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

Topic Area 5 - Instrumentation and Controls

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

IC-1: Sensors & Instrumentation | *Daniel Nichols, Federal POC*

IC-2: Advanced Control Systems| *Daniel Nichols, Federal POC*

IC-3: Advanced Nuclear Cybersecurity| *Rebecca Onuschak, Federal POC*

IC-4: Other Instrumentation and Controls Topics

Topic Area 5

Instrumentation and Controls Overview

- Research and development on sensors, instrumentation, controls and infrastructure technology that are necessary to address critical technology gaps to monitor and control both existing and advanced reactors
- Development of reliable and cost-effective sensors and detectors to provide real-time, accurate and high-resolution measurements of the performance of existing and advanced reactors' cores, fuel cycle systems, and plant systems
- Control algorithms to enable real-time control of plant or experimentation process variables to enhance plant reliability, availability, thermal performance, and resilience
- Communication technologies to enable real-time transmission of sufficient data for online monitoring and advanced data analytics
- Machine learning and artificial intelligence capabilities to enable semi-autonomous operations and maintenance by design
- Other relevant topics related to instrumentation and controls (I&C)

Topic Area 5 IC-1

Sensors and Instrumentation (IC-1)

Development of new, or the enhancement of existing sensor technologies, that support nuclear power plants in the current and future fleet.

Sensor technologies focused on the **existing reactor fleet** should address needs which help extend the plant operable lifetime and provide additionally capabilities to increase safety, reliability, and operational efficiency.

Technologies for **advanced reactor concepts** should tailor efforts towards accommodating the unique qualities of the future fleet such as smaller form factor, increased operating temperatures, and working fluid compatibility.

Applicants are encouraged to include development and demonstration of the instrumentation system, with data acquisition, under relevant conditions

Applications should:

- Identify the type of instrumentation to be developed, or enhanced, and should specify the relevant reactor conditions for which their technology is applicable; radiation tolerance, temperature tolerance, pressure tolerance, and working fluid compatibility (if applicable).

-or-

- Propose new sensor concepts or leverage existing technologies with the intent to enhance capabilities.

Topic Area 5 IC-1

On-Going NE Work Relevant to IC-1

The Advanced Sensors and Instrumentation (ASI) program has on-going research through many avenues of funding including directed research, NEUP, SBIR/STTR, and Industry FOA.

Previous or on-going research includes the following sensors and instrumentation technologies:

- Neutron Flux Detectors
- Acoustic Sensors
- Thermocouples
- Printed Sensors
- Linear Variable Differential Transformers
- Radiation Hardened Electronics
- Additively Manufactured Sensors

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 sensors and instrumentation R&D can be found on the ASI website: https://asi.inl.gov/#/researchlibrary

Topic Area 5 IC-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
- 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 proposal clearly demonstrates the application to nuclear energy.

Topic Area 5 IC-2

Advanced Control Systems (IC-2)

Development of semi-autonomous operations has been proposed to reduce costs for the next generation of nuclear reactors.

This call targets applications that will **enable semi-autonomous operation**, **fault-tolerant control systems**, **load-following**, and **load balancing of multi-unit nuclear power plants**.

Two necessary and important considerations for these control systems will be the **coupling of digital twin assets** and **incorporating robust cybersecurity** into the design.

Proposals are sought for novel control system approaches, designs and component innovations which enable semi-autonomous operation for advanced reactor concepts.

Applications should:

- Identify a real technology gap pertaining to an advanced reactor concept design.
- develop a control system, with the necessary components to address the scenario.
- Demonstrate and apply the completed control system to the technology gap and provide analysis of performance metrics

Topic Area 5 IC-2

On-Going NE Work Relevant to IC-2

The Advanced Sensors and Instrumentation (ASI) program has on-going research through many avenues of funding including directed research, NEUP, SBIR/STTR, and Industry FOA.

Previous or on-going research includes the following advanced control system technologies:

- Development of semi-autonomous control systems
- Preliminary development of digital twin applications
- Online monitoring and diagnostics of system components
- Operations and maintenance support provided by AI

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 control system R&D can be found on the ASI website: https://asi.inl.gov/#/researchlibrary

Topic Area 5 IC-2

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
- Nuclear weapons R&D
- Nuclear medical isotope production

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

Topic Area 5 IC-3

Advanced Nuclear Cybersecurity (IC-3)

Mission: enable science-based methods and technologies for cost-effective, cyber-secure digital instrumentation, control and communication for current and future nuclear power plants.

Vision: US nuclear fleet that embraces the use of advanced digital technologies to enhance technical and economic performance.

https://www.flickr.com/photos/thirdwaythinktank/37875478862/in/album-72157665372889289/

Key R&D Products:

- Techniques to identify and mitigate cybersecurity hazards during design
- Technical basis for documenting cyber risk in a way that can be credited during licensing
- Support for longer-term, post-deployment use cases that are currently cybersecurity-limited
- Technical tools, such as control system design requirements, supply chain protection methods and test beds

Topic Area 5 IC-3

Advanced Nuclear Cybersecurity (IC-3)

- The DOE-NE Cybersecurity program seeks to perform R&D in technologies that support and enable digital solutions for the U.S. nuclear sector.
- This year's opportunity offers a broader space of interest than in the past.
- Applicants are encouraged to offer 1) technical solutions to cybersecurity challenges associated with advanced technologies or use cases, or 2) solutions to improve the economics and/or effectiveness of cybersecurity management in the existing fleet.
- Other scope areas also reference cybersecurity. Those are intended to include its consideration when something else is the primary focus. This scope is cybersecurity-centric.

Topic Area 5 IC-3

Advanced Nuclear Cybersecurity (IC-3)

Examples of advanced technologies and use cases (applicants are not limited to these):

- machine learning, digital twins and other advanced data analytics tools to support design, maintenance and/or operations
- advanced cybersecurity analytics tools for attack detection and/or response
- remote and/or autonomous operations
- use of wireless sensors and/or controls in-plant for safety- or security-related functions
- advanced manufacturing tools or techniques that rely on data analytics for quality assurance and/or regulatory acceptance of nuclear plant components
- integration of electric and non-electric power applications at the same power plant (e.g. hydrogen production, process heat)

Topic Area 5 IC-3

Elements of Strong Applications

- Clearly defined nuclear-power-specific challenge not already being addressed by R&D focused on industrial control systems or critical infrastructure protection.
  - Tools and techniques may be adapted to the nuclear sector, but specific technical and/or regulatory challenges, requiring more than the implementation of standard cybersecurity practices, should be clearly described and addressed by the work.
- Clearly defined specific cybersecurity challenge being addressed by the research, including a description of how the proposed research addresses adversary behaviors or a specific threat model.
- Discussion of the current state of practice in the proposed work area, sufficient to demonstrate the potential value of the proposed approach.
  - Note that this does not preclude early concepts or “blue sky” ideas, but these should, if successful, address well-defined needs.

Topic Area 5 IC-3

Areas Not of Interest

- Attack models or intrusion detection tools for plant operations, similar to capabilities of existing commercial tools.
  - If attack scenarios or intrusion detection or mitigation tools are proposed, successful applications will include a clear business case for such R&D in the context of what already exists.
- High-performance computing capabilities, cryptographic algorithms and similar broad-purpose R&D (e.g. quantum computing platforms and associated cryptographic techniques).
  - Extremely novel/low technology-readiness-level hardware or software tools will be of interest only if they are highly specific to a nuclear power need or use case.
- Tools broadly applicable to industrial control systems or critical infrastructure environments, without a clear and direct application to nuclear-specific cybersecurity challenges.

Topic Area 5 IC-4

Other I&C Topics (IC-4)

Proposals that are relevant to I&C as described in the Topic Area 5 overview but are not covered by the previous topic categories can be submitted to IC-4 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.

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

Questions?