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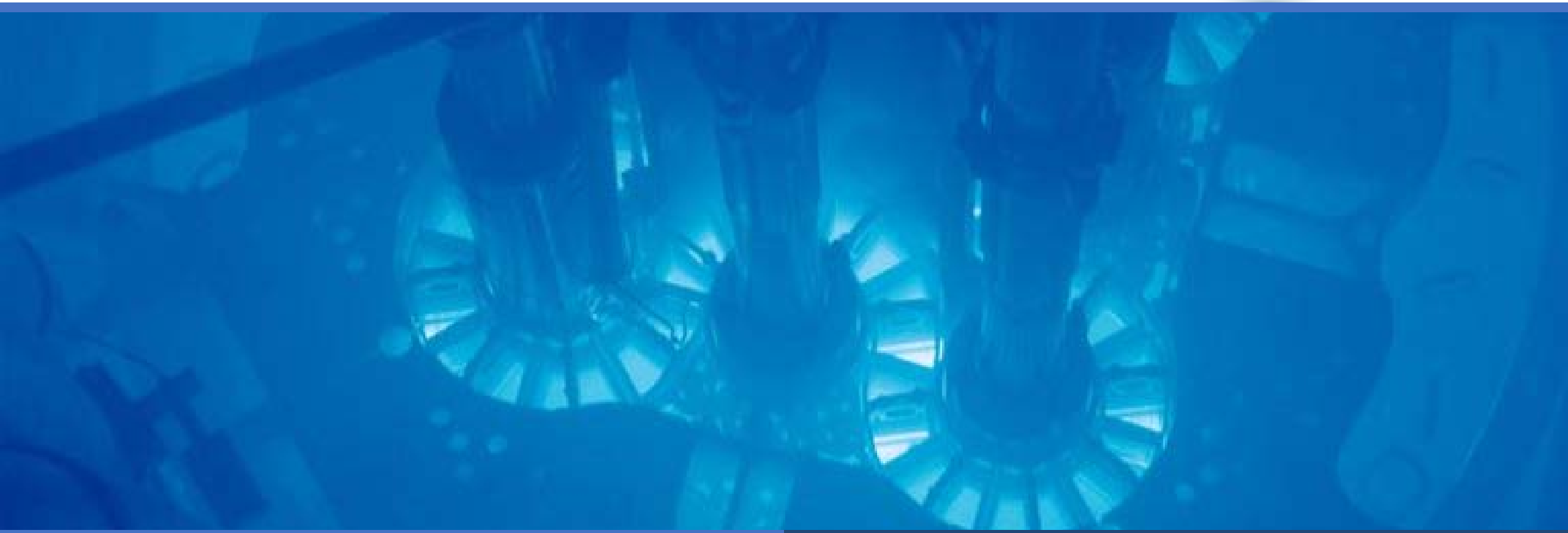


NE Microreactor Program Mission and Strategy

GAIN-EPRI-NEI Virtual Microreactor Workshop

August 2020

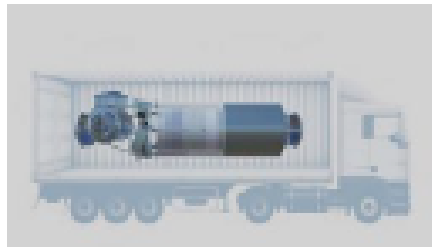
Federal Manager: Tom Sowinski, DOE-NE

National Technical Director: Dr. Jess C. Gehin, INL

Program Vision and Goals

Through cross-cutting research and development and technology demonstration support, by 2025 the Microreactor Program will:

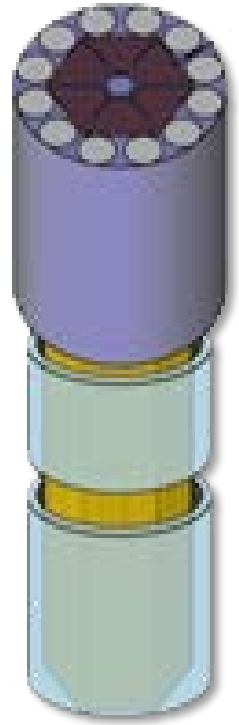
- Achieve technological breakthroughs for key features of microreactors
- Empower initial demonstration of the next advanced reactor in the US
- Enable successful demonstrations of multiple domestic commercial microreactors.



Objectives and Strategic Activities

Objectives

- Perform cross-cutting, national laboratory-led R&D activities to enable the demonstration and advancement of microreactor technologies
- Develop experimental infrastructure supporting microreactor system testing for early to mid-2020s demonstrations
- Provide cost-shared support for microreactor vendor concept development and licensing activities
- Remain closely engaged with the Nuclear Reactor Commission (NRC), industry, and Department of Defense (DoD) on related microreactor licensing and demonstration activities



Previous stakeholder feedback has motivated the following program activities:

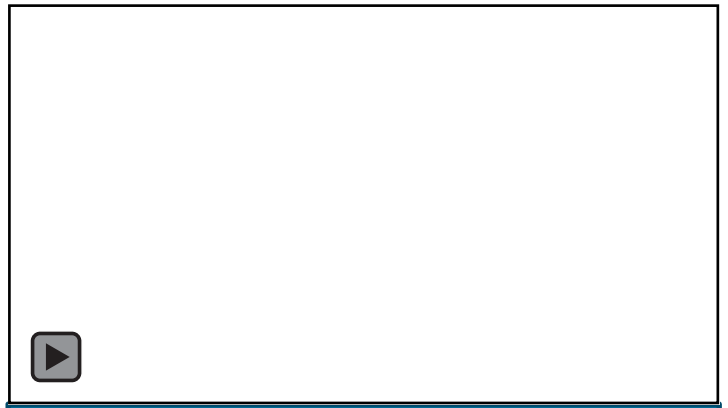
- Validation testing of integrated microreactor systems and end-user applications in both non-nuclear and nuclear prototypical environments
- Maturing cross-cutting microreactor technologies such as heat pipes, advanced moderators, advanced materials, and heat exchangers
- Testing and validating remote monitoring and semi-autonomous control systems
- Addressing technical licensing challenges for both near-term microreactor demonstrations and future “nth of a kind” commercial applications

Participating National Laboratories

- **INL (Lead National Laboratory)**
  - As the lead national laboratory, INL provides the following programmatic benefits:
    - Substantial technical expertise in relevant microreactor technology development areas
    - Significant historical background as a reactor demonstration location
    - Extensive nuclear energy R&D infrastructure
- **LANL, ORNL, ANL, SNL, PNNL (Participating National Laboratories)**
  - LANL and ORNL provide strong experience in small reactor designs for space applications and advanced materials and manufacturing capabilities
  - ANL supports advanced microreactor materials and legacy fuel data qualification
  - SNL conducts innovative microreactor energy conversion system R&D
  - PNNL supports development of microreactor transportation requirements

Program Structure

- **System Integration & Analyses**
  - Using NEAMS-developed modeling and simulation tools to analyze and understand the performance and behavior of microreactors
  - Performing techno-economic analyses of potential microreactor applications and regional markets
  - Identifying and resolving high-priority microreactor-specific regulatory technical challenges
- **Technology Maturation**
  - Investigating innovative microreactor moderators, reflectors, and high-temperature materials properties, fabrication, and performance
  - Maturing heat pipe and advanced heat exchanger technologies for integrating microreactor cores to power conversion units
  - Leveraging ongoing NE advanced sensor R&D for microreactor remote health monitoring and semi-autonomous control regimes
- **Demonstration Capabilities**
  - Operating and maintaining the MAGNET non-nuclear test bed platform for testing and gathering real-time data for key microreactor systems under electrically simulated prototypical nuclear response conditions
  - Constructing the MARVEL nuclear test bed to complement MAGNET and provide a unique nuclear environment for validating autonomous operation regimes and demonstrating integration of end-user applications to an actual nuclear system



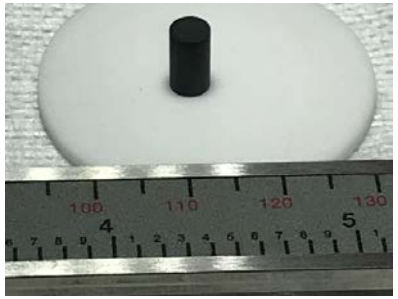
Integrated Simulation of heat-pipe microreactor

MAGNET Test Bed at INL Integrated Systems Laboratory

Recent Program Accomplishments

- **Completed design and initiated construction of MAGNET and initial test articles**
  - Fabricated initial 7-hole monolith, single heat pipe MAGNET test article
  - Initiated fabrication of subsequent 37-heat pipe, 75 kW MAGNET test article
- **Released legacy EBR-II HALEU solicitation for nuclear demonstration use at INL site**
  - Selection of Oklo announced in February 2020
- **Completed initial microreactor demonstration siting assessments at INL sites**
  - Siting assessment report released in March 2020
- **Initiated MARVEL design and safety case development**
- **Performed initial fabrication and testing of innovative hydride moderators**
- **Completing studies on potential domestic microreactor deployment markets**
  - INL-supported preliminary Puerto Rico microreactor deployment assessment report released by Nuclear Alternative Project in May 2020
- **Qualifying advanced high temperature materials for use in microreactor concepts**

7-hole and 37-heat pipe article test pieces



94% TD sintered YH2 pellet

Coordination with Industry Stakeholders

- **Microreactor developers**
  - Numerous microreactor developers are rapidly progressing towards demonstrations and commercialization
  - Program participates in workshops and meetings to receive input on industry priorities, communicate program outcomes, and seek feedback on program effectiveness
  - Program will ensure its research products (e.g., reports and data) and testing capabilities (e.g., experimental test beds) are readily and easily available to developers
- **End-users**
  - A variety of end-users (e.g., remote communities, islands, mining companies) are considering microreactors as a reliable and resilient energy option
  - The program will seek out these end-users to understand their needs and applications, as well as to provide information and outreach about microreactors
  - Initial market analyses, representing different regions and applications, have been performed to understand and inform developers on the most promising areas for deployment of microreactors

Coordination with other NE Programs

- **ART Reactor Campaigns**
  - Engagement and direct collaboration specifically on materials (structural, graphite), legacy fuel qualification
- **National Reactor Innovation Center**
  - Transition of activities on demonstration reactor siting, transportation to NRIC
  - Joint project on Microreactor Applications Research, Validation and Evaluation (MARVEL)
- **GAIN**
  - GAIN providing industry engagement support through workshops and Microreactor Program webpage
- **Nuclear Energy Advanced Modeling and Simulation**
  - Use of NEAMS-developed tools within the program to support research and provide feedback
  - Coordination on microreactor program experiments to specifically support NEAMS software (e.g. heat pipe experiments, MAGNET integrated testing.)
- **Advanced Sensors and Instrumentation**
  - Program utilizing sensor developed under ASI for experiments and research on microreactor instrumentation
  - Need for more collaboration on autonomous and remote operation
- **Transformational Challenge Reactor**
  - Increasing engagement on moderator development and testing

Collaborations with NE Programs (Cont.)

- **Advanced Reactor Regulatory**
  - Cross cutting scope for advanced reactors relevant for microreactors
- **Advanced Reactor Safeguards**
  - Current safeguards projects focusing on microreactors
- **Advanced Methods for Manufacturing**
  - Expand engagement between programs, sharing of relevant program research to AMM community
- **Nuclear Cyber Security**
  - Operating modes for remote monitoring, autonomous operations
- **Integrated Energy Systems**
  - Program activities on microreactor-application integration can leverage IES technologies and end-user engagement.
- **Nuclear Science User Facilities**
  - Strong needs for material irradiations for moderators, reflectors, structures
- **NE-4 Fuels**
  - Leverage advanced fuel R&D for microreactors – metallic, ceramic, TRISO
  - Collaboration on HALEU access

Coordination with Other Government Agencies

- **Department of Defense**
  - Potential synergies exist between the civilian and defense applications of commercial microreactor technologies
  - The program remains engaged with relevant DoD organizations to offer technical expertise and share publically available cross-cutting R&D results
- **Nuclear Regulatory Commission**
  - The NRC will license and regulate microreactors for commercial use
  - The program remains engaged with the NRC and industry stakeholders through periodic workshops/meetings on microreactor licensing needs
- **ARPA-E**
  - Participation in MEITNER program meetings, sharing of experience
  - Awareness of R&D in MEITNER, LISE, and OPEN to avoid duplication in efforts

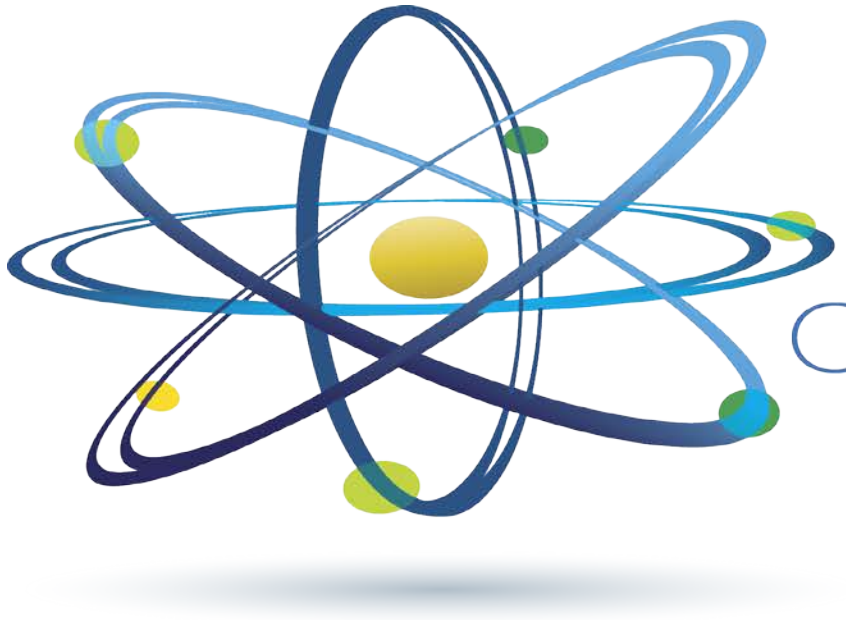
Proposed Future Activities

FY2021 (proposed)	
M21.1	Issue first version of advanced moderator material handbook
M21.2	Produce and test graphite and molybdenum-based structural material samples
M21.3	Complete test of 37-heat-pipe LANL test article in MAGNET
M21.4	Complete MAGNET non-nuclear test bed modification design for power cycle testing
M21.5	Complete preliminary design and NEPA analysis for MARVEL nuclear microreactor test bed
M21.6	Continue MARVEL safety analysis and begin fuel fabrication
M21.7	Complete Grade 91 steel code case development
FY2022 (proposed)	
M22.1	Complete MARVEL construction and perform initial criticality tests/test bed shakedown
M22.2	Continue testing on advanced material samples including molybdenum alloys, graphite, and other materials of interest
M22.3	Embed structural health monitoring equipment into a test object during fabrication and evaluate results
M22.4	Complete MAGNET procurements and modifications to enable power cycle testing
M22.5	Demonstrate a compact heat exchanger for near-term microreactor designs
M22.6	Complete legacy metallic fuel data qualification

Plans and Expected Outcomes (FY2021 – FY2026)

FY2023 (proposed)	
M23.1	Issue second version of advanced moderator material handbook with PIE results
M23.2	Test integrated core block, heat exchanger, and power conversion systems in MAGNET
M23.3	Complete first MAGNET power cycle test
M23.4	Validate microreactor M&S tools through data collected from MAGNET/MARVEL tests
M23.5	Build advanced heat pipe test articles with advanced wick using innovative fill process
FY2024 (proposed)	
M24.1	Test advanced heat pipe test articles in MAGNET and examine nominal/failed heat pipe cases
M24.2	Deliver a demonstrated method by which reactor components fabricated by AM processes can be qualified for use in elevated temperature nuclear construction
M24.3	Complete nuclear demonstration of autonomous operation using MARVEL
M24.4	Demonstrate combined heat and power applications using MARVEL
FY2025-26 (proposed)	
	Continue stakeholder engagement and access to MAGNET/MARVEL testing infrastructure to support ongoing demonstrations and emerging innovative technologies

Questions



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