NRIC National Reactor Innovation Center

Progress to NRIC-DOME Experiments

Update and Opportunities

Sam Reiss

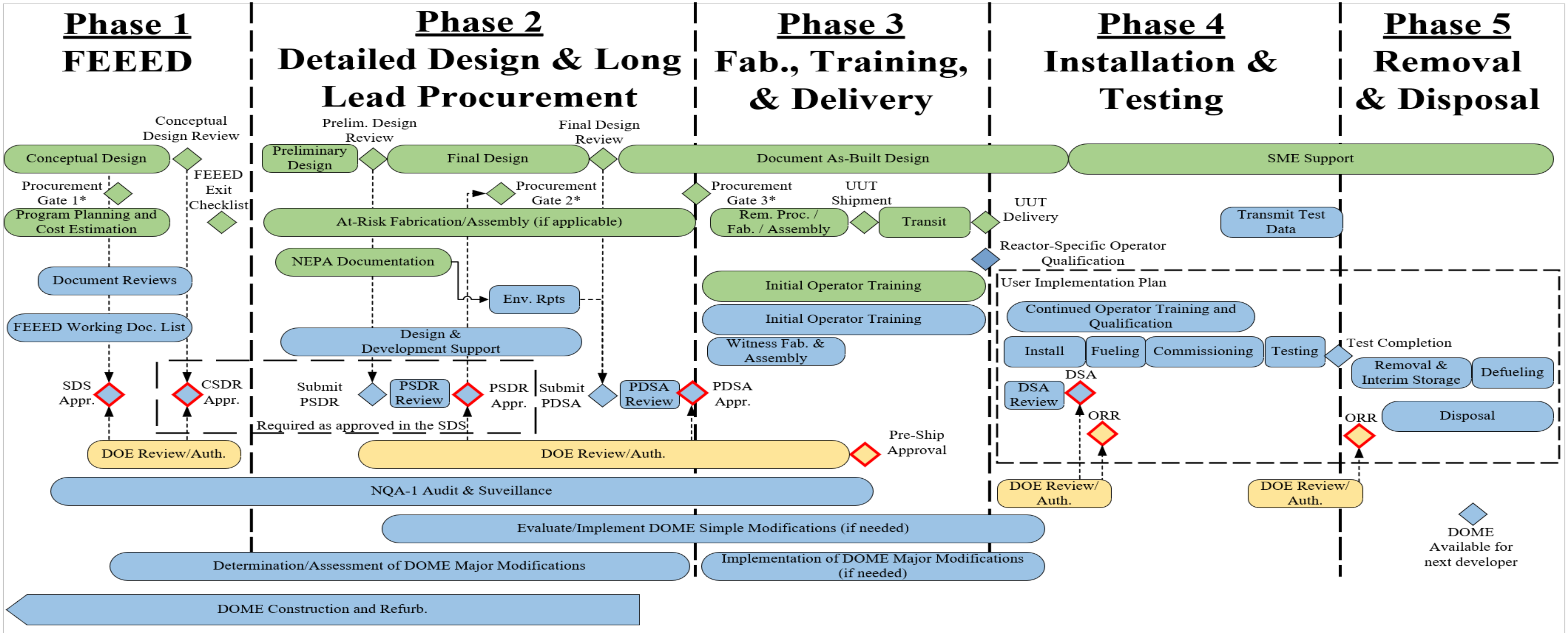
04/01/2025

MIS-25-83649

Outline

- The NRIC-DOME Process
- NEPA strategy and Update
- Updates on NRIC Partners
- Needs and Opportunities
- What’s Next

Advanced Reactor Testing in NRIC-DOME



Legend

- User Activity/Milestone
- NRIC Activity/Milestone
- DOE Activity/Milestone
- Requires DOE Approval

NRIC: National Reactor Innovation Center
DSA: Documented Safety Analysis
UUT: Unit Under Test
FEEED: Front-End Engineering and Experiment Design
PSDR: Preliminary Safety and Design Results

CSDR: Conceptual Safety Design Report
ORR: Operational Readiness Review
PDSA: Preliminary Design Safety Analysis
SDS: Safety Design Strategy
SME: Subject Matter Expert

*Procurement Gates
1: DOE approval required for all procurements
2: DOE approval required for only safety-significant procurements
3: All procurements can proceed

Draft date: 3/27/2024

NRIC-DOME National Environmental Policy Act (NEPA)

Environmental Assessment (EA) using a Plant Parameter Envelope (PPE):

- Desired outcome is Finding of No Significant Impact (FONSI).
- Developers fit the PPE or must develop their own NEPA strategy with the National Reactor Innovation Center (NRIC).

PPE Assumes:

- Use of Tristructural Isotropic (TRISO) fuel
- Less than 20MWth
- Operational life 6 to 24 months

Update:

- Department of Energy – Idaho (DOE-ID) approval of EA determination December 2023.
- NEPA draft EA submitted for DOE-ID comment on 7/18/2024.
- DOE public outreach period 10/8/2024 through 11/21/2024.
- 90-day extension for Department of Energy – Headquarters (DOE-HQ) approval for fuel disposition plan.
- In March 2025, an additional 180-day extension was approved.

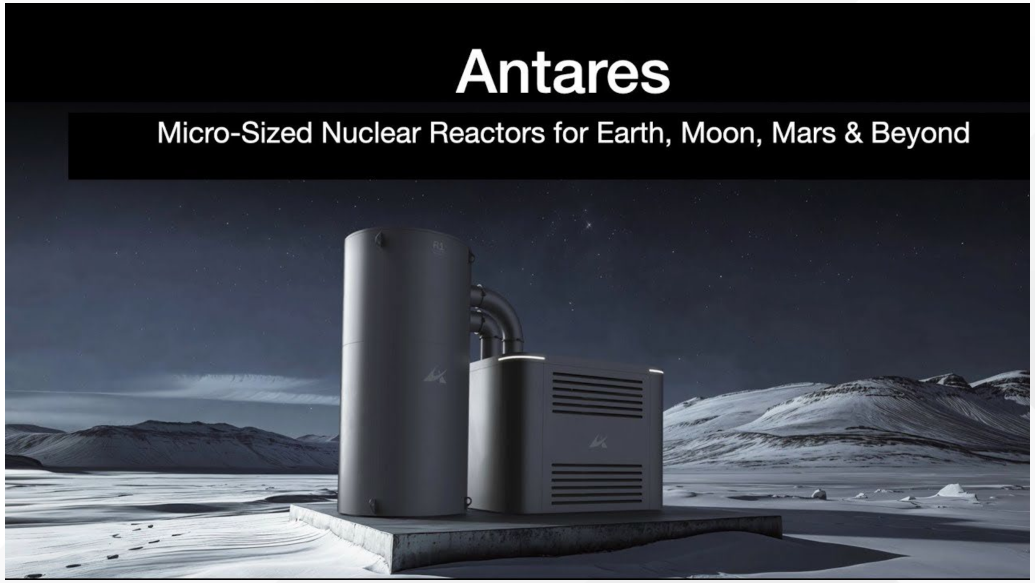
Antares

Accomplishments:

- Safety Design Strategy (SDS) submitted to DOE-ID.
- Front End Engineering and Experiment Design (FEEED) started.
- Completed Phase 1 on-site Qualified Supplier List (QSL) audit.

Next Steps:

- Complete QSL audits/get on Idaho National Laboratory (INL) QSL.
- Conceptual design review.
- Conceptual Safety Design Report (CSDR) submittal.



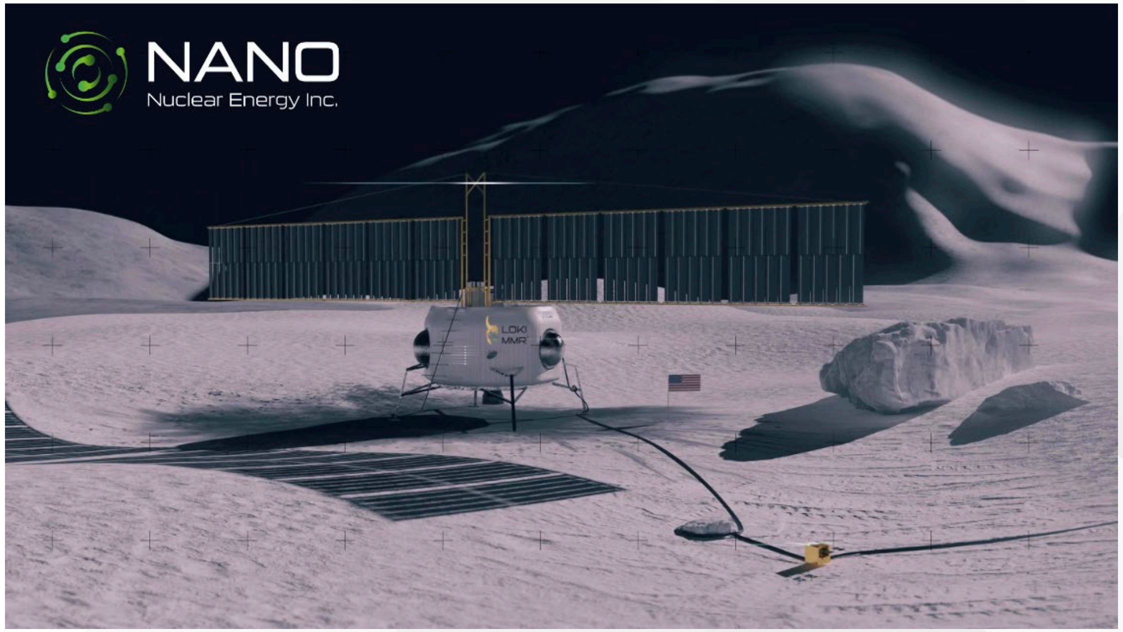
NANO Nuclear

Accomplishments:

- Resumption of activities on SDS, CSDR.
- Contract Initiation.
- Initiation of QSL activities.

Next Steps:

- Initiate QSL audits.
- INL/DOE-ID SDS and CSDR approval.
- INL/DOE-ID contract approval.



Radiant

Accomplishments:

- FEEED completed.
- Detailed Engineering and Experiment Planning (DEEP) started.
- Kaleidos passive cooldown test.
- SDS approved, CSDR submitted to DOE-ID.
- Long Lead Procurement (LLP) for materials started.

Next Steps:

- CSDR approval.
- Preliminary design review.
- Preliminary Documented Safety Analysis (PDSA) submittal.

RADIANT

NRIC National Reactor Innovation Center

Westinghouse

Accomplishments:

- FEEED complete.
- DEEP started.
- Preliminary Safety Design Report (PSDR) approved.
- PDSA has received INL comments.
- LLP process started.

Next Steps:

- PDSA submittal.
- LLP approvals.

Opportunities and Needs for 2026 Reactor Acceptance

- Fuel allocation decision from DOE-HQ.
- Continued and increased support for safety documentation review at INL and DOE-ID.
  - PDSA reviews will be more time consuming.
- NRIC-DOME scheduling process approval from DOE-HQ.
- Turnaround on contracts (CRADAs and SPPs) through BEA/DOE-ID process.
- Increased INL resources for quality, engineering, and nuclear safety.
- Front and backend reactor and fuel analysis from INL and DOE-ID.

What's Next?

1

Phase 1 – FEEED

Ongoing work with Antares and NANO Nuclear

2

Phase 2 – DEEP

INL expects two PDSAs this year, need prioritization, fuel allocation, and NEPA approval.

3

Phase 3 – Delivery and Installation

4

Phase 4 – Fueling and Operations

5

Phase 5 – Remove and Dispose

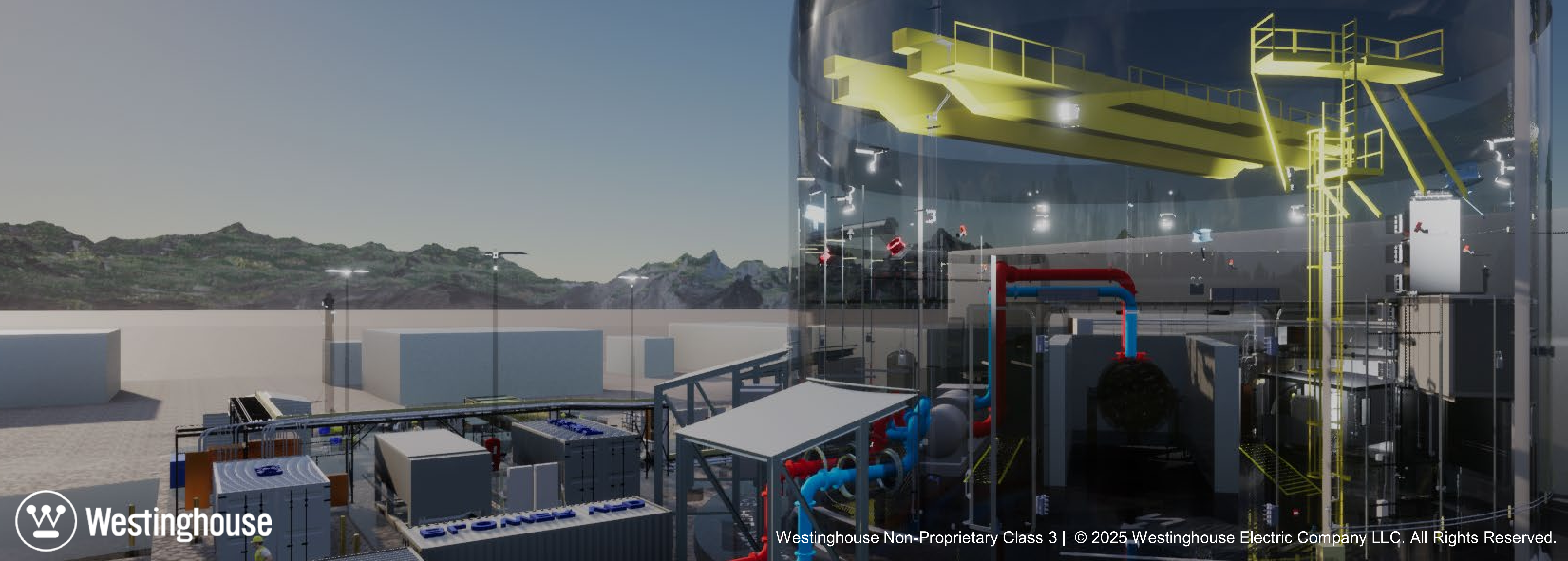
Questions?

NRIC National Reactor Innovation Center

eVinci™ Microreactor

Erin Orga
Nuclear Test Reactor Program Manager

04/01/2025

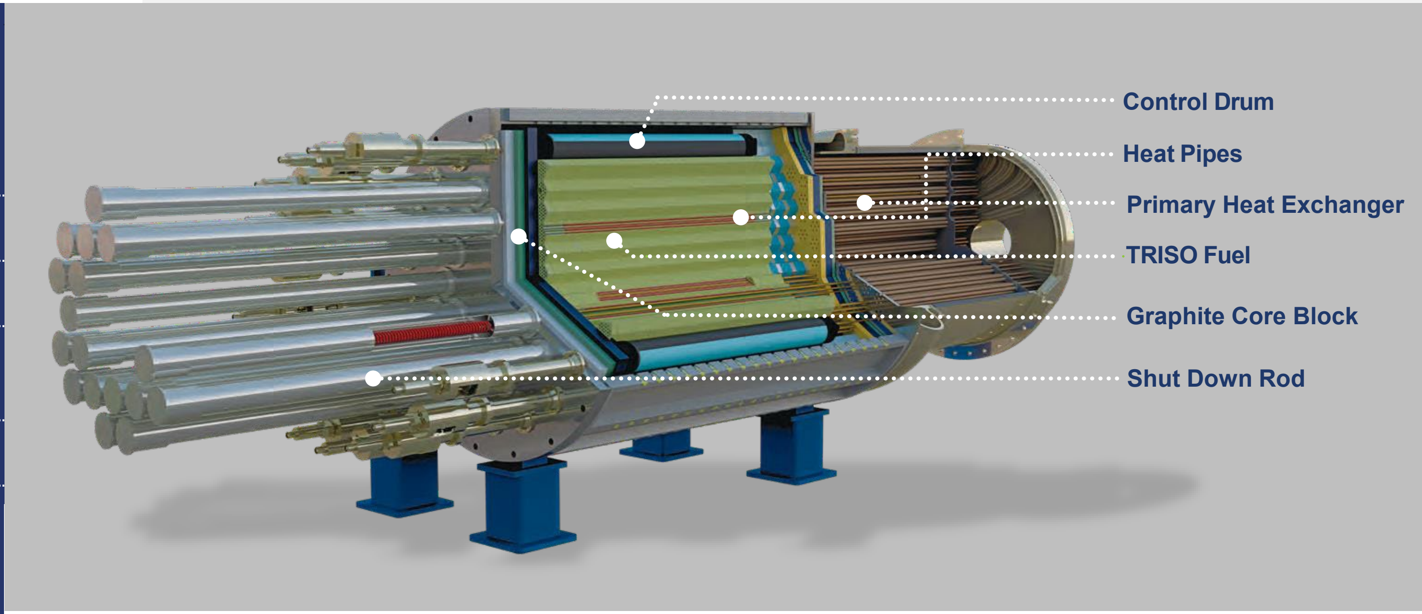


Westinghouse

eVinci™ Microreactor

Delivering nuclear energy to customers in the simplest, most passive and most hands-off experience possible

Technical Description	Heat pipe cooled, Tristructural Isotropic (TRISO)-fueled microreactor paired with an open-air Brayton power conversion system to produce a constant supply 5 MWe over an 8-year cycle
Capacity	5 MWe @4160V AC with 350F waste heat
Capacity Factor	99.9%
Fuel	TRISO in a Graphite Compact, High-Assay Low-Enriched Uranium (HALEU)
Cooling Method	Passive Heat Pipes
Shutdown Features	• Control drums with independent passive actuators • Shutdown rods • Passive cooling of the reactor core
Reactor Pressure	< 20 psi
Neutron Moderator	Graphite
Refueling Cycle	8+ years
Site Footprint	< 3 acres



The eVinci Microreactor Advantage

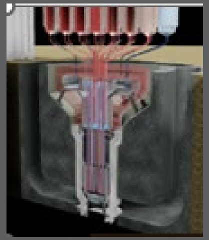
- No water needed for operation
- Low pressure systems
- No active cooling
- User-friendly instrumentation
- Simplified maintenance & operation
- Connect to grid or operate in island mode
- Transportable with no fuel handling on site

Westinghouse

eVinci™ Microreactor Development Timeline

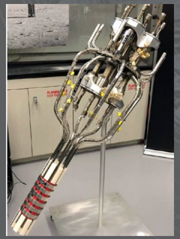
1960 – George Erikson invents the first heat pipe and conducts testing at Los Alamos National Lab

2015 – Westinghouse begins development of a heat pipe reactor concept



2018 – Technology transfer of heat pipes from Los Alamos National Labs to Westinghouse

2018 – LANL and NASA complete the KRUSTY experiment for KiloPower reactor



2020 – Deliver Conceptual Design for 1MWe Mobile System for Project Pele

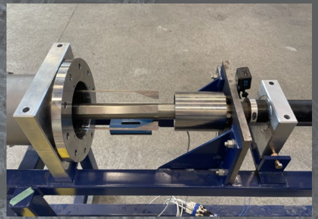
2020 – Completed construction of the eVinci microreactor test facility & manufactured first sodium heat pipe

2021 – Electrical demonstration of a seven heat-pipe core assembly at operating temperature

2022 – Development of heat pipe manufacturing equipment including patented Automated sodium fill system

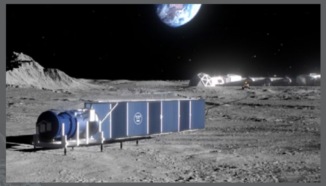
2022 – Completion of first manufacturing demonstration

Nov. 2023 – Completed fabrication of first 12 ft FeCrAl heat pipes



Nov. 2023 – Completed testing of key safety components Control Drums and Shut Down Rods

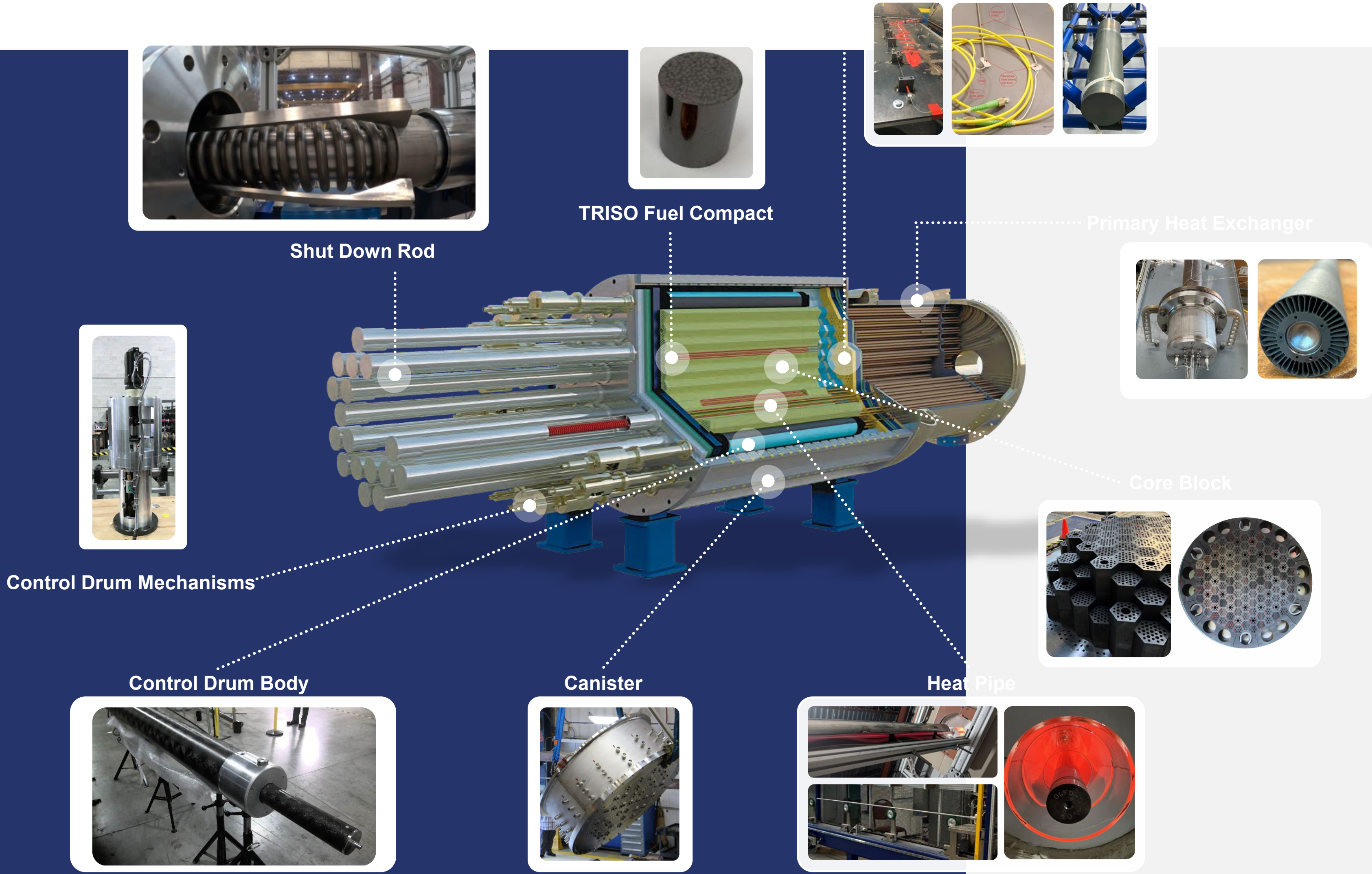
March 2024 – Completed phase 2 of electrical demonstration testing



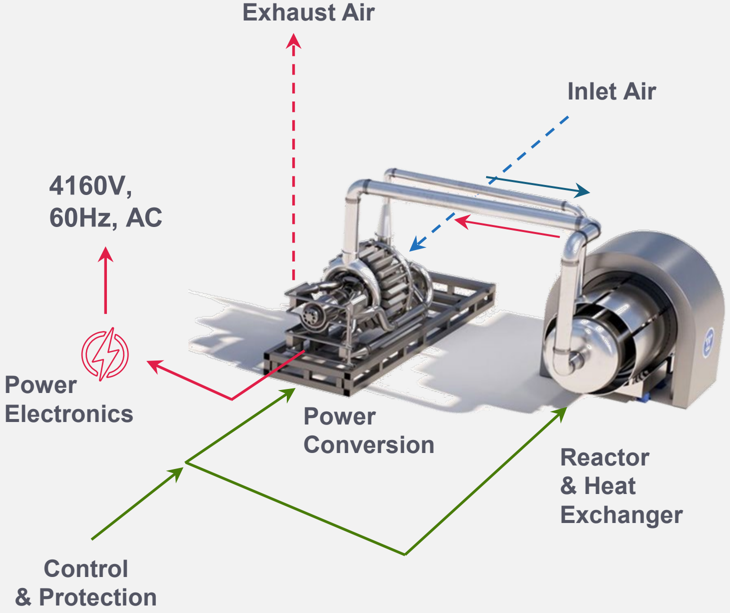
April 2024 – Westinghouse announces AstroVinci , heat pipe reactor for satellite and lunar power

Aug. 2024 – Full-Diameter Manufacturing Demonstration Unit, 32,000 lbs, 3.2 m Diameter

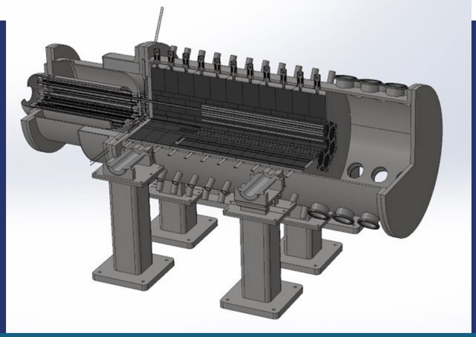
Transitioning from Component Prototypes to an Integrated System

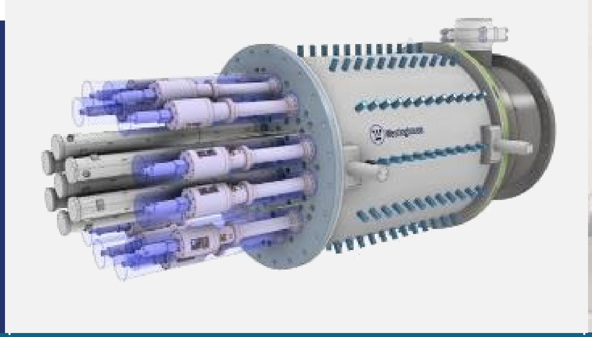


General Arrangement



Integrated Reactor Testing is Key to Advancing our Technology Readiness





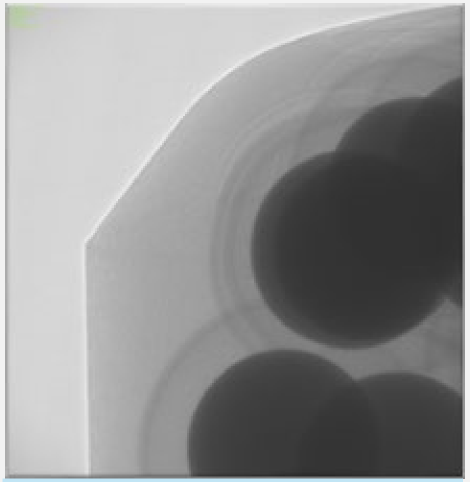
	Electrical Demonstration Unit 1 (EDU 1) - Proof of Concept	**EDU 2 Thermal 'Dry Run'**	**Nuclear Test Reactor Demonstration**	**Commercial Product**
Date	2021 – 2024	2025 – 2026	2027 – 2028	2030
Location	Westinghouse Testing Facility	eVinci Microreactor Hub	Idaho National Laboratory Dome	Customer Site
Scale	7x heat pipes	48x heat pipes	334x heat pipes	770x heat pipes
Method	Electric	Electric	Nuclear fuel, 2-3MWth	Nuclear fuel, ~5MWe
Control	Manual heaters	Improved manual heaters, replica heat exchanger	Manual control with drums	Automated controls

Integrated Nuclear & Thermal Testing

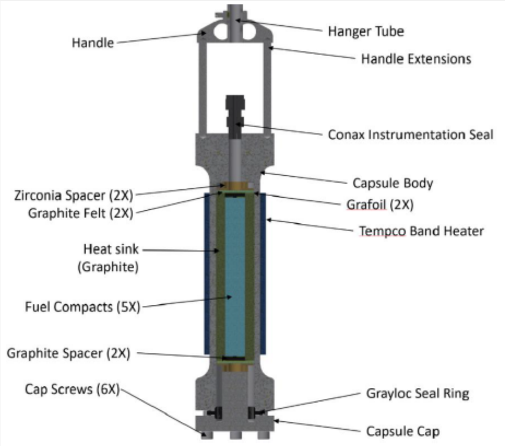
- Fuel Capsule Test @ Idaho National Laboratory's (INL) Transient Reactor Test (TREAT) Facility.
  - Beginning of life transients
  - Awaiting fuel delivery
  - TREAT insertion in Jul 2025
- eVinci Criticality Test @ Los Alamos National Laboratory (LANL) (NCERC)
  - Finalizing design and test article individual component fabrication
  - Insertion in Jan 2026
- Electrical Demonstration Unit 2
  - Fabrication underway
  - Testing starts Q2 2026

Demo Fuel Tubes for NCERC Criticality Test

Heat Pipes for EDU2

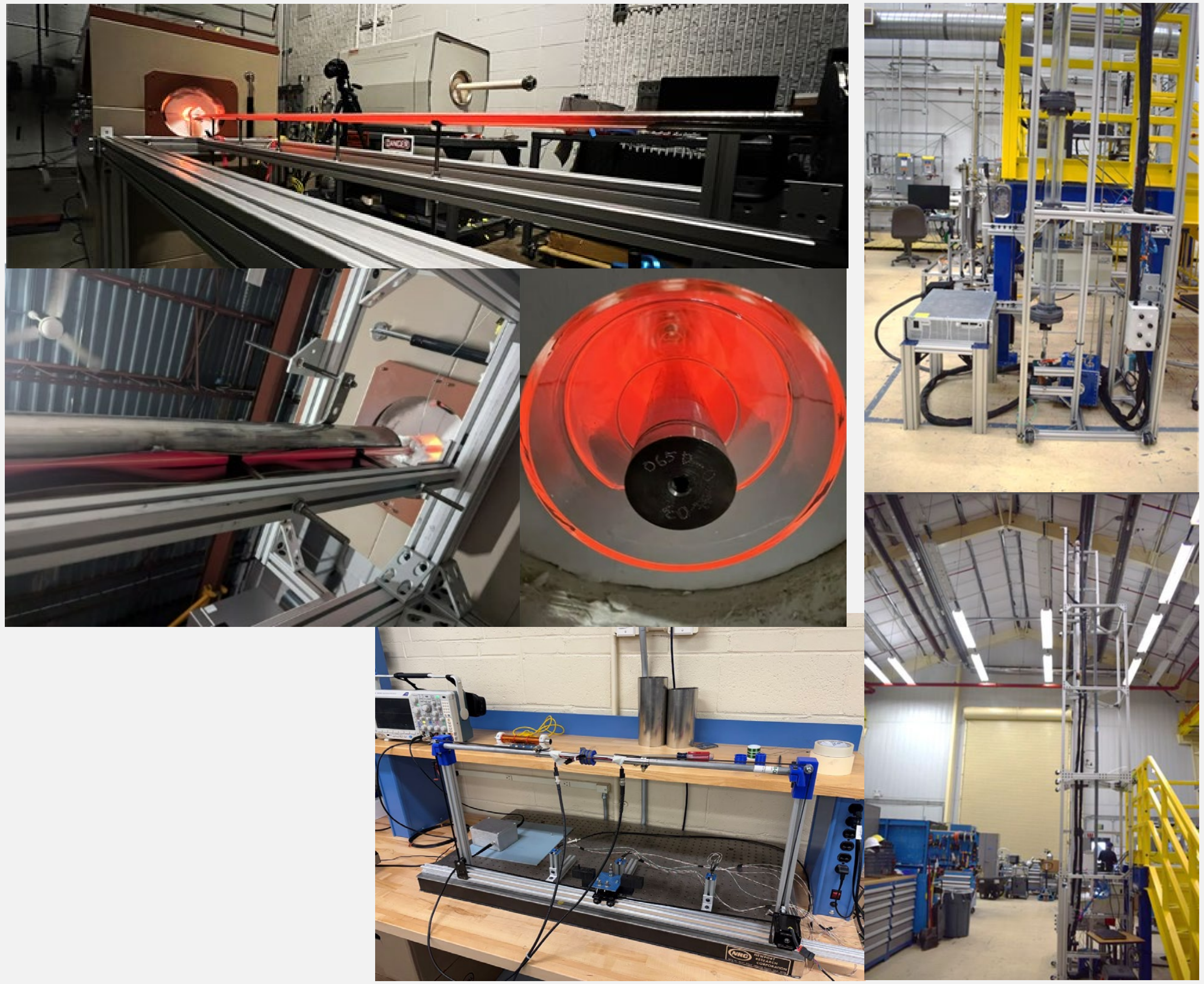


X-Ray tomograph of Westinghouse chamfered-edge Fuel Compact design (TRISO-X)

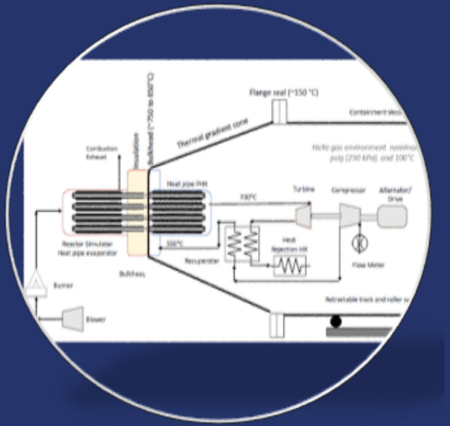


Component Testing

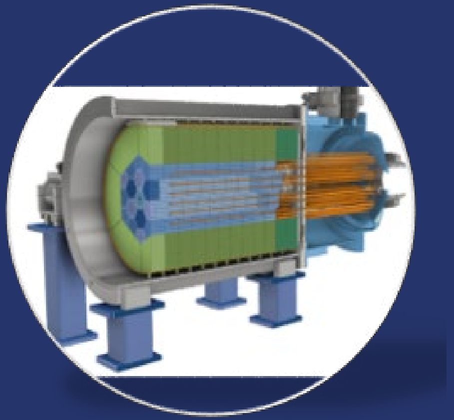
- Heat Pipes
  - Vapor Flow testing @ LANL & WEC
  - Life testing @ WEC
- Cantilever Bend testing
- Instrument Penetration Seal Leak testing
- Large Diameter Canister High-Temperature Seal testing
- Spring Pack creep test facility Factory Acceptance Test (FAT) in May
- Ongoing Rod & Drum testing
- Eddy Current Flow Measurement Sensor
- Non-standard Weld Qualification Tests



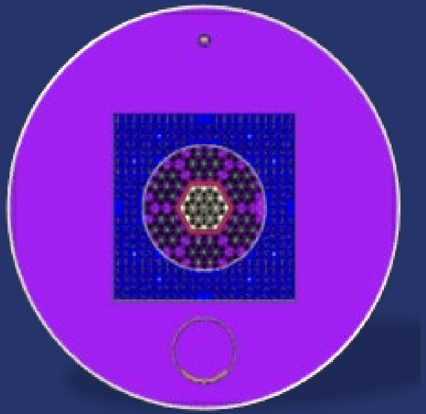
What's in the Pipeline for 2025



Brayton Cycle Test Bed development



Large-Scale Integrated Electrical Demonstration Unit for Thermal Benchmark

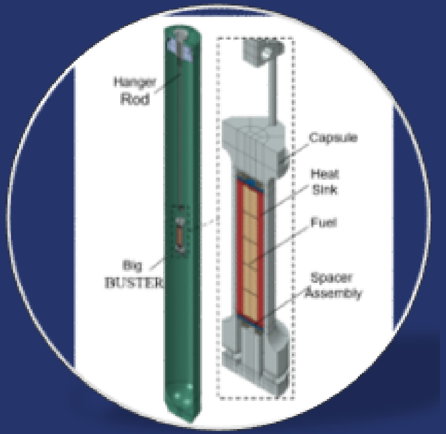


eDEIMOS Criticality Test with LANL

Limits Experiment of Advanced Heat Pipes (LEAHP)

Vapor Flow Test at LANL

Power Electronics Demo



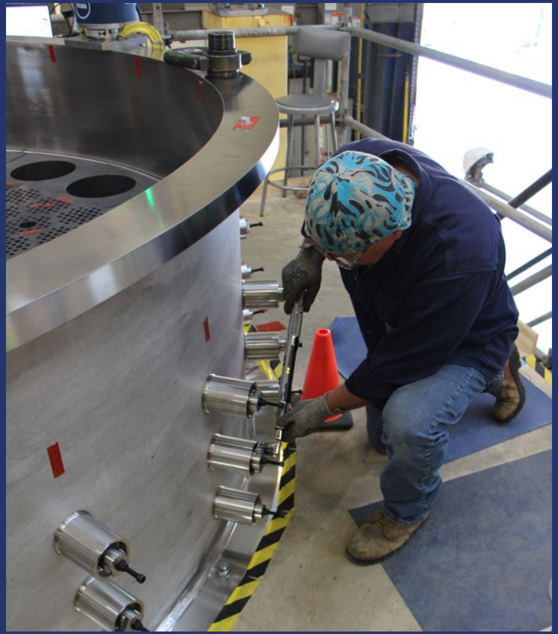
Fuel Capsule Test in TREAT Reactor at INL

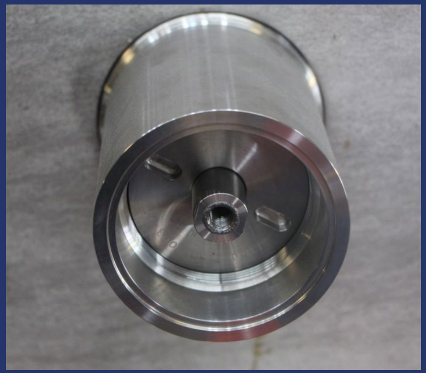
AND MORE...

Manufacturing – Core Block Demo










Manufacturing – Reactor Canister

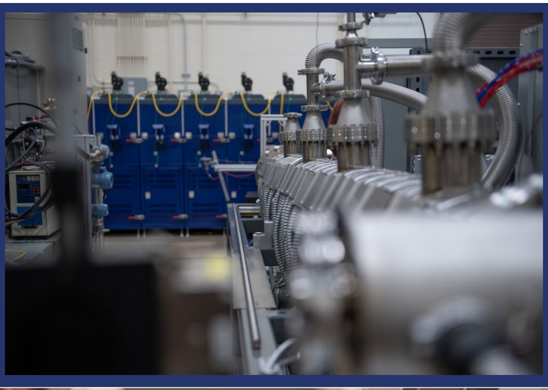

Manufacturing Demo Canister Machining at Newington

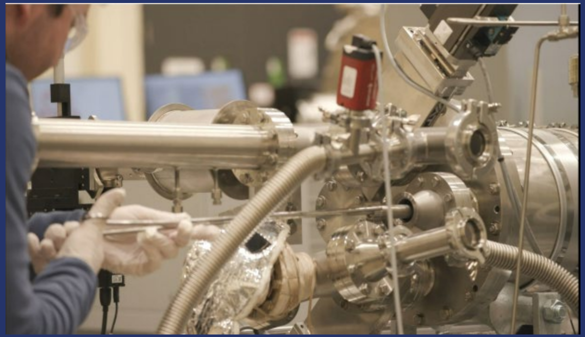

NTR Canister Flanges

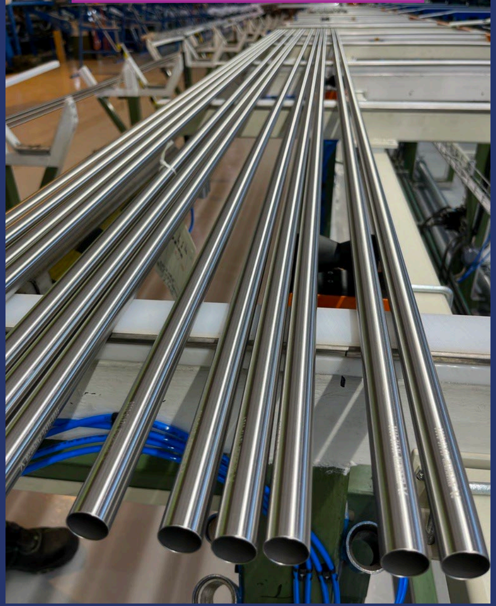

Weld Prep Axial Seam


NTR Canister Shell Arriving at Newington

Manufacturing – Heat Pipe Test Articles and Scale up Demos





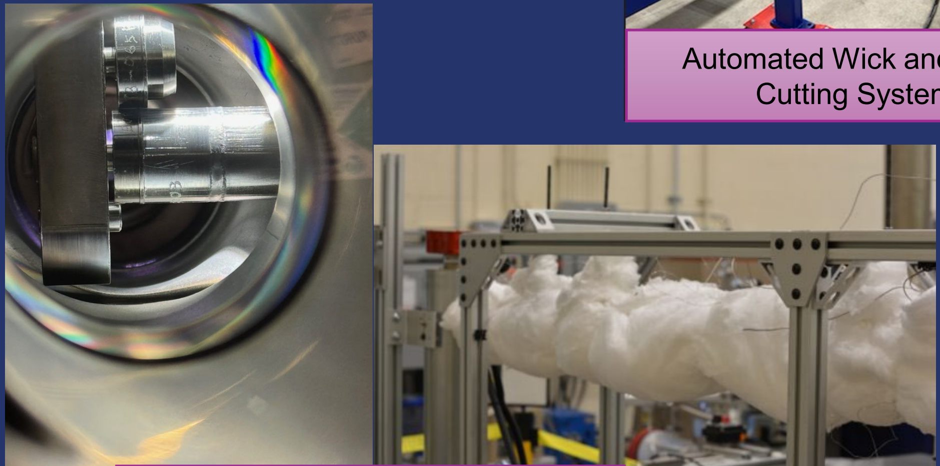


HP Tubing

12Ft Heat Pipe Test

Automated Wick and Tube Cutting System

Automated 9 Heat Pipe Fill System



Performance Limits Test

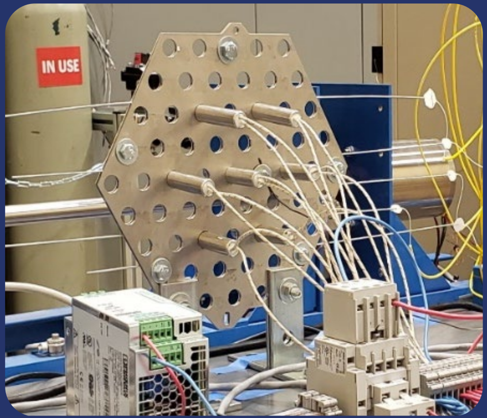
Manufacturing – Control Drum & Rod Demos

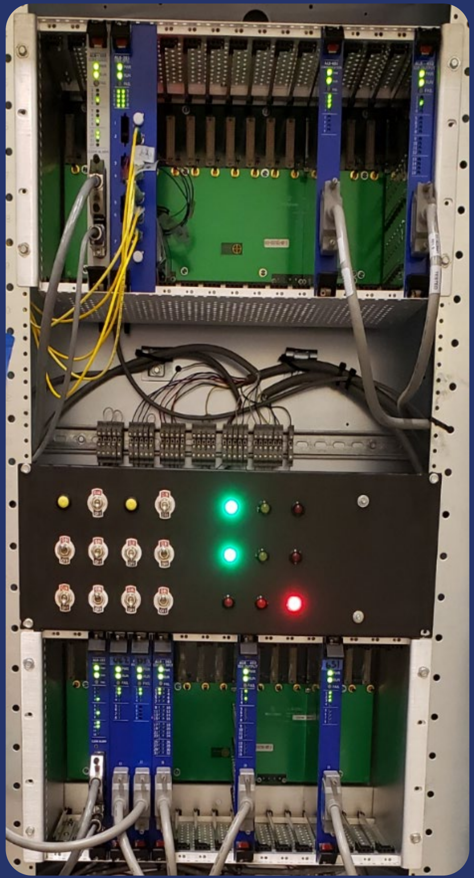

Demo – 51 Bridge Street


Drum Shell

Manufacturing – I&C Test Articles and Prototypes

Engineering EQ Cabinet

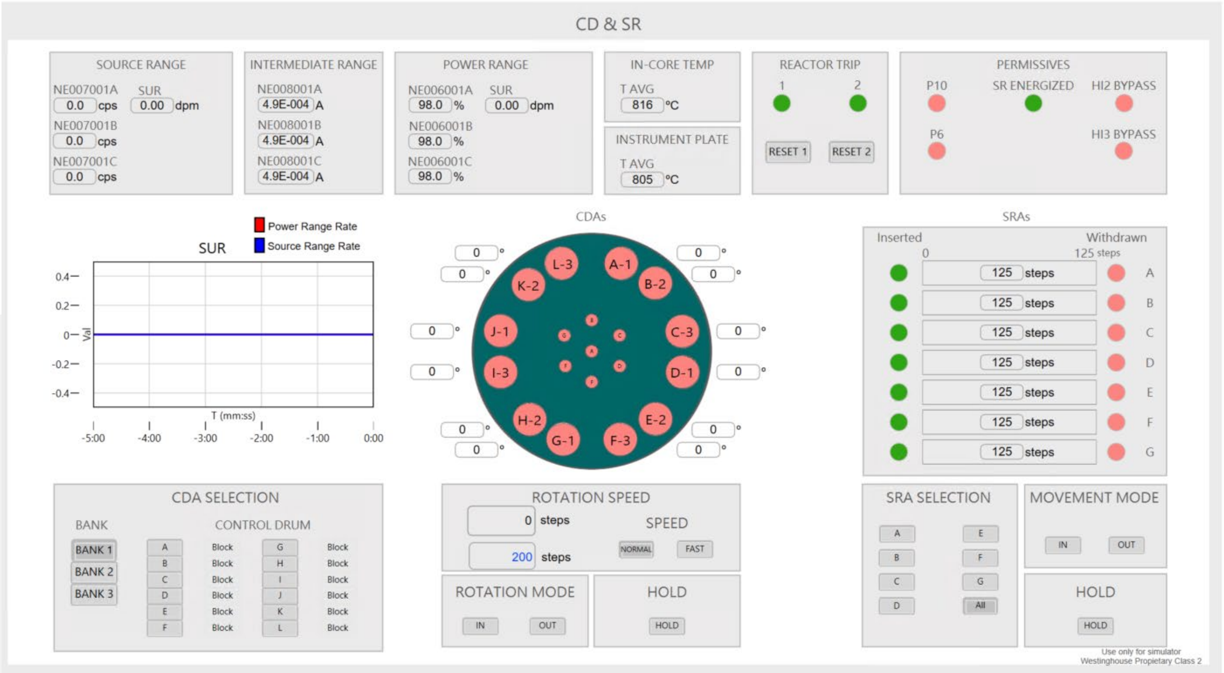


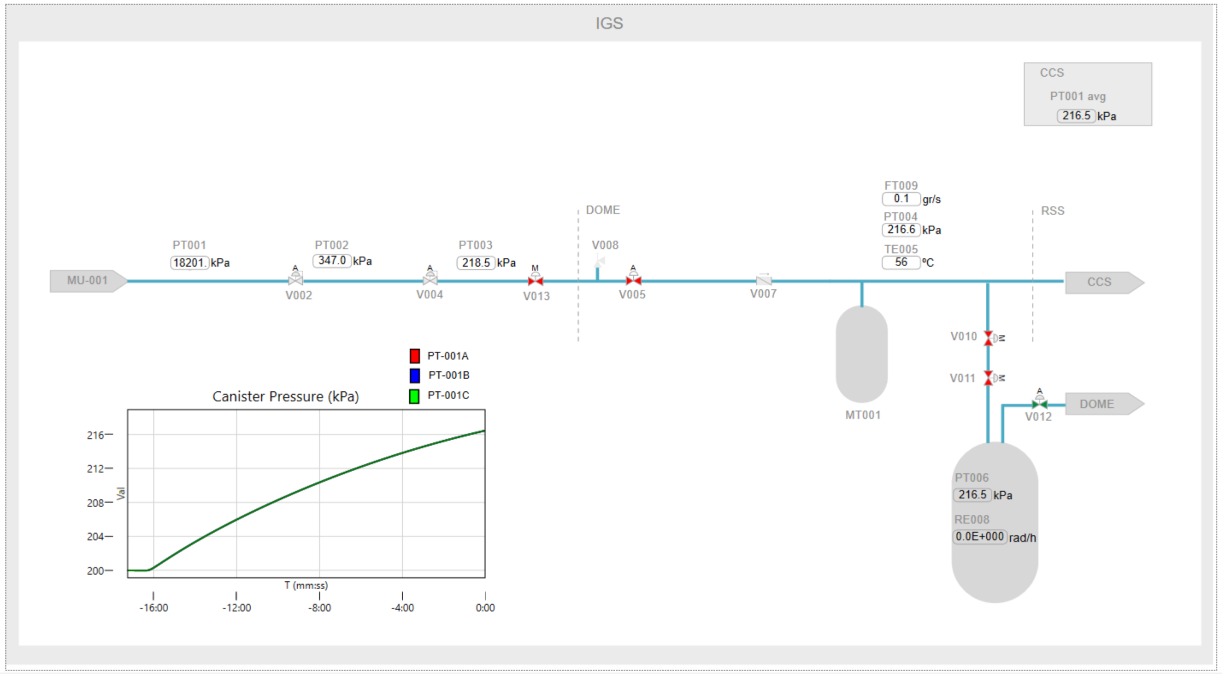


High-Temp Neutron Sensor Prototype

NTR Simulator

- Full scope of National Reactor Innovation Center-Demonstration of Microreactor Experiments (NRIC-DOME) & eVinci NTR to certify operators
- Real-time simulation over entire range of Operations from start-up to end-of-life
- Simulation of specific malfunctions associated with planned tests, high-risk events, & accidents
- Simulation of local actions that may be demanded by the operator. Environmental and boundary conditions can be modified by the operator
- Physical fidelity of the operating environment & display
- Fidelity in neutron, thermohydraulic, electrical, and control and protection loops behavior
- A simulation session can be started from any operating condition within range





Thank You

Westinghouse Electric Company

@WECNuclear

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Westinghouse

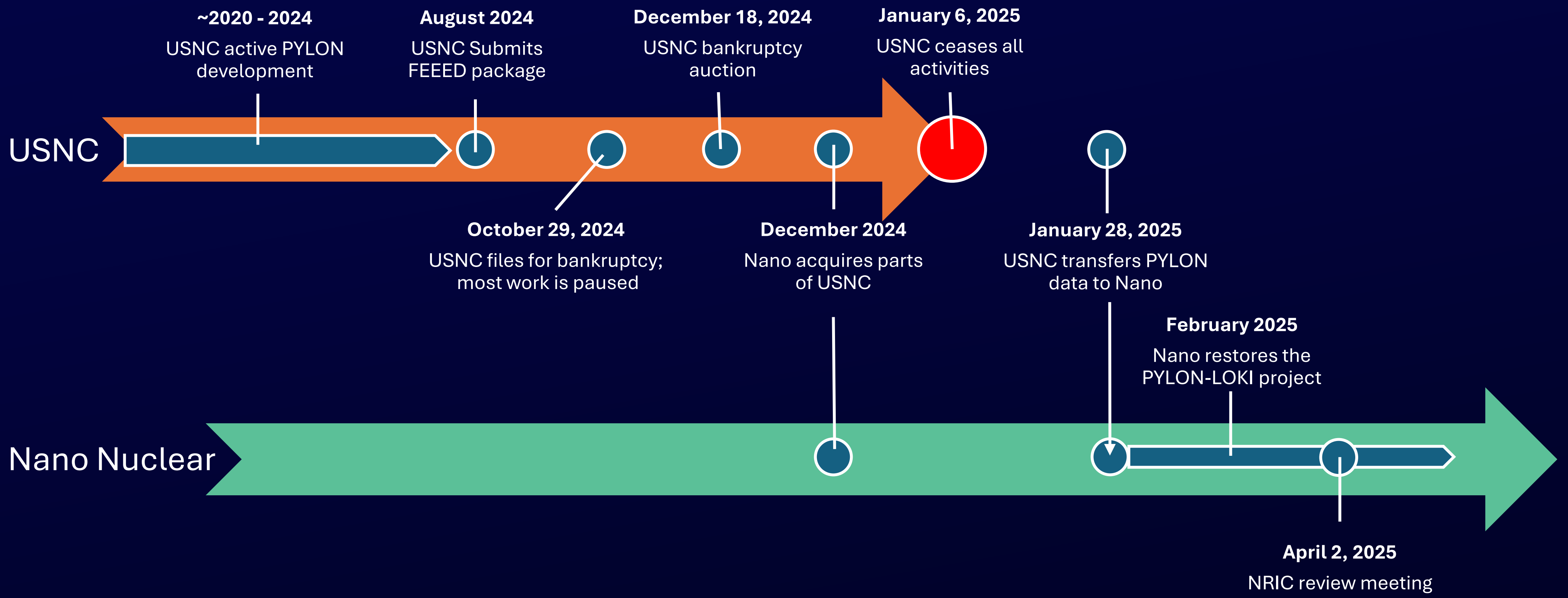
LOKI MMR™

NANO Nuclear Energy Inc.

LOKI Micro Modular Reactor Overview & Status

NRIC Review Meeting
Idaho National Laboratory, 04/01/2025

USNC, NANO & PYLON/LOKI TIMELINE



- Nano remains committed to the continued development of the LOKI (PYLON) reactor solution, pursuing the National Reactor Innovation Center-Demonstration of Microreactor Experiments (NRIC-DOME) demonstration opportunity.

NANO NUCLEAR ENERGY

Company Facts

- Founded in 2021
- 30 direct employees
  - 150+ extended employees
  - Fast growing
- IPO (NASDAQ) in May 2024
  - Best performer of the year
  - ~$1.5B valuation
  - Fully audited
  - $100M+ Cash Position
  - Access to capital markets
- Acquired strategic businesses to bootstrap project delivery
- World-renowned executive advisors for industrial and defense projects

Leadership Team

Jay Jiang Yu
Founder and President

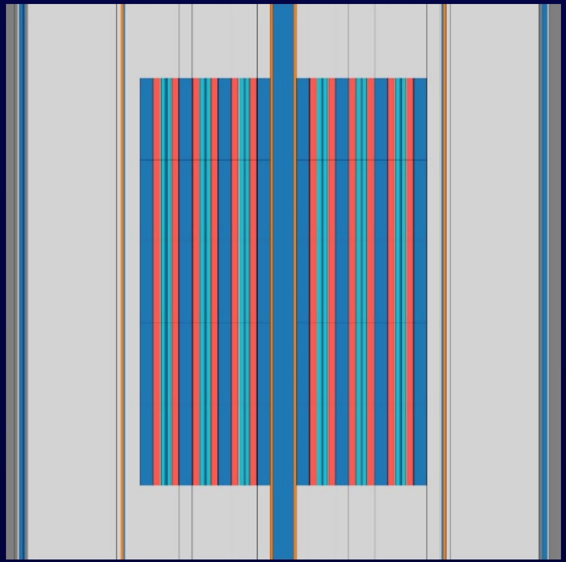
James Walker
CEO

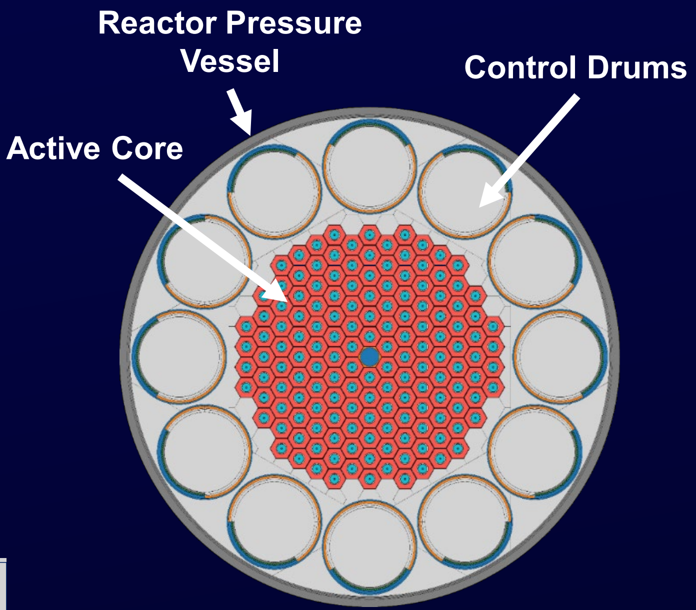
Florent Heidet
CTO and Head of Reactor Development

Main lines of business

- Micro reactor technology and projects
- Fuel Supply Chain
- Nuclear material transportation
- Nuclear Technologies Development
- Nuclear for Space applications

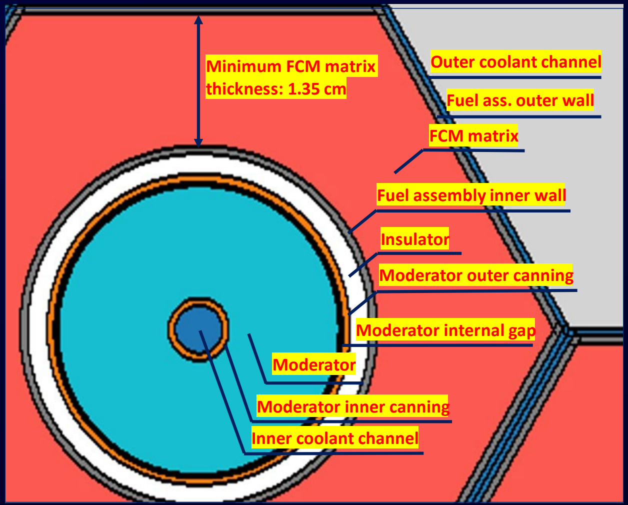
LOKI-PYLON Reactor Overview

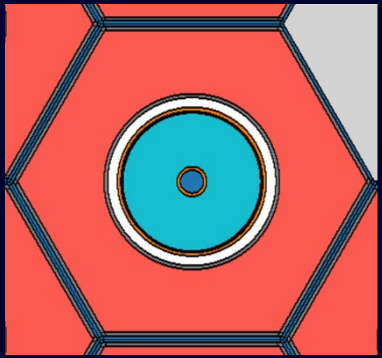




General Description
The fuel is directly cooled by flowing He and moderated using ZrH. Control Drums, containing B_4C, are used for primary reactivity control.

Key Performance Parameters	
Inlet/Outlet temperature (K)	604/1000
System pressure (MPa)	2
Core Flowrate (kg/s)	0.5
Max. Power (MWth)	1.0

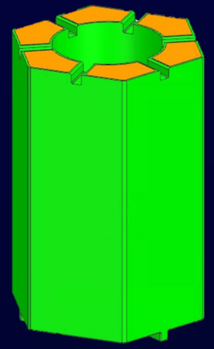




Fuel / Geometry Details	
Fuel Composition	AGR FCM TRISO
Fuel Assembly Can Composition	SiC
TRISO Loading (volume %)	58.0
Heavy metal mass (kg)	~370
Fuel Hex Flat-to-Flat (cm)	(proprietary)
Fuel Wall Thickness (cm)	(proprietary)
Min. Fuel Thickness (excl. wall) (cm)	(proprietary)
Moderator Thickness (cm)	(proprietary)
Moderator Can Wall Thickness (cm)	(proprietary)
Insulator Thickness (cm)	(proprietary)
Number of Assemblies	**150**

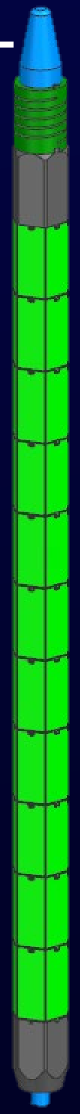
Fuel Assembly

- Individual Fuel Cup
  - Binder jet printed SiC shell
  - Filled w/ Tristructural Isotropic (TRISO) and fully densified with chemical vapor infiltration
- Fuel Stack Assy
  - Integrated 11x Fuel Elements, 2x graphite Axial Reflector, and spring
- Moderator
  - Annular Zirconium Hydride moderator encased in a 316SS can
  - Moderator hermetically welded from tube stock and custom machined ends
  - Wrapped in insulation jacket to thermally isolate ZrH from fuel
  - Moderator replaces Guide Rod for radial constraint in final configuration



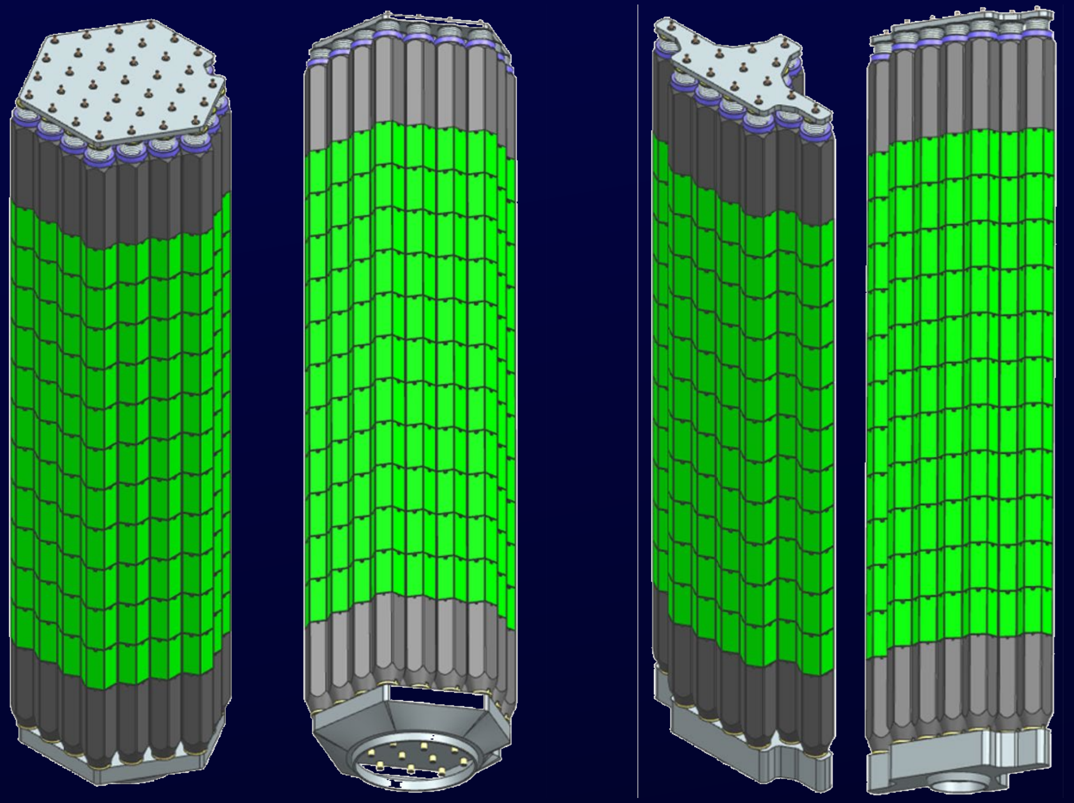
Individual Fuel Element

Guide Rod

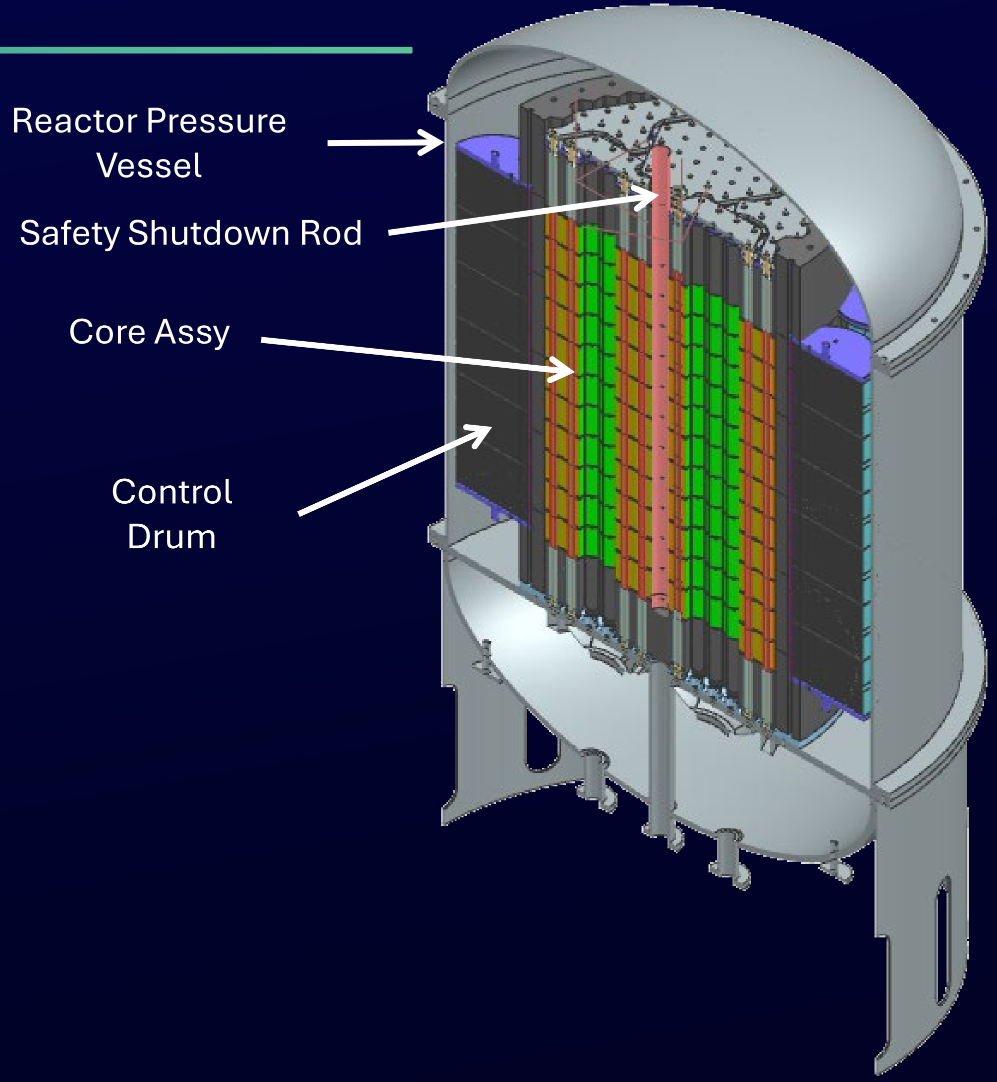


Fuel Stack Assy

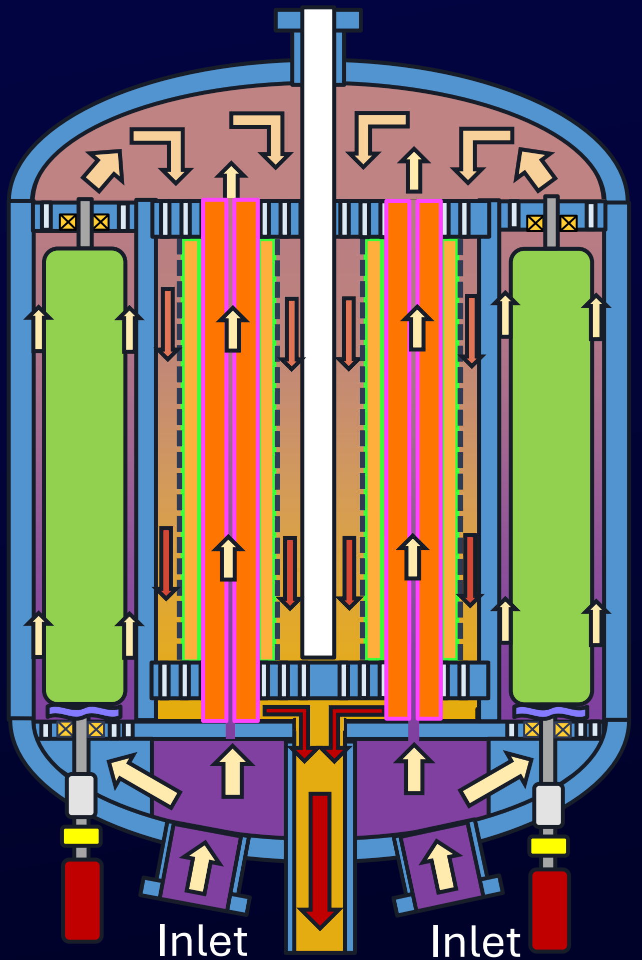
Core Structures

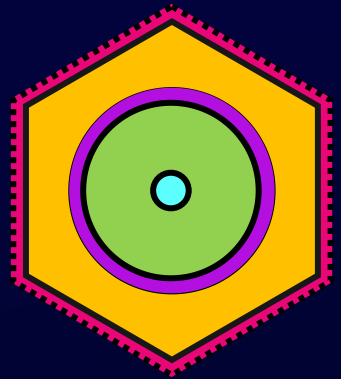


Pylon D1 Fuel and Reflector Supercell Assemblies



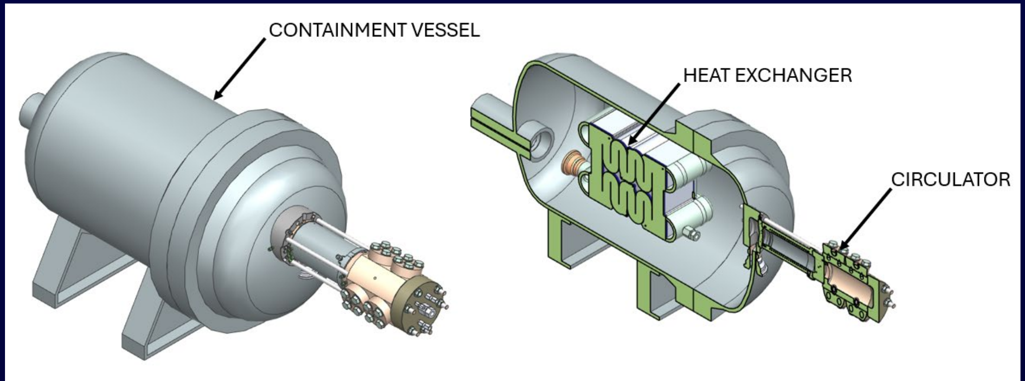
Core Heat Transfer

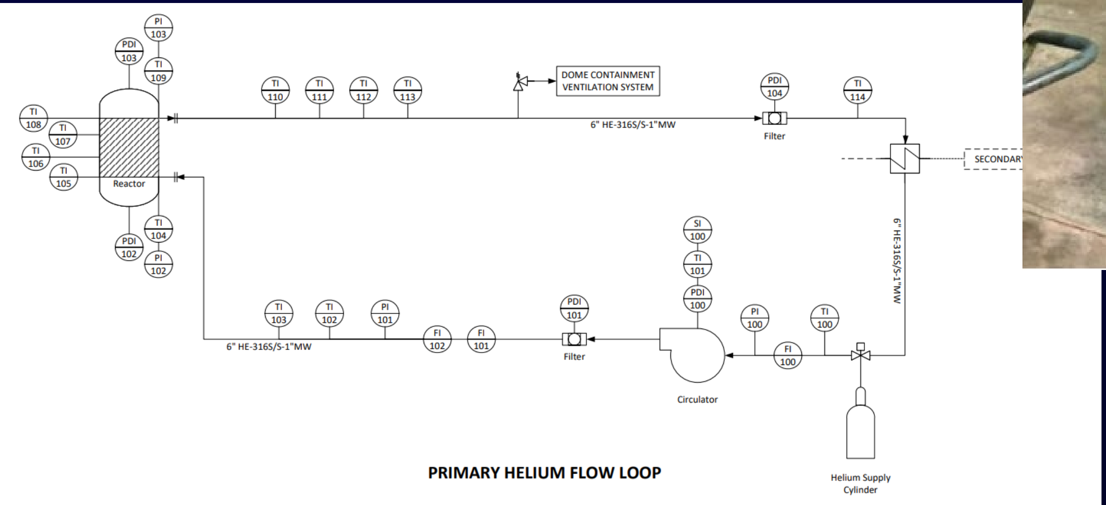


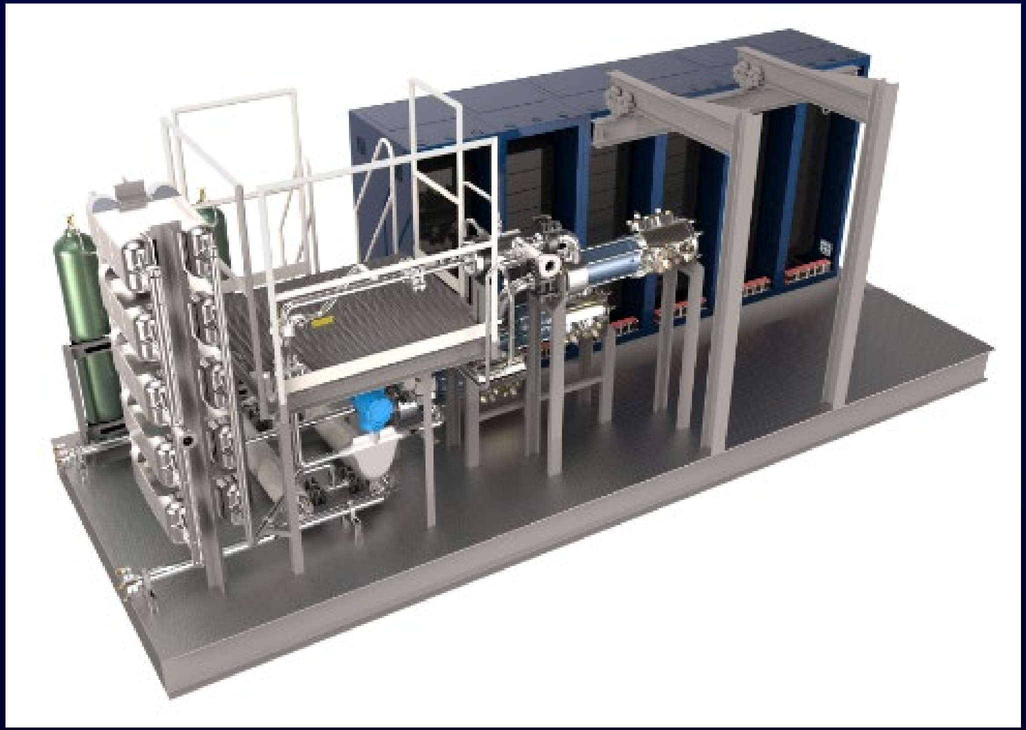


- Coolant Upflow Area
- Coolant Downflow Area
- Fuel Area
- Insulator Area
- Moderator Area
- Unit Cell Boundary

Secondary/BOP

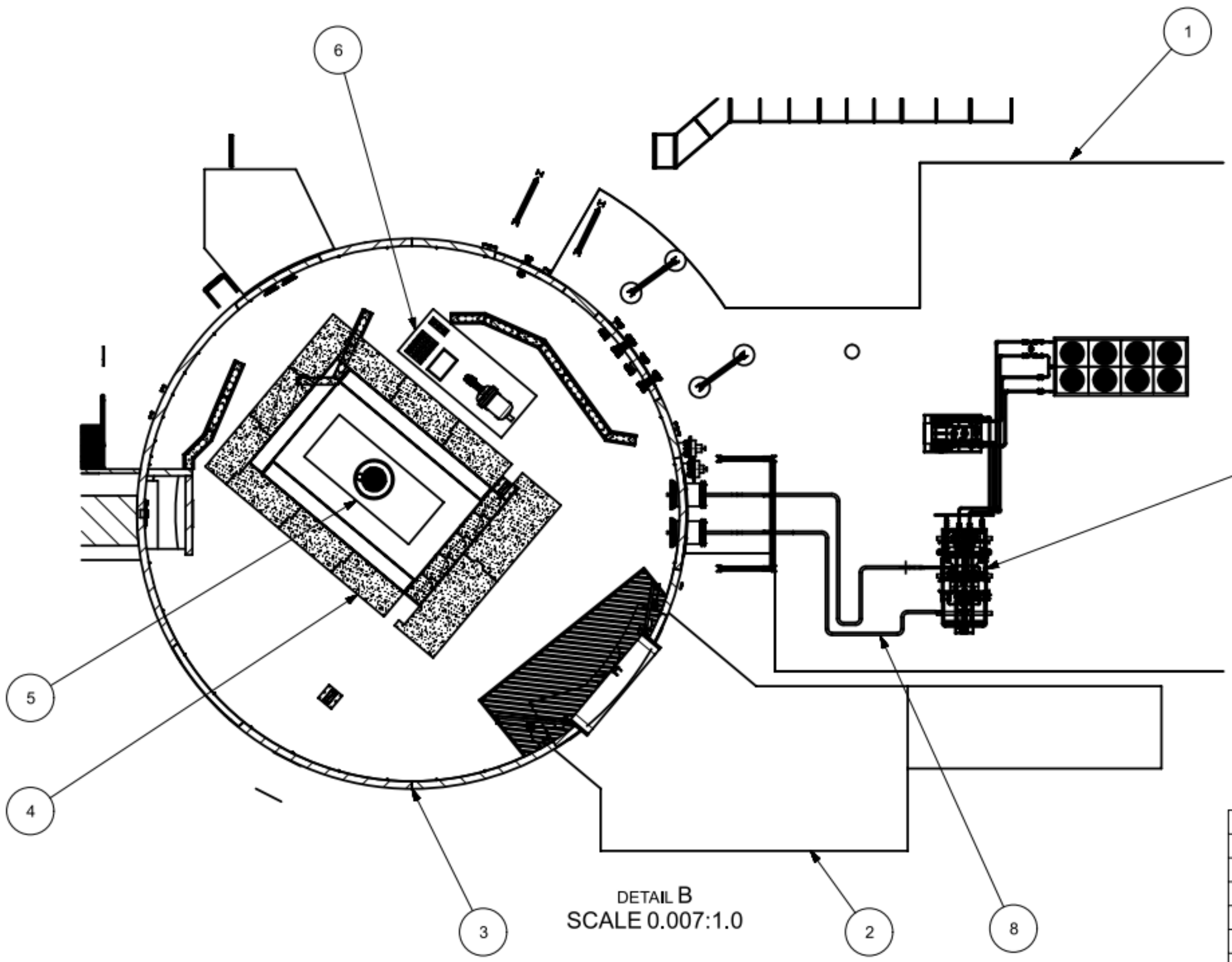






Courtesy of Peregrine Turbine Technologies

Conceptual Plant Layout



ITEM	PART NUMBER	REV	DESCRIPTION	QTY
8	035425	1	PIPING	1
7	035424	1	sCO2 POWER GENERATION ASSY	1
6	035247	1	EQUIPMENT SKID ASSY	1
5	035415	1	REACTOR SKID ASSEMBLY	1
4	035236	1	REACTOR SUPPLEMENTARY SHIELDING	1
3	035399	1	NRIC_DOME_TEST_BED_STRUCT.prt	1
2	035408	1	LOADING DOCK	1
1	035409	1	INL SITE	1

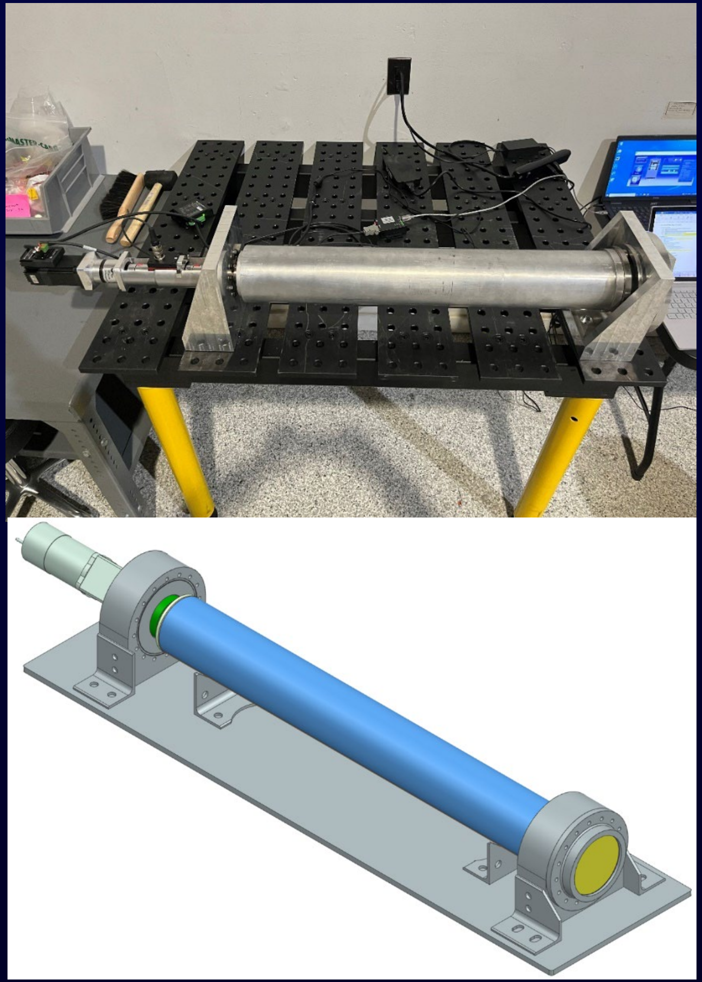
Wide Range of Analyses Completed

- Some of the key analyses completed, included in the Front End Engineering and Experiment Design (FEEED) package:
  - Fuel/moderator/insulator arrangement tradeoff
  - Control elements geometry and positioning tradeoff
  - Moderator material and can tradeoff
  - BOP components tradeoff
  - Vessel material tradeoff
  - Excess reactivity & shutdown margins
  - Thermal analysis
  - Fuel performance analysis
  - System-level analyses
  - Preliminary transient analyses

Derisking – Test Activities

ZrH Moderator Production Demonstration

Moderator Canning Demonstration and Hydrogen Dissociation Measurement



Control Drum Bench Testing

LOKI MMR™ NANO Nuclear Energy Inc.

Thank You!

Contact:
florent@nanonuclearenergy.com