The DOE Microreactor Program

Technology development and demonstration

Assembling the Pieces: Mobilizing Nuclear Energy with Factory-Fabricated and Transportable Micro-Reactors

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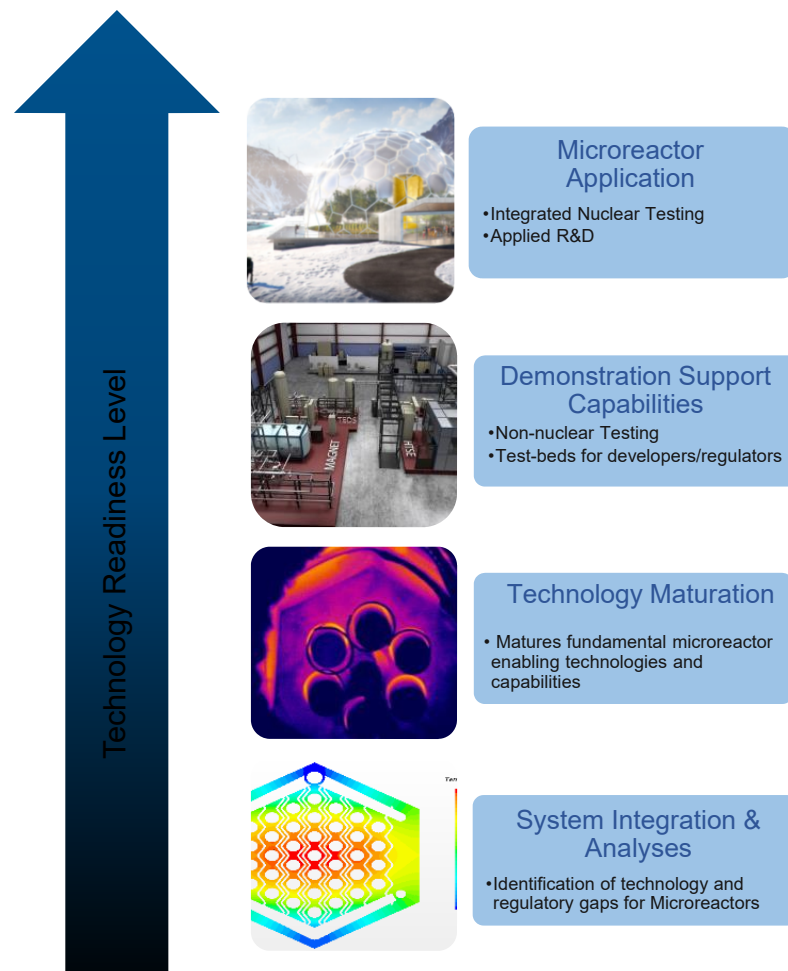# DOE Microreactor Program

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.
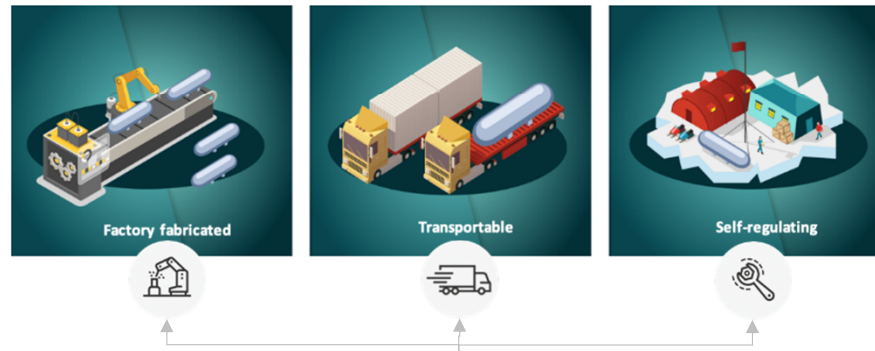
Program Objectives

- 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

MRP Microreactor Program

Microreactors
Megawatt-scale Advanced Nuclear Reactors

Factory fabricated   Transportable   Self-regulating

ENABLING TECHNOLOGIES

Fuel & Moderator	Reactor Controls	Power Conversion	Structural Material	Neutron Reflector	Transport & Siting

- Small Core,
- Long life,
- HALEU
- High-T Moderator

- Automation
- Compact, in-core sensors
- AI/ ML
- Remote Control

- Skid mounted
- High Temp.
- Robust
- Flexible operation

- Creep resistance
- ASME Sec III, Div. 5 compliant
- NQA-1 supply chain

- Low cost
- Manufacturability
- High moderating ratio
- High temperature

- NEPA
- Vibration isolation
- Transport shielding
- Licensing modernization

Demonstration Support - SPHERE and MAGNET testbeds

SPHERE - Single Primary Heat Extraction and Removal Emulator

- Single heat pipe coupled to forced convection cooling, surrounded by 6 electrical heaters

- Designed to quantify operational temperatures and heat rejection from of a single heat pipe

- Highly instrumented to measure temperature and strain distributions in a miniature monolithic core block

MAGNET – Microreactor AGile Non-nuclear Experimental Test Bed

- Engineering scale test bed for testing large sections of a monolithic core block with an array (e.g., 37) of heat pipes and electrical heaters

- Capable of testing advanced heat rejection systems or integral effects such as the potential for cascading failures of multiple heat pipes

- Helium component testing

Increasing complexity

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
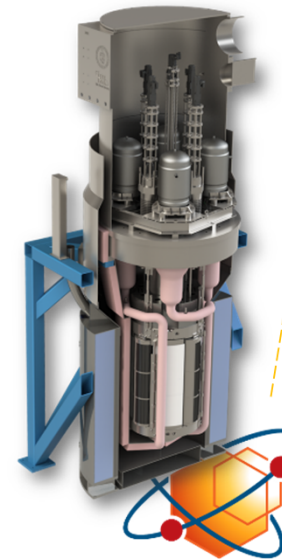
Primary Objectives:
- **Operational** microreactor
- Produce **combined heat and power (CHP)** to a functional **microgrid**

- **Share lessons learned** with commercial developers

- **Train** future operators

U.S. DOE Sponsor Program:

Create momentum,
Champion rapid technology maturation to de-risk industry
Collaborate and engage microreactor end-user companies

- 85 kW-thermal
- 20 kW-electric
- ~15 feet tall
- < 12 tons
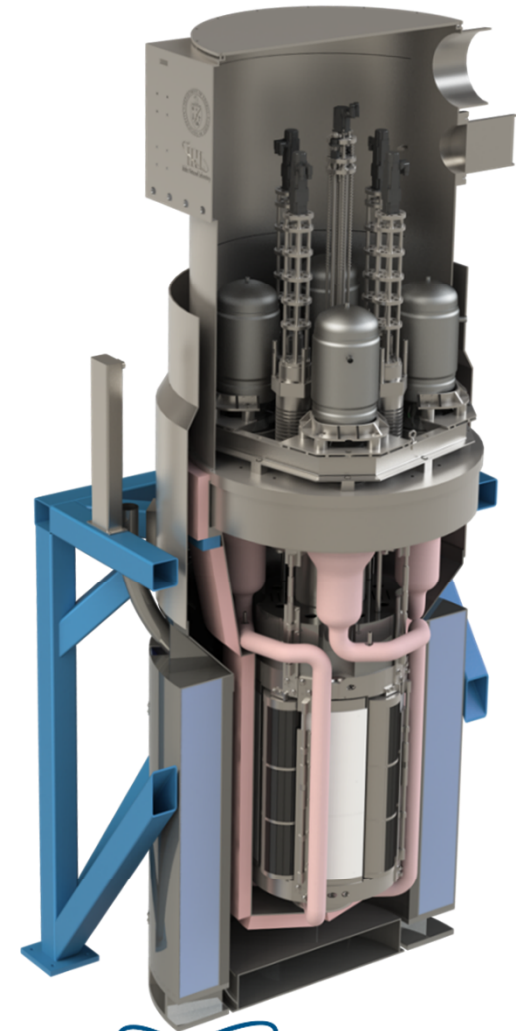- 2 operators
- Self-regulating

MARVEL - Test Microreactor

Microreactor Application Research, Validation and EvaLuation Project

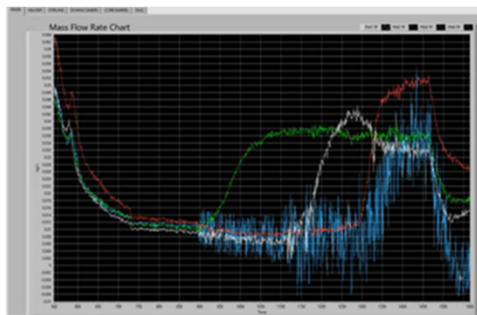| Key Design Features	
Thermal Power	85 kW nominal
Electrical Power	20 kWe (QB80 Stirling Engines)
Weight	< 12 US ton
Primary Coolant	Sodium-Potassium eutectic
Intermediate Coolant	Ga-In-Sn
Coolant Driver	Natural Convection, single phase
Fuel	HALE(UZrH), 304SS clad, end caps
Moderator	Hydrogen
Neutron Reflector	Graphite, Beryllium (S200), Beryllium oxide
Reactivity Control	Radial Control Drums, Central Absorber
Primary Coolant Boundary	SS316H

Innovation- MARVEL used an inherently safe research reactor fuel and designed a high-temperature advanced reactor

MRP Microreactor Program

MARVEL Thermal Hydraulic Prototype

- Thermophysical twin of MARVEL
- Full-scale, electrically heated
- Data used to validate models, per NQA-1
- Initial startup on September 19th, 2023 with demonstration of natural circulation and power generation
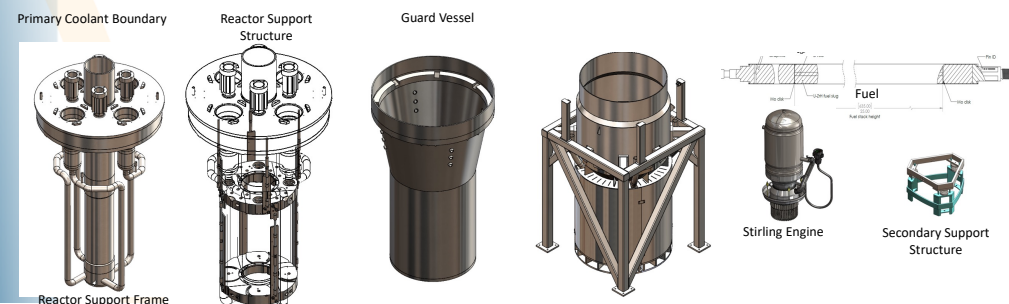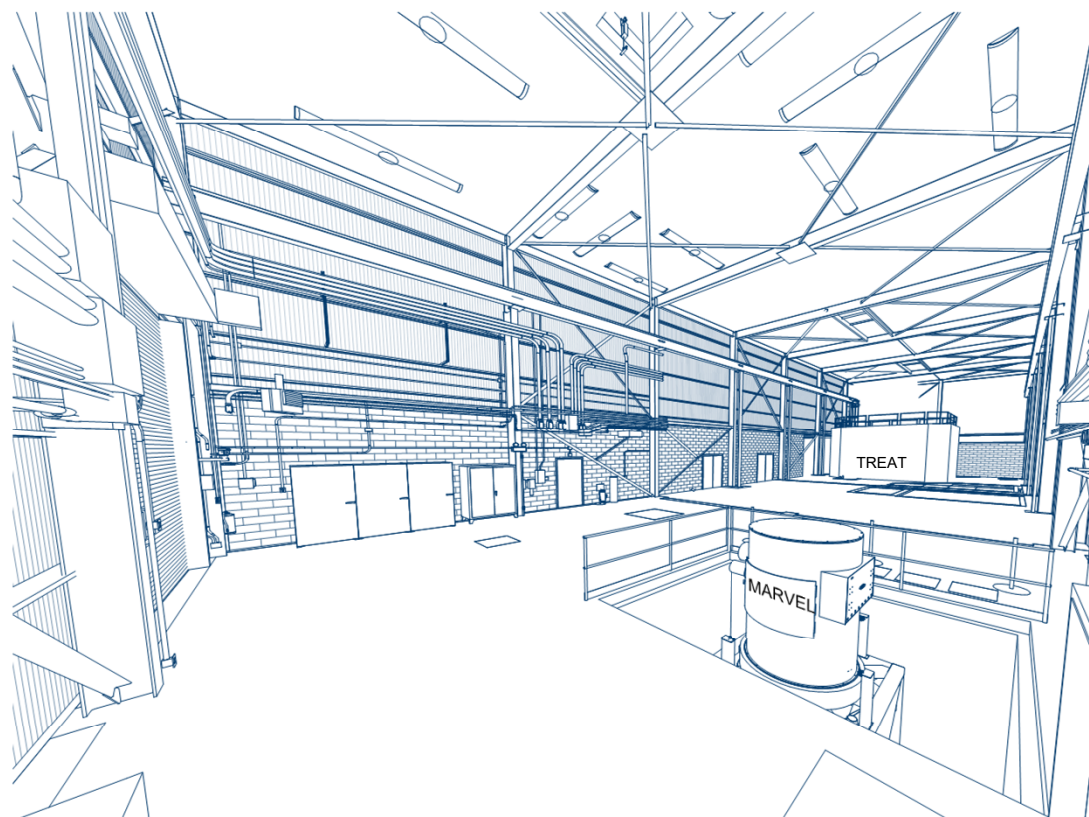

NaK flow measurements through 4 loops

Initiation of MARVEL Fabrication Phase

- **Final Design Review (completed)**
  - Live Review- Sept 2022
  - 440+ comments received
  - Final comments resolution meeting, Aug 2023
  - **90% Design Completion, per DOE-STD-1189** September 29, 2023!
  - Release of 260+ documents
- **MARVEL officially in fabrication phase**
  - Purchased materials, Long Lead Procurement #1 (completed)
  - Fabrication, LLP#2 (initiated)
  - RCS, LLP#3 (initiated)

Primary Coolant Boundary

Reactor Support Structure

Guard Vessel

Fuel

Stirling Engine

Secondary Support Structure

Reactor Support Frame

TREAT

MARVEL

MRP Microreactor Program

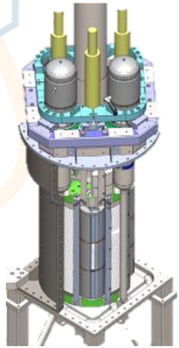# MARVEL Value Statement for Public/End Users

- Nuclear Energy is <u>new</u> to microreactor entry market
  - Operation complexity
  - Fear of colocation
  - Training needs
  - Reliability

- Customers reluctant to adopt microreactor technology unless they "see one" first (not willing to be the first in their backyard)

- <u>Having no real test reactor is a barrier to market entry</u>
  - End users deem it necessary to "interact" with a microreactor prior to providing customer requirements
  - End users unsure of technology potential prior to interaction

MARVEL will be the first microreactor to achieve criticality to demonstrate end user applications

MRP Microreactor Program

MARVEL Value Statement for Developers

"With many companies working on microreactor concepts behind closed doors, I see unique value in having a system that can be shared and discussed across teams "
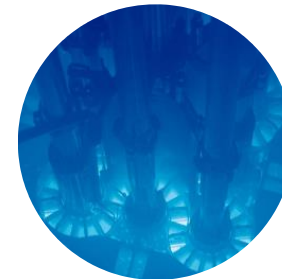
Fuel

Reactor Controls

NEPA

Fuel Loading

Power Conversion

Conceptual MARVEL utilization model