INL/CON-23-74036-Revision-0

National Reactor Innovation Center Overview

January 2024

Samuel Matthew Reiss

Changing the World's Energy Future

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National Reactor Innovation Center Overview

Samuel Matthew Reiss

January 2024

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

Prepared for the
U.S. Department of Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

National Reactor Innovation Center Overview

August 2023

Sam Reiss, Technical Program Manager

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nric.inl.gov

Advanced Fission

- Categorized in terms of capacity
  - Microreactors: <10 MWe
  - Small reactors: 10 MWe – <300MWe (SMRs use modular construction)
  - Medium reactors: 300MWe - 700 MWe
  - Large reactors: > 700 MWe
- Variety of coolants (gas, sodium, salt, lead, water, etc.)
- Improved safety, waste, security, and target economics
- 60+ private sector projects
- Diverse markets
- Clean, high availability

Small Town: 1 Megawatt (MW)
Mid-size City: 1 Gigawatt (GW)
The US: 1,000 Gigawatts

Image courtesy of GAIN and Third Way, inspired by the *Nuclear Energy Reimagined* concept led by INL. Learn more about these and other energy park concepts at thirdway.org/blog/nuclear-reimagined

NRIC is a DOE-NE program, launched in FY2020

NRIC National Reactor Innovation Center

NRIC Accelerates Nuclear Reactor Demonstrations

- Authorized by the Nuclear Energy Innovation Capabilities Act (NEICA)
- Partner with industry to bridge the gap between research and commercial deployment
- Leverage national lab expertise and infrastructure
- Manage demonstrations to success

NRIC INL

National Reactor Innovation Center

National Reactor Innovation Center (NRIC) – C300 Acting Director
Brad Tomer

Administrative Assistant
Nelly Olivas

Chief Operating Officer
Brad Tomer

Regulatory Manager
Stephanie Weir

Collaboration Manager
Sanjay Mukhi

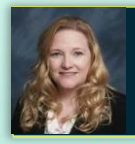
Demonstration Infrastructure and Support/Demonstration Project Partnerships – C310

Department Manager
Jack Britt

Technical Program Manager
Greg Core

Configuration Management Coordinator
Katelyn Mitchell

Technical Program Manager
Jacob Rymer



Configuration Manager
AnnMarie Marshall

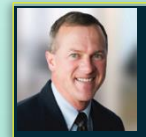
Technical Program Manager
Samuel Reiss

Senior Program Manager
Phil Schoonover

Technical Program Manager
Chance Price

Technical Program Manager
Troy Burnett

Technical Program Manager
Luke Voss



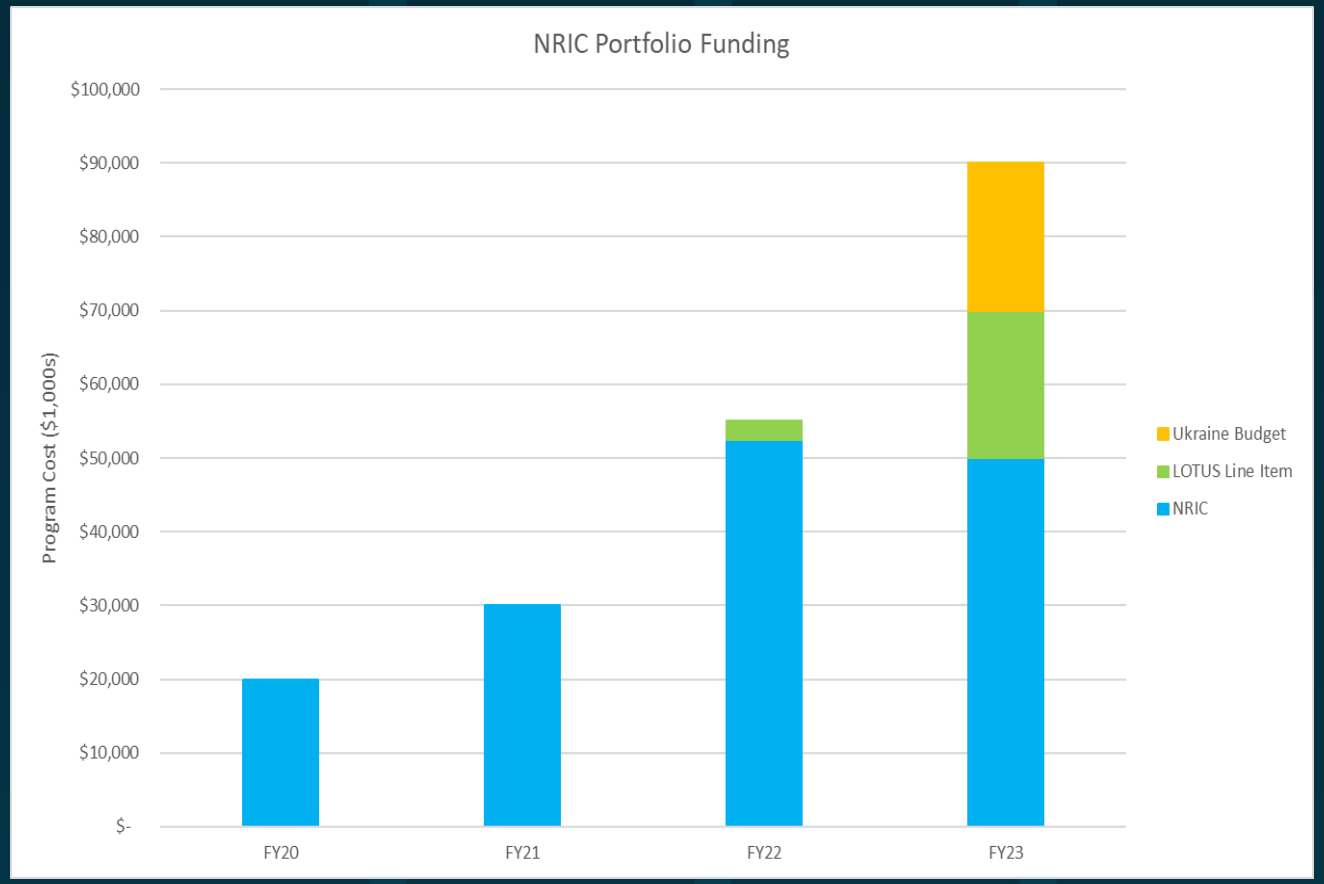
Project Manager
Marvin Fielding

Risk Coordinator/ Program Manager
Josh Kiel

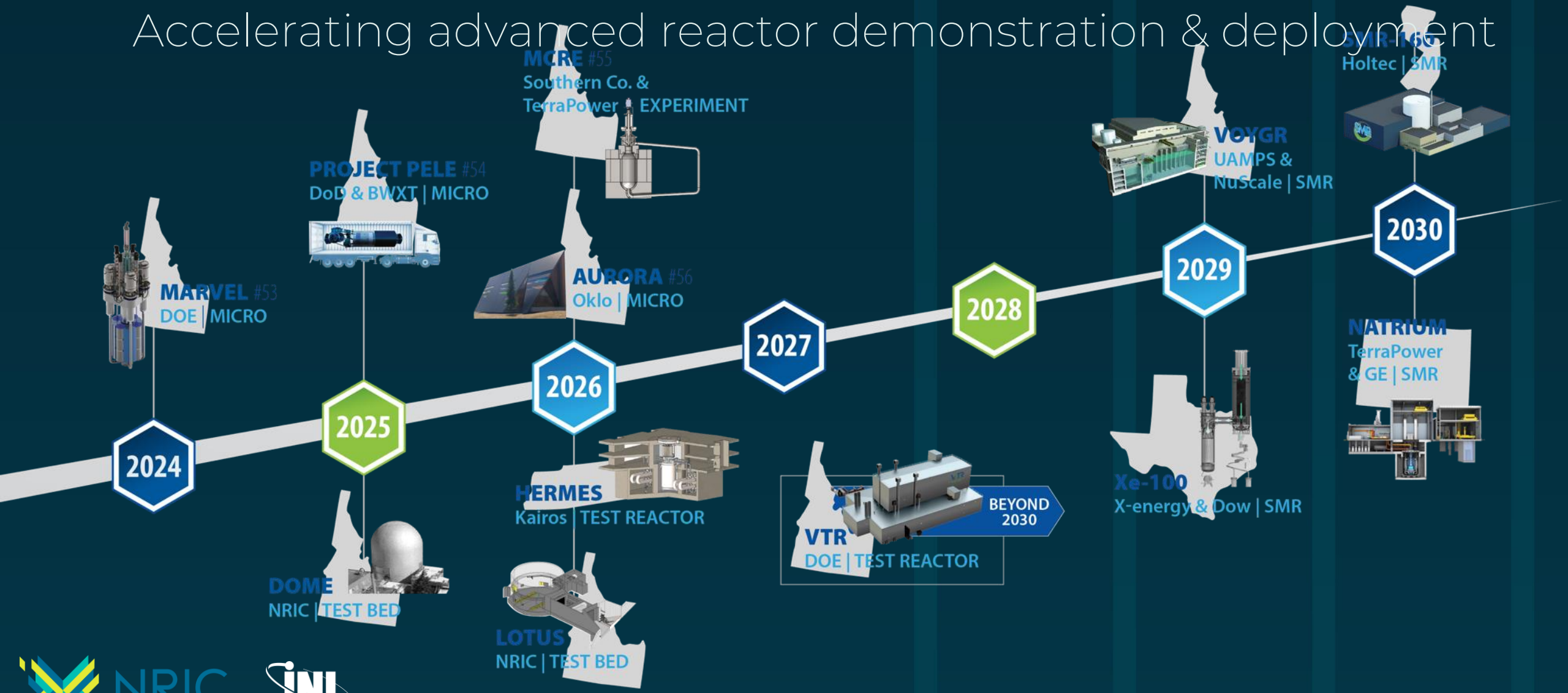
Project Manager
Jennifer Thornley

NRIC Portfolio Budget (FY20-FY23)

- FY20 $20M NRIC Program
- FY21 $30M NRIC Program
- FY22 $55M : NRIC Program $52.4M, LOTUS Line Item $2.6M
- FY23 $90M: NRIC Program $50M, LOTUS Line Item $20M, Ukraine $20M



Accelerating advanced reactor demonstration & deployment



NRIC

INL

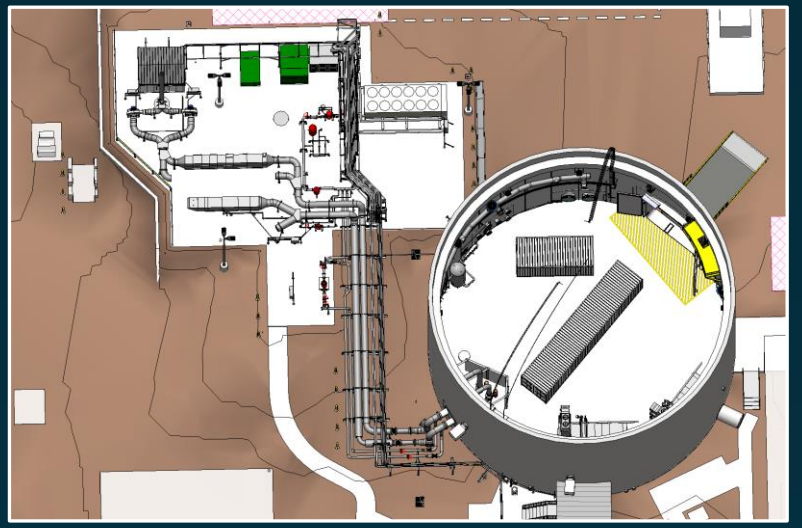
Empowering Innovators

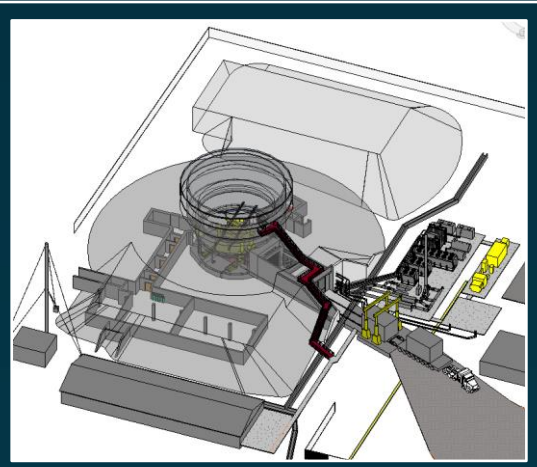
- Demonstration Test Beds
- Experimental Facilities
- Virtual Test Bed
- Regulatory Risk Reduction

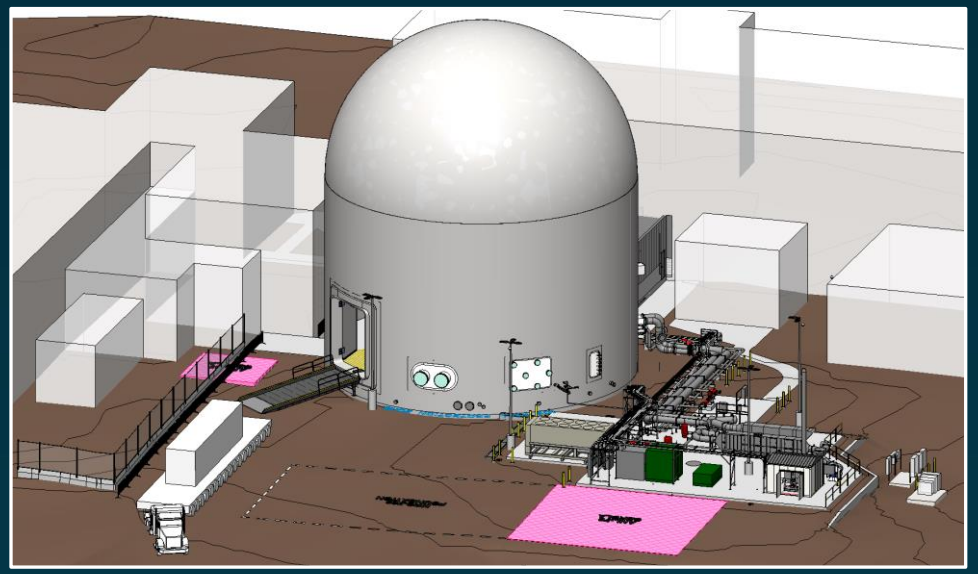
- Planning Tools
  - NRIC Resource Team
  - NEPA guidance
  - Demonstration Resource Network (https://nricmapping.inl.gov/)
  - Siting Tool for Advanced Nuclear Development

NRIC INL

NRIC Demonstration Test Beds



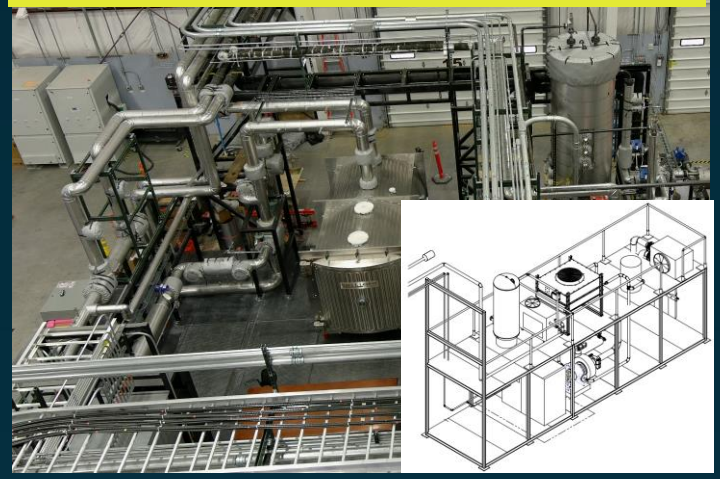


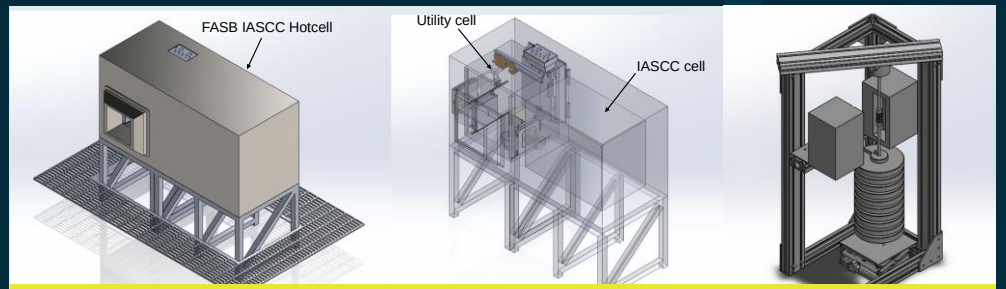


NRIC

NRIC Experimental Test Beds

Helium Component Test Facility [*2022*]

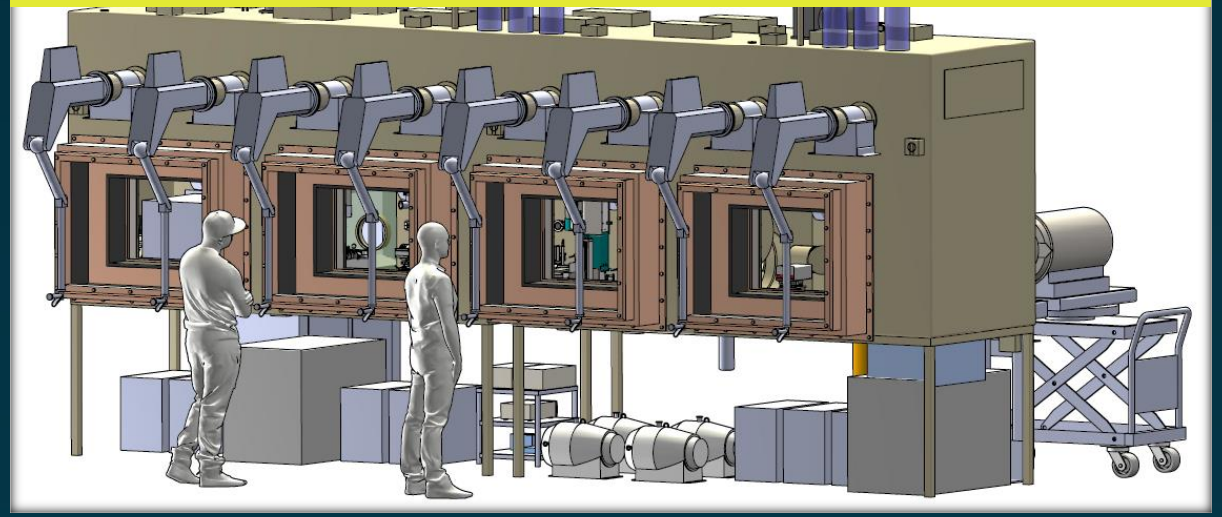


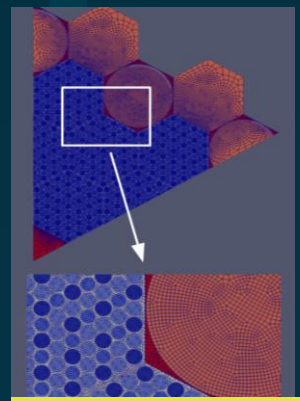


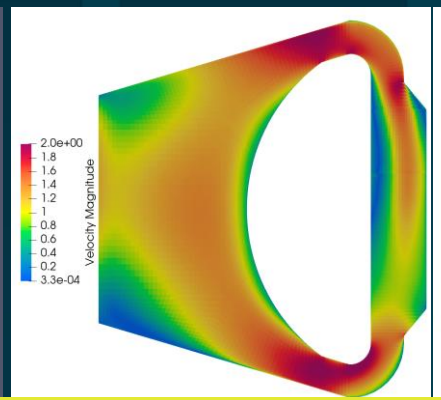
In-HotCell Thermal Creep Frame [*2022*]

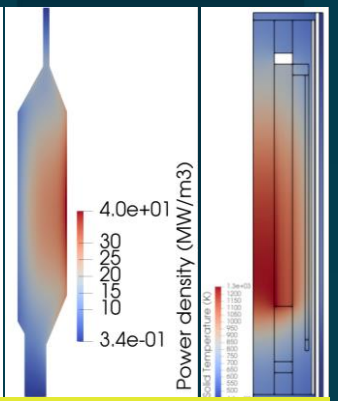
Mechanisms Engineering Test Lab (METL) [Operating]

Molten Salt Thermophysical Examination Capabilities (MSTEC) [*2024*]





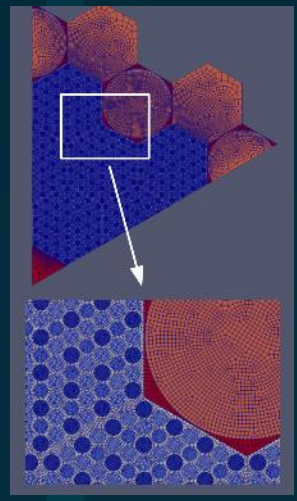


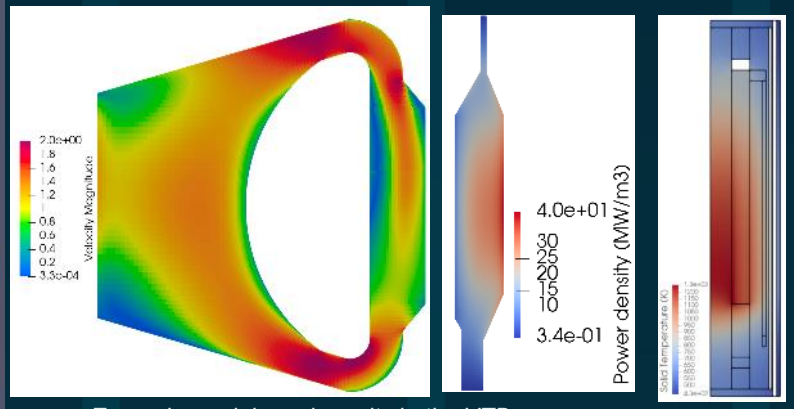


Virtual Test Bed [Launched 2020]

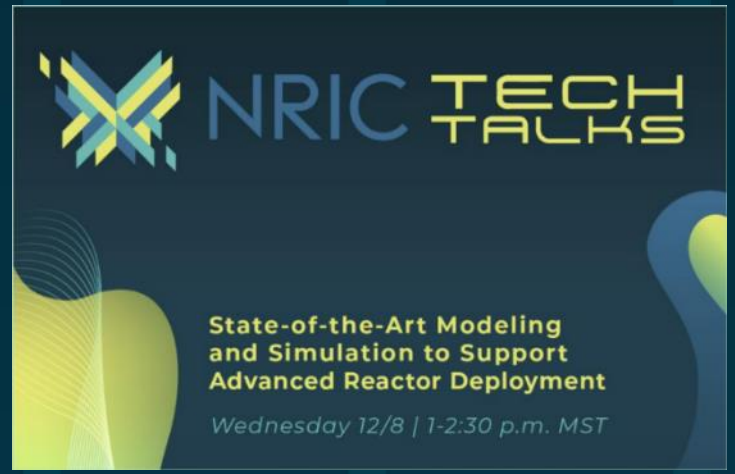
NRIC - Virtual Test Bed

- Central location for reactor developers/stakeholders to access/leverage state-of-the-art ModSim reactor models to evaluate performance and safety of their advanced reactors
- Cross-laboratory collaboration between NRIC and Nuclear Energy Advanced Modeling and Simulation (NEAMS) programs
- Repository/Library of NEAMS models of advanced reactors: sodium, microreactors, gas, molten salt, fluoride high-temperature reactors
- Currently hosting 30+ distinct advanced reactor models, with 7 NEAMS codes showcased… More coming soon!
- FY 22/23 accomplishments:
  - Repository maintenance; new external models hosted; new models developed; event presentations
  - 200+ users since started tracking in April 2023 (NRC/Industry/Academia)





Example models and results in the VTB repo



Announcement of Tech Talk on VTB

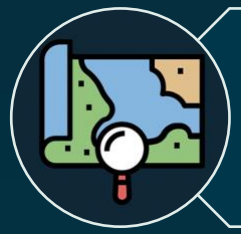
VTB Link: https://mooseframework.inl.gov/virtual_test_bed
ANS Special Session Link: https://www.ans.org/meetings/wm2021/session/view-874/
NRIC Tech Talk Link: https://nric.inl.gov/nric-tech-talks-modeling_simulation/

NRIC INL

Siting Tool for Advanced Nuclear Development - STAND

Provides a systematic way based on user siting preferences and priorities to:

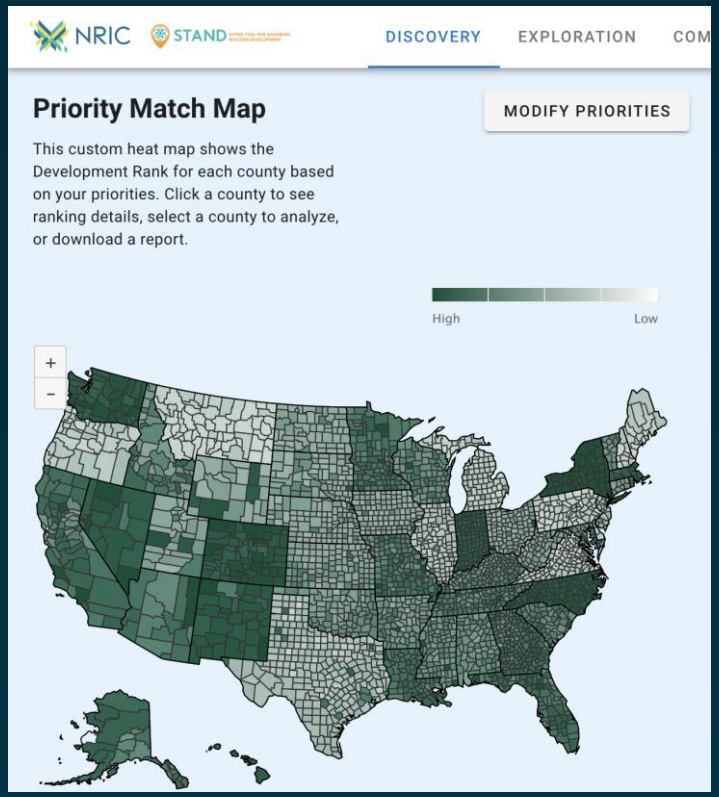
Discover areas that may be a good fit



Explore areas to identify specific sites

Compare sites to identify an optimal option

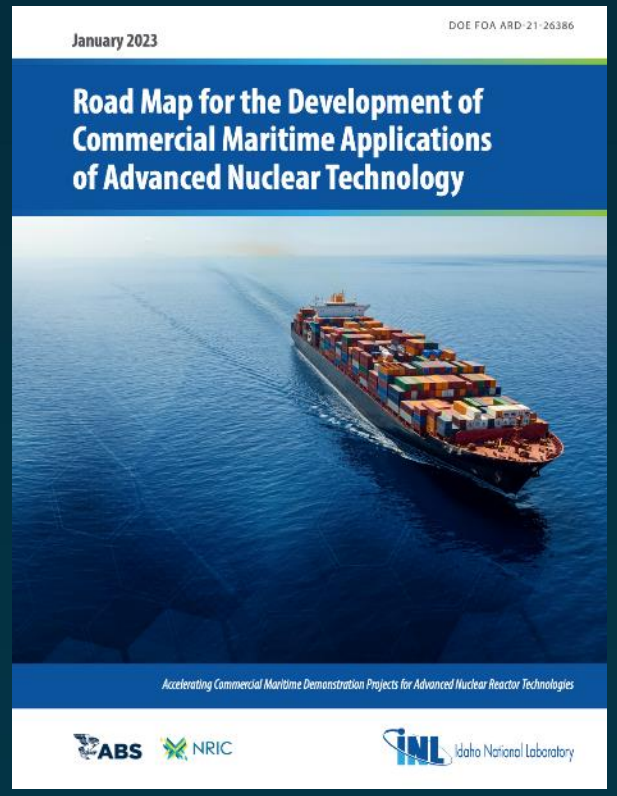
Launched at January 26th Tech Talk
https://nric.inl.gov/nric-tech-talks-stand-tool/

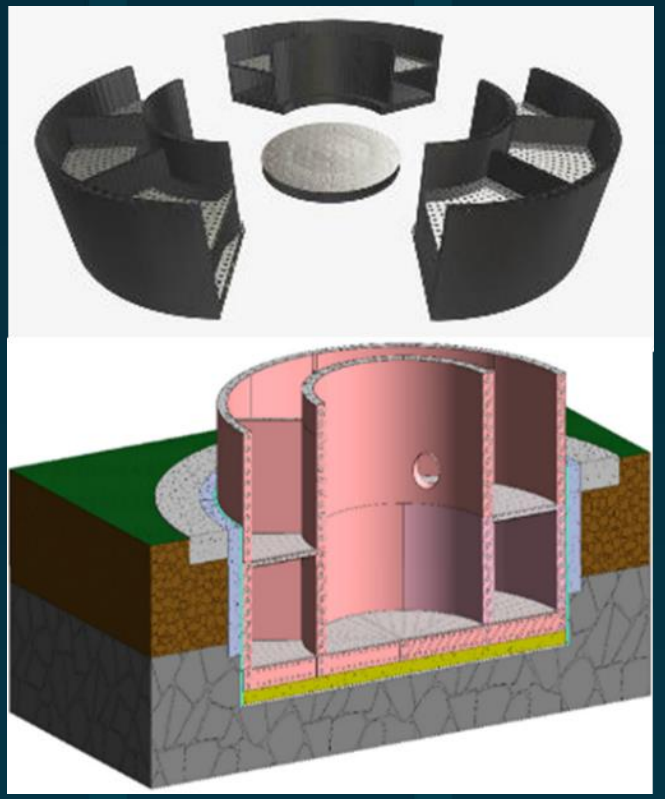


NRIC INL FASTEST PATH TO ZERO UNIVERSITY OF MICHIGAN OAK RIDGE National Laboratory Argonne NATIONAL LABORATORY

Addressing Cost and Markets

- Advanced Construction Technologies – Project kicked off Jan 2022
- Digital Engineering & Knowledge Sharing/Lessons Learned
- Demonstration/Deployment Opportunities (Maritime)

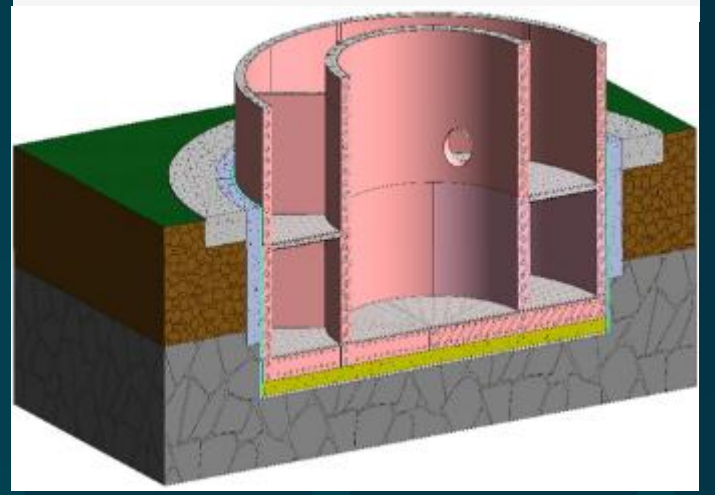




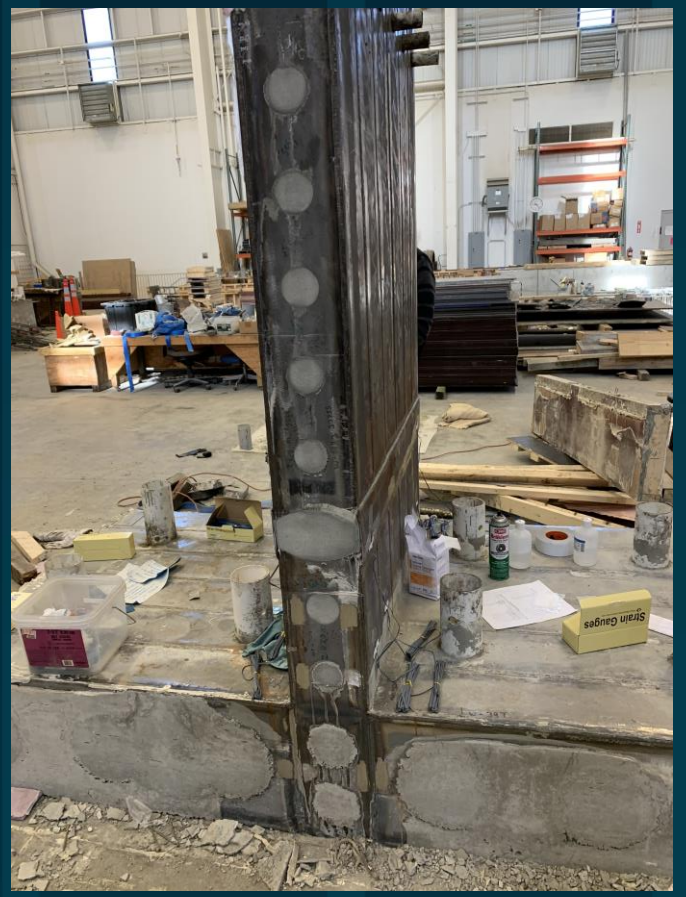
NRIC INL

Advanced Construction Technology

- Project Awarded – January 2022
- Team - General Electric Hitachi
  - EPRI, Black & Veatch, Purdue, UNCC, Nuclear Advanced Manufacturing Research Centre, Caunton Engineering w/Modular Walling Systems Ltd and Tennessee Valley Authority
- Purpose - demonstrate technologies to:
  - Reduce the cost of new nuclear builds by >10 percent
  - Speed the pace of advanced nuclear deployment
- Two phase project with demonstration in FY2024/25
  - Vertical shaft excavation techniques
  - Steel Bricks™
  - Advanced monitoring & digital twin technology



NRIC INL

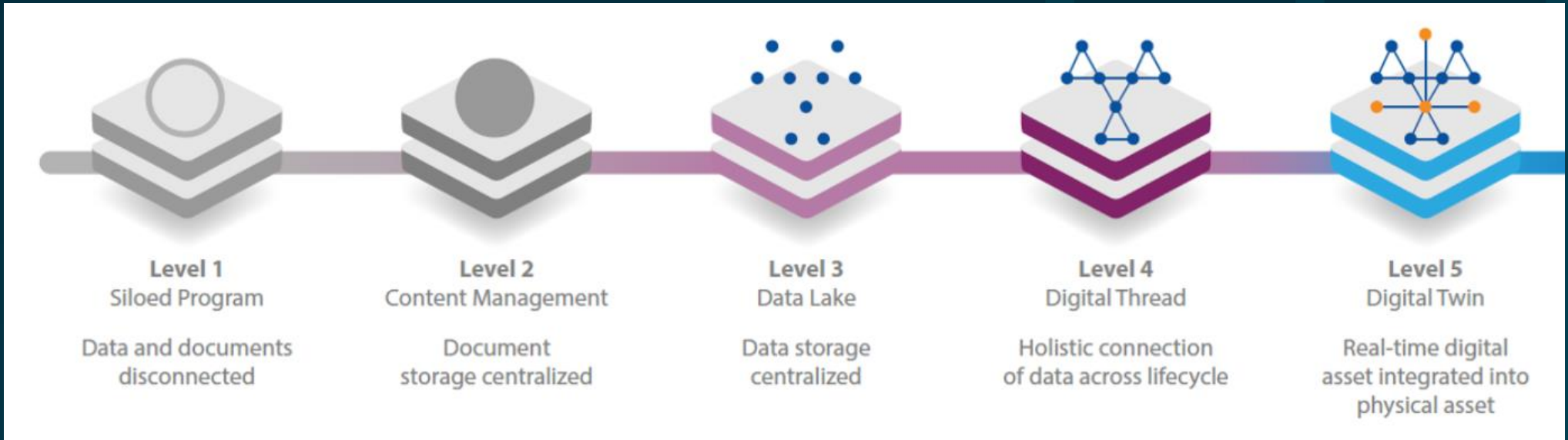


- Steel Brick™ prototypes at Purdue from Caunton Engineering/Aecon.
- Filled with Concrete and imperfections for Stress Testing and Non-Destructive Examination
- Measure strength of splices/connections - generate data for digital twin and regulator acceptance as containment application

NRIC INL

NRIC Systems/Digital Engineering Overview

- Holistic approach to the design of a complex system:
  - Design using models/data instead of documents
  - Integration of data across models to realize significant risk reduction on project cost and schedule
  - Applying state-of-the art Model Based Systems Engineering Tools from requirements engineering through design, construction, and operations
  - NRIC-DEN (Digital Engineering for Nuclear) sharing this tool set architecture with industry partners and others to facilitate cost reductions and improve advanced reactor deployment



Evaluating Maritime Applications
NRIC & American Bureau of Shipping (ABS)

1) Maritime Nuclear Application Group

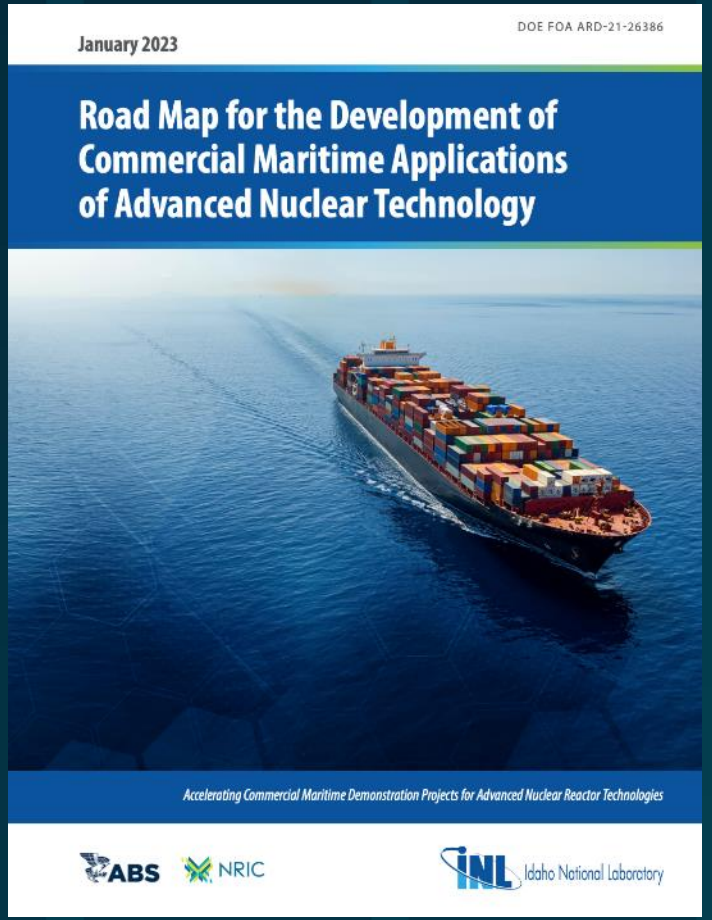
- Collaboration with ABS and Morgan & Lewis Law Firm to establish a forum for the maritime and nuclear energy sectors to demonstrate advanced nuclear technologies in the maritime industry
- Identifies domestic and international legal and regulatory hurdles, catalogs and share relevant information resources, and collaborates with global stakeholders of all types

2) Industry FOA Award 2022 - ABS Accelerating Commercial Maritime Demonstration Projects for Advanced Nuclear Reactor Technologies System

- Develop roadmap for maritime application test/demonstration projects
- Reconcile maritime and nuclear licensing and conduct a regulatory gap analysis
- Develop business cases & 2050 market potential for nuclear-marine applications

3) University of Texas in Dallas – Nuclear Energy University Partnership Phase 1 award

- Integrated Thermal-Electric Energy Management of All-Electric Ship with Advanced Nuclear Reactors
- Model and evaluate the use of advanced nuclear reactors in future nuclear-powered ships with integrated power system, to enhance the efficiency, reliability, and resilience of shipboard energy systems.



NRIC INL MARITIME NUCLEAR APPLICATION GROUP

NRIC Resource Team Program

- 200hrs National Lab expert time/demo/year
- # of awards limited by funding availability
- Current labs with NRIC funded resource teams include
  - ANL/INL/ORNL/PNNL/LANL/LLNL
- Large range of scope:
  - Collaboration on testing plans (e.g. oxidation, mechanical strength, liquid metal viewing)
  - ASME code interpretation
  - Simulation setup, review, verifications, analysis, results.
  - Fuel consultation (various)
  - DOE site use permit application assistance
  - Demonstration of pressure drop in heat exchanger
- Status:
  - 12 new resource teams 2022
  - 5 new resource teams 2023
  - Oversubscribed and working on a new process for selection

"has helped build stakeholder confidence and allow [company] to continue on a path toward commercialization"

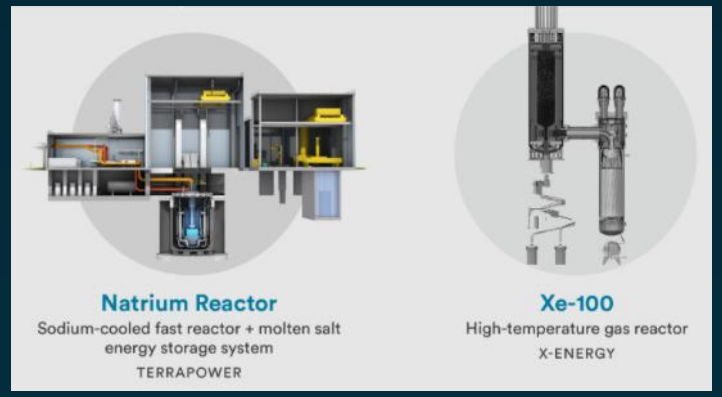
*"**NRIC Resource Team support** has been critical in the design progress made by [company] in 2021 and **is the single most flexible and rapid federal support we have experienced to date."***

NRIC INL

INL Participation in ARDP Projects

- 9 projects supported
- Scope range
  - Modeling & Simulation
  - Irradiation & PIE
  - Fuel design & fabrication
- ~$175M – 7 years
  - $1M - $75M per project
- NRIC/INL Coordinator
- NRIC Deployed Digital Engineering and project management tools

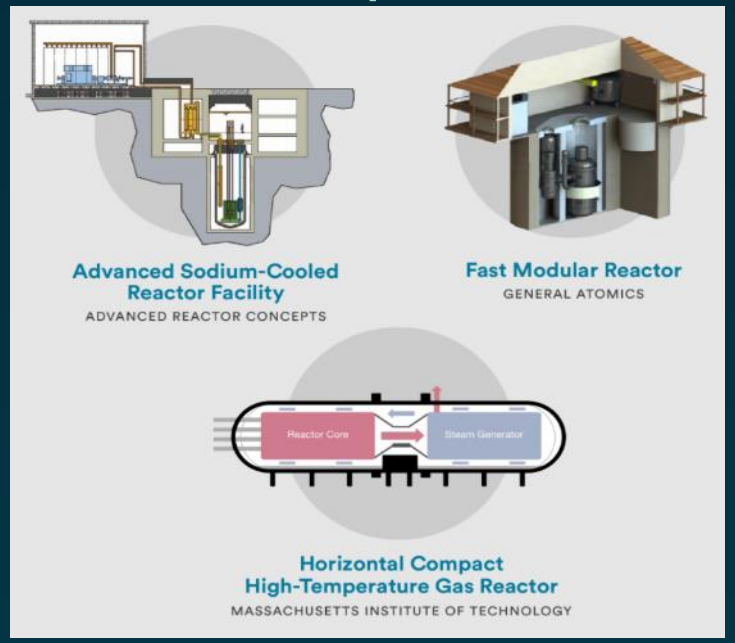
Demonstration



Natrium Reactor
Sodium-cooled fast reactor + molten salt energy storage system
TERRAPOWER

Xe-100
High-temperature gas reactor
X-ENERGY

Concept Development

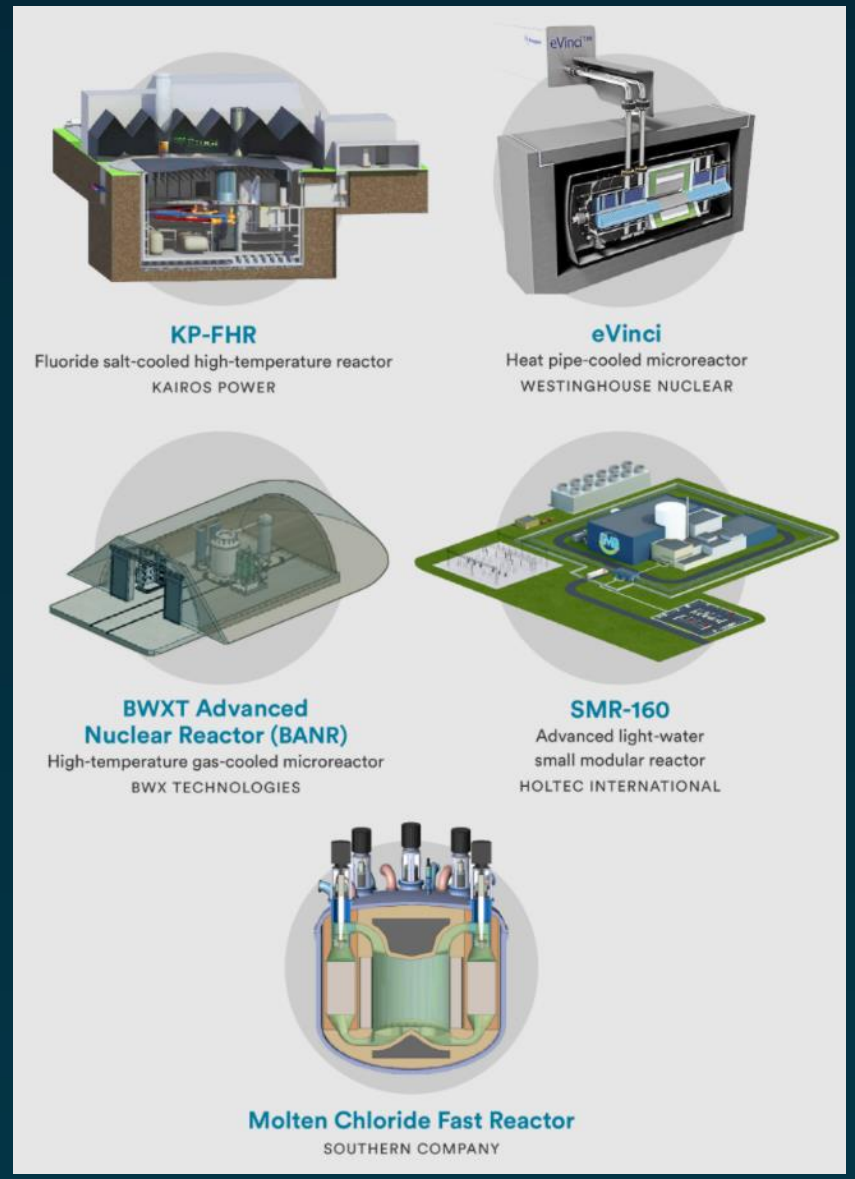


Advanced Sodium-Cooled Reactor Facility
ADVANCED REACTOR CONCEPTS

Fast Modular Reactor
GENERAL ATOMICS

Horizontal Compact High-Temperature Gas Reactor
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Risk Reduction



KP-FHR
Fluoride salt-cooled high-temperature reactor
KAIROS POWER

eVinci
Heat pipe-cooled microreactor
WESTINGHOUSE NUCLEAR

BWXT Advanced Nuclear Reactor (BANR)
High-temperature gas-cooled microreactor
BWX TECHNOLOGIES

SMR-160
Advanced light-water small modular reactor
HOLTEC INTERNATIONAL

Molten Chloride Fast Reactor
SOUTHERN COMPANY

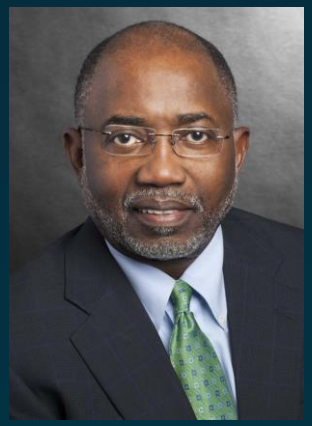
Companies NRIC works to support include:

- Terrapower
- X-energy
- Kairos
- BWXT
- Oklo
- Holtec
- ARC Clean Energy
- General Atomics
- Micronuclear
- Radiant
- GE-Hitachi
- CorePower
- Westinghouse
- USNC
- GERA

NRIC INL

NRC Collaboration

- Congress recognized the importance of agency coordination in the Nuclear Energy Innovation Capabilities Act
- DOE/NRC MOU to "coordinate DOE and NRC technical readiness and sharing of technical expertise and knowledge on advanced nuclear reactor technologies and nuclear energy innovation, including reactor concepts demonstrations, through the [NRIC]."
  - NRIC Rotations



Fred Sock
Office of Nuclear Regulatory Research

Allen Fetter
Office of Nuclear Reactor Regulation

- Monthly Coordination Calls – DOE/NRC/NRIC

NRIC INL

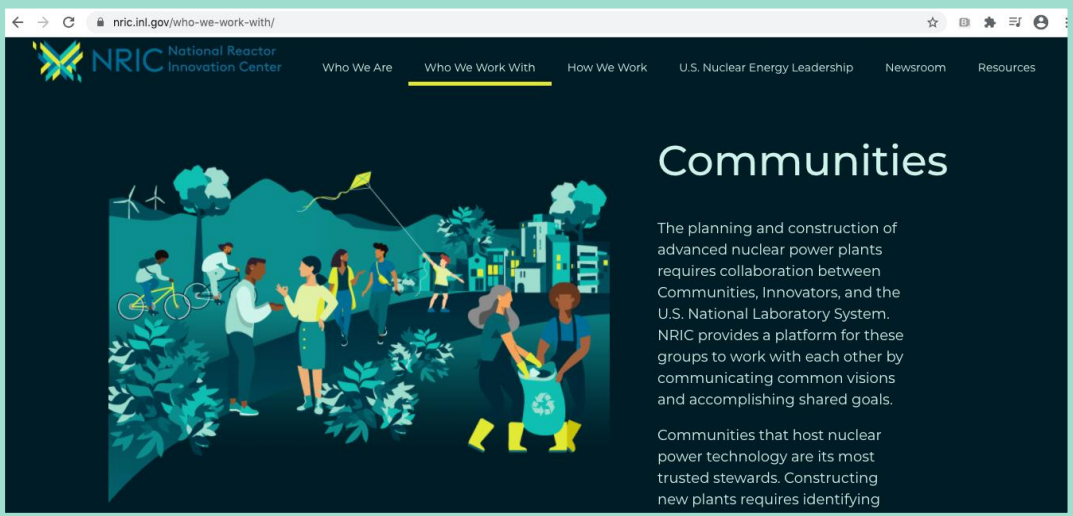
Proactive Impact Management

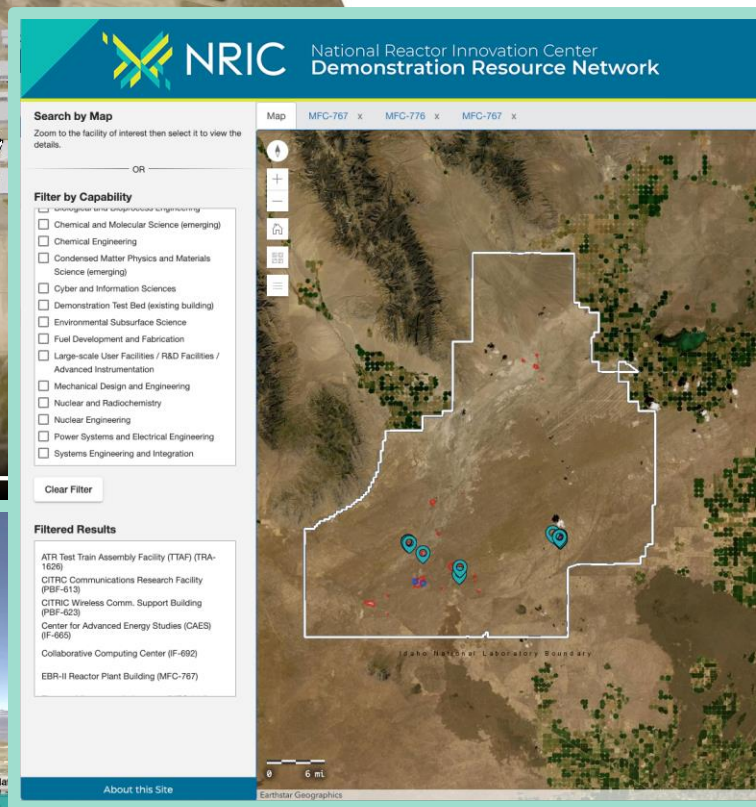
- Environmental impact assessment
  - Cultural and biological surveys
  - Plant parameter envelope
  - Water use
- Packaging, storage, and transport

NRIC INL

Engagement

- Tools
  - Web/Social
  - Flyover, Mapping, Videos
- Best practices development
  - University of Michigan, FPTZ
- University grants for social science efforts



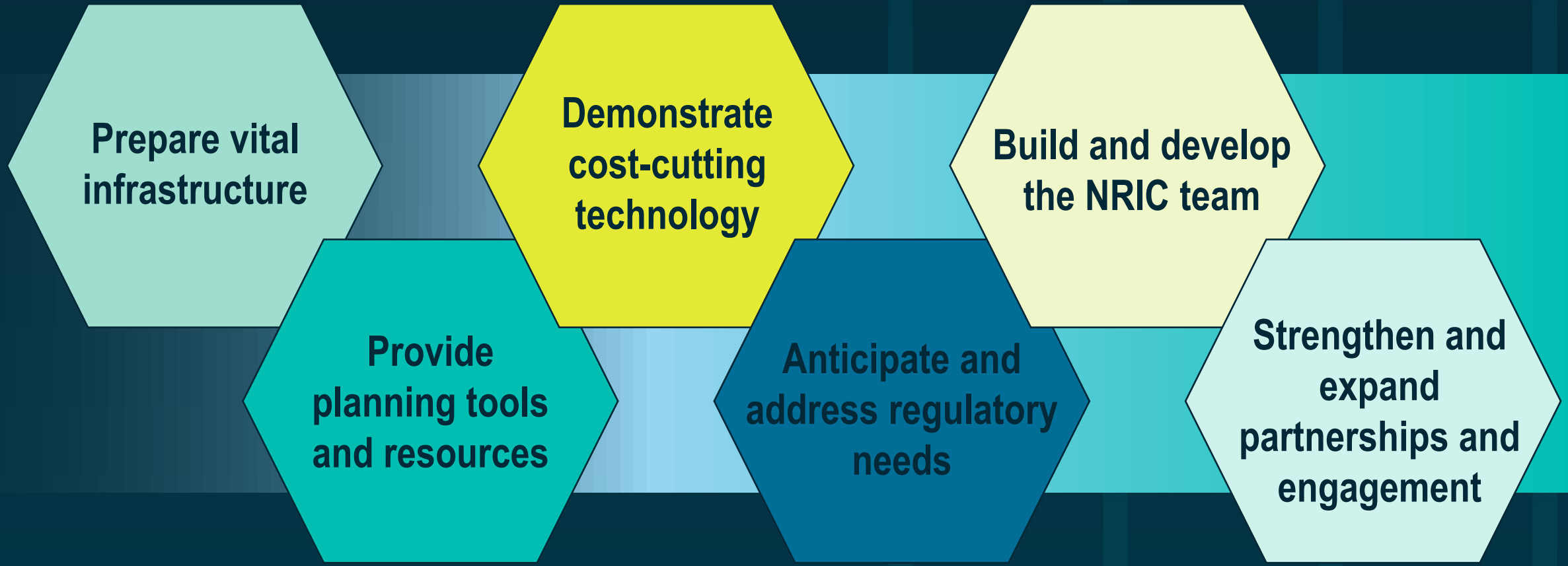


Nuclear Energy University Program Awards

- Engaging Wyoming Communities in an Environmental Justice Approach for Advanced Nuclear Energy Facility Siting (UWy, $800k)
- Environmental Justice and Equity Framework for siting nuclear energy in America's Arctic (U AK-Fairbanks, $800k)
- Integrated Thermal-Electric Energy Management of All-Electric Ship with Advanced Nuclear Reactors (UTD, $400k)
- Open Architecture for Nuclear Cost Reduction (UWM, $800k)

Goals for FY23

Maintain progress to support demonstrations by the end of 2025 and sustained innovation



NRIC INL

Thank you!

Questions?