INL/MIS-25-83368 Rev 001

Microreactor Program FY2026

Program Review – March 3-5th, 2026

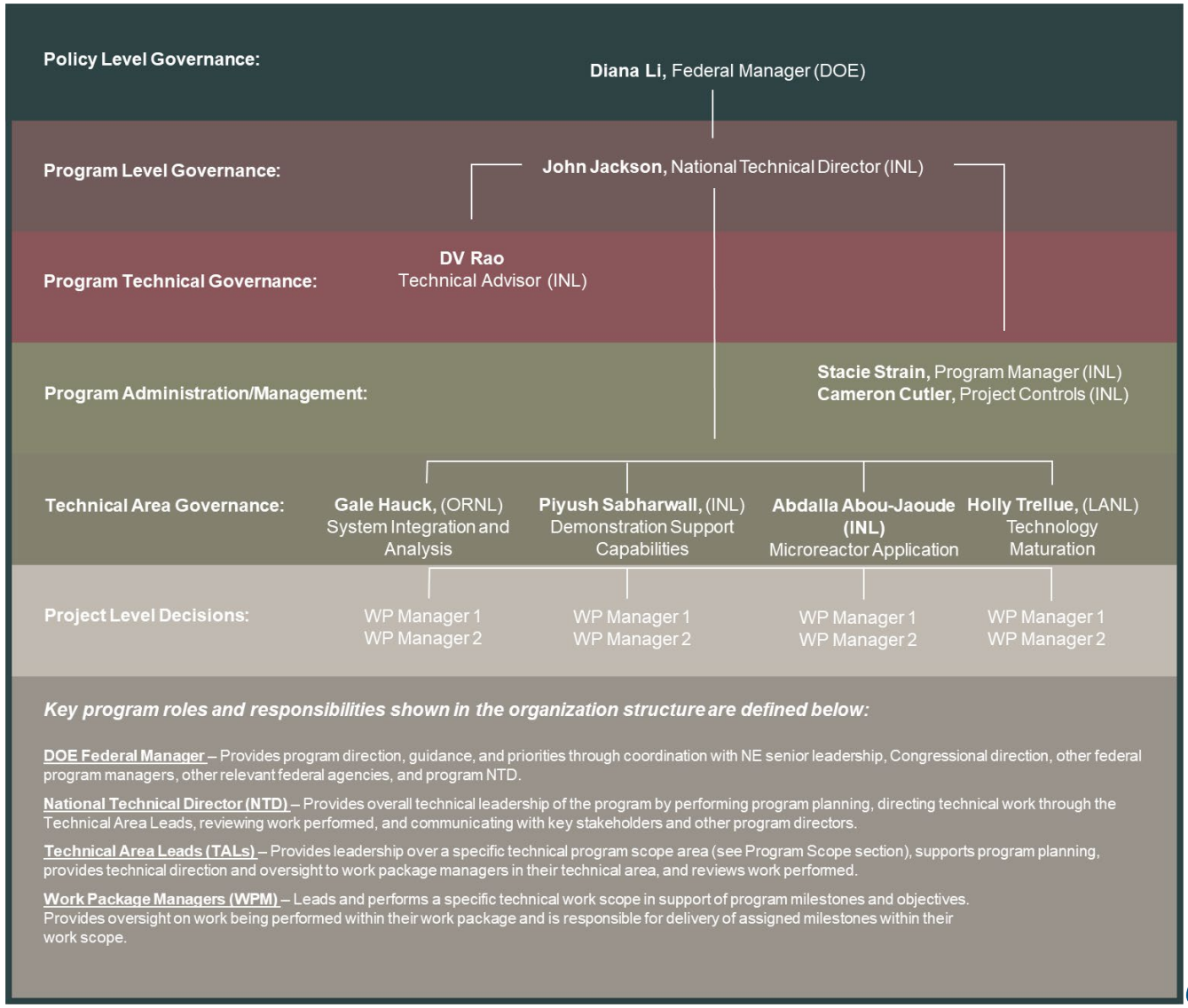
John Jackson, Ph.D.
National Technical Director

Meeting Logistics and Objectives

- Please mute your microphone and turn your camera off
  - Ask questions during Q&A by raising your hand or using chat during the discussion
  - Speakers will turn on their cameras
- Primary purpose for the meeting is to review mid-year progress and focus on known and potential issues for FY26
- Introduce changes to the program
- Share with developers and other stakeholders
- This is a self assessment so it's "open season" for any suggested changes/updates

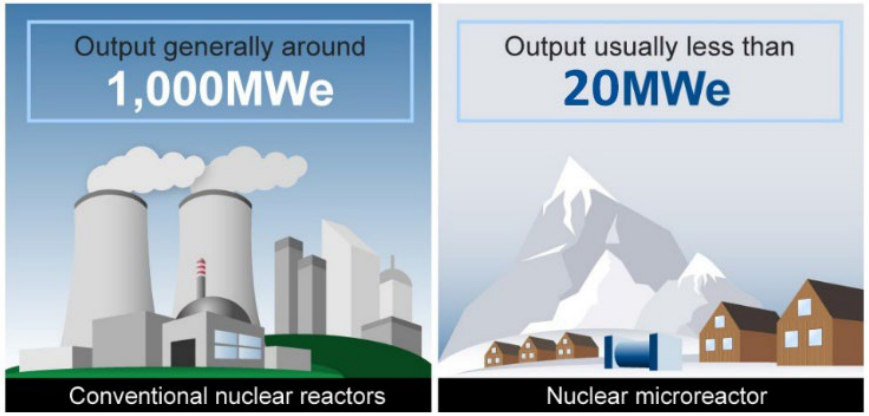
MRP Microreactor Program

Current Microreactor Program Org Chart



MRP Microreactor Program

What are Microreactors?



Source: GAO. | GAO-20-380SP

- Electrical output up to 50 MWe
- Much smaller and simpler than traditional nuclear power reactors.
- Technologies evolving from advances in materials, space reactor technologies, advanced nuclear fuels, and modeling & simulation.

- Minimum site preparation
- Flexible operation
- Enhanced safety
- Refueling (every 2-10 years)
- Operational lifetime: 5 – 20 years.

MRP Microreactor Program

DOE Microreactor Program

Program Vision

Through cross-cutting research and development and technology demonstration support, the Microreactor Program will enable broad deployment of microreactor technology by:

- Achieving technological breakthroughs for key features of microreactors
- Identifying and addressing technology solutions to improve the economic viability and licensing readiness of microreactors.
- Enabling successful demonstrations of multiple domestic commercial microreactors.

Program Objectives

- Address critical cross-cutting R&D needs that require unique laboratory/university capability or expertise
- Develop R&D infrastructure to support design, demonstration, regulatory issue resolution, and M&S code validation
- Develop advanced technologies that enable improvements in microreactor viability

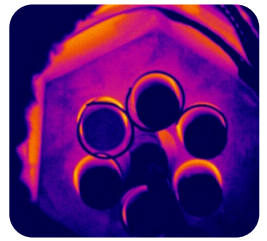
Technology Readiness Level

Microreactor Application

- Integrated Nuclear Testing
- Applied R&D

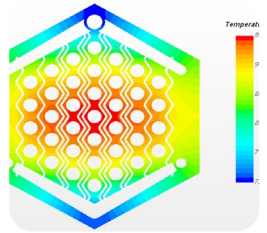
Demonstration Support Capabilities

- Non-nuclear Testing
- Test-beds for developers/regulators



Technology Maturation

- Matures fundamental microreactor enabling technologies and capabilities



System Integration & Analyses

- Identification of technology and regulatory gaps for Microreactors

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Microreactor Market Economics

Hawaii
Residential: **45.19¢/kWh**
Highest in the nation (US Avg ~17 ¢/kWh)

Alaska
Residential: **24.9¢/kWh**
One of the highest in the nation

Diesel dependent cities in AK
Adak: **26.2¢/kWh**
Bethel: **27.0¢/kWh**
Nome: **28.0¢/kWh**
(reflects the current cost of diesel)

Source: https://www.eia.gov/ (summarized by Copilot)

Liquid-Metal Microreactor

Market Segment	1 Unit	5 Units	10 Units	20 Units	50 Units	100 Units
Remote communities	Partial Penetration	Full Penetration	Full Penetration	Full Penetration	Full Penetration	Full Penetration
Defense	No Penetration	Full Penetration	Full Penetration	Full Penetration	Full Penetration	Full Penetration
Island & Mining	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Full Penetration	Full Penetration
Alaska railbelt electricity	No Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Full Penetration
Alaska railbelt generation	No Penetration	No Penetration	No Penetration	No Penetration	No Penetration	No Penetration
U.S. grid electricity	No Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration
U.S. grid generation	No Penetration	No Penetration	No Penetration	No Penetration	No Penetration	No Penetration

Gas-Cooled Microreactor

Market Segment	1 Unit	5 Units	10 Units	20 Units	50 Units	100 Units
Remote communities	Partial Penetration	Partial Penetration	Full Penetration	Full Penetration	Full Penetration	Full Penetration
Defense	No Penetration	Partial Penetration	Full Penetration	Full Penetration	Full Penetration	Full Penetration
Island & Mining	No Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration
Alaska railbelt electricity	No Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration	Partial Penetration
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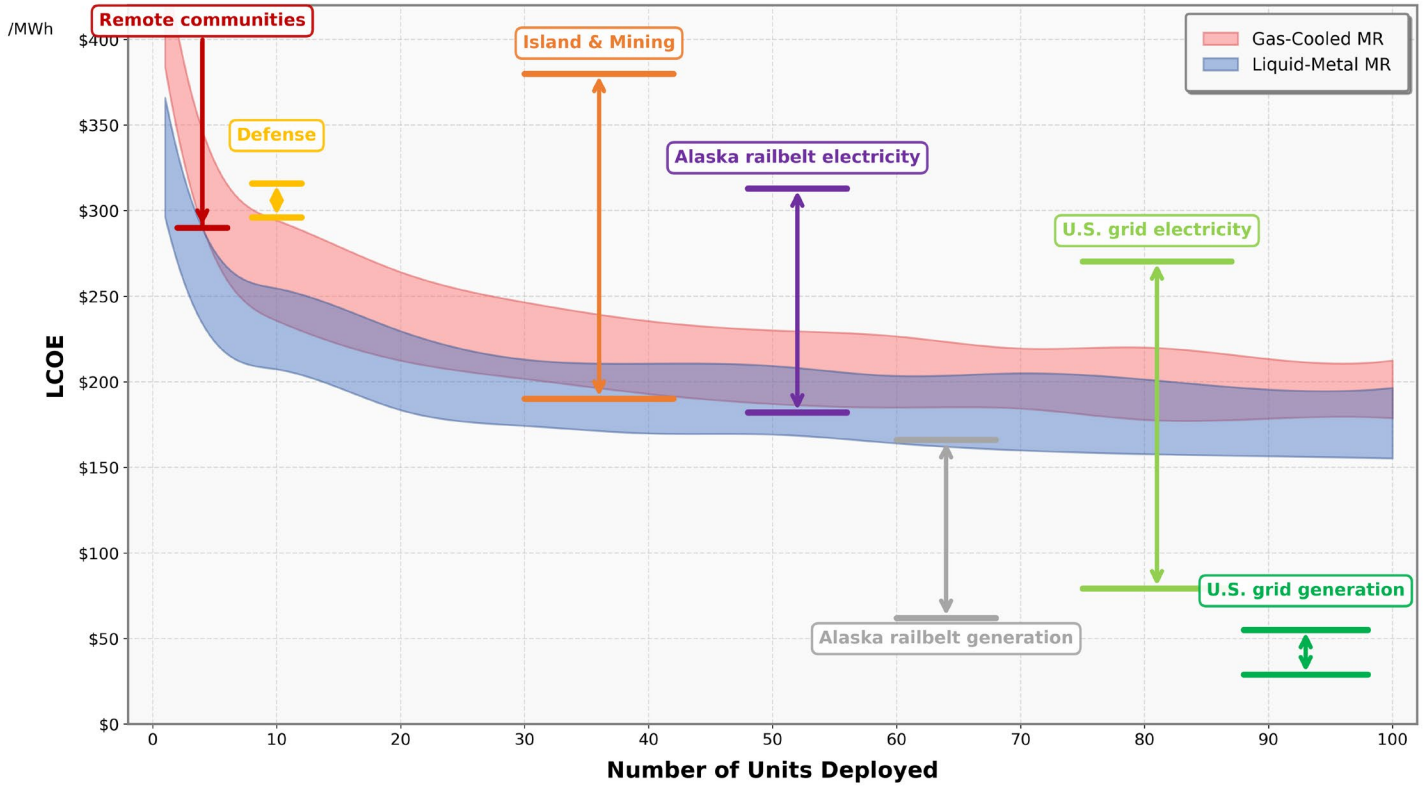
U.S. grid generation	No Penetration	No Penetration	No Penetration	No Penetration	No Penetration	No Penetration

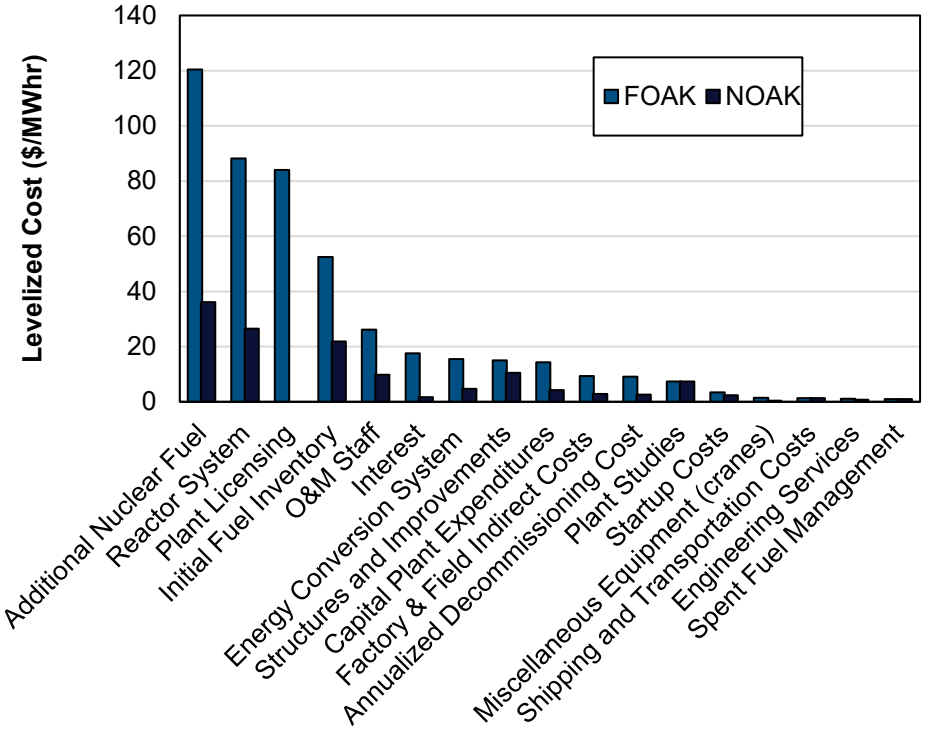
Source: https://www.osti.gov/biblio/1811894



Path to commercialization (what needs to be achieved?)

- De-risk technical challenges & drive down costs
  - Materials*, structural health monitoring, remote/automated operation, instrumentation and control, efficient shielding, core heat utilization, validated design tools (e.g. computer models), transportation
  - Establish robust supply chains (materials, fuels, training/experience)
- Right sized regulation
  - Concise source term analyses and associated code validation
  - Practical and realistic emergency planning zone
  - Reasonable and realistic licensing time frames
- Demonstration of technology
  - Power conversion
  - Microgrid connectivity
  - Process heat utilization

Example Breakdown of Microreactor Cost Driver



Source: https://www.osti.gov/biblio/2447366

*AMMT scope

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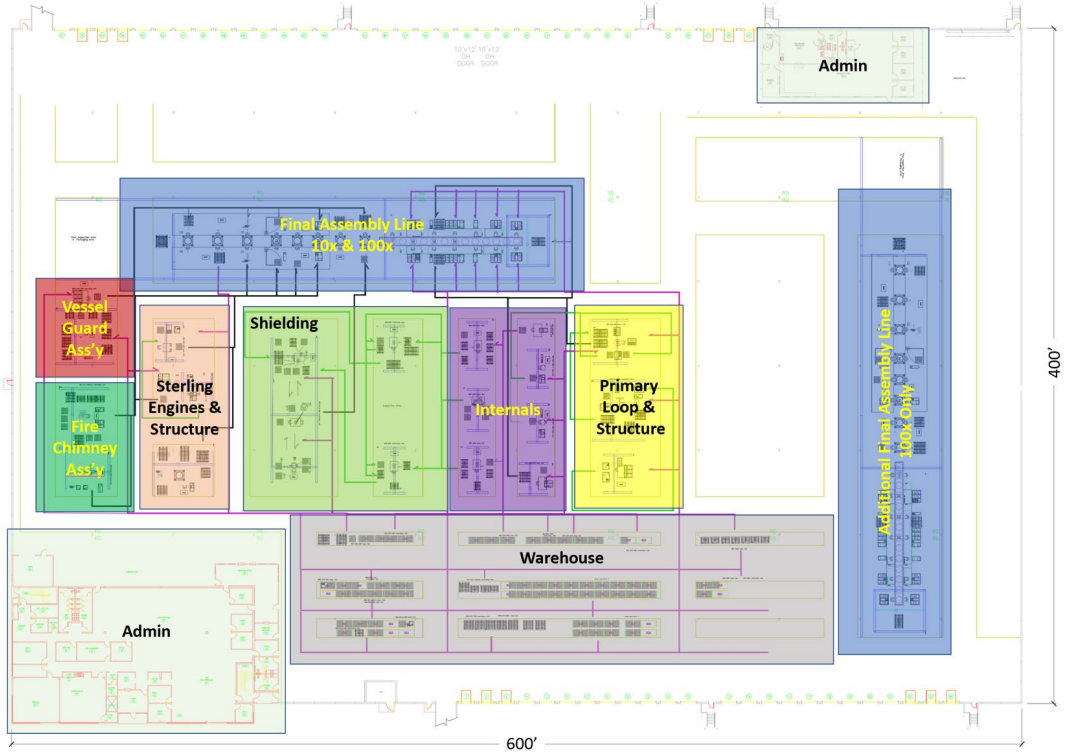
Post commercialization – long term needs

- Improved economics for broad market penetration
  - Toward autonomous operation
  - Optimized fuel systems/utilization
  - High efficiency power conversion systems
  - Efficient transportation and rapid deployment
- Develop factory fabrication model(s)
  - Understand/determine regulation boundaries
  - Service centers?
- Early analyses point towards potential broader competitiveness of microreactors beyond niche markets (B. Hanna 2024, M. Venatta 2024)

Analysis of Microreactor Factory Layout



Source: https://doi.org/10.1080/00295450.2023.2206779

MRP Microreactor Program

Microreactor Concepts Under Development in the U.S. (that we're aware of)

Developer	Design Name(s)	Reactor Type	Power Output (MWe/MWth)	Enrichment	Fuel form	Coolant	Moderator	Refueling Interval	Electrical Conversion
Aalo Atomics	Aalo 1; Aalo X prototype	STR	7 MWe/20MWth	HALEU	UO2	Sodium	N/A (fast)	3-5 years	Steam Rankine
Alpha Tech Research	ARC micro MSR	MSR	12 Mwe/30 MWth	LEU		Flouride salt	YH	N/A (continuous ops)	
Antares Industries	Antares-1	Heat pipe	1.2 MWth	HALEU	TRISO	Sodium	Graphite	4-6 years	Brayton Cycle
Avant Tech	MN-350	Not published	350 kWe / 1 MWt					10 years	Supercritical CO_2 Brayton
BWX Technologies	BANR	HTGR	17 MWe/50 MWth	HALEU	TRISO	Helium	Graphite	5 years	Brayton Cycle
Deep Fission, Inc.	DFBR 1	PWR	1-15 MWe	LEU	PWR-type	Water	Water	4-6 years	Steam Rankine
Deployable Energy	Unity Nuclear Battery	Not published	1 MWe	LEU		Water	Water	5 years	
Emerald Horizon	ADES	Particale accelerato	25MWt/12MWe		ThF4	Molten Salt		20 years	Supercritical CO_2 Brayton
General Atomics	GA Micro	HTGR	1-10 MWe			Helium		10 years	
Hadron Energy, Inc.	Hadron microreactor	LWR?	~2 MWe	LEU		Water	Water		Steam Rankine
HolosGen LLC	Holos Quad	HTGR	10MWe/22 MWt		TRISO	Helium/CO2	Graphite	10 years	Brayton Cycle
Last Energy, Inc.	PWR 20	PWR	20 MWe	LEU	PWR-type	Water	Water		Steam Rankine
Micro Nuclear, LLC	MsNB	MSR/heat pipe	10 MWe	HALEU	UF4	FLiBe	YH	10 years	
NANO Nuclear Energy	Zeus/Odin	HTGR/MSR	1.0 MWe/2.5 MWth		TRISO/UZrH	Helium/salt			Brayton Cycle
Natura Resources	MSR 1	MSR	1 MWt	HALEU	UF4	Molten salt	Graphite	N/A (research ops)	N/A
NuCube Energy, Inc.	NuSun™	Heat pipe	1 MWe/3 MWth		TRISO	Sodium	Graphite	10 years	
NuGen, LLC	NuGen Engine™	HTGR	2-4 MWe		TRISO	Helium		15 years	Direct Brayton
NuScale Power	NuScale Microreactor	LMTM/heat pipe	<10 MWe		Metallic	Liquid Metal	Liquid Metal	10 years	TPV
Odin Electric, Inc.	TBD	Not published	10 kWe	Thorium					
Oklo, Inc.	Aurora	SFR	15 - 50 MWe	HALEU	U-Zr	Sodium	N/A (fast)	10 years	Brayton Cycle
Radiant Industries	Kaleidos	HTGR	1 MWe/3 MWt		TRISO	Helium	Graphite	4-6 years	Brayton Cycle
Tam Fortis Solutions	TBD	Not published	15 W – 40 kWe	HALEU					
Terra Innovatum	SOLO	HTGR	1 MWe	LEU -> HALEU		Helium			Brayton Cycle
Valar Atomics	TBD	Not published	Not published						
X energy	XENITH™	HTGR	5 MWe/10 MWth		TRISO	Helium	Graphite	3 years	Direct Brayton

Notes:
1) Westinghouse eVinci has been deprioritized
2) USNC was purchased by NANO Nuclear

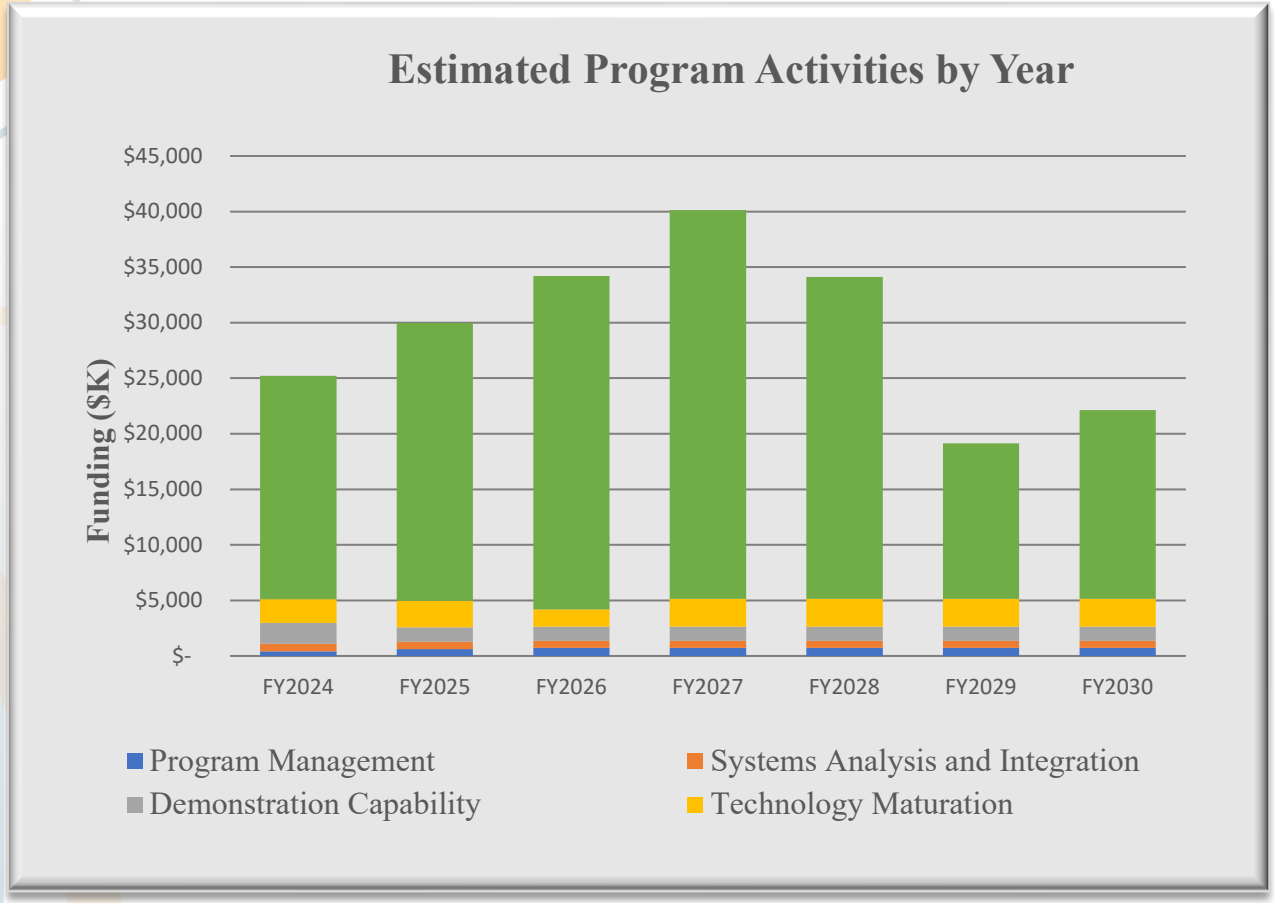
MRP Microreactor Program

Nuclear Energy University Program (NEUP)

- (Project 21-24226) Cost Reduction of Advanced Integration Heat Exchanger Technology for Micro-Reactors – U of Wisconsin
- (Project 22-26910) Demonstrating Autonomous Control, Remote Operation, and Human Factors for Microreactors Under Prototypic Conditions in PUR-1 – Purdue
- (Project 22-27123) Development of Hydrogen Transport Models for High Temperature Metal Hydride Moderators – CSM
- (Project 23-29622) Development of the Technical Bases to Support Flexible Siting of Microreactors based on Right-Sized Emergency Planning – Penn State
- (Project 23-29834) Transforming Microreactor Economics Through Hydride Moderator Enabled Neutron Economy – Stonybrook
- (Project 23-29784) Deciphering Irradiation Effects of YHx through In-situ Evaluation and Micromechanics for Microreactor Applications – UNM
- (Project 24-32112) Feasibility Study of Micro-Nuclear Reactor Thermal Output for Air Rotary Kilns in the High-Temperature Manufacturing of Portland Cement Clinker – Penn State
- (Project 24-31551) Sodium heat pipes; design and failure mode assessment for micro-reactor applications – U of Wisconsin

MRP Microreactor Program

Microreactor Program funding profile



- Funding levels for Microreactor R&D and MARVEL
  - FY2025 enacted: NLT $20.7M MARVEL, $5M Microreactor R&D
    - ART program decision: $30M MARVEL, $5M Microreactor R&D
  - FY2026 Request: $5M Microreactor R&D and $21M MARVEL
  - FY2025 House: No less than $21M MARVEL (silent on microreactor R&D)
  - FY2025 Senate: N/A as of 08/21/2025
- Planning targets
  - $4M (MR R&D), $21M (MARVEL) – target (assumes temporary CR)
  - $4.2M (MR R&D), $30M (MARVEL) – guidance over target

MRP Microreactor Program

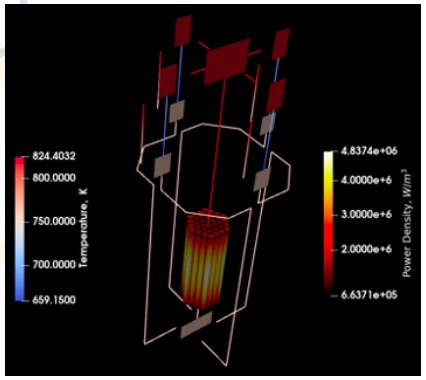
FY26 Microreactor Program Planned Outcome Highlights

1) Demonstrate power conversion and distribution to a microgrid using MAGNET
2) Complete Plan of Action for microreactor relevant codes and standards
3) Publish a web-based version of the MOUSE tool for microreactor cost estimating
4) Integrate MACS/ViBRANT with MAGNET to demonstrate automated control
5) Complete development of the Advanced Moderator Module
6) Develop shock and vibration test plan for transportation using MARVEL as a surrogate
7) Investigate potential for use of AI tools to prepare transportation safety analysis reports
8) Develop machine learning algorithm to process data from distributed sensor arrays
9) MARVEL: Complete fabrication of Primary Coolant System and Reactor Support Structure
10) MARVEL: Complete fuel fabrication and receive at INL
11) MARVEL: Design and build MARVEL instrumentation and controls
12) MARVEL: Complete power system design
13) MARVEL: Complete SAR for dry criticality

MRP Microreactor Program

MARVEL Beyond the Reactor: Non-Nuclear Integration and Controls as a Stepping-Stone

Virtual simulation of MARVEL core physics



Electric heat output and outlet temperatures

MAGNET
(non-nuclear heat source with test article integrated power conversion unit)

Drum position and core response

MACS Hardware
(non-nuclear surrogate for MARVEL controls)

Electricity generation and dispatch

RAPID MIB
(Microgrid in a box)

Mobile Data Center

Nuclear-powered data center demonstration

Demonstrate Autonomous & remote operation in non-nuclear system first, prior to testing in MARVEL

MRP Microreactor Program

MARVEL Can Enable a New Class of Nuclear Reactors

(Microreactor Applications Research, Validation & EvaLuation)

- ***Project Goals:***
- Development of a small-scale microreactor that provides a platform to test unique operational aspects and applications of microreactors
- ***Primary Objectives:***
- **Operational** microreactor
- Produce **combined heat and power (CHP)** to a functional **microgrid**
- **Share lessons learned** with commercial developers
- **Train** future operators
- ***National Impact:***

Train staff and exercise processes at labs to

Share data and lessons learned to

Demonstrate passive safety and self-regulation to

Provide an instrumentation platform to

Generate electricity to

Provide heat for stakeholders to

ENABLE

Follow-on demonstrations within DOE system

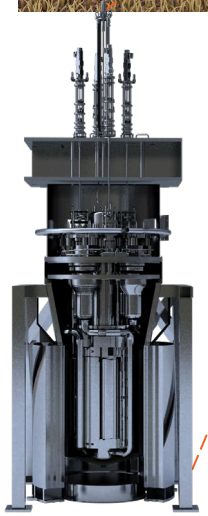
Maturation of commercial microreactor designs

Publication acceptance of microreactor technology

Novel control paradigms for microreactors

Commercial deployment of nuclear-power microgrids

Commercial deployment of nuclear for industrial applications



- 85 kW-thermal
- <20 kW-electric
- ~15 feet tall, <10 tons
- NaK primary coolant, natural circulation
- TRIGA fuel
- Radial control drums
- Graphite, Be and BeO reflector
- 2 operators
- Self-regulating

MRP Microreactor Program

Questions?