Microreactor Program FY2025

Winter Program Review – March 4-5th, 2025

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 FY25
- 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

Policy Level Governance:
Diana Li, Federal Manager (DOE)

Program Level Governance:
John Jackson, National Technical Director (INL)

Program Technical Governance:
DV Rao
Technical Advisor (INL)

Program Administration/Management:
Stacie Strain, Program Manager (INL)
Joshua Bisnett, Project Controls (INL)

Technical Area Governance:
- **Alex Huning**, (ORNL) System Integration and Analysis
- **Piyush Sabharwall**, (INL) Demonstration Support Capabilities
- **Abdalla Abou-Jaoude (INL)** Microreactor Application
- **Holly Trellue**, (LANL) Technology Maturation

Project Level Decisions:
- WP Manager 1, WP Manager 2
- WP Manager 1, WP Manager 2
- WP Manager 1, WP Manager 2
- WP Manager 1, WP Manager 2

Key program roles and responsibilities shown in the organization structure are defined below:

DOE Federal Manager – Provides program direction, guidance, and priorities through coordination with NE senior leadership, Congressional direction, other federal program managers, other relevant federal agencies, and program NTD.

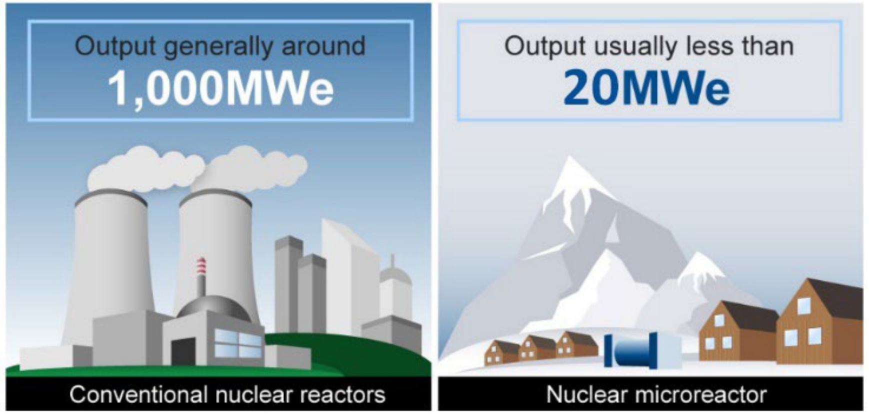
National Technical Director (NTD) – Provides overall technical leadership of the program by performing program planning, directing technical work through the Technical Area Leads, reviewing work performed, and communicating with key stakeholders and other program directors.

Technical Area Leads (TALs) – Provides leadership over a specific technical program scope area (see Program Scope section), supports program planning, provides technical direction and oversight to work package managers in their technical area, and reviews work performed.

Work Package Managers (WPM) – Leads and performs a specific technical work scope in support of program milestones and objectives. Provides oversight on work being performed within their work package and is responsible for delivery of assigned milestones within their work scope.

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.

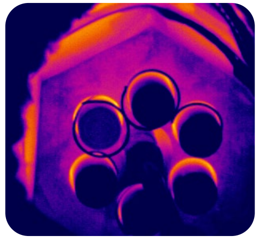
Program Objectives

- 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

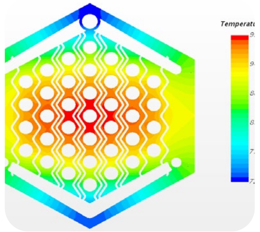
Technology Readiness Level

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: **37.34¢/kWh**
Highest in the nation

Alaska

Residential: **17.88¢/kWh**
2nd highest in the nation

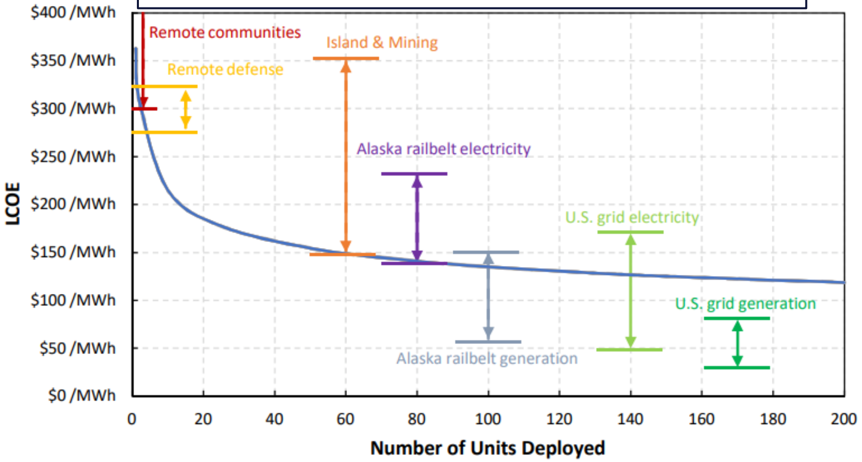
Source: https://www.eia.gov/

Adak, Alaska

Population: 164 (2023)
Commercial: **84.11¢/kWh**
Residential: **84.35¢/kWh**
Industrial: **16.82¢/kWh**

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

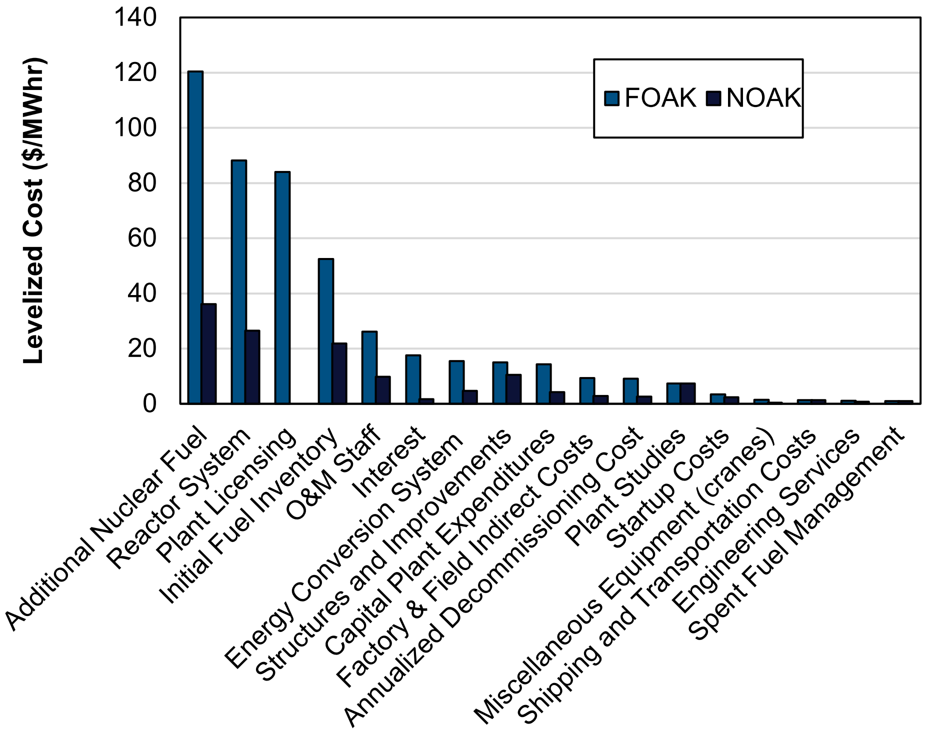
Timeframe		Cost Targets at Cumulative Number of Builds				
1st Units	Profile Markets	1-9	10	100	1,000	10,000
2020-2030	FOAK units/ DoD Units	<$0.60/kWh				
2030-2035	Remote Operations		<$0.50/kWh	<$0.35/kWh	<$0.20/kWh	<$0.15/kWh
2035-2040	Distributed Energy			<$0.35/kWh	<$0.20/kWh	<$0.15/kWh
2040-2050	Resilient Cities				<$0.20/kWh	<$0.15/kWh



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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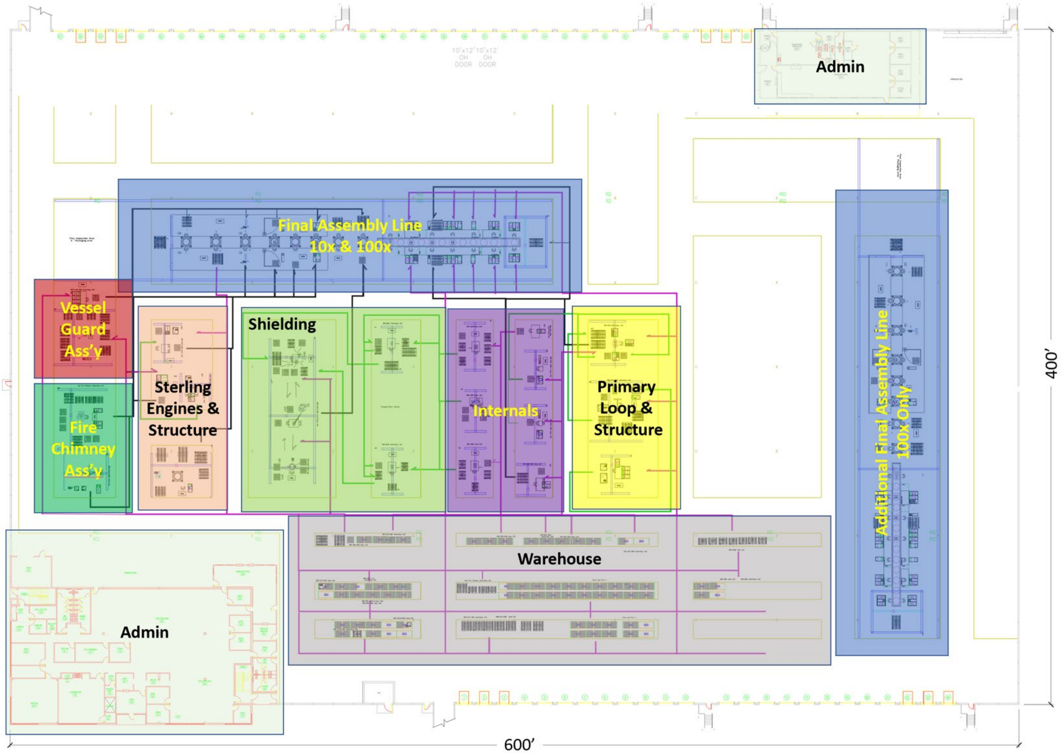
Post commercialization – long term needs

- 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

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

Developer	Name	Type	Power Output (MWe/MWth)	Fuel	Coolant	moderator	refueling interval	PCU
Aalo Atomics	Aalo One	STR	7 MWe/20MWth	U-Zr-H	Sodium	H	3-5 years	Steam Rankine
Alpha Tech Research Corp	ARC Nuclear Generator	MSR	12 Mwe/30 MWth	LEU	Flouride salt		intermittent	
Antares Industries		Heat Pipe	1.2 MWth	TRISO	sodium	graphite		Brayton Cycle
BWXT	BANR	HTGR	17 MWe/50 MWth	TRISO	Helium	graphite	5 years	Brayton Cycle
Deep Fission	TBD	PWR	1-15 MWE	LEU	Water	Water	4-6 years	Steam Rankine
General Atomics	GA Micro	HTGR	1-10 MWe		gas			?
HolosGen	HolosQuad	HTGR	13 MWe	TRISO	Helium/CO2		10 years	Brayton Cycle
Micro Nuclear, LLC	Micro Scale Nuclear Battery	MSR/heat pipe	10 MWe	UF4	FLiBe	YH	10 years	
Nano Nuclear	Zeus/Odin	HTGR/MSR	1.0 MWe/2.5 MWth	UO2	Helium			Brayton Cycle
NuCube	Nu3	heat pipe	1 MWe/3 MWth	TRISO	sodium	graphite	10+ years	
NuGen, LLC	NuGen Engine	HTGR	2-4 MWe	TRISO	Helium			Integral direct cycle
NuScale Power	NuScale Microreactor	LMTM/heat pipe	<10 MWe	metallic	Liquid Metal	Liquid Metal	10 years	TPV
Oklo	Aurora	SFR	15 MWe	metallic (U-Zr)	Sodium		10+ years	Steam Rankine
Radiant Nuclear	Kaleidos Battery	HTGR	1.2 MWe	TRISO	Helium	graphite	4-6 years	
Nano Nuclear (Ultra Safe Nuclear)	KRONOS (Micro Modular Reactor)	HTGR	15 MWe/45 MWth	TRISO	Helium	graphite	20 years	Rankine
Westinghouse	eVINCI	heat pipe	5 MWe/15 MWth	TRISO	Sodium	graphite	8 years	Brayton Cycle
X-Energy	XENITH	HTGR	5 MWe/10 MWth	TRISO	Helium	graphite	3+ years	Open air Brayton Cycle

StarCube	TBD
Mobile Nuclear	TBD
Odin Electric	TBD

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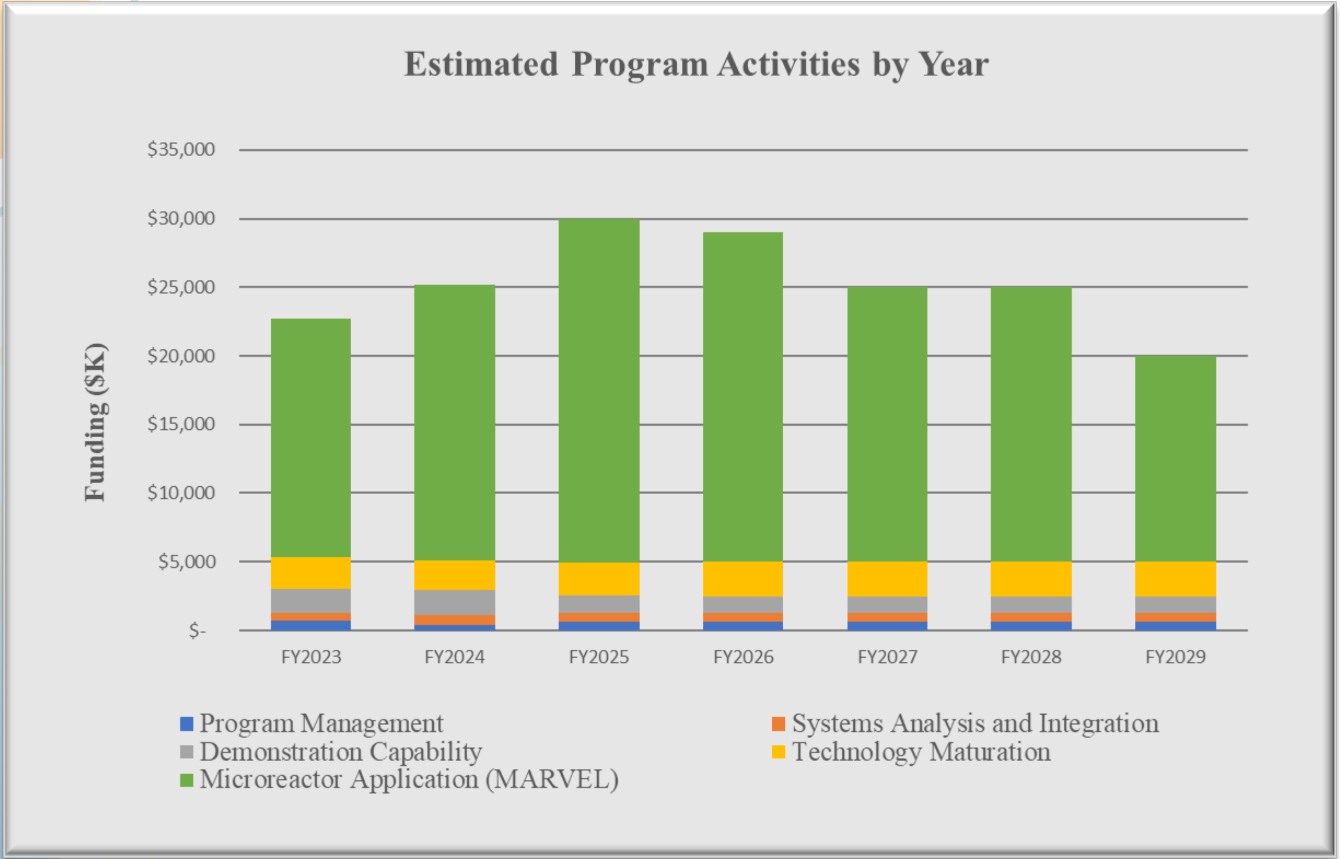
Nuclear Energy University Program (NEUP)

- (Project 21-24152) Direct heating of chemical catalysts for hydrogen and fertilizer production using Microreactors – Kansas State/Purdue
- (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
  - FY2024 enacted: NLT $20M MARVEL, $5M Microreactor R&D
    - Program decision: $20.19M MARVEL, $4.81M Microreactor R&D
  - FY2025 Request: $5M Microreactor R&D and $16.5M MARVEL
  - FY2025 House: No less than $25M MARVEL (silent on microreactor R&D)
  - FY2025 Senate: Up to $25M for MARVEL, No less than $15M for MW scale reactor R&D
- Planning targets for FY25
  - $4M (MR R&D), $16.5M (MARVEL) – target (assumes temporary CR)
    - $4.81M (MR R&D), $20.19 M (MARVEL) under full CR
  - $4.81M (MR R&D), $25M (MARVEL) – guidance over target

FY25 Microreactor Program Planned Outcome Highlights

1) Integrate Power Conversion Unit with MAGNET to enable integrated microreactor heat transfer system testing
2) Complete shake down testing for MAGNET Power Conversion Unit
3) Build13 heat pipe graphite core block test article at LANL and deliver to INL
4) Implement and demonstrate a MARVEL startup sequence utilizing MACS and ViBRANT
5) Create a bottom-up microreactor cost estimation tool to support developers and investors
6) Complete PIE for HFIR irradiated Yhx to fill irradiation performance gaps
7) Finalize Microreactor Transportation Safety Program Planning framework
8) MARVEL: Complete fabrication and initial testing of reactivity control system
9) MARVEL: Begin fuel fabrication
10) MARVEL: Establish Primary Coolant System fabrication contract and kick off

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

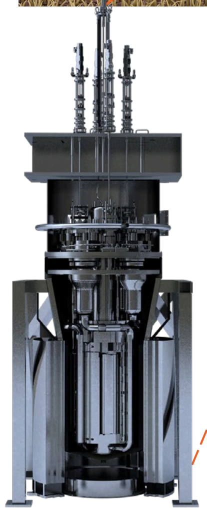
Maturation of commercial microreactor designs

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

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Questions?

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