U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Topic Area 1 - Reactor Development and Plant Optimization

Up to 3 years and up to $1,000,000

RDO-1: Advanced Reactor Development| *Janelle Eddins, Federal POC*

RDO-2: Improving Economic Competitiveness| *Jason Tokey, Federal POC*

RDO-3: Integrated Energy Systems and Industrial Applications| *Jason Marcinkoski, Federal POC*

RDO-4: Remote Deployment/Dedicated Power Supplies Including Siting| *Diana Li, Federal POC*

RDO-5: Implementation of Artificial Intelligence and Machine Learning| *Daniel Nichols, Federal POC*

RDO-6: Other Reactor Development and Plant Optimization

Topic Area 1

Reactor Development and Plant Optimization Overview

- NE supports existing and advanced reactor designs and technologies to enable industry to address technical challenges with maintaining the existing fleet of nuclear reactors, and to promote the development of a robust pipeline of advanced reactor designs and technologies and supply chain capabilities.
- Advances in reactor development, design, and testing that improve technical, cost, safety, and security issues associated with the existing commercial light water reactor fleet and advanced reactor technologies, such as small modular reactors (SMR), microreactor designs, fast reactors using liquid metal coolants, and high temperature reactors using gas or liquid salt coolants are of interest.
- NE is also interested in research related to plant optimization including, but not limited to, siting, economics, construction and scheduling outcomes, reducing cost and deployment timelines, remote deployment of reactors, environmental justice and equity considerations, and secure operations, among other relevant topics.

Organization for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) Nuclear Education, Skills and Technology (NEST)

- Incremental funding is potentially available through participation in the OECD NEA NEST program
- NEST ties together university research projects across multiple countries to provide students a fuller professional experience as they pursue their degree
- NEST funds are provided to allow travel for students to interact with colleagues in other NEST countries in accordance with NEST program rules
- The NEST program is most interested in projects that advance the deployment probability of advanced reactors, to include economics, community acceptance, and business deployment opportunities
- **Applications submitted to this work-scope do not require NEST participation**
- Access to NEST funds requires investigators to agree to participate in NEST
- Investigators must clearly indicate in their application if they are willing to join as a NEST project
- Anticipated budget requirements for NEST participation must not be included in an application submitted to this topic area
  - NEST funding received by successful applicants will not be included or tracked as part of the overall project budget and is not subject to inclusion in project financial reporting
- **Participation in NEST will not be a factor considered in the review of applications**
- Applies to IRP-1 and all sub-topics within Topic Area 1

Topic Area 1 RDO-1

Advanced Reactor Development (RDO-1)

- Advanced reactors have the potential to offer significant benefits
- Proposals are sought for activities that could help reduce the technical risks associated with these designs, including light water SMRs, microreactors, fast reactors using liquid metal coolants, and high temperature reactors using gas or liquid salt coolants
- Proposals should clearly identify the challenge being addressed and how proposed activities will support the development, demonstration and future deployment of advanced reactor concepts
- Some potential challenges that could be addressed include, but are not limited to:
  - Advanced reactor component development and testing
  - Transient and safety analysis
  - Thermophysical and thermochemical properties determination of molten salts associated with Ab Initio Molecular Dynamics simulations
  - Graphite-salt interaction studies
  - Innovative reactor core and system design or modifications
  - Characterization of bypass flow for pebble bed reactors
- Applicants are encouraged to think expansively and suggest innovative solutions

Topic Area 1 RDO-1

Ongoing NE Work Relevant to RDO-1

- Advanced Reactor Technologies (ART) Program
  - Molten Salt Reactor (MSR) Research Campaign: https://gain.inl.gov/SitePages/Molten%20Salt%20Reactor.aspx
  - Gas-cooled Reactor Research Campaign: https://gain.inl.gov/SitePages/HighTemperatureReactor.aspx
  - Fast Reactor Research Campaign: https://gain.inl.gov/SitePages/Fast%20Reactor.aspx
  - Microreactor Research Campaign: https://gain.inl.gov/SitePages/MicroreactorProgram.aspx
- Cost-shared Partnerships with Industry
  - Advanced Reactor Demonstration Program (ARDP) Risk Reduction Awards: https://www.energy.gov/ne/articles/energy-departments-advanced-reactor-demonstration-program-awards-30-million-initial
  - Advanced Reactor Concepts-20 (ARC-20) Awards: https://www.energy.gov/ne/articles/energy-departments-advanced-reactor-demonstration-program-awards-20-million-advanced
  - NuScale and Carbon Free Power Project: https://www.energy.gov/ne/advanced-small-modular-reactors-smrs
- Other on-going research through many avenues of funding including directed research, NEUP, SBIR/STTR, and Industry FOA.

The above list of R&D examples is not exhaustive, and it is provided to assist applicants in identifying research that is not duplicative of previous or on-going research.

More information about past/current advanced reactor R&D can be found at:https://www.energy.gov/ne/advanced-reactor-technologies and www.neup.inl.gov

Topic Area 1 RDO-1

Areas Not Of Interest

Applications should focus on research that support the **DOE-NE mission**

Applications with the following focuses would be considered not relevant to this topic:

- Nuclear non-proliferation purposes
- Technologies solely for nuclear fusion applications
- New reactor designs
- Nuclear medical isotope production
- Technical solutions solely focused on the existing fleet

Applications on technologies that crosscut any of these areas could be considered responsive if proposal clearly demonstrates the application to nuclear energy.

Topic Area 1 RDO-2

Improving Economic Competitiveness (RDO-2)

- The existing nuclear fleet continues to face economic pressures which are resulting in premature plant shutdowns, and advanced reactors must prove their economic competitiveness against nascent technologies for widespread deployment to be successful.
- Proposals are being sought for innovative solutions to improve the economic competitiveness of existing and future nuclear power plants.
- Proposals should clearly identify the challenge being addressed and how proposed activities will support improved economic competitiveness from existing and/or advanced nuclear technologies.
- Some potential challenges that could be addressed include, but are not limited to:
  - **Evaluations of cost drivers for existing and/or advanced nuclear technologies**
  - **Development of new methods, processes, or technologies to reduce costs related to construction, operations and/or maintenance**
  - **Modernization of the existing fleet**
  - **Reduction in uncertainty in safety margin calculations that drive unnecessarily conservative assumptions**

Topic Area 1
RDO-2

Ongoing NE Work Relevant to RDO-2

- NE supports a wide range of programs that intersect with this economic competitiveness area of interest including:
  - Light Water Reactor Sustainability (LWRS) Program
  - Advanced Reactor Technologies (ART) Program
  - Advanced Reactor Demonstration Program (ARDP) Risk Reduction Awards
  - Advanced Reactor Concepts-20 (ARC-20) Awards
  - Advanced Reactor Safeguards (ARS) Program
  - Other on-going research through many avenues of funding including directed research, NEUP, SBIR/STTR, and Industry FOA.

The above list of R&D examples is not exhaustive, and it is provided to assist applicants in identifying research that is not duplicative of previous or on-going research.

Topic Area 1
RDO-2

Areas Not Of Interest

Applications should focus on research that support the **DOE-NE mission**

RDO-2 is a broad statement of work. Before applying to RDO-2, applicants should ensure that potential topics are not better aligned with other Topic Areas under this solicitation.

Applications with the following focuses would be considered not relevant to this topic:

- New reactor designs
- Development of reactor fuels (See Topic Area 3)
- Instrumentation and Controls (See Topic Area 5)
- Cybersecurity (See Topic Area 5)

Topic Area 1
RDO-3

Integrated Energy Systems and Industrial Applications (RDO-3)

Nuclear reactors are an attractive technology to power several applications where clean, reliable energy, or high-quality heat is needed with very high availability.

- hydrogen
- synthetic fuels
- polymers
- chemicals
- minerals production
- refineries
- district heating

Nuclear reactors offer the ability to provide heat and electricity at the location where it is needed, greatly reducing the cost to transmit/distribute energy.

Topic Area 1
RDO-3

Ongoing NE Work Relevant to RDO-3

Projects are sought to **develop reference designs** for nuclear-integrated industrial plants.

Proposed tasks could include, but are not limited to:

- Chemical/industrial process models for integrating nuclear energy inputs (electricity, heat).
- Design of thermal, electrical, and chemical distribution and storage systems, including control system components and sensors.
- Innovative designs for physical protection, barriers.
- Nuclear and industrial plant layouts.

Topic Area 1
RDO-3

Areas Not Of Interest

Proposals for new reactor designs are not within scope.

Dispatch optimization for power to the grid, or controlling multiple loads.

Topic Area 1
RDO-4

Remote Deployment/Dedicated Power Supplies Including Siting (RDO-4)

- Some advanced reactors, such as microreactors, are uniquely suited for servicing non-traditional energy markets such as off-grid communities, remote locations, military bases, and disaster relief missions.
- Additionally, new large electrical loads pose several challenges to the U.S. electric power grid that could potentially be addressed through use of microreactors or small advanced reactors to serve as dedicated power sources.
- Proposals are sought that identify high value opportunities for advanced reactors to service non-traditional energy markets and/or provide a dedicated supply of heat and/or electricity.
- Proposals may consider some of the following activities:
  - techno-economic analysis
  - environmental justice considerations in siting advanced nuclear projects
  - technical interface considerations and regulatory analysis
  - details on reactor type, size, variability of loads, thermal and electrical output capacity
  - startup and shutdown requirements under planned and unplanned conditions
  - site requirements such as containment, methods and capacity to transfer heat to the environment in various operating conditions, access, and physical security boundaries, operator and security staff

Topic Area 1 RDO-4

Ongoing NE Work Relevant to RDO-4

- Microreactor Research Program
  - Non-nuclear integrated system testing supporting commercial demonstrations and end-user applications
  - Maturation of innovative components and semi-autonomous operating regimes
  - Microreactor Applications Research, Validation and Evaluation (MARVEL)
- Maritime Applications for Nuclear Energy
  - Maritime Nuclear Application Group
  - FY22 CINR award to the University of Texas at Dallas for project titled “Integrated Thermal-Electric Energy Management of All-Electric Ship with Advanced Nuclear Reactors
  - Industry Award to the American Bureau of Shipping for project titled “Accelerating Commercial Maritime Demonstration Projects for Advanced Nuclear Reactor Technologies”
- Other on-going research through many avenues of funding including directed research, NEUP, SBIR/STTR, and Industry FOA.

The above list of R&D examples is not exhaustive, and it is provided to assist applicants in identifying research that is not duplicative of previous or on-going research.

More information about past/current advanced reactor R&D can be found at: https://gain.inl.gov/SitePages/MicroreactorProgram.aspx and https://neup.inl.gov/FY22%20Abstracts/CFA-22-26915_TechnicalAbstract_2022CFATechnicalAbstractCFA-22-26915.pdf

Topic Area 1
RDO-4

Areas Not of Interest

Applications should focus on research that support the **DOE-NE mission**

Applications with the following focuses would be considered not relevant to this topic:

- Technologies solely for nuclear fusion applications
- New reactor designs
- Nuclear medical isotope production
- Activities focused solely on traditional integrated energy systems applications such as hydrogen production (See RDO-3)

Applications on technologies that crosscut any of these areas could be considered responsive if proposal clearly demonstrates the application to nuclear energy.

Topic Area 1
RDO-5

Implementation of Artificial Intelligence and Machine Learning (RDO-5)

Artificial intelligence and machine learning (AI/ML) have been identified as critical tools to support optimization of a wide variety of systems pertinent to the growth and sustainability of the nuclear power industry.

These tools can **expedite development and deployment of nuclear reactors**, lower costs, and provide faster solutions to unique problems.

Proposals are sought that leverage these highly advantageous tools to solve problems such as, but not limited to, structural design optimization, process optimization, economic optimization, manufacturing optimization, hazard detection, and non-nominal condition monitoring. The goal is to promote interest growth from the AI community while focusing on supporting the Office of Nuclear Energy's mission.

Applicants should:

- Describe the AI/ML method proposed and explain expected impact on the intended reactor system
- Identify (if applicable) the necessary source of data used for training algorithms, and describe methods of procuring the needed data
- If the proposed AI method is novel, provide a basis of comparison against conventional methods, to demonstrate feasibility and advantages

Topic Area 1
RDO-5

Ongoing NE Work Relevant to RDO-5

Artificial intelligence and machine learning methods have been used in a wide variety of applications through avenues of funding including directed research, NEUP, SBIR/STTR, and Industry FOA.

Previous or on-going research includes the following AI/ML applications:

- Partial or full-autonomous reactor control
- Expedited material discovery via simulation and modeling
- Computer vision for plant navigation and analog gauge observation
- Automated manufacturing of advanced components

The above list of R&D examples is not exhaustive, and it is provided to assist applicants in identifying research that is not duplicative of previous or on-going research.

Topic Area 1
RDO-5

Areas Not Of Interest

Applications should focus on research that support the **DOE-NE mission**

Applications with the following focuses would be considered not relevant to this topic:

- Nuclear non-proliferation purposes
- Technologies solely for nuclear fusion applications
- Personnel dose monitoring
- Nuclear weapons R&D
- Nuclear medical isotope production
- Nuclear medicine related technologies

Applications on technologies that crosscut any of these areas could be considered responsive if the proposal clearly demonstrates the application to nuclear energy.

Topic Area 1
RDO-6

Other Reactor Development and Optimization Topics (RDO-6)

Proposals that are relevant to Reactor Development and Plant Optimization as described in the Topic Area 1 overview but are not covered by the previous topic categories can be submitted to RDO-6 for consideration.

It is important to note that any submission to this category can be crosscutting, but must reinforce the Office of Nuclear Energy's mission and the following supporting goals:

"Advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs."

1. Enable continued operation of existing U.S. nuclear reactors.
2. Enable deployment of advanced nuclear reactors.
3. Develop advanced nuclear fuel cycles.
4. Maintain U.S. leadership in nuclear energy technology.

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Questions?