Pre-release Information - Nuclear Energy University Programs (NEUP) Integrated Research Project (IRP) Summaries

***Disclaimer**: This document contains pre-release information supporting an upcoming NEUP request for applications and as such, provides information that is appropriate for planning purposes only. Thus, any and all potential applicants should refer the official Call for Proposals (CFP) when it is released to obtain the full and final official details for this solicitation.*

Purpose – Provide potential applicants with appropriate background information regarding the planned scope for IRPs to facilitate planning in advance of issuance of the NEUP IRP CFP in May 2012 (subject to program priorities).

Background – The primary mission of the Department of Energy's (DOE) Office of Nuclear Energy (NE) is to advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs by resolving technical, cost, safety, proliferation resistance, and security barriers through research, development, and demonstration as appropriate.

NEUP's goal is to support outstanding, cutting-edge, and innovative research and development (R&D) at United States (U.S.) universities. Dr. Peter Lyons, Assistant Secretary for Nuclear Energy, has affirmed an update to the NEUP strategy commencing in fiscal year (FY) 2011 to include a three-component, graded approach to its program based upon appropriate program linkage and relevance. The three components are Program Directed (PD), Program Supporting (PS), and Mission Supporting (MS).

IRPs are a significant element of the NEUP program and represent the PD component of the NEUP strategy by providing R&D solutions that are the most directly relevant to the near-term, significant needs of the NE R&D programs. IRPs complement the other NEUP components, which include PS & MS university-based R&D awards, PS University Reactor and General Equipment Infrastructure Grants, and MS Student Fellowship and Scholarship Grants.

IRPs will be significant, three-year projects within specific research areas. The research areas (IRP CFP scope) will address specific needs, problems or capability gaps identified and defined by the NE R&D programs and are intended to develop a capability within each area. These projects will be multidisciplinary and require multi-institutional partners.

Summary - The following three IRP focus areas will be addressed in the upcoming FY 2012 CFP:

- Advanced Nuclear-Cladding and Fuel Materials with Enhanced Accident Tolerance for Current Generation & GEN III+ Light Water Reactors ($1.17M/yr totaling up to $3.5M)

- Degradation of Used Nuclear Fuel in Storage ($1.67M/yr totaling up to $5.0M)
- Inherently Safe Light Water Reactors ($2.0M/yr totaling up to $6.0M)

NE has identified these three topic areas as presenting a critical barrier to achieving its goals as defined in the NE R&D Roadmap. Within the NEUP R&D structure, each IRP will comprise a highly collaborative team, spanning multiple scientific, engineering, and, where appropriate, economics and public-policy disciplines. IRPs are to be led by Universities partnering with top talent across the full spectrum of R&D performers. Each IRP is expected to deliver an exemplary product for use within the NE R&D portfolio. IRPs will bring together the skills and talents of multiple investigators to enable fundamental research of a scope and complexity that would not be possible with the standard individual investigator or small group research project. As such, the IRPs will strengthen and complement the existing portfolio of the single Principal Investigator and small group research projects currently supported within NEUP. The IRPs will foster unique scientific collaboration that will be critical to success and must be backed by a meaningful and sustained investment.

Although a proposing team must have a lead university and at least one other university, the team may include multiple universities and national laboratories. Also, the Department strongly encourages effective partnerships and will include this criterion as part of its program relevancy evaluation and scoring. Accordingly, industry partners are strongly encouraged and may receive funding support from the project, although no more than 20 percent of the funding can go to a non-university U.S. participant. International partners are equally encouraged on a non-government funding basis, and strong consideration will be given to proposals that include effective partnerships with underrepresented groups and/or minority serving institutions. Access to existing DOE supported facilities may be requested and utilized as required and available.

Specific Nuclear Energy University Programs (NEUP) Integrated Research Project (IRP) Scopes:

1. Advanced Nuclear-Cladding and Fuel Materials with Enhanced Accident Tolerance for Current Generation & GEN III+ Light Water Reactors

Recent events in the nuclear industry have increased interest in developing advanced nuclear fuels with enhanced tolerance to accidents. During accident and off-normal conditions, the fuel and the associated cladding material in a light water reactor experiences significant rapid heating and significantly higher temperatures. These increased temperatures can result in: increased internal pressures of the fuel; higher fuel-cladding temperatures; coolant boiling and evaporation; exothermic oxidation of the zirconium-based cladding; and the production of hydrogen gas, which can become explosive. Research is needed on advanced materials and/or

fuel-cladding concepts suitable for use in existing light-water reactors or light-water reactors with design certifications (GEN-III+) that would improve performance and safety, both during reactor service and during long-term storage in spent fuel cooling pools.

The Department of Energy's NEUP is seeking proposals for an IRP to develop one or more advanced cladding materials and/or fuel-cladding concepts with enhanced accident tolerant characteristics. Improvements to the fuel/cladding system may be accomplished through many possible approaches including innovative designs (e.g. coatings/liners for zirconium-based cladding), novel materials, or combinations of the two. Some design objectives identified as important to improve accident tolerance include: higher temperature and strength capability, reduced or eliminated hydrogen generation, improved fission product retention, and increased resistance to bulk steam oxidation. In all cases the material must withstand the expected thermal neutron flux during the residence time in a light water reactor without significant degradation in structural properties.

The proposed accident tolerant advanced materials and concepts must be able to be qualified for use in currently operating reactors and reactors with design certifications and should not require significant plant modifications to implement. Proposed concepts must maintain or improve: cycle length, reactivity coefficients, safety margins such as departure from nucleate boiling, and response to design-basis accidents. Emerging areas in material science, such as nanotechnology, may prove useful in developing new and innovative designs although others are possible.

Proposals are sought from research teams to conduct research and development with the goal of producing one or more advanced materials and/or fuel-cladding concepts that would enhance the accident tolerance of the nuclear fuel system. Proposals should be for a period of three years and a total cost not to exceed $3.5 million.

The proposal should include a detailed evaluation and identification of the relevant conditions during accidents and off-normal events and identify the resultant technical requirements that would guide research and development. A desired outcome of this IRP is the identification of one or more advanced materials or materials systems along with physical samples that can be tested in DOE facilities, e.g., LOCA testing, and irradiation testing at Advanced Test Reactor user facility or other national laboratory reactor. Therefore, proposals should include development, preliminary irradiation, and demonstration within the allotted time period of technical feasibility.

This IRP may recognize and be coordinated with, if desired, another IRP on Inherently Safe Light Water Reactors.

2. Used Nuclear Fuel Storage

The Department of Energy's NEUP is seeking proposals for an IRP related to extended storage of used nuclear fuel (UNF). Material degradation issues associated with long-term behavior of high burnup UNF (>45 gigawatt-days/metric ton) is of specific concern. This IRP is an extension of an earlier IRP that concentrated on hydride effects and creep of fuel cladding, canister corrosion, and advanced instrumentation and monitoring systems. This IRP is focused on other issues related to other components of the storage system. DOE is also interested in more efficient packaging of canisters as identified in item numbers 4 through 9. Interested Proposers are encouraged to visit the NEUP website (www.neup.gov) to review what has been awarded to date. The list below contains the research activities for processes and degradation mechanisms for long-term storage system components that the DOE has a high interest in. Therefore, proposals that address all of the nine issues below will be given the highest consideration for award since all activities are important. However, the DOE also recognizes that addressing all of these issues in a proposal may be very difficult for some university teams. To address this issue, the first three items must be included and at least four of the remaining six must also be included in the proposal. If the first three and at least four of the remaining items are not included in the proposal it will be considered as non-responsive and it will not evaluated. Again it is emphasized that proposals with all nine items included will be given highest consideration. Activities of interest include:

1. Fuel assembly hardware
2. Neutron poisons
3. Bolts and seals of casks and possible canisters
4. Reducing canister drying times issues
5. Materials that could be added to a canister to maintain geometry configuration
6. Sealing canisters without welding
7. Rapid welding of canisters
8. Rapid processing of canisters at a utility to reduce radioactive dose
9. Numerical modeling for more efficient loading of canisters with used nuclear fuel.

The funding will support research and development to better understand long-term degradation mechanisms relevant to these processes and components of the storage system. Proposed activities should address, where possible and appropriate, the need to develop data applicable to time periods significantly longer than the period of testing. Proposed experimental and modeling approaches must be developed enough to be operational in a laboratory by the end of the three-year period of performance. The product of this research could eventually inform the technical basis for extended storage.

Proposals should be for a period of three years and a total cost not to exceed $5.0 million. The proposal may include a combination of experimental work and computer simulations.

3. Inherently Safe Light Water Reactors

The 2011 earthquake and nuclear accident in Japan have generated renewed interest in the development of advanced nuclear reactor systems that are inherently safe. Generation III+ reactors designs have shown substantial reductions in the probability of reactor core damage with elements of passive safety; however, there may be opportunities for further improvements.

The Department of Energy's NEUP is seeking proposals for an IRP to develop advanced light water reactor designs with inherent safety features. Emerging designs for Small Modular Reactors are already leveraging many of the enhanced safety characteristics of compact reactor systems. This IRP should focus on larger (greater than 1000 megawatt electric) light water reactor designs that further improve the performance and inherent safety compared to existing Generation III+ light water reactor systems. These improvements may be achieved through novel and innovative reactor systems, components, materials, new fuel forms (including non-UO_2 fuels), or passive safety features that are substantially different from those used in existing designs. In addition to safety and reliability, improved performance with respect to each of the Generation IV performance goals should be considered, including sustainability (fuel utilization/waste minimization), economics, proliferation resistance, and physical protection.

In order to fully realize the potential of these advanced systems, the reactor system and fuel must be addressed in an integrated approach. The project must include conceptual designs and safety analysis, with specifically defined performance criteria, that would support and justify the development of an inherently safe light water reactor based system. A comprehensive research plan for addressing key issues related to development and commercialization of innovative features, including the use of experimental facilities necessary to develop critical components and subsystems of the proposed design, should be included.

Proposals are sought from research teams prepared to conduct research and development with the goal of producing designs that are inherently safe. Proposals should be for a period of three years and a total cost not to exceed $6.0 million.

This IRP may recognize, and be coordinated with, if desired, another IRP on Advanced Nuclear-Cladding and Fuel Materials with Enhanced Accident Tolerance for Current Generation & GEN III+ Light Water Reactors.