to select a final set of projects to be "invited" to provide a full application.

Note: 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 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.

2. PS/MS/NSUF Full Applications

Multiple peer reviewers will independently employ a semi-blind process to evaluate the applications in accordance with the peer review evaluation criteria described in this FOA. Also, a program relevancy/priority review process will be completed by DOE 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.

3. IRP Full Applications

Multiple peer and federal program reviewers will independently evaluate the applications in accordance with the review criteria and weighted as described above. DOE will consider the overall evaluation results and subjective programmatic factors to ultimately recommend applications for approval by the Selection Official.

4. Selection Official Considerations

The Selection Official will consider the merit review recommendations, subjective factors such as program policy considerations, and the amount of funds available to make final project selections.

C. ANTICIPATED NOTICE OF SELECTION AND AWARD DATES

DOE will strive to make selections within six to eight months after receipt of applications.

PART VI - AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

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 G 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.

2. Notice of Award

An Assistance Agreement issued by the Contracting Officer is the authorizing award document. 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 10 CFR part 600; 5) National Policy Assurances To Be Incorporated As Award Terms; 6) Budget Summary; and 7) Federal Assistance Reporting Checklist, which identifies the reporting requirements.

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. .

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. 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

1. Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 10 CFR 600 (See: http://ecfr.gpoaccess.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.

- **DUNS and SAM Requirements –** Additional administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR, Part 25 (see http://ecfr.gpoaccess.gov). Prime awardees must keep their data at System for Award Management (SAM) current. Subawardees at all tiers must obtain Data University Numbering System (DUNS) numbers and provide the DUNS to the prime awardee before the subaward can be issued.
- **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://ecfr.gpoaccess.gov). Prime awardees must register with the new 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.

2. Special Terms and Conditions and National Policy Requirements

Note: Awards made under this FOA after December 26, 2014, will follow 2 CFR 200 for the general terms and conditions.

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.

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 university researcher.

- **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 if requested.

- **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 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 journal peer review requirements. The peer reviews shall be documented and maintained by the university. Peer review documentation and results shall be provided to DOE, if requested.

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.

4. Lobby Restrictions

By accepting funds under this award, you 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.

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.
- No officer or agent of the corporation has been convicted of a felony criminal violation for an offense arising out of actions for or on behalf of the corporation under Federal law in the past 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.

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 Statement of Substantial Involvement may be negotiated with the recipient prior to award. It will be something similar to the following:

- **Recipient's responsibilities:**
    - Performing the activities supported by this award, including providing the required personnel, facilities, equipment, supplies, and services (except as otherwise specified in the award).
    - Defining approaches and plans, submitting the plans to DOE for review, and incorporating DOE comments.
    - Managing and conducting the project activities, including coordinating with a DOE management and operating (M&O) contractor and/or FFRDC on activities performed under the M&O contract that are related to the project.
    - If requested, attending program review meetings and reporting project status.
    - Submitting technical reports as stated in the Federal Assistance Reporting Checklist, and incorporating DOE comments.
    - Updating project costs and performance data in the DOE-NE Performance

Information Collection System (PICS). Recipient personnel will update project information at the work breakdown level agreed to in separate negotiations. Schedules will be developed at the appropriate level of detail to define work, key milestones will be provided with the reasonable costs assigned, and personnel will be assigned clear responsibility to update and submit work package information.

- Presenting the project results at appropriate technical conferences or meetings as directed by the DOE Project Officer.

- **DOE responsibilities:**
  - Reviewing, in a timely manner, project plans and redirecting the work effort if the plans do not address critical programmatic issues.
  - If necessary, conducting 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.
  - Serving as scientific/technical liaison between awardees and other program or industry staff.

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. The checklist is available at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms under Award Forms.

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 workscopes may be submitted to the DOE federal and technical POCs listed in Appendices A, B, C, and D. Answers to questions submitted that contain information about the FOA or the FOA process that would be necessary for the preparation of applications will be posted at 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 Q&As as early in 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. Shawn Tinsley
E-mail: tinslesm@id.doe.gov

C. INFORMATIONAL WEBINAR

DOE, Office of Nuclear Energy, holds a webinar each year to discuss changes to its FOAs and workscope areas for upcoming opportunities. Applicants can watch the live webinars and submit questions to be answered in real time. All webinar presentations are recorded and posted on www.NEUP.gov for review by applicants. Webinar presentations from past years can also be found in the "Archive" section of the neup.gov website.

PART VIII - OTHER INFORMATION

A. MODIFICATIONS

Notices of any modifications to this announcement will be posted on www.NEUP.gov. It is recommended that you check the NEUP.gov site frequently 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 conflict-of-interest 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 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 (10 CFR Part 600 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 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/patents-licensing-and-patent-waivers 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 nonprofit organizations to retain title to subject inventions. Therefore, small businesses and nonprofit organizations do not need to request a waiver.

H. UNDERSTANDING COST SHARING REQUIREMENTS (NOT REQUIRED FOR UNIVERSITIES AND FFRDCS)

Department-wide cost sharing requirements are established by Section 988 of the Energy Policy Act of 2005 (EPAct). The DOE Financial Assistance Rules at 10 CFR 600 implement cost sharing requirements (see §600.30, §600.123, §600.224, or §600.313). 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).
2. 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 TAC 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) x (***total project cost***)
Cost Share = (20%) x ($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) x (total project cost)
Cost Share = (20%) x ($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 which 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 3 months before the original project end date.

K. CONFERENCE SPENDING

The recipient shall not expend funds for the purpose of defraying the cost to the United States Government of a conference [described in subsection (c) of the Consolidated and Further Continuing Appropriations Act, 2013] that was more than $20,000, or 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 that is not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded.

PART IX - APPENDICES/REFERENCE MATERIAL

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

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

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

Appendix D: Advanced Test Reactor National Scientific User Facility Access Only Projects

Appendix E: Data Needs for Validation

Appendix F: Accessing the Advanced Test Reactor National Scientific User Facility

Appendix G: Advanced Test Reactor National Scientific User Facility User Agreement

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

Experimental Validation of Gas-Cooled Reactor Simulations (RC-1)

(Federal POC – Steve Reeves & Technical POC – Hans Gougar)

Experimental Validation of Gas-Cooled Reactor Simulations is focused on providing high quality data for the validation of system and computational fluid dynamics models of high temperature gas-cooled reactor (prismatic or pebble bed) phenomena. These phenomena have been identified as relevant to core safety and performance but for which insufficient data exist for validating models and codes. They include: air and water ingress, core heat transfer, plenum-to-plenum heat transfer by natural circulation, heated two-component stratified flow in the outlet plenum, bypass flow between fuel or reflector blocks, dust and fission product transport in the reactor coolant system, and performance of reactor cavity cooling systems in cooling the pressure vessel (ex-core heat transfer).

Validation of codes that capture these phenomena requires the coordinated completion of a number of fundamental, separate effects (SET), mixed effects (MET) such as combined mass flow and heat transfer, and integral tests, all properly scaled to reproduce the thermal fluid conditions bounding gas-cooled reactor under nominal and accident scenarios. Integral testing facilities are generally large, long-term investments generally beyond the scope of NEUP awards, however, a few have been built for this purpose using other sources of funding. The High Temperature Test Facility (at Oregon State University), the Natural circulation Shutdown Test Facility (Argonne National Laboratory), and the Matched Index of Refraction Facility (Idaho National Laboratory) are examples of those available for integral tests that can complement the smaller and generally less expensive experiments that can be effectively conducted at universities.

Proposals are sought that will fill the gaps in the data needed for high temperature reactor code validation with appropriately scaled fundamental, SET, or MET experiments that complement those that have been, or can be, conducted at HTTF, NSTF, MIR, or other suitable integral facilities not identified here. Investigators who wish to propose new experiments using one or more of these facilities are strongly urged to coordinate with the Principal Investigators at those facilities before submitting the final proposal to obtain guidance on costs, schedule, and quality assurance.

Experimental investigations can and should be conducted in conjunction with pre-test and post-test simulations using system, computational fluid dynamics, or other suitable codes. Nonetheless, the emphasis is on the generation of high quality experimental data that can be used for the validation of different analysis codes rather than the development of those codes. All data and simulation results are to be uploaded (preferably in real-time if possible) and archived on the NGNP Data Management and Analysis System (NDMAS) hosted at the Idaho National Laboratory. Investigators are strongly urged to coordinate with INL personnel to link to NDMAS. Contact information for the INL and Integral Facility personnel can be obtained from the Points of Contact listed above).

All validation and verification benchmark problems must be performed using NQA-1 2008, with 2009 NRC-accepted paragraphs on quality assurance practices.

Advanced Technologies, Development and Demonstration (RC-2)

(Federal POC – Carl Sink & Technical POC – Bob Hill)

Advanced non-light water reactors differ from current commercial plants in their fundamental design features. This leads to new technological challenges but also allows designers to take advantage of additional passive safety features and inherent protections. Advanced reactor component development and analysis as well as innovative engineering techniques for operations and reliability are sought to increase levels of safety and robustness, present new functionalities, and improve system performance. Applications are sought that support the identified needs of the advanced reactor technology program including those applicable to advanced non-light water reactors in the following areas: develop and demonstrate advanced reactor technology solutions for hybrid energy systems, in-service inspection techniques for innovative reliability and maintenance applications, and alternative designs for heat exchangers (e.g. printed circuit, twisted tube designs). Experimental demonstration/validation is encouraged.

Advanced Structural Materials (RC-3)

(Federal POC – Bill Corwin & Technical POC – Sam Sham)

Specific areas of materials technology supporting the development of advanced reactor systems are recognized as needing additional research. In FY 2015, the areas of interest are specific to Alloy 709 as described below.

Alloy 709 is an austenitic alloy that has been down-selected for further evaluation by DOE's Advanced Reactor Technologies Program for sodium fast reactor applications because of significant potential improvement on reactor economics, safety margins, and design flexibility. The design lifetime for these applications is 60 years. Alloy 709 is a nitrogen-stabilized and niobium-strengthened alloy and is based on the Fe-20Cr-25Ni composition that provides excellent oxidation resistance at high temperatures while the niobium and nitrogen additions increase the tensile and creep strength.

RC-3.1: Creep and creep-fatigue deformation and grain boundary cavitation mechanisms

While it is anticipated that structural components of the reactor fabricated from Alloy 709 will operate at 550C it is desirable to develop accelerated testing to characterize creep and creep-fatigue behavior. Understanding deformation mechanisms (e.g. dislocation or diffusion controlled creep), microstructural evolution, and damage mechanisms (e.g. grain boundary cavitation) is critical to intelligently applying and interpreting data from accelerated testing. Fundamental understanding of the deformation and damage mechanisms is necessary to correlate behavior at higher temperature, for example 650C, and stress to the anticipated operating conditions for development of ASME Code allowable stresses.

The proposed research should focus on similarities or differences in the deformation and damage mechanisms and microstructural evolution characteristics between the accelerated test conditions and fast reactor operating conditions. Approaches might include novel experimental and characterization methods. The outcome of selected projects is expected to provide a validated approach to extrapolate from accelerated test conditions to fast reactor operating conditions in support of ASME Code allowable development.

RC-3.2: Creep and creep-fatigue crack growth mechanisms

A flaw evaluation procedure for the disposition of detected flaws during in-service inspection is an integral part of reactor operations, and hence the development of a flaw evaluation procedure is an important area to be addressed for the licensing of a sodium fast reactor.

While it is anticipated that structural components of the reactor fabricated from Alloy 709 will operate at 550C it is desirable to develop accelerated testing to characterize creep and creep-fatigue crack growth behavior. Understanding creep and creep-fatigue crack growth mechanisms in as-received and service-exposed material conditions is also critical to intelligently applying and interpreting data from accelerated testing and to correlate behavior at higher temperature, for example 650C, and stress to the anticipated operating conditions for development of flaw evaluation procedure.

The proposed research should focus on similarities or differences in the creep and creep-fatigue crack growth mechanisms between the accelerated test conditions and fast reactor operating conditions, and between data from as-received materials and materials that have undergone prior service conditions. Approaches might include novel experimental and characterization methods and engineering flaw evaluation analysis techniques. The outcome of selected projects is expected to provide a validated flaw evaluation procedure in support of sodium fast reactor licensing activity.

Program Supporting: Nuclear Reactor Technologies

MAaD & RISMC Integration: Models for Materials Degradation (RC-4)

(Federal POC – Rich Reister & Technical POC – Curtis Smith)

A unique challenge to light water reactor sustainability concerns aging of materials, including how to understand and manage potential degradation in a risk-informed manner. Currently, limitations exist in the applications of aging models in a risk analysis approach. Past applications include flow accelerated corrosion (e.g., NUREG/CR-5632) as applied to probabilistic risk analysis. However, these past attempts have been limited in scope and relied on older analysis methods. The Light Water Reactor Sustainability (LWRS) Program is developing predictive models based on modern computing techniques to support safe nuclear power plant operation including plant aging management programs and plant-owner/operator decision-making on long-term operation.

The LWRS Program has selected the MOOSE (Multiphysics Object Oriented Simulation Environment) framework as the basis for development of the "RISMC (Risk Informed Safety Margin Characterization) Toolkit" to enable faster model development and ease of coupling of the models needed for a specific simulation. One of the tools under development is the Grizzly components and structures aging models. Plans for Grizzly include simulation of damage evolution for the RPV, core internals, and concrete support and containment structures subjected to a neutron flux, corrosion, and high temperatures and pressures.

To support the development of Grizzly, the LWRS program seeks applications covering the development of predictive models for key forms of degradation relevant to extended service, and formulation of a MOOSE-based module incorporating this information. Materials of interest include (but are not limited to)

- concrete,
- cable insulation,
- reactor pressure vessel steels,
- core internal stainless steels,
- Ni-base alloy piping, and
- weldments

under relevant LWR operating conditions for operating periods to 60 years of service and beyond. Applications can include development of one or more of the predictive models as well as the associated MOOSE-based module(s). Applications should also include validation and verification; this is an essential component for success and relevance to the LWRS program.

The activities awarded under this workscope will be closely coordinated with and guided by the LWRS Program Materials Aging and Degradation (MAaD) and Risk Informed Safety Margin Characterization Pathways.

Information, Information and Control Systems (II&C): Computer Vision and Image Processing Technologies for Nuclear Power Plant Workers (RC-5)

(Federal POC – Rich Reister & Technical POC – Bruce Hallbert)

Research is sought to develop computer vision and image processing technologies that can be used in applications of nuclear power plant field workers. The types of applications sought are intended to be integrated with early generation (i.e., prototypes and beyond) computer-based procedures being developed and tested at participating nuclear power plants. Applications of interest include but are not limited to:

object recognition; positional accuracy determination; hazard proximity identification; detection of equipment and field conditions necessary to the performance of work; and other 'heads-up' capabilities that improve the efficiency and reliability of procedure execution as well as compliance with safety standards.

Computational Methodologies to Support Design and Analysis of Sodium-cooled Fast Reactors (RC-6)

(Federal POC – Thomas Sowinski & Technical POC – Tanju Sofu)

The R&D activities on computational methodologies under the DOE-NE's Advanced Reactor Technologies (ART) program is focused on development of modeling and simulation tools to study the Sodium-cooled Fast Reactor (SFR) core neutronics/thermal-hydraulics/structural performance during normal operations and postulated accidents. The objective is to raise the technical readiness of SFR concepts and support commercial deployment by a vendor. Modeling and simulation focus covers a range from neutronics analysis of complex reactivity feedback mechanisms to thermal-hydraulics analysis of very low Prandtl-number liquid metal flow and heat transfer to systems analysis of whole-plant dynamics. Code development activities include enhanced transient analysis and severe accident capabilities tailored to important SFR phenomena and behavior. Ongoing experiment-focused activities under the ART program include integral effects tests on ex-vessel cooling at Argonne's Natural-circulation Shutdown Test Facility (NSTF), and archiving of data from past integral transient testing in EBR-II, FFTF, and TREAT reactors to support code validation efforts.

To support development of an integrated and validated multi-physics analysis tool suite, contributions to development of advanced modules are being requested in following areas:

- Modeling pin-power reconstruction, temperature gradient, and reactivity feedback distributions within a SFR subassembly using transport based flux solutions for evaluating the steady-state thermal-hydraulic analysis and the bowing effect, and

- Modeling the mixing and thermal-stratification in large volumes (e.g., upper plena) following a scram, and its influence on natural circulation flow rates and decay heat removal in a pool type SFR.

Mission Supporting: Nuclear Reactor Technologies

Reactor Concepts RD&D (MS-RC-1)

(Federal POC – Thomas Sowinski & Technical POC – Bob Hill)

Development of new reactor concepts that may offer the potential for revolutionary improvements to reactor performance and/or safety is sought. Such advanced reactor concepts could include the incorporation of advanced systems or components into existing concepts (e.g., Generation-IV systems), inclusion of innovative design alternatives (e.g., new fuel type, nano-engineered coolants, etc.), or designs employing radically different technology options (e.g., advanced coolants, fuel, or operational regimes). Concepts could also include reactors with unique capabilities to address operational missions other than the delivery of base load electric power, such as industrial process heat, hybrid systems with multiple energy product lines, or mobile reactors. The scope of the proposed project should include a thorough viability assessment of the concept, a detailed technology gap analysis and a comprehensive technology development roadmap that identifies research needed on key feasibility issues.

Space Nuclear Power Systems R&D (MS-RC-2)

(Federal POC – Scott Harlow & Technical POC – Stephen Johnson)

The Space and Defense Power Systems program has designed, developed, built and delivered radioisotope power systems (RPS) for space exploration and national security applications for over fifty years. The program also supports technology development efforts for space reactor power systems for use on the surface of planets, in deep space, and for propulsion. The Department of Energy is currently supporting NASA technology development for space reactor power systems and for nuclear thermal propulsion. Space nuclear power systems enable missions that require a long-term, unattended source of electrical power and/or heat in harsh and remote environments. RPS systems are reliable, maintenance free, and capable of producing heat and electricity for decades. These systems convert the decay heat from Pu-238 into electricity.

Applications are sought for the development of a conceptual design for a reactor and the fuel to cover a range of power outputs from 2-3 kWe to 40 kWe for space nuclear applications that benefit NASA and National Security users. An emphasis should be placed on leveraging existing fuel and reactor designs to maximize the power per unit mass as well as minimize the total mass of the system. The reactor would be an enabling technology for the science to be accomplished and support for human exploration needs.

Innovative designs for the reactor, the fuel, and the power conversion means must take into consideration the restrictions placed on space applications. Ideas involving an integrated system approach or a major subsystem will be considered.

Additionally, applications are sought related to the possible use of Am-241 for heat sources for radioisotope power systems. Specifically, in the area of nuclear safety performance where much less is known about Am-241 versus Pu-238 with regard to interactions with the environment. There are several areas that are of particular interest: 1) investigation of release and transport mechanisms of Am-241 in the environment and understanding receptor pathways for dose assessments as part of nuclear risk assessments; and, 2) developing approaches and methodologies for nuclear risk assessment of space radioisotope power system applications.

Material Recovery and Waste Form Development (FC-1)

(See below for POCs)

This program element develops innovative methods to separate reusable fractions of used nuclear fuel (UNF) and manage the resulting wastes. These technologies, when combined with advanced fuels and reactors, form the basis of advanced fuel cycles for sustainable and potentially growing nuclear power in the U.S.

FC-1.1: ELECTROCHEMICAL SEPARATIONS
(Federal POC – Stephen Kung & Technical POC – Mark Williamson)

To enhance electrochemical separation process development and facilitate predictive model development relevant to nuclear fuel recycling via (1) determining fundamental thermodynamic properties (e.g., activity and electrochemical potential) of transuranic elements in molten salt systems; (2) deducing phase equilibria in binary and higher order molten salt systems that contain actinide halides; (3) determining parameters important to electrochemical systems such as the diffusion coefficient of actinide and fission product species in molten salt systems; and (4) establish the performance of materials in electrochemical systems proposed for used fuel treatment.

FC-1.2: MATERIALS RECOVERY
(Federal POC – Jim Bresee & Technical POC – Terry Todd)

Critical gaps exist in our knowledge underlying aqueous separations processes being considered currently for used fuel recycle for the separation of trivalent actinides (Am and Cm) from lanthanides.

Understanding is generally needed on control of actinide oxidation states, complexation of actinides in aqueous solution, and selectivity of solvent extraction systems for actinides, lanthanides, and fission products. For example, knowledge is very limited regarding redox mechanisms, structure of coordination complexes, and complex speciation in extraction solvents. Research should be directed toward questions dealing with structure, thermodynamics, and kinetics specifically dealing with established or developing process concepts such as ALSEP, SANEX, GANEX, advanced TALSPEAK, or methods making use of the high oxidation states of Am.

Development of new materials for the capture of volatile off-gas species, particularly tritium, iodine and krypton is needed. A fundamental understanding of the mechanisms with which the species is separated along with performance data to allow objective comparison on separation media and methods is desired. Development of models to predict performance of media and separation efficacy is also desired. Research is needed to enable "clean" separation of volatile species, i.e. very low or no cross contamination of species such as iodine and tritium.

FC-1.3: ADVANCED WASTE FORMS-1
(Federal POC – Kimberly Gray & Technical POC – John Vienna)

Develop a fundamental understanding of the phase transitions leading from melt to multiphase (glass ceramics) waste form as functions of cooling rate and composition. The glass ceramic should be a borosilicate based melt precipitating Powellite, Oxyapatite, and/or lanthanide borosilicates. Cooling rates tested should encompass those expected in full-scale high-level waste glass canisters. This will support the development, testing, and qualification of an advanced glass ceramics waste form for aqueous processing high-level waste.

FC-1.4: ADVANCED WASTE FORMS-2
(Federal POC – Kimberly Gray & Technical POC – John Vienna)

Investigate the relative volatility at 300-400 C of used nuclear fuel zirconium cladding component chlorides, including alloying agents and residual radionuclides, such as niobium, iron, antimony, and cesium chloride species that are known to have similar volatility to zirconium tetrachloride. This will support the development of zirconium purification from fuel cladding materials, which may significantly

reduce the amount of highly radioactive waste form fuel processing.

Advanced Fuels (FC-2)

(Federal POC – Frank Goldner & Technical POC – Jon Carmack)

This program element develops advanced nuclear fuel technologies using a science-based approach focused on developing a microstructural understanding of nuclear fuels and materials. The science-based approach combines theory, experiments, and multi-scale modeling and simulation to develop a fundamental understanding of the fuel fabrication processes and fuel and clad performance under irradiation. The objective is to use a predictive approach to design fuels and cladding to achieve the desired performance (in contrast to more empirical observation-based approaches traditionally used in fuel development).

The advanced fuels program conducts research and development of innovative next generation LWR and transmutation fuel systems. The major areas of research include: enhancing the accident tolerance of fuels and materials, improving the fuel system's ability to achieve significantly higher fuel and plant performance, and developing innovations that provide for major increases in burn-up and performance. The advanced fuels program is interested in advanced nuclear fuels and materials technologies that are robust, have high performance capability, and are more tolerant to accident conditions than traditional fuel systems. Model development should be consistent with the placement and use in the NEAMS MOOSE-BISON-MARMOT (MBM) fuel performance code structure.

Technologies NOT of interest in this workscope include thorium-based fuels and molten salt-based technologies.

Proposers should also be familiar with the ongoing advanced fuels program and its past NEUPS to avoid duplication of activities already being supported or pursued.

FC-2.1: Advanced Nuclear Fuel, Cladding, and Core Components

Advanced fabrication techniques applicable to fuel and core related systems (control rods, channels, guide tubes, etc) of interest to the Advanced Fuels Program, (ie, accident tolerant fuels for light water reactors and transmutation fuels for fast spectrum reactors). Novel fabrication techniques for fuels and core structural materials, having the potential for economic, material performance, or manufacturability improvements over existing fabrication techniques, are desired for the fuel systems currently under study by the Advanced Fuels Program.

FC-2.2: Advanced Characterization Techniques

Advanced characterization techniques to enhance the ability to link integral experimental data with microstructural-level material property behavior are desired. Ideally, these experimental techniques will produce data to be used in the validation of material property and fuel performance models. The data should be consistent and compatible with the NEAMS MBM fuel performance tools.

Nuclear Materials Control and Instrumentation (FC-3)

(Federal POC – Daniel Vega & Technical POC – Mike Miller)

This program element develops technologies and analysis tools to support next generation nuclear materials management and safeguards for the current and future U.S. fuel cycles. Of specific interest are technologies and approaches to the safeguarding and monitoring of used fuel dry cask storage and electrochemical recycling technologies. New and improved sensors capable of detecting key elements, isotopes, and process parameters in a timely fashion while handling the harsh environments involved are needed for electrochemical processing. For used fuel dry cask storage we are seeking innovative security technologies that increase effectiveness while at the same time reduce overall costs (e.g., manpower). In addition,

modeling tools that can assist in safeguards and security approach development are needed.

Used Nuclear Fuel Disposition (FC-4)

(Federal POC – JC De La Garza & Technical POC – Peter Swift)

Assessments of nuclear waste disposal options start with the degradation of waste forms and consequent mobilization of radionuclides, reactive transport through the near field environment (waste package and engineered barriers), and transport into and through the geosphere. Research needs support the development of modeling tools or data relevant to permanent disposal of used nuclear fuel and high-level radioactive waste in a variety of generic disposal concepts, including mined repositories in clay/shale, salt, and crystalline rock, and deep boreholes in crystalline rocks. Key university research needs for the disposal portion of this activity include:

- Improved understanding of degradation processes (i.e., corrosion and leaching) for used nuclear fuel and waste forms that could be generated in advanced nuclear fuel cycles (i.e., glass, ceramic, metallic) through experimental investigations under variable conditions of saturation, temperature, and water chemistry, leading to the development of improved models to represent these processes;

- Improved understanding of the degradation processes (i.e. corrosion) for heat generating waste containers/packages considering direct interactions with buffer materials in a repository reducing environment leading to the development of improved models to represent the waste container/package long term performance. Improved understanding of the degradation processes for engineered barrier materials (i.e., waste containers/packages, buffers, seals) and radionuclide transport processes through these materials leading to the development of improved models to represent these processes;

- Improved understanding of coupled thermal-mechanical-hydrologic-chemical processes in the near-field of relevant disposal model environments, leading to the development of improved models to represent these processes;

- Improved understanding of large-scale hydrologic and radionuclide transport processes in the geosphere of relevant disposal model environments, leading to the development of improved models to represent these processes;

- Development of new techniques for in-situ field characterization of hydrologic, mechanical, and chemical properties of host media and groundwater in a borehole or an excavated tunnel;

- Aqueous speciation and surface sorption at elevated temperatures and geochemical conditions (e.g., high ionic strength) relevant to the disposal environments being considered;

- Consideration of how specific waste forms may perform in different disposal environments using theoretical approaches, models and/or experiments, with quantitative evaluations including uncertainties of how the long-term performance of waste forms can be matched to different geologic media and disposal concepts; and

- Experimental and modeling investigations for the effect of radiolysis on used fuel, high-level waste, and barrier material degradation at temperatures and geochemical conditions relevant to potential storage and disposal environments.

Program Supporting: Fuel Cycle Technologies

Fuel Cycle Option Analysis (FC-5)

(Federal POC – Kenneth Kellar & Technical POC – Temi Taiwo)

This program element is interested in the development of a visualization tool to communicate to the public the outcomes of implementing different fuel cycles that have been identified to offer promise in the Evaluation and Screening Study finalized by DOE-NE in 2014. This tool will allow the comparative analysis of those nuclear energy systems to one another and a reference nuclear energy system and also to other energy sources, e.g., solar, biomass, oil, natural gas, wind, etc. When completed this tool must be publicly available, easy and intuitive to use, and should be usable on different computer platforms, including laptop and handheld devices. An example website that might provide ideas for the development of this tool is http://my2050.decc.gov.uk/. See also http://2050-calculator-tool.decc.gov.uk/pathways/11111111111111111111111111111111111111111111111111111/primary_energy_chart.

Fuel Resources (FC-6)

(Federal POC – Stephen Kung & Technical POC – Phillip Britt)

(Up to 3 years and $600,000)

The secure and economical supply of nuclear fuel is essential for the long-term use of nuclear power for energy applications. Continued federal R&D investment in uranium resources will be the foundation to enable future nuclear power expansion. The fuel resources program element is seeking "game-changing" approaches that are not presently being addressed by private industry or non-governmental organizations. For example, seawater contains more than 4 billion tons of dissolved uranium. This unconventional uranium resource, combined with a suitable extraction cost, can potentially meet the uranium demands for centuries to come. Specific R&D areas of interest include: (1) molecular-level understanding of the coordination modes, sorption mechanisms, and kinetics of uranium extraction; (2) design and synthesis of functional ligands with architectures tailored chemical performance; (3) physical and chemical tools for characterizing of adsorbent materials; (4) development of new polymer sorbents via advanced manufacturing and surface grafting techniques; and (5) development of innovative elution processes.

Mission Supporting: Fuel Cycle Technologies

Fuel Cycle R&D (MS-FC-1)

(Federal POC – David Henderson & Technical POC – Kemal Pasamehmetoglu)

Sustainable fuel cycle options are those that improve uranium resource availability and utilization, minimize waste generation, and provide adequate capability and capacity to manage all wastes produced by the fuel cycle. The key challenge is to develop a suite of options that will enable future decision-makers to make informed choices about how best to manage the used fuel from reactors. Applications should address the technologies and options that would allow for the sustainable management of used nuclear fuel that is safe, economic, and secure and widely acceptable to American society. Examples of topics may include advanced fuel treatment or material recovery processes, innovative fuel designs, and innovative fuel cycle analysis tools. Areas of interest include "blue sky" concepts for advanced methods of managing used nuclear fuel, such as innovative recycling, transport, storage, and disposal concepts. Areas of interest for transmutation fuel include, but are not limited to, existing LWRs, other thermal, and fast or mixed spectrum reactors. Advanced fuel concepts may also include LWR fuel with improved performance benefits and fast reactor fuel with improved cladding performance (e.g., ability to withstand 400 dpa). Extended use of nuclear power may drive improvements in defining resource availability and on fuel resource exploration and mining.

Program Supporting: Nuclear Energy Advanced Modeling and Simulation

Nuclear Energy Advanced Modeling and Simulation (NEAMS-1)

(Federal POC – Dan Funk & Technical POC – David Pointer)

The Nuclear Energy Advanced Modeling and Simulation (NEAMS) program is developing a Simulation Toolkit that takes advantage of modern computing architectures and state-of-the-art mechanistic models to allow scientists and engineers to better understand reactor materials properties and coupled phenomena in nuclear energy systems. This "pellet-to-plant" simulation toolkit covers length-scales from atomic to meso-scale to continuum and time-scales form pico-seconds to seconds, to days. The new advanced computational tools will predict the performance and safety of a broad class of nuclear reactor systems. Validation of the underlying mechanistic models (materials science, thermal-hydraulics, neutronics, continuum and structural mechanics) both in standalone and coupled simulations, is essential for ensuring the toolkit is accurate, robust, and useful. It is as important for the program that the computational tools are validated in the sense that the simulations capture the essential features of the real systems for a specific class of reactor component and key phenomena.

We are seeking applications that contribute to improving the mechanistic models, computational methods, and validation of NEAMS tools in the toolkit [MARMOT, BISON, SHARP, RELAP-7; for detailed descriptions, see the Nuclear Energy Advanced Modeling and Simulation (NEAMS) Program Plan. Applications may include a) New models of materials properties as function of reactor environment parameters such as temperature or neutron flux, b) New mathematical or computational methods for improving scale or physics coupling and c) New experimentation designed explicitly for validation, analysis of existing benchmark datasets, development of new benchmark datasets, calibration of models, as well as direct comparison of datasets with toolkit simulations.

Known priorities include ideas that

a) accelerate work to extend of the NEAMS ToolKit's Fuels Product Line's macroscale (Bison) and mesoscale (Marmot) components to fuel types other than conventional LWR oxide fuels,
b) expand the applicability of the NEAMS neutronics module (PROTEUS) to a wider range of transients and demonstrate it's applicability to a wider range of reactor core configurations,
c) expand the turbulence modeling options available in the NEAMS thermal fluids module (Nek5000) and demonstrate it's applicability to a wider range of reactor types and conditions, and
d) expand the validation of the NEAMS structural mechanics module (Diablo) and implement models within it which enhance it's ability to predict the behavior of reactor structures, possibly leveraging the ToolKit's existing meso-scale capabilities.

Model development and validation can span the entire hierarchy from single-scale and single-effects experiments designed to address individual phenomena to integrated models or experiments that address strong coupling of multiple phenomena. Applications to run simulations or conduct experiments at DOE laboratories in support of the NEAMS Toolkit are encouraged, though computation or experimentation at university laboratories is equally acceptable. Collaboration with members of the NEAMS development team residing at DOE laboratories is strongly encouraged.

Program Supporting: Nuclear Energy

Cyber Security R&D (NE-1)

(Federal POC: Trevor Cook & Technical POC: Steven Hartenstein)

University nuclear research reactors rely on components and systems that protect against cyber-attacks that can alter or extract data, induce unsafe conditions or system failures, disable operations, or cause a release or perception of release of nuclear or radiological materials. Applications are sought that will demonstrate the robustness or vulnerabilities of university research reactor digital control, monitoring and communication systems subject to cybersecurity challenges. Research will include hypothesizing a credible vulnerability and resolving the potential impact and/or consequences of an attack against the vulnerability through application of theoretical, modeling and simulation, and experimental proof-of-principle. Applications should address the potential for applying the research methodology and results to enhance the University's curriculum in cybersecurity for engineering students. Note that applications to address the regulatory compliance status of a university research reactor or methodology for assuring compliance are not of interest and should not be offered.

Mission Supporting: Nuclear Energy

Integral Benchmark Evaluations (MS-NE-1)

(Federal POC: Rob Versluis & Technical POC: Gilles Youinou)

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 and produce 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 to provide complete benchmark evaluations of existing experimental data that support current and future R&D activities.
The IRPhEP and ICSBEP Handbooks are the collaborative efforts of nearly 500 scientists from twenty-four 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 reactor safety and design, criticality safety, nuclear data, and analytical methods development specialists to perform necessary validations of calculational techniques and are expected to be valuable resources for future decades.

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. All evaluations must be completed according to the requirements, including peer review, of the IRPhEP and the ICSBEP. Benchmark evaluations in support of transient testing at TREAT are of particular interest and are a focus of the IRP-NE-1 workscope in Appendix C.

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

Advanced Methods for Manufacturing (NEET-1)

(Federal POC – Alison Hahn & Technical POC – Jack Lance)

(Up to 3 years and $800,000)

The Advanced Methods for Manufacturing program seeks applications for research and technology development to improve the methods by which nuclear equipment, components, and plants are manufactured, fabricated, and assembled. The focus and emphasis will be placed on technologies that can be deployed in the near-term. One application for consideration is "modular construction" which has been proven in shipbuilding and other industries, and is being exploited in SMRs and, to a limited degree, in modern ALWR construction. This application provides the economic benefit of all new nuclear plants by reducing the need for costly on-site construction and the capability to manufacture them in a factory setting. Most importantly, reducing the cost of construction here in the U.S. for both ALWRs and SMRs will result in cheaper electricity for American families and businesses. Applications should pursue innovative methods to manufacture or fabricate components faster and with better quality; and to improve factory assembly and field deployment of plant modules, thereby reducing the cost and schedule requirements for new nuclear plant development.

Specific goals include:

- Accelerate deployment schedule by at least 6 months compared to current new plant construction estimates;
- Reduce component fabrication costs by 20% or more, and;
- Increase installation of key subsystems without cost increase or schedule delay.

The program seeks to develop manufacturing and fabrication innovation, assembly processes and materials innovation that support the "factory fabrication" and expeditious deployment of new technologies. Potential areas for exploration include:

- Factory and field fabrication techniques that include strength assistance tooling, advances in verification of designed configuration, improvements in manufacturing technologies such as advanced (high speed, high quality) welding technologies, practical (shop floor) applications of electron beam welding for fabricating heavy sections, surface modification and metal spraying techniques that reduce erosion, corrosion and wear on component surfaces.
- Assembly and material innovation to enhance modular building techniques such as advances in high performance concrete and rebar, design innovation using concrete composite and steel form construction methods, inspection processes and equipment, and innovative rebar pre-fab and placement systems. Innovations in concrete materials or design of structures that can reduce the total volume of concrete poured or the overall thickness of concrete sections are relevant to this program.
- Advances in manufacturing processes for reactor internals, fuel cladding and fuel support assemblies. Research could include advanced manufacturing methods for individual components or fabrication of assemblies. Cladding or surface modification methods to resist corrosion and wear are relevant to this research topic.
- Improved concrete inspection, measurement and acceptance technology, techniques and methods to facilitate the pour and curing of nuclear plant concrete.

Details of several areas for innovation can be found in the NEET 2010 Workshop report (http://www.ne.doe.gov/pdfFiles/Neet_Workshop_07292010.pdf).

Through innovation in manufacturing, fabrication and assembly, significant advancements in nuclear technology quality, performance and economic improvements will be achieved. One of the key success criteria for the program is the development of products or components that will gain acceptance by the appropriate regulatory or standard-setting bodies and licensing for commercial nuclear plant deployment.

Advanced Sensors and Instrumentation (NEET-2)

(Federal POC – Suibel Schuppner & Technical POC – Bruce Hallbert)

The Advanced Sensors and Instrumentation program seeks applications for **digital technology qualification demonstration** for embedded digital devices. An embedded digital device is an electronic sub-component of a plant component (e.g. instrument or circuit breaker) which uses software or software-developed logic for some aspect of its operation. The qualification method will demonstrate a cost-effective means of ensuring that the device is not subject to software common cause failure.

The selected digital equipment shall be for multiple reactors or fuel cycle applications, i.e. crosscutting, include a nuclear industry partner, and the research products shall address the following technical challenges:

- Proof of acceptable software operational reliability;
- Comprehensive non-destructive testability;
- U.S. NRC regulatory requirements;
- Ability to detect defects introduced through the entire supply chain;
- Ability to qualify commercial-grade devices dedicated for safety-related usage ; and
- Cost-effective and broadly applicable to multiple small plant components.

Reactor Materials (NEET-3)

(Federal POC – Sue Lesica & Technical POC – Jeremy Busby)

The NEET Crosscutting Reactor Materials program seeks applications for advanced materials discovery and development. Successful completion of awards will provide piping, structural, or clad materials that dramatically improve performance over traditional materials used current and next generation reactors and in the nuclear fuel cycle. Specific goals may include:

- Improvement in mechanical performance by a factor of 5-10 over traditional materials
- Increase in maximum operating temperature of greater than 200 C over an 80 year lifetime
- Increased radiation tolerance to beyond 300 dpa

Such performance would enable significantly improved safety, performance and reliability for future advanced reactor and fuel cycle designs. However, such improved performance cannot be at the expense of other properties or performance.

There are many conceptual routes for material design that may be considered, including composition, microstructure, and fabrication methods. For metals and alloys, some potential concepts may include (but are not limited to):

- *Optimized alloy composition*
- *Engineered microstructures*
- *Age-tempered microstructures*
- *Combinations of all of the above*

Other, more radical concepts may also be explored to enable even greater performance. While non-metallic materials may also create new challenges in fabrication or licensing, their impact via improved properties may justify the development costs (even over an extended period). While the number of options available is nearly limitless, some ideas may include (but are not limited to):

- *Bi-metallic layers*
- *Metal/Ceramic composites*
- *Ion-beam or surface modified alloys*

Applications are requested that describe innovative materials concepts, concept advantages, concept limitations, and key development needs. Successful applications will describe innovative materials that offer the potential for revolutionary gains in reactor and fuel cycle performance. Materials that can be applied to multiple reactor designs, components, and concepts will be given preference over materials restricted to a single reactor concept, component, or coolant.

Cyber Security R&D (NEET-4)

(Federal POC: Trevor Cook & Technical POC: Steven Hartenstein)

Operating challenges for future nuclear fuel cycle facilities and power reactors include stresses from grid disturbances, component degradation, component failure, and operator errors. These stresses can be relieved through engineered solutions that are dependent upon robust instrumentation and control (I&C) systems and reliable communication networks. As future nuclear components and systems become even more dependent upon these digital systems, the nuclear energy ecosystem also will become more dependent upon cybersecurity technologies that protect the integrity and reliability of these digital technologies from cyber-attacks. These cybersecurity technologies will need to protect against attacks that can alter or extract data, induce unsafe conditions or system failures, disable operations, or cause a release or perception of release of nuclear or radiological materials.

Applications are sought that will address the cybersecurity challenges of complex, uniquely-nuclear interfaces introduced by digital and communications systems for protection, monitoring, safety, security, safeguards, balance-of-plant, and/or emergency response. Research will include the development and application of a science-based methodology for resolving the consequences of a hypothesized cyber-physical vulnerability(ies) through application of theoretical, modeling and simulation, and experimental proof-of-principle. Research should consider application of the results beyond nuclear power plants or specific reactor designs. Note that methodologies to address compliance of nuclear facilities with current regulatory standards or evaluation of the effectiveness of a single commercial cybersecurity technology are not of interest and should not be included in the workscope.

Control System Modernization for the Advanced Test Reactor Critical Facility (ATRC) (NEET-5)

(Federal POC: Jason Tokey & Technical POC: Craig D. Jackson)

The Department is seeking applications for the development of a detailed design to modernize control systems for the ATRC at Idaho National Laboratory (INL). The ATRC is a low-power reactor designed and constructed in the early 1960s. The mission of the ATRC is to obtain accurate and timely data on nuclear characteristics of the Advanced Test Reactor (ATR) core such as rod worths and calibrations, excess reactivities, neutron flux distributions, gamma-heat generation rates, fuel loading requirements, and effects of insertion and removal of experiments. The ATRC typical operating power level is 600 Watts (W) or less, with a maximum allowable power of 5kW. The core is cooled via natural convection of light water, is light water moderated and reflected by beryllium. Some of the ATRC-generated information is used to ensure that the ATR core, 250 MWth, can be operated safely within its safety basis envelope during performance of various nuclear research activities.

Demand for ATRC has grown significantly in recent years as a result of increased use of ATR and the standalone ATRC experiments (11 ATRC runs in 2010, 65 projected runs in 2014). A modern control system will help to ensure continued availability and reliability of the ATRC for experimental use.
The majority of the existing ATRC control system is original 1960's or early 1970's vintage equipment and is well beyond its expected product life cycle. Spare parts availability and technical support for much of the instrumentation and control (I&C) equipment currently in use at ATRC is virtually nonexistent, making continued operation and maintenance extremely difficult. The goal of this workscope is to design a reliable I&C system for operation of ATRC for 15 to 20 years following system replacement.

The work scope includes the design changes necessary to make the reactor shutdown system compliant with

current standards and requirements, but limits the application of digital processor technology to non-safety functions. All safety class functions would continue be performed with analog I&C components. The applicant must also be able to meet all applicable access and quality assurance requirements.

This detailed design effort would include the following systems:

- Reactor Shutdown System (RSS)
    - Neutron Level Subsystem
    - Log-N/Period Subsystem
    - Manual Scram Subsystem
    - Scram Logic Subsystem
- Log Count Rate Meter (LCRM) System
- Non-RSS Scram System
    - Seismic Switch Subsystem
- Rod Control System
    - Safety Rod Controls Subsystem
    - Outer Shim Controls Subsystem
    - Neck Shim Controls Subsystem
    - Neutron Start-up Source Control Subsystem
    - Control Element Drive Interlock Function Subsystem
- Digital Reactivity Measurement System

Annunciator System and Indicator Lights System

Mission Supporting: Nuclear Energy Enabling Technologies (NEET)

Nuclear Energy Related R&D (MS-NEET-1)

(Federal POC: Rob Versluis & Technical POC: Rory Kennedy)

This workscope solicits applications for nuclear energy related research projects that may not completely align with one of NE's R&D programs (e.g. Nuclear Reactor Technologies, Fuel Cycle Technologies, and Nuclear Energy Enabling Technologies) and the other workscopes identified in this FOA. However, applications submitted to this workscope must still support the Department of Energy Office of Nuclear Energy's mission. Information regarding the current Nuclear Energy Research and Development Roadmap as well as specific research areas can be found at http://energy.gov/ne/mission.

Additionally, applicants interested in utilizing Advanced Test Reactor National Scientific User Facility (ATR NSUF) capabilities and who are also interested in research support should submit research applications under this workscope, if the proposed research does not align with one of the other workscopes identified in this FOA.

As part of this FOA, ATR NSUF provides access to unique nuclear energy R&D infrastructure in the areas of irradiation, post irradiation examination and beamline experiments; thus enabling research in critical areas as described below.

Core and Structural Materials

This element is primarily focused on understanding material degradation mechanisms and developing radiation resistant materials for application in current and future reactors. Proposed projects may involve R&D in the areas of material irradiation performance and combined effects of irradiation and environment on materials.

Nuclear Fuel Behavior and Advanced Nuclear Fuel Development

This program element is primarily focused on increasing our fundamental understanding of the behavior of nuclear fuels (including cladding) in reactor and research and development activities for advanced nuclear fuels and improving the performance of current fuels. Areas of interest include irradiation and thermal effects on microstructure development and the effects on, for example, thermophysical and thermomechanical properties as well as chemical interactions. Advanced fuels applicability extends to fast spectrum transmutation systems, coated particle fuels for high-temperature reactor systems, and robust fuels for light water reactors including accident tolerant fuels. Activities should be aimed at designing simple irradiation experiments and post irradiation examination that investigate fundamental aspects of fuel performance such as radiation damage, amorphization, fuel restructuring, species diffusion, and fission product yields for TRU materials.

Advanced In-reactor Instrumentation

This program element includes development of advanced in-reactor instrumentation for characterization of materials under irradiation in test reactors and for on-line condition monitoring in power reactors. Applications should address the development of radiation resistant sensors for measurement of thermal conductivity, dimensional changes (specifically diameter and volume), crack propagation in materials, and internal fission gas pressure. Development of practical techniques that are non-intrusive with respect to irradiation specimens is encouraged, as are concepts that examine the feasibility and practical use of nontraditional methods such as optical fibers and ultrasonic techniques as well as other incorporated wireless transmission techniques.

Experiments with Synchrotron Radiation at the Advanced Photon Source

Proposed research includes the use of facilities at the Materials Research Collaborative Access Team (MRCAT) beamline located in the Advanced Photon Source Facility at Argonne National Laboratory. Proposals requesting the use of these facilities should focus on post-irradiation examination or concurrent use with ongoing irradiations at ATR NSUF. Experiments conducted at MRCAT will be facilitated by the Illinois Institute of Technology. Experiments that can currently be carried out at the MRCAT include x-ray diffraction (XRD), x-ray absorption (XAS), x-ray fluorescence (XRF), and 5 μm spot size fluorescence microscopy.

Research Areas for Experiments with Synchrotron Radiation The research areas listed here represent promising applications of synchrotron x-ray techniques in characterizing microstructural evolution and associated physical and mechanical properties of materials under irradiation.

- Fundamental Aspects of Radiation Damage
- Phase Stability and Phase Transformation under Irradiation
- Surfaces and Grain Boundaries in Irradiated Materials
- Deformation and Fracture of Irradiated Materials
- Physics and Chemistry of Nuclear Fuels

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

Program Directed: Fuel Cycle Technologies

Evaluation of Fuels and Systems with Enhanced Accident Tolerance (IRP-FC-1)

(Federal POC – Frank Goldner & Technical POC – Jon Carmack)

(Up to 3 years and $3,000,000 total project cost)

Since FY2012, the U.S. Department of Energy (DOE) has been funding programs to promote the development of fuels and systems with enhanced accident tolerance for light water reactors (LWRs). This has included, but has not been limited to, development of new cladding and fuel concepts and the generation of performance and fundamental data. As part of these programs, the development of metrics to evaluate the performance of these potential ATFs has also been considered, with work continuing in that area.

The goal of this Integrated Research Project (IRP) is to promote the development of advanced modeling tool(s) capable of simulating the behavior of a fuel system at the core level needed to assess the time to melting of the fuel and core components. Ideally, the computational tool(s) will, to as great an extent as reasonable, be built upon the advanced modeling and simulation tools under active development, and already at an advanced state, by DOE-NE's NEAMS program. In particular, development and coupling of appropriate behavior models and a consistent simulation strategy to effectively analyze the following key areas up to the point of melting:

- Cladding and core component performance
- Thermo-mechanical fuel performance
- Steady-state and transient neutronics
- Thermal hydraulics

Most importantly, the tool(s) must be able to provide an estimate of the time to melt for core components.

While a number of advanced simulation tools have been developed by the NEAMS program for the analysis of LWR fuels, gaps have been identified which limit their immediate use for ATF analysis due to either understanding of phenomena, or the ability to accurately model and predict the performance (operational and time to melt) of these new concepts. Applications are sought to extend one or more of the simulation tools necessary (such as the NEAMS MOOSE/BISON fuel performance tool-set) in order to allow for a more accurate and representative analysis of the core wide performance of ATF concepts.

It is recognized that individual Universities may not have the full capability or capacity to address all of the technical areas listed. Therefore, collaborations are encouraged, utilizing the appropriate expertise from within the academic sector as well as appropriate DOE laboratories and industry.

DOE seeks innovative thinking by applicants that would provide the most effective and efficient solution to the near to medium term evaluation of ATF concepts. The proposed solutions must be applicable to conventional LWR fuels as well as to ATF concepts being currently considered by the DOE Advanced Fuels Campaign. Examples of ATF systems of include advanced steels, coated refractory metal (zirconium or molybdenum), or silicon carbide ceramic cladding, or ceramic fuels with enhanced fission product retention capabilities or improved thermo-mechanical properties. Focus of R&D activities on advanced steels and ceramic (SiC) claddings will be highest priority.

Canister Corrosion Evaluation (IRP-FC-2)

(Federal POC – JC De La Garza & Technical POC – Peter Swift)

(Up to 3 years and $3,000,000 total project cost)

INTRODUCTION

The majority of used nuclear fuel dry storage systems include a stainless steel canister to house the used fuel. The canister can then be transferred to the storage overpack and transportation overpack without having to handle individual fuel assemblies. During storage in the overpack, there is technical and regulatory concern that over time, deliquescence of atmospheric water will create a condition of corrosion initiation. This corrosion initiation, coupled with canister surface conditions and residual welds, may lead to stress corrosion cracking in the canister. R&D work is needed from experimental, field testing, and analytical areas.

BACKGROUND

Experimental: It is assumed that stress corrosion cracking (SCC) will occur during the storage life of the canisters. Work is needed to demonstrate SCC initiation conditions, crack growth rates, and crack arrest conditions and characteristics. This work will help to define timelines of concern for SCC and provide guidance for inspection intervals during service.

Field testing: Collaboration with industry and the DOE labs is needed to develop diagnostic tools for detection of cracks and assessment of crack growth. This diagnostic tool development will include work in a highly rad field involving canisters that are in service.

Analytical application: Create a tool, based on the experimental and field testing work that provides a predictive capability for different storage systems and environmental conditions. The intent here is not to develop a new platform, but to adapt existing codes where possible to provide the predictive capability that is needed.

The focus of this work will be applied engineering to solve a regulatory and technical issue facing the commercial nuclear industry. Work with the DOE labs is important to strike the right balance between understanding the science and delivering a useful end product that can be used by industry.

WORK TO BE PERFORMED

The research needs for this IRP will include the following scope of activities:

- **Innovative Methodology Development**

  Describe the underlying fundamental principles and description of the technology to be developed with an assessment of any limitations. Justification for how the technology will be successful should be provided based on any experimental or analytical studies that may be available.

- **Proof of Principle Evaluation**

  Develop and demonstrate feasibility of the methodology for multi layered and different material systems. Here the opportunity exists to establish the degree of conformance to the initial expectation of performance and provide any refocus needs.

- **Identify and Quantify Inherent Uncertainties**

  Systematically develop uncertainties associated with the methodology and its application to a basic system. All non-destructive evaluation systems have both bias and uncertainty. It is important to understand and quantify these bias/uncertainties, and incorporate the uncertainties in the data evaluation process.

- **Develop and Implement a "mock-up" Test Program**

  To the degree possible tests should be conducted, initially on a cask/container with no fuel elements and then follow up with a structurally representative fuel internals. At this stage no irradiated materials need be considered. The test results should provide calibration for the use of the developed technology system to similar enclosed cask/container designs.

- **Assemble a System for Field Demonstration**

  Put together a system that can be taken to the field where multiple casks/containers can be evaluated. The system should be able to withstand storage site radiation levels.

- **Conduct a Field Demonstration**

  Working with a storage facility operator, conduct a field demonstration of the system in the field in a high rad environment and develop an evaluation of the field study.

- **Prepare a Detailed Final Report**

  The report will document the R&D elements of the IRP, provide bias/uncertainty in the system and discuss the lessons learned from the effort.

TASKS TO BE PERFORMED

- **Task 1:** Development of an integrated plan technology development and testing – 3 months after beginning of performance period;
- **Task 2:** Methodology development – 9 months after beginning of performance period;
- **Task 3:** Proof of principle testing and uncertainty evaluation – 15 months after beginning of performance period;
- **Task 4:** Develop and implement "mock-up" tests – 26 months after beginning of performance period;
- **Task 5:** Field demonstration – 33 months after beginning of performance period.
- **Task 6:** Complete project report – 36 months after beginning of performance period

DELIVERABLES

- **Technology Assessment Report**

  Eighteen months into the project, a progress report must be submitted to the DOE that provides a technical assessment of progress made toward solving the issues discussed above.

- **Final Report**

  Thirty-six months into the project, a report will be submitted to the DOE that discusses the technologies developed and how they can be effectively implemented.

Program Directed: Fuel Cycle Technologies

Cask Condition Evaluation Techniques (IRP-FC-3)

(Federal POC – JC De La Garza & Technical POC – Peter Swift)

(Up to 3 years and $3,000,000 total project cost)

INTRODUCTION

There are many types and designs of spent nuclear fuel casks and containers currently in storage around the country at various nuclear power plant sites. The inventory of spent fuel in these casks/containers is large and with varying burn-up rates and out-of-reactor times. The casks/containers have multiple internal components that are designed to provide structural integrity during storage and in some cases during transportation. The long-term internal stability of the internals and spent fuel and its cladding is important to maintain sub-criticality of the fissile materials in the casks/containers. Given the desired attributes for the cask/container designs it is a challenge to assess the condition of the internals and the spent nuclear fuel non-intrusively after prolonged storage periods. This research topic addresses the development of innovative technologies to determine the extent of any damage or degradation of internal components from prolonged storage or handling at storage sites.

BACKGROUND

There are non-destructive examination techniques currently in use where surface damage and in some cases volumetric assessments can be performed on a reasonable scale on concrete or metal components. The technology becomes limited when layered and inaccessible components with different materials and varying gaps between the layers are encountered. An opportunity exists to develop fundamental technologies that can discern the condition of the internals of a spent fuel storage cask/container and its components after prolonged storage with a high degree of reliability. The development of a new technology or a combination thereof can support the designing simplified tools that can be used at "orphan" nuclear reactor sites and Spent Fuel Storage Installations (ISFSIs) for sorting and isolating any operationally degraded casks/canister at those locations.

WORK TO BE PERFORMED

The research needs for this IRP will include the following scope of activities:

- **Innovative Methodology Development**

  Describe the underlying fundamental principles and description of the technology to be developed with an assessment of any limitations. Justification for how the technology will be successful should be provided based on any experimental or analytical studies that may be available.

- **Proof of Principle Evaluation**

  Develop and demonstrate feasibility of the methodology for multi layered and different material systems. Here the opportunity exists to establish the degree of conformance to the initial expectation of performance and provide any refocus needs.

- **Identify and Quantify Inherent Uncertainties**

  Systematically develop uncertainties associated with the methodology and its application to a basic system. All non-destructive evaluation systems have both bias and uncertainty. It is important to understand and quantify these bias/uncertainties, and incorporate the uncertainties in the data evaluation process.

- **Develop and Implement a "mock-up" Test Program**

  To the degree possible tests should be conducted, initially on a cask/container with no fuel elements and then follow up with a structurally representative fuel internals. At this stage no irradiated materials need be considered. The test results should provide calibration for the use of the developed technology system to similar enclosed cask/container designs.

- **Assemble a System for Field Demonstration**

Put together a system that can be taken to the field where multiple casks/containers can be evaluated. The system should be able to withstand storage site radiation levels.

- **Conduct a Field Demonstration**

  Working with a storage facility operator, conduct a field demonstration of the system in the field in a high rad environment and develop an evaluation of the field study.

- **Prepare a Detailed Final Report**

  The report will document the R&D elements of the IRP, provide bias/uncertainty in the system and discuss the lessons learned from the effort.

TASKS TO BE PERFORMED

- **Task 1:** Development of an integrated plan technology development and testing – 3 months after beginning of performance period;
- **Task 2:** Methodology development – 9 months after beginning of performance period;
- **Task 3:** Proof of principle testing and uncertainty evaluation – 15 months after beginning of performance period;
- **Task 4:** Develop and implement "mock-up" tests – 26 months after beginning of performance period;
- **Task 5:** Field demonstration – 33 months after beginning of performance period.
- **Task 6:** Complete project report – 36 months after beginning of performance period

DELIVERABLES

- **Technology Assessment Report**

  Eighteen months into the project, a progress report must be submitted to the DOE that provides a technical assessment of progress made toward solving the issues discussed above.

- **Final Report**

  Thirty-six months into the project, a report will be submitted to the DOE that discusses the technologies developed and how they can be effectively implemented.

Program Directed: Nuclear Energy

Transient Fuel Testing (IRP-NE-1)

(Federal POC – Robert Versluis & Technical POC – Dan Wachs)

(Up to 3 years and $4,000,000 total project cost)

The Transient Reactor Test (TREAT) facility, located at Idaho National Laboratory (INL), has a long history dating back to the 1950s of testing light water reactor (LWR) and sodium-cooled fast reactor (SFR) fuel behavior under power/coolant mismatch conditions that may challenge fuel integrity and/or influence overall reactor response. This capability has enabled the understanding of fundamental physical processes occurring in fuel under conditions ranging from normal operating conditions all the way up to severe accidents. This information has been crucial to the design of high performance nuclear fuel systems and to support the subsequent regulation of nuclear energy applications. After a long outage (TREAT has not operated since 1994), operations are expected to by 2018.

The TREAT restart effort is progressing under the constraints of historic empirical codes and by leveraging previous irradiation test vehicle designs. However, newly developed mechanistic models and computational tools, developed as part of the Nuclear Energy Advanced Modeling and Simulation (NEAMS) program and others, may be able to improve pre-test analytical design of the TREAT experiments and offer a significant increase in the efficiency of reactor/test vehicle configuration qualification.

To support development and validation of these new tools, DOE is seeking applications that will develop benchmark cases to use in the validation of TREAT modeling and simulation codes. Key data types are anticipated to include temperature and radiation field distributions across the core over a timeframe characteristic to the transient. The development of accurate reactor benchmark cases (and subsequently validated advanced analysis tools) can serve to:

- Minimize the need to physically perform calibration experiments;
- Provide a basis for evaluation of new TREAT core designs (including both reconfigurations and the use of LEU based fuel designs);
- Support measurement of separate effects test data appropriate for validation of future fuel performance simulation software and enable enhanced experimental design capabilities, and;
- Provide the foundation necessary to improve test vehicle design by allowing for integrated analysis that emphasizes control of the test environment as the key reactor performance metric.

Three tasks are identified to support both the reactor benchmark case and its coupling to test conditions.

Task 1: Neutronics Benchmarks

Evaluate existing TREAT neutronics data according to established guidelines per the *International Handbook of Evaluated Reactor Physics Benchmark Experiments (IRPhEP Handbook)*. The IRPhEP data evaluation process entails:

- Detailed Descriptions of the Experiments and Measured Data;
- Comprehensive Evaluation of Experiment Parameters, Including Assessment of Unavailable Information;
- Provision of Benchmark Specifications, Addressing Known Simplification Biases;
- Provision of Best-Estimate Sample Calculations, and;
- Appendices with Input Codes and Other Supporting Information.

Current simulation capabilities are utilized to propagate the effects of known uncertainties in measured data and assess their impact upon the derived models and benchmark specifications. Where measurement uncertainties are unavailable, reasonable estimates are derived using available data and best engineering judgment. The final assessment of the benchmark quantities is provided to appropriately reflect the accuracy and quality of the experimental data. Comprehensive descriptions of benchmark experiment models include the following key sections:

- Assessed Simplification Biases, Including Bias Uncertainties;

- Detailed Descriptions of System Geometry with Dimensions;
- Materials and Key Material Properties Necessary for the Analysis, and;
- Initial and Boundary Conditions Pertinent to the Benchmark Specifications.

Best-estimate sample calculations provisioned using contemporary nuclear codes, methods, and empirical data demonstrate the adequacy in evaluating the experimental data, corresponding uncertainties and biases, and benchmark model development. Multiple levels of peer review provide additional means of data verification and validation of the evaluated uncertainties and biases, including derivation of the benchmark parameters and models, thus enhancing the quality of benchmark experiments accepted as standard handbook data.

Note that Task 1 focuses on the physics of the reactor with only some degree of consideration to the experimental loops located in the central position of the core. The rationale is that the experimental loops have only a very limited impact on the power transients which depend essentially on two reactor physics quantities related to the driver fuel: the inserted reactivity and the temperature reactivity feedback.

Task 1a: Steady-State

Evaluated experimental data may include, but are not limited to, cold-critical and at-power steady-state measurements such as k_{eff}, reactivity effects such as control rod worths, temperature coefficients, reaction-rate distributions, kinetics parameters, power coupling factors, etc. The evaluation should emphasize data quality assessments including, for example, uncertainty determinations a described above. The evaluation report(s) should receive internal and independent review and then be submitted to the International Reactor Physics Experiment Evaluation Project (IRPhEP) the first year of this IRP. This will allow the data to receive international peer-review prior to acceptance as evaluated benchmark data. Feedback from the IRPhEP community should be implemented and the final report(s) prepared for handbook publication. This information will subsequently be used for code validation purposes.

Task 1b: Transient

Building upon the efforts of Task 1a (which is a pre-requisite to Task 1b), researchers should investigate available transient data to establish, as much as possible, benchmark evaluation(s) investigating measurements performed during transient TREAT operations. A wide range of configurations should be investigated including several delayed and prompt critical transients as well as temperature limited and shaped transients. This research should also investigate the effect of biases and uncertainties in the steady state model on transient predictions. Coordination with the International Benchmarking Program will be essential to address development of the transient benchmark report format. Limitations and absence of data in available transient measurements under evaluation should be identified and quantified with realistic uncertainties and biases as part of the benchmark evaluation process. Analyses should be carried out with 3D neutron kinetics codes available to the researchers in order to compare their respective performances (these codes must be able to account for temperature reactivity feedback). Submission of reviewed benchmark report(s) should be coordinated through the IRPhEP during the second year of this IRP. As in Task 1a, this information will subsequently be used for code validation purposes.

Task 2: Loop Thermal-Hydraulics

The effective use of the TREAT facility for experiments requires a detailed understanding of the reactor, the experimental test vehicle, and their coupling. The most complex TREAT experiment types utilize flowing coolants to create a prototypic thermal hydraulic environment. DOE is supporting the development of two loop systems based on recirculating sodium and water coolant, respectively, which are expected to be the primary TREAT vehicles used for this purpose. Significant historical experience was developed at TREAT with compact, self-contained Na loops and future loop designs will be based on this information. However, a completely new water loop system will be required. Although very little experience exists with this type of water system, the loop will be designed based on the same principles as the Na loop.

Program Directed: Nuclear Energy

Task 2a: Na Loops

To support analysis and design of the Na loop system and to complement the reactor benchmark data discussed in Task 1, this IRP will include the collection of benchmark data generated during operation of Na test loops during TREAT calibration runs (i.e. M8-CAL and RFT-CAL tests). Experimental data will include loop configuration, coolant flow rates, time-dependent coolant temperature distributions, integrated energy deposition profiles, and time dependent energy deposition (via hodoscope outputs). The data describing conditions observed in flow loops should be validated using appropriate modeling and simulation tools and will require implementation of various models relevant to sodium systems including low-Pr coolants, electromagnetic pumps, and compact heat exchangers.

Task 2b: Water Loop

To provide operational benchmark data for proposed high pressure, high temperature LWR water loop systems, a functional prototype water loop will be fabricated and installed. The loop design will be based on conceptual design work performed at INL (initiated in FY14 and to be completed in FY15) to simulate PWR conditions. Preliminary information regarding this loop design is available from INL to applicants upon request and detailed information and technical support from INL will be available to the awardee. This IRP will include enhancements that address final detailed design (as-required for fabrication), instrumentation selection to support characterization, and modularization that will allow for reconfiguration and study of various component types and flow tube arrangements. The loop will include electrical heating to simulate fuel pin power. Benchmark data to be collected will include loop configuration, coolant flow rates, coolant pressure, time-dependent coolant temperature distributions, and multi-phase flow parameters (as needed). The loop will also be used to evaluate operational parameters of small, high-temperature, high-pressure, fixed volume systems. A series of operations tests to determine the optimal loop control parameters, experiment environment, and the potential for running tests at steady state and loss-of-flow/loss-of-coolant thermal hydraulics conditions. These test results will be validated against analysis performed using appropriate modeling and simulation tools.

Task 3: Core Instrumentation

Results from the first two tasks will be utilized to identify both measurement and instrumentation needs necessary to develop benchmark-quality transient-testing data and to optimally support test-environment monitoring during experiments. A strategy is to be developed that includes not just recommendations for instrumentation selection, but design of appropriate experiments to determine the most efficient placement of additional instrumentation. These recommendations will serve as a basis for focused physics testing in TREAT, with the ultimate goal of enhancing operational activities and simulation strategies. Once awarded, this effort will be integrated with and complementary of the instrumentation development work underway with the FY14 Transient Testing IRP.

An initial analytical evaluation, using appropriate modeling and simulation tools that couple to the instrumentation plan, will be prepared in advance of actual experimentation to support planning for benchmark data collection. This modeling effort will also provide a template for completion of the actual model-to-data benchmark report to be performed once TREAT is operational, and the reactor physics tests are completed (which is beyond the scope of this IRP). The uncertainty analysis performed as a standard part of such evaluations will also highlight how improved core physics data outlined in the study would be beneficial to the accuracy of TREAT reactor simulation efforts.

Appendix D: Advanced Test Reactor National Scientific User Facility Access Only Projects

ATR NSUF Access (NSUF-1)

(Federal POC: Bradley Williams & Technical POC: Rory Kennedy)

Applicants interested in utilizing Advanced Test Reactor National Scientific User Facility (ATR NSUF) capabilities only should submit "access only" applications under this workscope. Applications must support the Department of Energy Office of Nuclear Energy's mission. Information regarding the current Nuclear Energy Research and Development Roadmap as well as specific research areas can be found at http://energy.gov/ne/mission.

ATR NSUF provides access to unique nuclear energy R&D infrastructure in the areas of irradiation, post irradiation examination and beamline experiments; thus enabling research in critical areas as described below.

Core and Structural Materials

This element is primarily focused on understanding material degradation mechanisms and developing radiation resistant materials for application in current and future reactors. Proposed projects may involve R&D in the areas of material irradiation performance and combined effects of irradiation and environment on materials.

Nuclear Fuel Behavior and Advanced Nuclear Fuel Development

This program element is primarily focused on increasing our fundamental understanding of the behavior of nuclear fuels (including cladding) in reactor and research and development activities for advanced nuclear fuels and improving the performance of current fuels. Areas of interest include irradiation and thermal effects on microstructure development and the effects on, for example, thermophysical and thermomechanical properties as well as chemical interactions. Advanced fuels applicability extends to fast spectrum transmutation systems, coated particle fuels for high-temperature reactor systems, and robust fuels for light water reactors including accident tolerant fuels. Activities should be aimed at designing simple irradiation experiments and post irradiation examination that investigate fundamental aspects of fuel performance such as radiation damage, amorphization, fuel restructuring, species diffusion, and fission product yields for TRU materials.

Advanced In-reactor Instrumentation

This program element includes development of advanced in-reactor instrumentation for characterization of materials under irradiation in test reactors and for on-line condition monitoring in power reactors. Applications should address the development of radiation resistant sensors for measurement of thermal conductivity, dimensional changes (specifically diameter and volume), crack propagation in materials, and internal fission gas pressure. Development of practical techniques that are non-intrusive with respect to irradiation specimens is encouraged, as are concepts that examine the feasibility and practical use of nontraditional methods such as optical fibers and ultrasonic techniques as well as other incorporated wireless transmission techniques.

Experiments with Synchrotron Radiation at the Advanced Photon Source

Proposed research includes the use of facilities at the Materials Research Collaborative Access Team

(MRCAT) beamline located in the Advanced Photon Source Facility at Argonne National Laboratory. Proposals requesting the use of these facilities should focus on post-irradiation examination or concurrent use with ongoing irradiations at ATR NSUF. Experiments conducted at MRCAT will be facilitated by the Illinois Institute of Technology. Experiments that can currently be carried out at the MRCAT include x-ray diffraction (XRD), x-ray absorption (XAS), x-ray fluorescence (XRF), and 5 μm spot size fluorescence microscopy.

Research Areas for Experiments with Synchrotron Radiation The research areas listed here represent promising applications of synchrotron x-ray techniques in characterizing microstructural evolution and associated physical and mechanical properties of materials under irradiation.

- Fundamental Aspects of Radiation Damage
- Phase Stability and Phase Transformation under Irradiation
- Surfaces and Grain Boundaries in Irradiated Materials
- Deformation and Fracture of Irradiated Materials
- Physics and Chemistry of Nuclear Fuels

Appendix E: Data Needs for Validation

Data Needs for Modeling and Simulation

As you formulate your applications in response to this FOA, consider that there are cross-cutting data needs that support NE's modeling and simulation efforts. High priority data needs are listed below for both the Nuclear Energy Advanced Modeling and Simulation program (NEAMS) and the Energy Innovation Hub for Nuclear Energy aka the Consortium for Advanced Simulation of Light Water Reactors (CASL). If a application addresses any of these critical data needs, please highlight this possibility in your application and work with the Department to ensure that data are captured in a useable format. Application submission will include an opportunity to specifically highlight this connection.

NEAMS is an advanced modeling and simulation codes and methods development program. NEAMS is focused on providing a Toolkit that can be used in whole or in part to simulate a wide range of nuclear processes for both light water reactors and advanced reactors. Key components of the NEAMS Toolkit are already in use by the national laboratories, academia, and industry. CASL is an important user of NEAMS technologies. Additional information on NEAMS can be found at http://energy.gov/ne/advanced-modeling-simulation.

As the Energy Innovation Hub for Nuclear Energy, CASL is developing predictive capability for addressing technical issues in currently operating nuclear power plants' performance and safety. Termed "Challenge Problems," these issues include complex phenomena that are multi-physics and multi-scale in nature. Challenge Problems include: Crud-Induced Power Shift (CIPS); Crud-Induced Localized Corrosion (CILC); Pellet-Cladding Interactions (PCI); Grid-to-Rod-Fretting (GTRF); Departure from Nucleate Boiling (DNB); Loss of Coolant Accident (LOCA); and Reactivity Initiated Accident (RIA). Additional details about the Challenge Problems and CASL can be found at: http://www.casl.gov/strategy.shtml.

Critical Data Needs for Nuclear Energy Advanced Modeling and Simulation (NEAMS)

The data needs for the NEAMS product lines are described as follows.

Fuels Product Line

Engineering-scale Fuel Performance (BISON Validation):

For fission gas behavior models, improved temperature-dependent diffusion coefficient measurements of Xe in UO_2 are needed. Also, fission gas release histories (as opposed to just end-of-life measurements) are needed to validate gas release models, especially during power transients.

Mechanical behavior (yield stress, creep behavior, failure data) for zircaloy cladding that has been irradiated and exposed to chemical environments conducive to stress corrosion cracking. Data is needed for various Zr alloys, heat treatments, etc.

For pellet-cladding mechanical interaction, data that captures 3D effects in defective LWR fuel, such as a missing pellet surface (MPS), is needed to validate our 3D models. Data could include cladding and/or fuel temperatures, cladding stress/strain, diameter evolution in the vicinity of the MPS.

Meso-scale Microstructure Evolution (MARMOT Validation):

Property measurements as input to microstructure simulations are needed. Specifically, well-controlled and characterized experiments that measure the grain boundary mobility, grain boundary energy, grain boundary structure, and defect properties in UO_2 specimens with no porosity are of interest.

For validation, grain growth data either in bicrystals or polycrystals for UO_2 for which grain boundary properties are available is needed. We also need experiments showing temperature gradient-driven migration of pores or grain boundaries in UO_2. We need data showing fission gas bubble behavior correlated with microstructure in UO_2 (e.g., grain boundary type, dislocations, etc.) and data from well-controlled experiments showing the impact of defects on UO_2 thermal conductivity.

Lower Length-scale Model Development (i.e., atomistic simulations)

Fission gas and fission product diffusivities in $UO_{2\pm x}$ under controlled conditions (i.e., known oxygen potential or non-stoichiometry, well characterized microstructure, and known irradiation history/conditions) is needed. The measurements should be performed to allow determination of effective activation energies and pre-exponential factors, which implies measurements over a reasonably wide range of temperatures. Diffusion at microstructure features such as grain boundaries is also of interest. Validation is also needed or at least desired for the defect properties underlying the prediction of fission gas and fission product diffusivities.

The distribution of fission gas bubbles and fission product precipitates in irradiated UO_2 as well as the elemental distribution within UO_2 grains, ideally as function of time, chemistry, irradiation history and temperature is needed.

The thermal conductivity of $UO_{2\pm x}$ and $UO_{2\pm x}$ containing fission gas/fission products, as well as UO_2, with well-characterized irradiation histories is needed.

Reactor Product Line

Thermal Fluid Simulations (Nek5000 Validation)

Time-resolved turbulent heat transfer/transport data is needed for validation of computational fluid dynamics tools applied to advanced reactor coolants (e.g., liquid sodium, helium, and liquid salts) and operating conditions. Data should support validation of turbulence field predictions using high-resolution methods such as Large Eddy Simulation and Direct Numerical Simulation. Data for realistic fuel assembly geometries and data sets that include well-resolved characterizations of conjugate heat transfer in structural elements are of particular interest.

Also of interest is high-resolution data that supports validation of predictive capabilities for assessment stability of thermal fluid transport phenomena, particularly in natural or mixed convection flow regimes. Data relevant to advanced reactor coolants and/or conditions is preferred.

Structural Mechanics Simulations (Diablo Validation)

In advanced reactor applications, deformation of core structural components is often an important reactivity feedback that must be accurately represented in assessments of the reactor's transient response. Validation data is needed to confirm the accuracy of predictions of deformation of core structural component (e.g., fuel assembly ducts, core plates, upper internal structures, control rod drive lines) as a result of thermal cycles, creep, swelling and combinations of the above. Data sets that provide well-resolved characterizations of the response of single components as well as multicomponent systems with load pads or other contacts are especially desirable.

Data is also needed to support validation of predictions of inelastic creep and irradiation swelling in structural (non-fuel) component materials at anticipated advanced reactor (e.g., SFR, VHTR, FHR) conditions (e.g. pressure, temperature, irradiation). Consistent uni-axial and multi-axial loading data for classes of materials at selected conditions is desirable.

Integrated Multiphysics Simulations (SHARP Toolset Validation)

Data is needed to support validation of the integrated SHARP Toolset, which includes neutronics (PROTEUS), thermal fluid (Nek5000) and structural mechanics (Diablo) capabilities. While collection of integrated reactor dynamics data for validation the system of three components is likely beyond the scope of NEUP, there is significant interest in data for validation of bi-lateral combinations of the three toolset components. For example, thermal fluid and structural response data for components subjected to transient

thermal stratification or thermal striping conditions is of interest.

Validation Data to Support the Consortium for Advanced Simulation of Light Water Reactors (CASL) Challenge Problems

A recent survey of validation data needed to support Challenge Problems identified several areas where additional data are highly desirable. In particular, the study highlights the need for accurate measurements of low length scale phenomena and multi-physics interactions modeled in CASL computer codes.

Further, value of a dataset for a Challenge Problem validation depends on relevance and scaling of experimental conditions (including geometry, materials), and uncertainty of measured data. Accurate estimates of experimental uncertainties will be valuable.

In addition to experimentation, meeting the data needs for validation of advanced modeling and simulation requires substantial efforts in (i) development of advanced diagnostics methods; (ii) using advanced simulation and VUQ methods to design and guide the validation experiments; and (iii) collection, characterization, warehousing, and preparation of data for an integrated model calibration and validation process. Your coordination of relevant efforts in these areas with CASL is also strongly encouraged.

The data needs for the CASL Challenge Problems are described as follows.

CRUD Challenge Problems (CIPS, CILC)

While extensive databases exist for CRUD from plant observations and measurements, detailed phenomena in CRUD are poorly characterized. Most critical are phenomena at the interface between reactor coolant chemistry, materials, and thermal-hydraulics.

The following topics are identified CRUD validation data needs:

1. Crud deposition thermo-dynamics;
2. Chemical reactions in crud;
3. Composition of complex spinel and other oxide phases in crud;
4. Crud deposition efficiency as a function of dub-cooled boiling rate;
5. Measure erosion rate of previously deposited crud on fuel rods after sub-cooled boiling stops;
6. Measure mass evaporation rate as a function of heat flux on PWR fuel rods;
7. Fuel assembly crud mass;
8. Fractalline properties of crud;
9. Crud growth rate vs. peak clad temperature; and
10. CILC failure mechanism.

It is important that validation experiments are performed (when practical) under conditions that scale well to PWR prototypic conditions (high pressure, high heat fluxes, low concentrations of chemicals). It is noted that it is difficult to obtain well-scaled data on crud transport and deposition from integral-effect tests. High priority is given to a program of small-scale tests. Innovative experimental approaches are needed to investigate the basic chemistry and thermo-hydraulics inside a manufactured crud deposit (with accurately

characterized morphology). Advanced instruments may be needed to obtain spatially and temporarily resolved temperature, chemical concentrations, B^{10} precipitation, boiling velocity, etc. during the experiment. A new kind of sample probe may be needed to accurately measure reactor coolant particle concentrations and crud concentrations at critical locations.

GTRF Challenge Problem

Experimental data is needed in three main areas.

Wear measurements of different couples of irradiated materials (oxide/oxide, oxide/metal, metal/metal) under different vibration modes (sliding, impact, etc.) at different amplitudes are needed.

Time dependent cross-flow effect on rod vibration, as part of turbulence pressure on fuel rod studies is needed. Direct measurement of instantaneous dynamic pressure on fuel rod surface is critical data to validate CFD simulation. Tests can be based on small scale rod bundle (e.g., 5x5) with grid spacers and three spans.

Data related to grid-to-rod gap formation is needed. This is a complex process, involving dimensional changes due to fuel rod creep down, grid spring relaxation, and complex creep behavior due to variations in local cold work, and grid cell growth. High precision experiments are needed to characterize these processes.

PCI Challenge Problem

Experiments are needed in two main areas: fuel pellet cracking and relocation and Zr-alloy multi-axial thermal creep. In both cases, out-of-pile separate-effect tests and in-pile integral-effect tests would provide complementary data to support validation.

The out-of-pile experiment would evaluate pellet cracking and fragment movement during normal operation. UO_2 fracture behavior and frictional interaction between pieces would be studied under representative thermal and stress conditions. Such separate effects tests include using electrically heated pellets to obtain fracture characteristics and crack roughness parameters.

In-pile tests would measure pellet-cladding mechanical interaction during in-pile power maneuvers to evaluate gap closure and pellet mechanical compliance. In-pile testing would use single rod experiments under different burnup, peak power, and power ramp rates. On-line diameter and temperature measurements would be needed. Design of such experiments and development and demonstration of in-pile measurement techniques are of high priority.

DNB Challenge Problem

Existing datasets have been successfully used for fuel design improvement and DNB prevention, as well as for assessment of sub-channel codes. However, the data quality is not adequate for validating DNB simulations under the plant design conditions, and for calibration and validation of advanced mechanistic DNB and/or two-phase flow CFD models. Areas where additional data are most needed include the effect of rod surface characteristics on DNB, void measurements in subcooled flow boiling in rod bundles, high-fidelity turbulent mixing, including the impact of spacer grid design features `on DNB, and transient DNB testing.

High precision void fraction distributions in boiling channels under reactor prototypic conditions are identified as a cross-cutting area of the highest priority for calibrating and improving thermo-hydraulics methods (THM) used in CRUD, DNB and other Challenge Problems. Experiments with void measurements by radiographic imaging or other techniques are needed for subcooled and saturated boiling conditions at high pressures and flow conditions simulating reactor operational, transient and accident conditions. Design of such experiments and development and demonstration of high-fidelity imaging techniques are of high priority.

Appendix F: Accessing the Advanced Test Reactor National Scientific User Facility

As previously described in this document, the NSUF provides cost-free access to DOE, University, and Industry facilities. The access to these facilities also includes the support of the technical staff at each facility to ensure that the applicant is able to successfully complete their research. With the integration of NSUF access into this FOA, the process for application for NSUF access will be different from previous NSUF solicitations. An additional requirement to forward fund awards also significantly changes the previous NSUF solicitation process. Figure E-1 depicts the new process that implements these changes. Note that NSUF Rapid Turn-around Experiments (RTE) are not part of this FOA or new process and will continue on a three calls per cycle. .

Unlike the other workscopes 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 will be required to contact the NSUF Program Office to identify a NSUF technical lead and submit a letter of intent to apply for the FOA. After the LOI is received, the applicant and NSUF technical lead will work together to develop the Pre-Application and begin the process to define the scope of the application and estimate cost.

For all applications, the NSUF facility technical lead will work with the applicant to define the scope in the form of a Statement of Work (SOW). The SOW will be reviewed and approved by the NSUF Program Office. As a minimum, the SOW will include the following (as applicable):

1. Specific requirements for specimen acquisition, e.g. material acquisition, fabrication requirements, specimen configuration,
2. 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.
3. Specific requirements for Post Irradiation Examination (PIE) of each specimen, e.g. visual examination, dimensional examinations, tensile testing radiography, microscopy, etc.
4. Proposed time-line

The approved SOW will be utilized by the NSUF facility technical staff to develop an execution plan and cost estimate for the SOW. The execution plan will typically address the following elements (as applicable):

1. Concept for the irradiation device including fabrication and assembly plans
2. Irradiation position and duration,
3. Experiment shipping
4. Disassembling and cataloging the experiment
5. Specimen preparation and shipping
6. Specimen examination details
7. Waste disposal
8. Resource loaded schedule

The information in the execution plan will then be used by the NSUF facility to develop a cost estimate for the proposed scope of work. The cost estimate will then be reviewed by the NSUF Program Office to determine if the proposed scope of work will fit into the anticipated award budget

for this FOA. If the cost estimate is higher than the budget, the NSUF Program Office may negotiate a scope decrease, if appropriate, with the PI and technical lead in order to properly size the scope of work. After negotiation, the SOW and cost estimate will be updated to match the negotiated scope so that this information can be incorporated into the full application.

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 G contains a typical User Agreement. The SOW swill 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 facilities performing the work defined the in SOW and experiment execution plan.

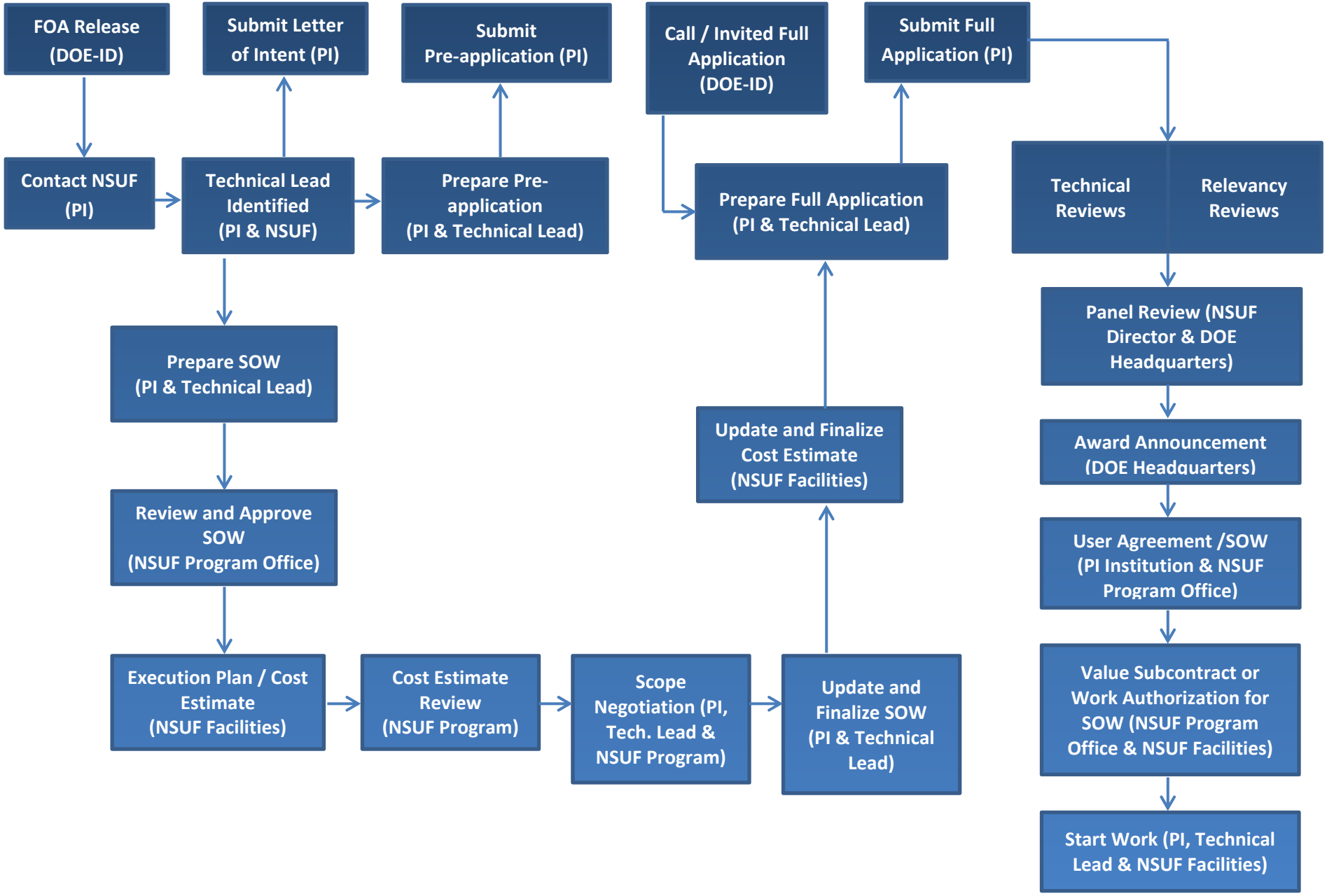
NSUF Quality Assurance Requirements

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

As previously described, applicants may apply for NSUF access with or without support from other works scopes in this FOA. Bridge funding will no longer be available through NSUF, so applicants need to ensure that the following cost elements are covered by other work scopes in this FOA or via another fund source:

1. Travel costs to NSUF facilities for facility access training, technical meetings, examinations, experiment loading, etc.
2. Applicant Salary support
3. Graduate Student support
4. Post Doc or other researcher support
5. Materials and supplies support at the PI's work location


FOA Release (DOE-ID)
Submit Letter of Intent (PI)
Submit Pre-application (PI)
Call / Invited Full Application (DOE-ID)
Submit Full Application (PI)
Contact NSUF (PI)
Technical Lead Identified (PI & NSUF)
Prepare Pre-application (PI & Technical Lead)
Prepare Full Application (PI & Technical Lead)
Technical Reviews
Relevancy Reviews
Prepare SOW (PI & Technical Lead)
Panel Review (NSUF Director & DOE Headquarters)
Update and Finalize Cost Estimate (NSUF Facilities)
Award Announcement (DOE Headquarters)
Review and Approve SOW (NSUF Program Office)
User Agreement /SOW (PI Institution & NSUF Program Office)
Execution Plan / Cost Estimate (NSUF Facilities)
Cost Estimate Review (NSUF Program)
Scope Negotiation (PI, Tech. Lead & NSUF Program)
Update and Finalize SOW (PI & Technical Lead)
Value Subcontract or Work Authorization for SOW (NSUF Program Office & NSUF Facilities)
Start Work (PI, Technical Lead & NSUF Facilities)

Appendix G: Advanced Test Reactor National Scientific User Facility User Agreement

INL Non-Proprietary User Facility Agreement

Idaho National Laboratory

Non-Proprietary User Agreement

User Facility Agreement No. 10-008 BETWEEN

BATTELLE ENERGY ALLIANCE, LLC

(" CONTRACTOR")

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

AND

The Regents of the University of

-

("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 10 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 as specified in the attached Funding Statement.

ARTICLE IV: ADMISSION REQUIREMENTS

USERs and Particpants 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. 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. Materials (including residues and/or other contaminated material) remaining after performance of the work or analysis will be removed in their then condition by USER at USER's expense. 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.

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 of the U.S. Department of Energy (DOE), which are 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 person acting on their behalf: (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 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: Todd Allen

TITLE: Deputy Laboratory Director, Science and Technology

DATE: _____

User's Formal Name (USER):

BY: _____

Signature

NAME: _____

Printed

TITLE: _____

DATE: _____

ADDRESS: _____

TELEPHONE: _____

***** Any changes to the *** or substantive changes to the non *** provisions will require formal written approval by DOE.**