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

Office of Nuclear Energy R&D Programs Overview

NE-42: Advanced Fuels Technologies | *Bill McCaughey, Office Director, by Ken Kellar*

NE-43: Materials and Chemical Technologies | *Stephen Kung, Office Director*

NE-51: Nuclear Energy Technologies | *Suibel Schuppner, Office Director*

NE-52: Office of Nuclear Reactor Deployment | *Alison Hahn, Office Director*

NE-81: Spent Fuel & Waste Science and Technology | *Bill Boyle, Office Director, presented by John Orchard*

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Office of Fuel Cycle Technologies Overview

https://www.energy.gov/ne/initiatives/fuel-cycle-technologies

NE-43
Office of Materials and Chemical Technologies
Overview

FY 2023 CINR FOA Webinar
Tuesday, August 9, 2022
11:30 am EDT

Stephen Kung
301-903-8074
Stephen.kung@nuclear.energy.gov

U.S. DEPARTMENT OF ENERGY

Presentation Outline

- NE Organization and NE-43 Program Managers
- NE-43 Program Stewardship and R&D Approaches
  - Material Recovery and Waste Form Development (MRWFD)
  - Materials Protection, Accounting, and Control Technologies (MPACT)
  - Innovative Nuclear Materials (INM)
- NE-43 US Programs and International Collaborations
- NE-43 FY 2023 CINR Topics

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August 2022

NE-1/2
Assistant Secretary for Nuclear Energy
Dr. Kathryn Huff, Assistant Secretary
Vacant, Principal Deputy Assistant Secretary

Stakeholder Advisory Groups

Senior Advisor Staff

Communications

NE-20
Chief Operating Officer
Dennis Miotla

Office of Human Capital & Business Services
Deborah Sharpe

Office of Budget & Planning
...trick Edgerton

NE-3
Deputy Assistant Secretary for Nuclear Infrastructure Programs
Tracey Bishop

Office of Nuclear Facilities Management
Sujita Pierpont

Office of Nuclear Materials Production, Management & Protection
Vacant

NE-4
DAS for Nuclear Fuel Cycle and Supply Chain

Office of Advanced Fuels Technologies
Bill McCaughey

NE-43
Office of Materials and Chemical Technologies

NE-5
Deputy Assistant Secretary for Reactor Fleet and Advanced Reactor Deployment
Alice Caponiti

Office of Nuclear Energy Technologies
Suzbel Schuppner

Office of Nuclear Reactor Deployment
Alison Hahn

NE-6
DAS for International Nuclear Energy Policy and Cooperation
Aleshia Duncan

Office of Bilateral, Multilateral and Commercial Cooperation
Vacant

Office of International Nuclear Safety
Vacant

Manager, Idaho Operations Office
Robert Boston

NE-8
Deputy Assistant Secretary for Spent Fuel & Waste Disposition
Samuel Brinton

Office of Spent Fuel and Waste Science and Technology
William Boyle

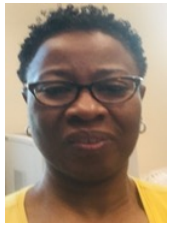
Office of Integrated Waste Management
Erica Bickford, Acting

Positions noted in red are approved in the FY21 Staffing Plan
Positions noted in blue are approved in the FY22 Staffing Plan

NE-43 Staff Members

Dr. Stephen Kung, Office Director
Aqueous Separations & Hybrid ZIRCEX Demonstration

Ms. Susan Lesica, Materials Engineer
NE Materials R&D & Program Coordination



Ms. Kimberly Gray, General Engineer
Off-Gas & Waste Forms Developments

Ms. Tansel Selekler, Nuclear Engineer
EBR-II Acceleration & Materials Protection, Accounting & Control Technologies

Dr. Jim Willit, Nuclear Engineer
Molten Salt Chemistry, Pyro-Processing

NE-43 Program Stewardship (I)

(1) Material Recovery and Waste Form Development (MRWFD)

Develop advanced fuel recycle technologies to improve resource utilization, reduce waste generation and limit proliferation risk.

MRWFD Research Focus Areas:

- Aqueous Technologies
- Molten Salt Technologies
- Off-gas and Waste Form Technologies

MRWFD research priorities are guided by Workshop Reports:

Technology and Applied R&D Needs for Molten Salt Chemistry

Co-chairs: David F. Williams and Phillip F. Britt (2017)
https://www.ornl.gov/sites/default/files/Molten%20Salt%20Workshop_Final_092917.pdf

Innovative Separations R&D Needs for Advanced Fuel Cycles

Co-chairs: Bruce A. Moyer and Gregg J. Lumetta (2021)
https://www.ornl.gov/file/innovative-separations-research-and-development-needs-advanced-fuel-cycles/display

NE-43 Program Stewardship (II)

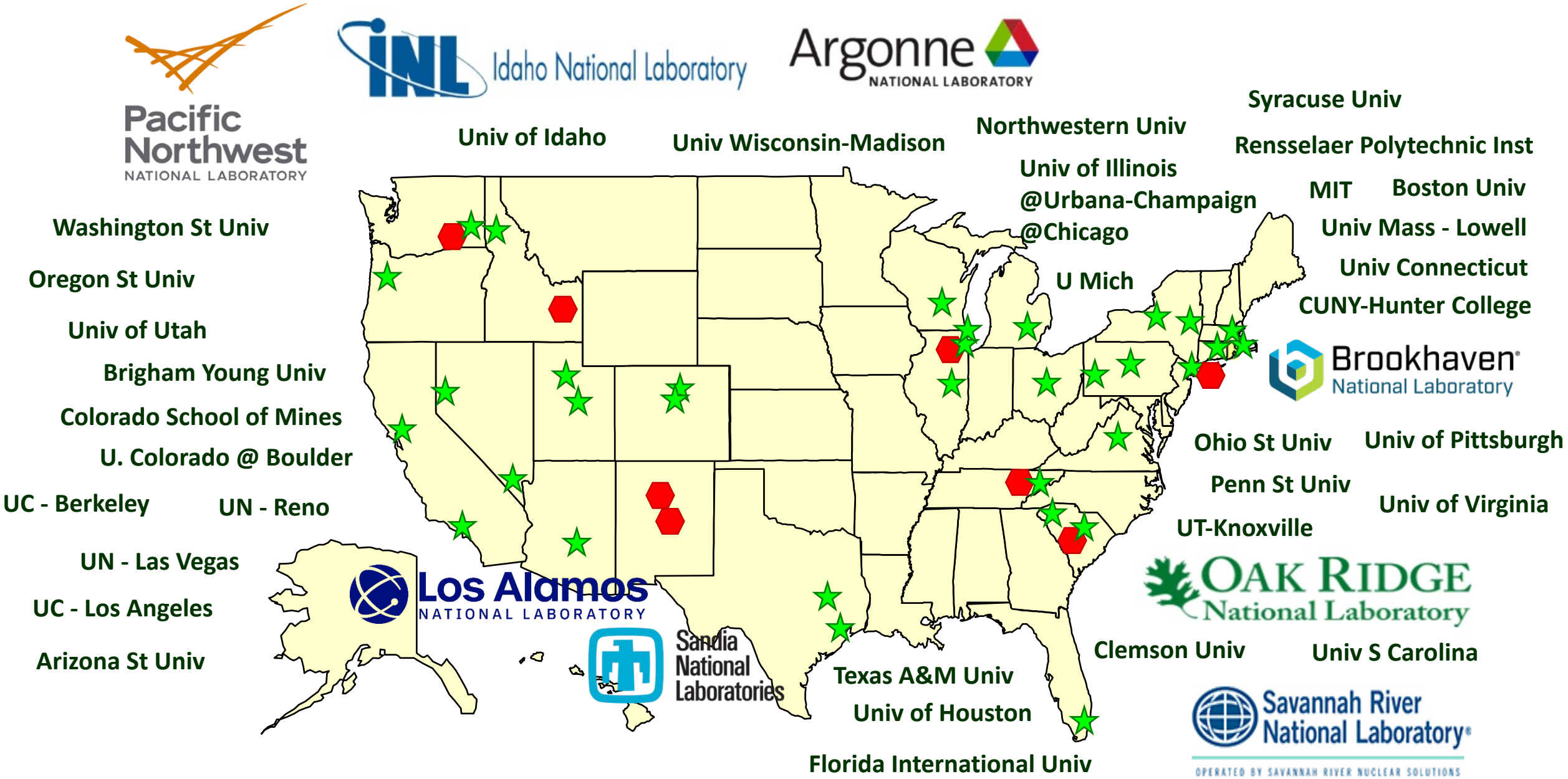
(2) Materials Protection, Accounting, and Control Technologies (MPACT)

- Develop innovative technologies, analysis tools and advanced integration methods to enable U.S. domestic nuclear materials management and safeguards for emerging nuclear fuel cycles.
- MPACT supports the U.S. advanced fuel cycles technology developers to effectively and economically address nuclear materials control and accounting requirements.

(3) Innovative Nuclear Materials (INM)

- Focus on longer-term new core and cladding materials discovery and aging tests.
- Innovative approaches to accelerate the pace of discovery and reduce experimental burden and costs, building on recent advances in AI/ML, theory, modeling, and computation, and advanced characterization tools.

NE-43 Investments at DOE National Labs and US Universities



NE-43 International Collaborations

Department for Business, Energy & Industrial Strategy

NATIONAL NUCLEAR LABORATORY

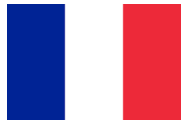
Simplified Single Cycle Recycling Technologies,
Iodine Off-gas Capture and Immobilization,
Molten Salt Waste and Pyro-Chemistry

文部科学省
MEXT
MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

JAEA Japan Atomic Energy Agency

CRIEPI
Central Research Institute of Electric Power Industry

Electrochemical Reduction
Molten Salt Waste Processing



French Alternative Energies and Atomic Energy Commission

DE LA RECHERCHE À L'INDUSTRIE
cea

Radiation Chemistry & Degradation Mechanisms,
Advanced On-line Measurement Technologies

Ministry of Science and ICT

KAERI Korea Atomic Energy Research Institute

Joint Fuel Cycle Study

Natural Resources Canada

AECL Atomic Energy of Canada Limited

EACL Énergie atomique du Canada limitée

Canadian Nuclear Laboratories

Nobel Gas Capture (inactive)

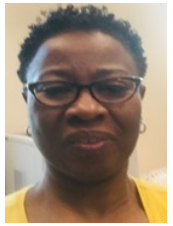
NE-43 Solicitation Areas

Aqueous Separations Chemistry and Technology	Support R&D in chemical speciation, complexation, radiation, and process chemistry to predict and improve actinide separation efficiencies.
Molten Salt Chemistry & Pyro-Processing	Support transformative salt chemistry R&D to enable tailoring and optimizing of salt properties and behaviors for salt technology applications.
Materials for Off-Gas and Waste Form Applications	Develop advanced materials for waste forms and off-gas capture and immobilization to enhance waste loading, durability, and cost reduction.
Materials Protection, Accounting, and Control Technologies	Develop innovative safeguards and materials control and accounting technologies, tools and integration methods for nuclear fuel cycles.
Innovative Nuclear Materials	Innovative approach to accelerate the discovery and reduce experimental burden and costs for new cladding materials and aging tests.

NE-43 Program Managers & FY 2023 CINR FOA Solicitation Topics

FC-1: AQUEOUS SEPARATIONS CHEMISTRY
(FEDERAL POC – STEPHEN KUNG)

NM-2: ADVANCED REACTOR CORE OR STRUCTURAL MATERIALS
(FEDERAL POC – SUE LESICA)



NM-4: MATERIAL FOR FUEL RECYCLING APPLICATIONS
(FEDERAL POC – KIMBERLY GRAY)

LS-3: ADVANCED REACTORS AND FUEL CYCLE FACILITIES MATERIALS ACCOUNTANCY, CONTROL, AND PHYSICAL PROTECTION
(FEDERAL POCS – SAVANNAH FITZWATER & TANSEL SELEKLER)

FC-2: MOLTEN SALT SEPARATIONS AND SOLUTION CHEMISTRY
(FEDERAL POC – JIM WILLIT)

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Office of Nuclear Energy Technologies

Suibel Schuppner
Director, Nuclear Energy Technologies
Office of Nuclear Energy

CINR Webinar

August 9, 2022

NE-51

Office of Nuclear Energy Technologies

Enabling Technologies Team

Nuclear Energy Enabling Technologies

- Advanced Modeling and Simulation
- Advanced Materials and Manufacturing Technologies
- Advanced Sensors and Instrumentation
- Nuclear Cybersecurity
- Nuclear Science User Facilities

University and Competitive Research Team

University Support

- Nuclear Energy University Program
- Research Reactor Infrastructure
- University Nuclear Leadership Program

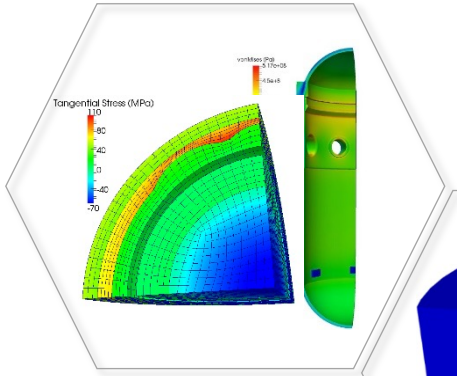
Industry Support

- Advanced Nuclear Energy Funding Opportunity (Industry FOA)
- Gateway for Accelerated Innovation in Nuclear
- Small Business Innovative Research (SBIR) / Small Business Technology Transfer (STTR)
- Technology Commercialization Fund (TCF)

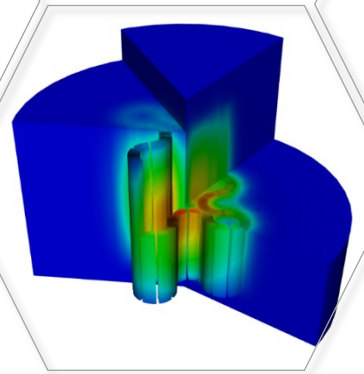
Nuclear Energy Advanced Modeling and Simulation (NEAMS)

NEAMS aims to develop and deploy predictive M&S tools and methods to enable and accelerate advanced reactor deployment and improve existing fleet operations.

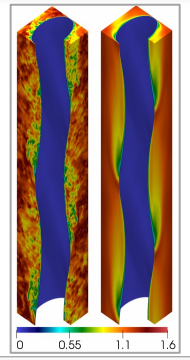
NEAMS core competencies:



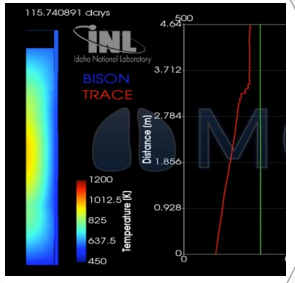
Multiscale fuel performance and structural materials degradation modeling:
BISON, GRIZZLY, YellowJacket



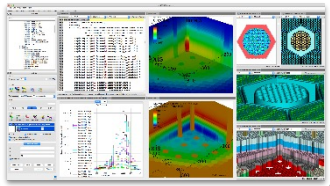
Reactor Physics:
GRIFFIN, MPACT, Shift



Multiscale thermal fluids:
CTF, SAM, PRONGHORN, Sockeye, Nek5000



Multiphysics:
MOOSE, VERA



Workflow Management:
Workbench

NEAMS develops modeling tools for others to use, thus ***coordination and interaction with industry and NE's reactor and fuels R&D programs is critical.***

NEAMS work needs to be informed by experimental capabilities and data in order to best support reactor deployment and operation.

Key Success Metric: Use of NEAMS technology (either software or R&D) by stakeholder to improve how they "do business."

Advanced Materials and Manufacturing Technologies (AMMT)

Development, Qualification and Demonstration

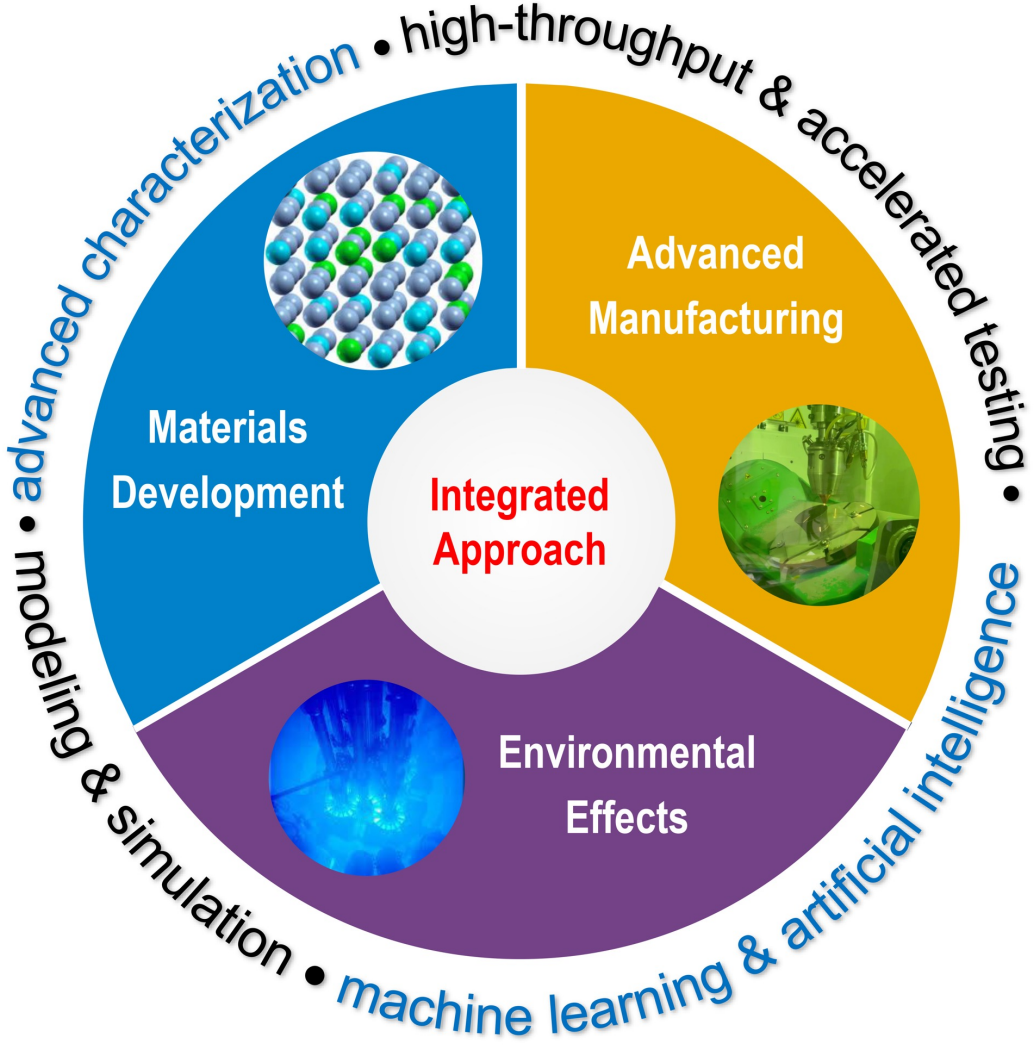
- Develop advanced materials & manufacturing technologies
- Establish a rapid qualification framework
- Evaluate material performance in reactor environments
- Technology demonstration and deployment

Capability Development & Transformative Research

- Develop high-throughput, accelerated testing and characterization techniques
- Develop modeling capabilities for materials design, development and qualification
- Perform transformative research to develop new material concepts and design

Collaborative Research and Development

- Investigate a broad range of advanced materials and manufacturing technologies
- Address reactor-specific issues
- Provide near-term material solutions to nuclear industry

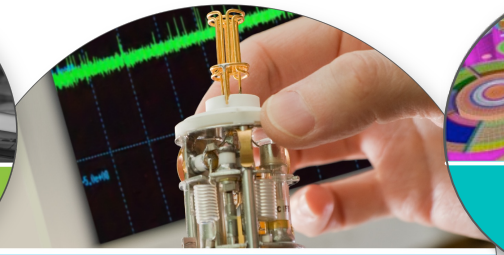


Advanced Sensors and Instrumentation (ASI)

Develop advanced sensors and instrumentation & controls (I&C) that address **critical technology gaps** for monitoring and controlling existing and advanced **reactors** and supporting **fuel cycle** development

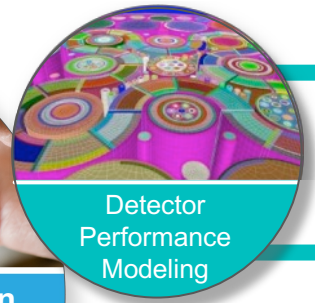
Resilient, real-time transmission of sufficient amount of data for online monitoring and advanced data analytics

Communication



Sensors and Instrumentation

Reliable, cost-effective, real-time, accurate, and high-resolution measurement of the performance of existing and advanced reactors core and plant systems



Detector Performance Modeling

Modeling of instrumentation performance to enable predictive capabilities and integration in Digital Twins

Machine learning and artificial intelligence processes to enable semi-autonomous operation and maintenance by design

Big data, Machine Learning, Artificial Intelligence

Material Science

Innovative sensor materials and advanced manufacturing techniques applied to instrumentation design and fabrication

Advanced Control Systems

Enable near real-time control of plant or experiments process variables to enhance performance

Nuclear Cybersecurity Research

Small, narrowly focused program:

- Emphasizes NE mission, enabling advanced technology deployment and improving efficiency/performance - not primarily a security program.

- Address any nuclear-specific needs not addressed by broader programs such as at DHS or CESER (emphasizing next-generation fleet)
- Address barriers to adoption of best-in-class cybersecurity solutions developed for other sectors

Key R&D Products:

- Techniques to identify and mitigate cybersecurity hazards during design
- Support for longer-term, post-deployment use cases that are currently cybersecurity-limited (e.g., wireless safety-related controls, remote/autonomous operations, advanced applications of digital twins)
- Technical tools, such as control system design requirements, supply chain protection methods and test beds

Nuclear Science User Facilities (NSUF)

Neutron Irradiations	Ion Irradiations	Gamma Irradiations	Hot Cells & Shielded Cells	Low Activity Laboratories	Beamlines	High Performance Computing
INL Idaho National Laboratory	Wisconsin University of Wisconsin-Madison	INL Idaho National Laboratory	INL Idaho National Laboratory	INL Idaho National Laboratory	Brookhaven National Laboratory	INL Idaho National Laboratory
Oak Ridge National Laboratory	University of Michigan	Oak Ridge National Laboratory	Oak Ridge National Laboratory	CAES Center for Advanced Energy Studies	Argonne National Laboratory	
Massachusetts Institute of Technology	Argonne National Laboratory	Sandia National Laboratories	PNNL	Oak Ridge National Laboratory	NC State University	
NC State University	Sandia National Laboratories		Los Alamos National Laboratory	Cal	Los Alamos National Laboratory	
Ohio State	Texas A&M University		Westinghouse	PNNL		
Sandia National Laboratories	Lawrence Livermore National Laboratory		University of Michigan	Los Alamos National Laboratory		
SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire			SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire	NC State University; University of Michigan; Purdue University; Wisconsin; University of Florida		
				SCK•CEN Studiecentrum voor Kernenergie Centre d'Etude de l'Energie Nucleaire		

Coordinates a consortium of institutions to provide access, at no cost to the user, to unique and highly specialized nuclear research facilities and technical expertise.


Thank you!
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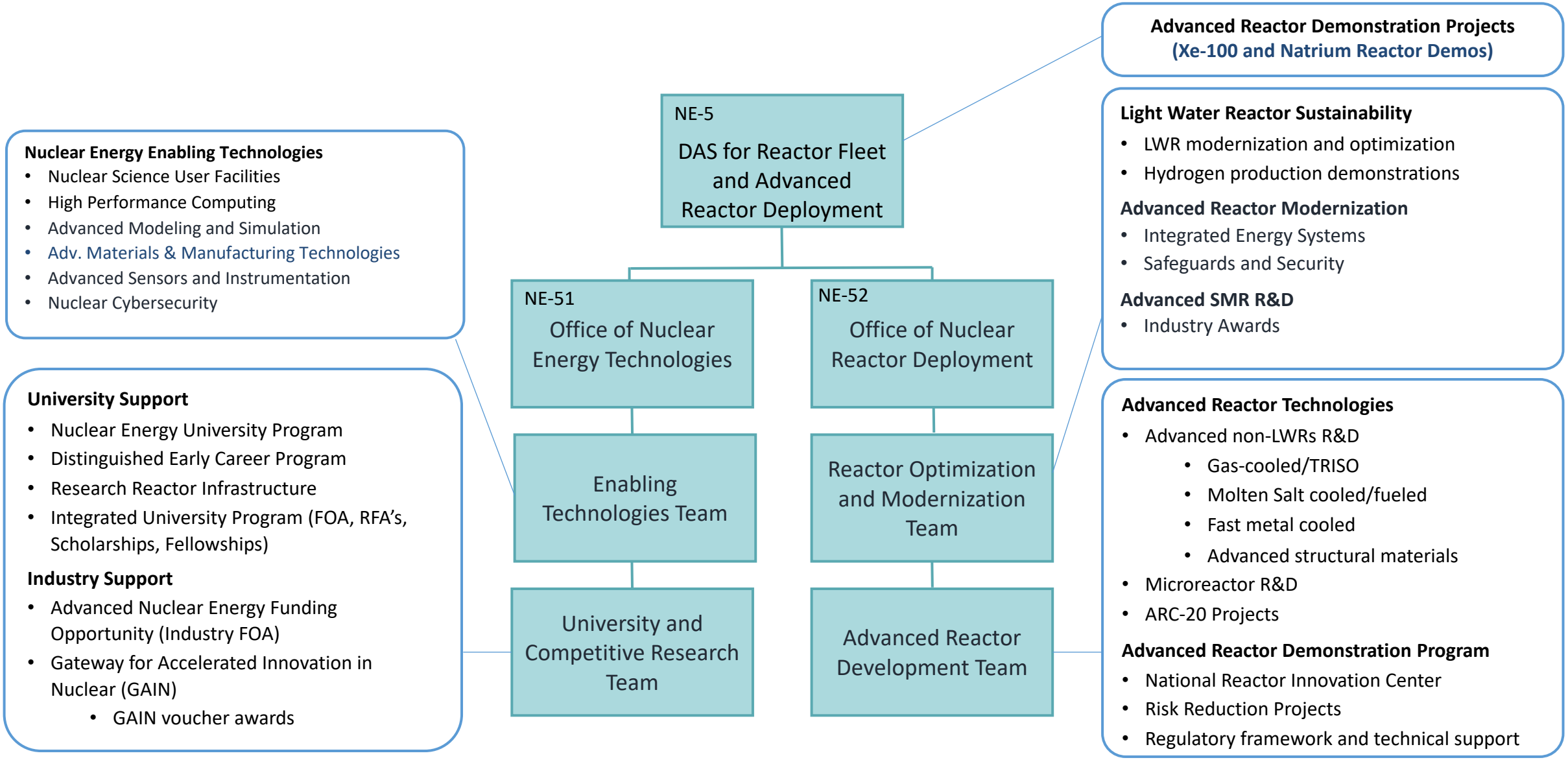
Office of Nuclear Reactor Deployment (NE-52) Overview

Alison Hahn, Director

FY2023 CINR Webinar

August 9, 2022

Organization and Program Accountability



Light Water Reactor Sustainability Program Overview

LWRS Mission: Enable long term operation of the existing commercial nuclear power fleet.

Focus: Originally material issues related to SLR applications, recent shift toward improving economic competitiveness

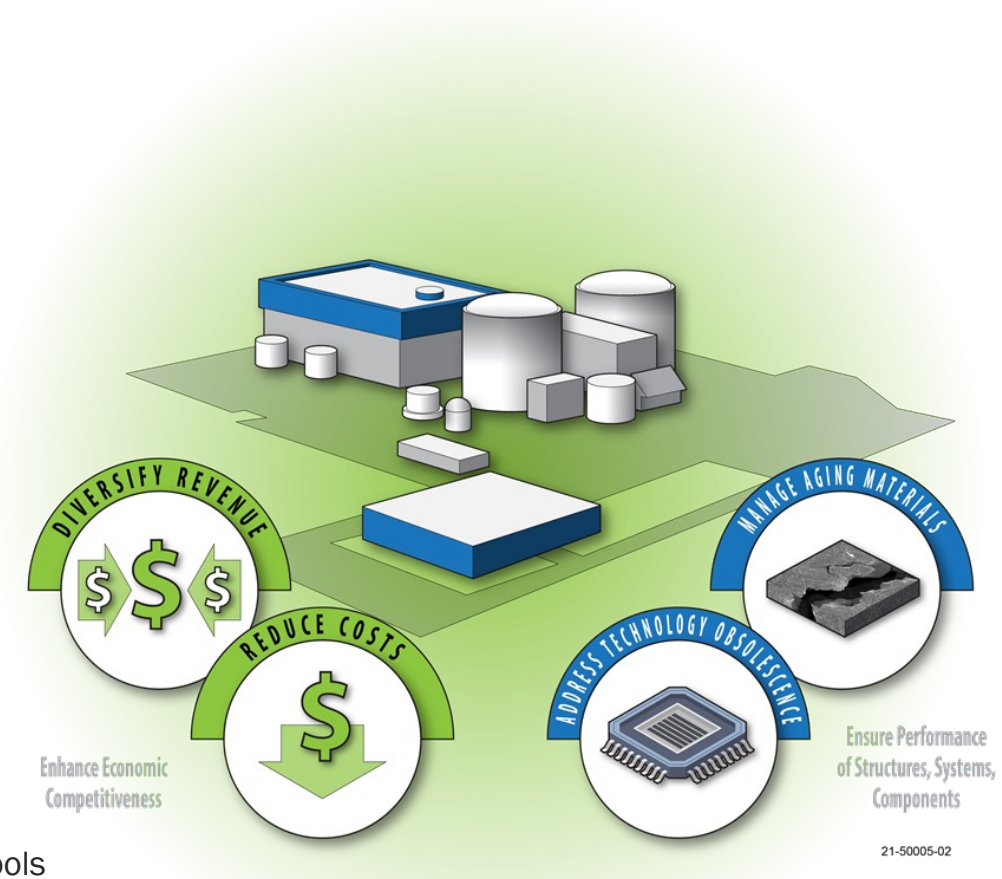
Plant Modernization
- Modernize technology by replacing existing I&C technologies with digital systems
- Leverage digitalization to modernize business model

Flexible Plant Operation and Generation
- Maximize revenue by producing new economic products and integrating energy storage
- Decarbonize industrial processes and support the grid as variable resources increase

Risk Informed System Analysis
- Applies quantitative methods to optimize safety, reliability, and economics
- Coupling probabilistic risk assessment and systems margin quantification to achieve accurate modeling and representation of safety margins

Materials Research
- Understand and predict long-term behavior of materials
- Including detecting, characterizing, and mitigating aging degradation

Physical Security
- Improve efficiency of physical security posture
- Conduct research on risk-informed techniques, apply advanced modeling and simulation tools assess benefits from proposed enhancements and novel mitigation strategies



The Future Landscape for Nuclear Energy Systems

Nuclear Energy Generation

Light water reactors, high temperature advanced reactors, small modular reactors, microreactors

Other Energy Generation

Variable renewables, municipal waste, fossil with carbon capture, etc.

Biofuel

New chemical processes

Clean water

Industry

Electricity

Hydrogen for vehicles and industry

Advanced Reactor Safeguards Program Areas

Physical Protection Systems

- Reduce number of on-site responders
- Reduce upfront costs
- Evaluate enhanced safety systems
- Evaluate unique sabotage targets

Pebble Bed Reactor MC&A

- Evaluate regulatory approach
- Determine driving requirements
- Evaluate new monitoring technologies

Microreactor PPS and MC&A

- Develop a licensing framework
- Develop approaches appropriate to the very small scale
- Evaluate new monitoring technologies

Liquid Fueled MC&A

- Evaluate regulatory approach
- Develop baseline accountancy approaches
- Evaluate new measurement and monitoring technologies

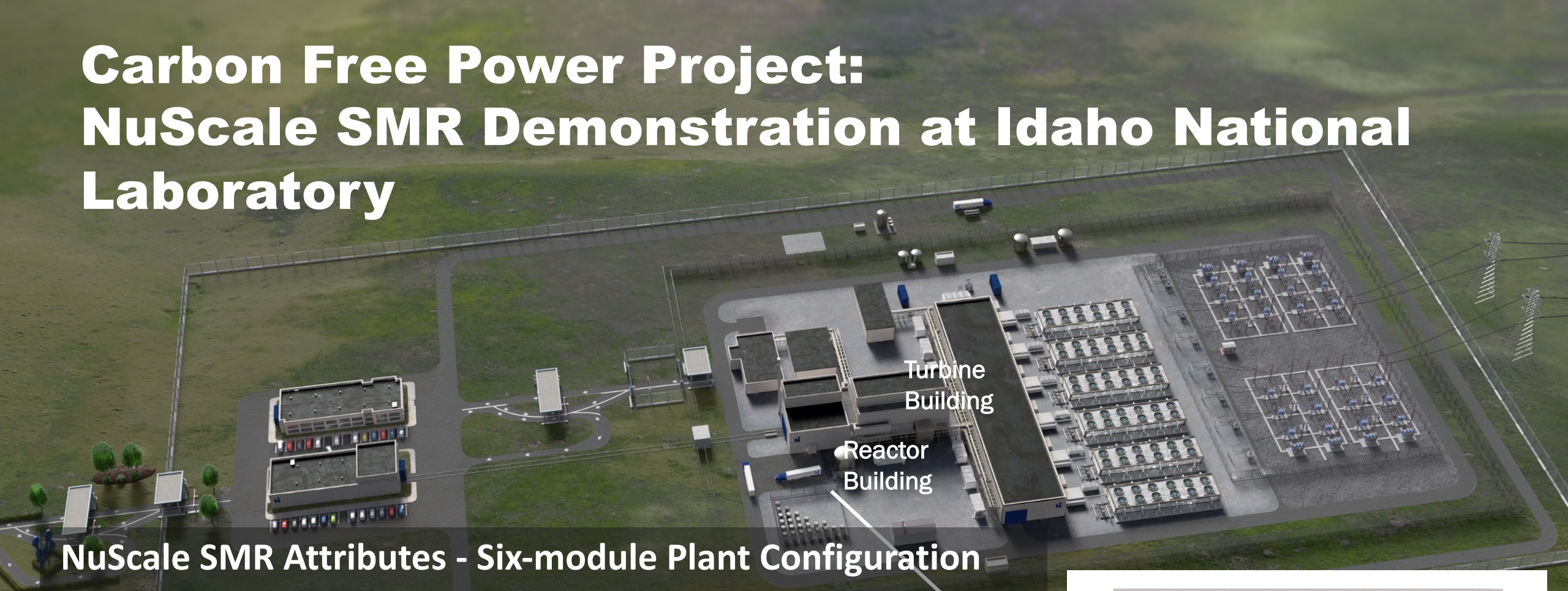
International Considerations

- Consider international safeguards requirements
- Interface with NNSA programs
- Support the Gen-IV PR&PP working group

Vendor Engagements

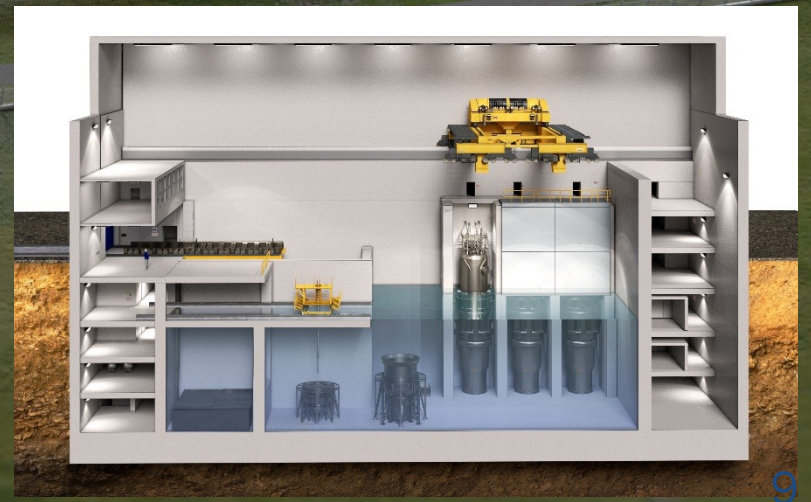
- Design-specific MC&A and PPS challenges
- NNSA partnerships
- Translate to lessons learned or generic deliverables

Carbon Free Power Project: NuScale SMR Demonstration at Idaho National Laboratory



NuScale SMR Attributes - Six-module Plant Configuration

- 6 Nuclear Power Modules - 462MWe (77 Mwe per module)
- Leverages proven and commercially-available LWR fuel
- Air Cooled Condensers – significantly reduces water use
- Initial site characterization work completed
- First module operation planned for 2029



Advanced Reactor Technologies (ART) Program

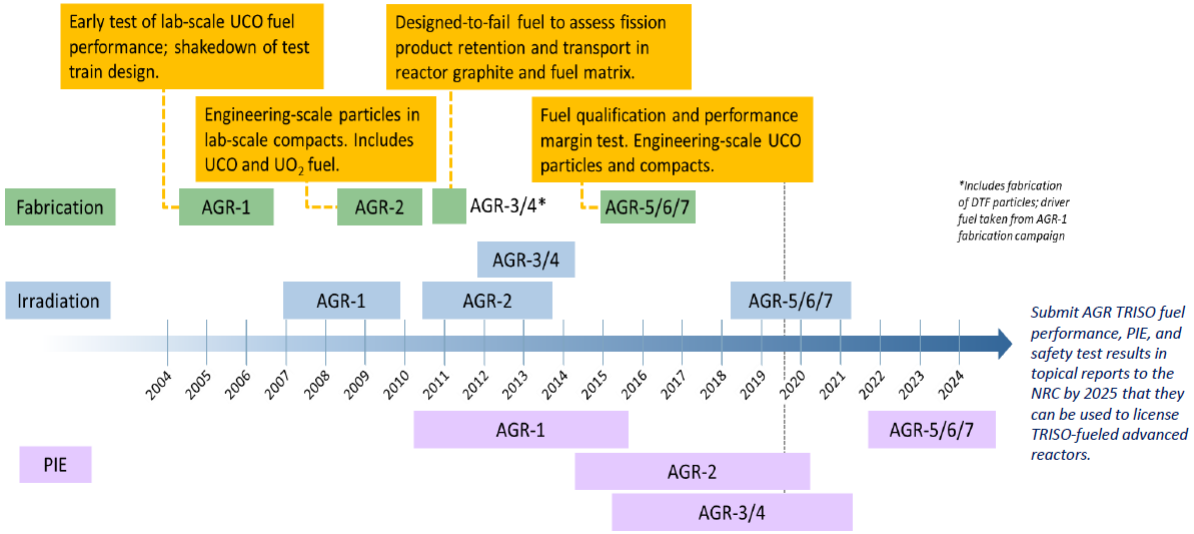
Mission: Support the development and commercialization of innovative concepts including microreactor, fast reactor, molten salt reactor (MSR), and high temperature gas-cooled reactor (HTGR) technologies through national laboratory-led R&D, university research programs, and cost-shared private-public industry partnerships.

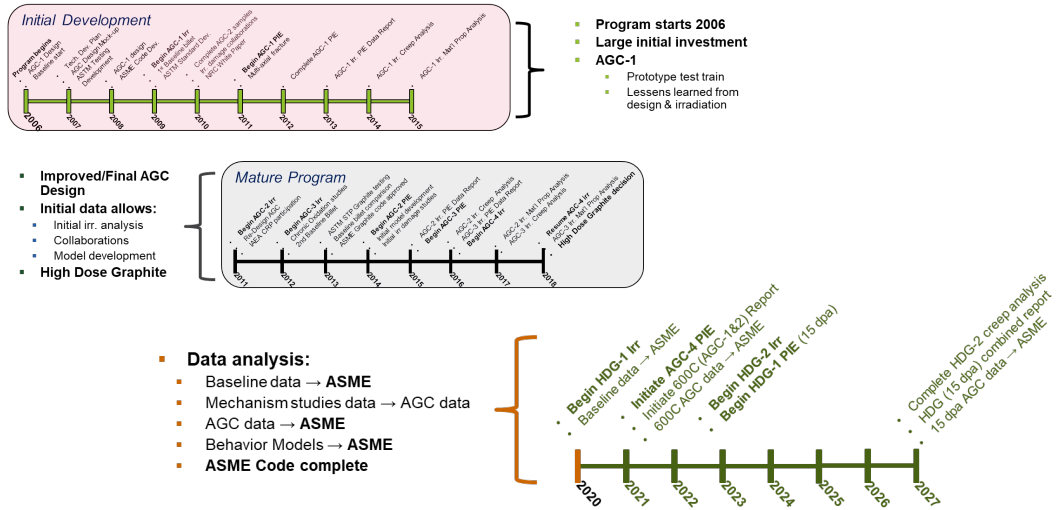
- Fast Reactor Technologies
  - Demonstrate feasibility of advanced systems and component technologies
  - Methods and code validation to support design and licensing
- Gas Reactor Technologies
  - Advanced alloy qualification
  - Scaled integral experiments to support design and licensing
- MSR Technologies
  - Investigate fundamental salt properties
  - Materials, models, fuels and technologies for salt-cooled and salt-fueled reactors
- Microreactors
  - Non-nuclear and nuclear integrated system testing supporting commercial demonstrations and end-user applications
  - Maturation of innovative components and semi-autonomous operating regimes

METL Facility , Argonne National Laboratory

TRISO Fuel and Graphite Qualification Program

- TRISO Fuel Development and Qualification
  - Generate UCO TRISO fuel performance data to support fuel qualification.
  - Establish a domestic commercial TRISO fuel fabrication capability.
- Graphite Qualification
  - Select, irradiate, and characterize existing nuclear grades.
  - Qualify nuclear grade graphite and establish design rules for use in HTGR core.

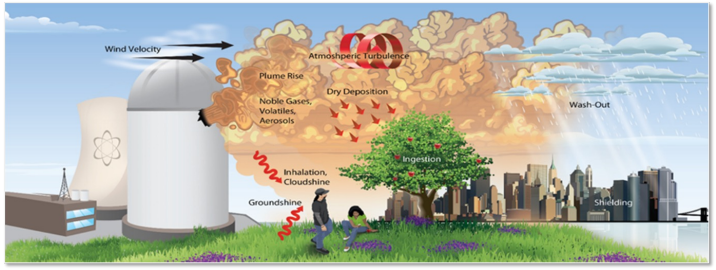




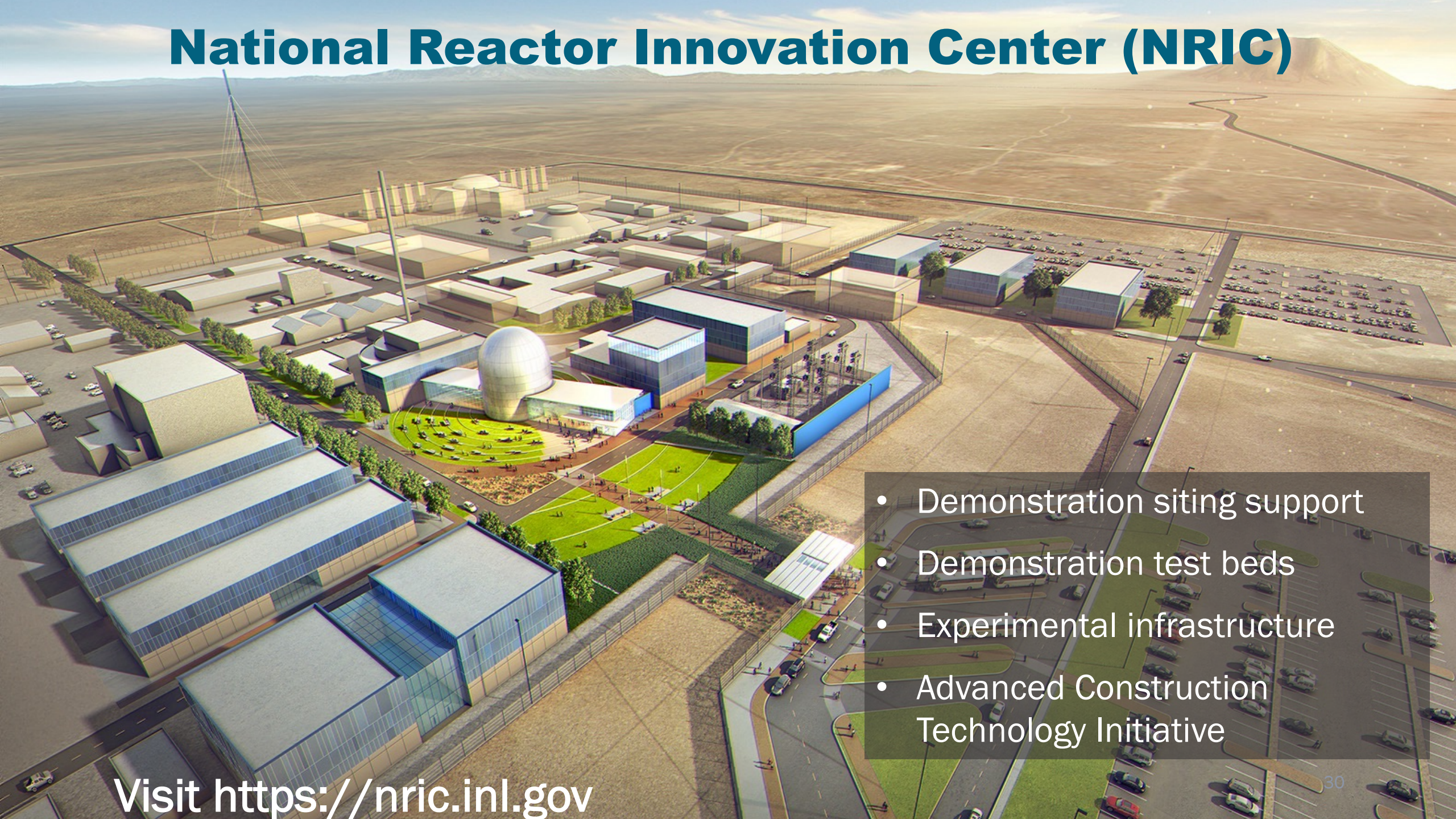
Advanced Reactor Regulatory Development

Mission: Coordinate with the Nuclear Regulatory Commission (NRC) and industry to address and resolve key regulatory framework issues that directly impact the "critical path" to advanced reactor demonstration and deployment.

- DOE NE cost-share support of industry-led initiatives to adapt and establish a regulatory framework for advanced reactors
  - Technology-Inclusive Content of Applications Project (TICAP) is a risk-informed, performance-based (RIPB) approach to right-size information in a license application to increase efficiency of generating and reviewing an application
  - Builds on NRC-endorsed Licensing Modernization Project systematic risk-informed process
  - Opportunity for early movers to demonstrate implementation of risk-informed, performance-based approach
- NE R&D activities directly reduce technical and regulatory risks by providing bases for establishment of licensing technical requirements
  - Establish technical insights and tools regarding radionuclide transport and release from advanced reactors, including fast reactors, gas-cooled reactors, and molten salt reactors
  - Supporting NRC endorsement of codes and standards important for the manufacture of advanced reactor components
  - Validation and access to priority material property data to be used in safety codes and models



National Reactor Innovation Center (NRIC)

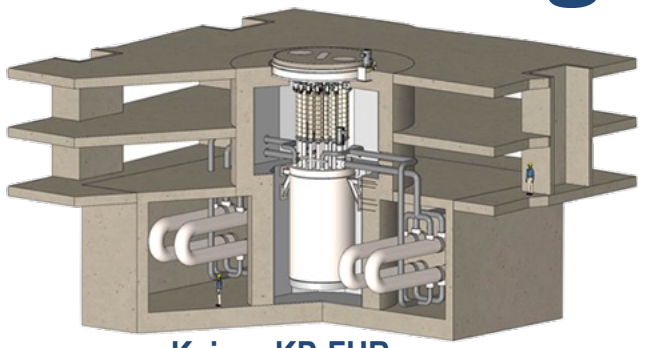


- Demonstration siting support
- Demonstration test beds
- Experimental infrastructure
- Advanced Construction Technology Initiative

Visit https://nric.inl.gov

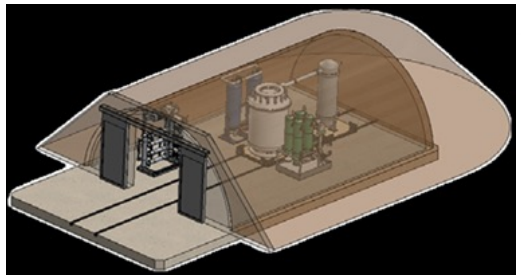
Risk Reduction Pathway Selected Technologies

- Kairos KP-FHR fluoride salt-cooled, TRISO pebble fueled MSR
- Westinghouse eVinci microreactor – heat pipe cooled, TRISO compact fueled
- BWXT BANR – transportable microreactor, TRISO fueled
- Holtec SMR-160 – LWR-cooled SMR (only LWR design supported under ARDP)
- Southern/TerraPower Molten Chloride Fast Reactor (only liquid fueled design supported under ARDP)

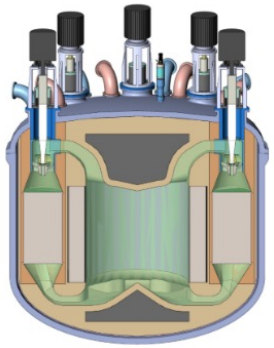


Kairos KP-FHR

Westingouse eVinci



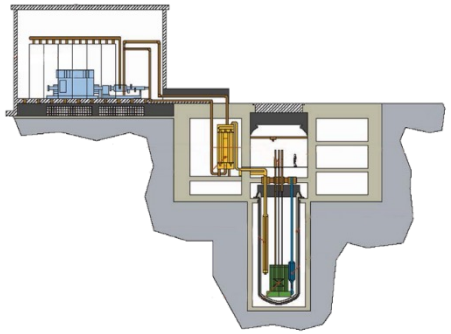
BWXT BANR



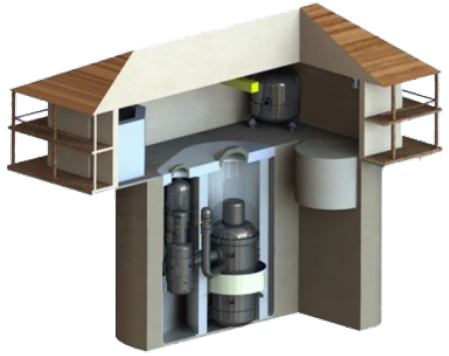
TerraPower MCFR

Holtec SMR-160

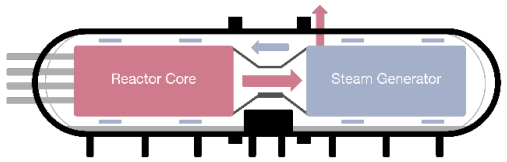
Advanced Reactor Concepts (ARC)-20 Awards



Advanced Reactor Concepts

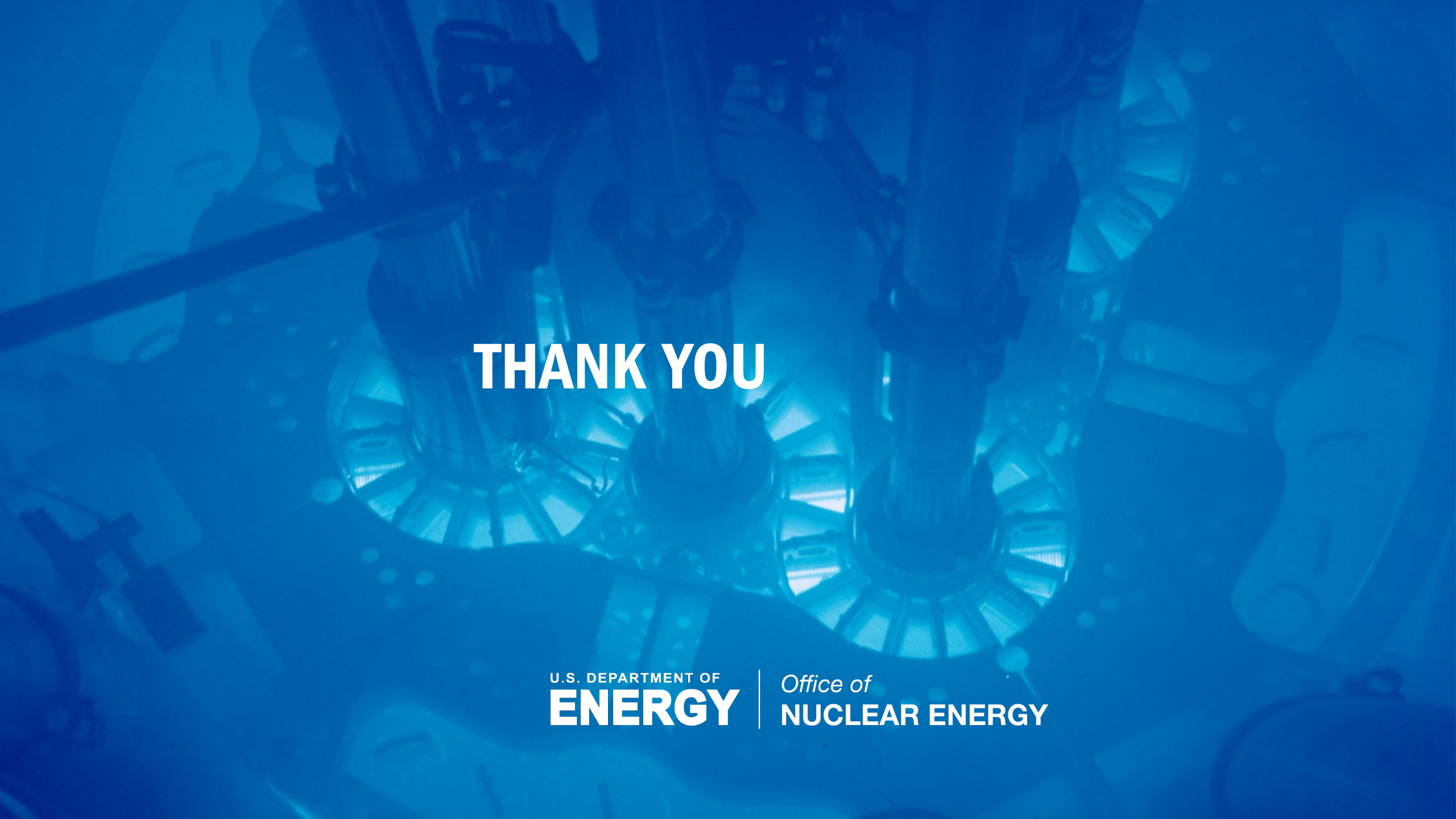


General Atomics



MIT

Prime Applicant	Reactor Type	Key Deliverables
Advanced Reactor Concepts	ARC-100 100 MWe pool type sodium-cooled fast reactor	Conceptual and preliminary design of a seismically isolated advanced sodium-cooled reactor facility
General Atomics	GA-EMS 50 MWe gas-cooled fast modular reactor	Conceptual design, Increase maturity of systems and components, develop prelim. cost estimates
MIT	Modular Integrated Gas-cooled High Temperature Reactor (MIGHTR)	Conceptual design and support for future commercialization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Office of Spent Fuel & Waste Science and Technology Overview

Spent Fuel and Waste Science and Technology

- As our country continues to deploy nuclear energy as a solution for decarbonization, increasing access to energy, and tackling climate change, we need to make progress on the back end of the fuel cycle.
- The U.S. Department of Energy Office of Spent Fuel and Waste Disposition is responsible for managing the nation's spent nuclear fuel and high-level radioactive waste, including finding sites to store and dispose of the spent nuclear fuel.
- To focus on this challenge, the Office of Spent Fuel and Waste Disposition has established two offices: the Office of Integrated Waste Management, which is the applied side that focuses on the design and siting of consolidated interim storage and preparing for transportation to the interim storage, and the Office of Spent Fuel and Waste Science and Technology, which focuses on the R&D side.
- The mission for the Office of Spent Fuel and Waste Science and Technology is to provide a sound technical basis for the safety and security of long-term storage, transportation, and disposal of spent nuclear fuel and high-level radioactive wastes from commercial nuclear power plants.

Disposal Research Mission

- Provide a sound technical basis for assurance that the US has multiple viable disposal options for mined deep geologic repository available when national policy is ready
- Identify and research generic sources of uncertainty that challenge the viability of disposal concepts
- Increase confidence in robustness of generic disposal concepts to reduce the impact of site-specific complexity
- Develop the science and engineering tools required to address the needs above

Storage & Transportation Mission

Develop the technical bases:

- To demonstrate spent fuel integrity for extended storage periods
- To support fuel retrievability and transportation after extended storage
- For transportation of high burnup fuel