Microreactor Program: System Integration and Analysis

Microreactor Program Winter Review Meeting
Los Alamos National Laboratory

March 4th, 2025

Alex Huning, ORNL

Agenda

8:25	**System Integration and Analysis Overview**	**Alex Huning (ORNL)**
8:40	Microreactor Cost Basis	Abdalla Abou-Jaoude (INL)
9:10	CRAB/MELCOR – FATE Comparison	Manit Shah (ORNL)
9:30	Planning for Microreactor Transportation	Steve Maheras (PNNL)
10:00	Development of the Technical Bases to Support Flexible Siting of Microreactors Based on Right-Sized Emergency Planning Zones	Saya Lee (PSU)
10:25	Feasibility Study of Micro-Nuclear Reactor Thermal Output for Air Rotary Kilns in the High-Temperature Manufacturing of Portland Cement Clinker	Martin Nieto Perez (PSU)
10:40	Wrap up	

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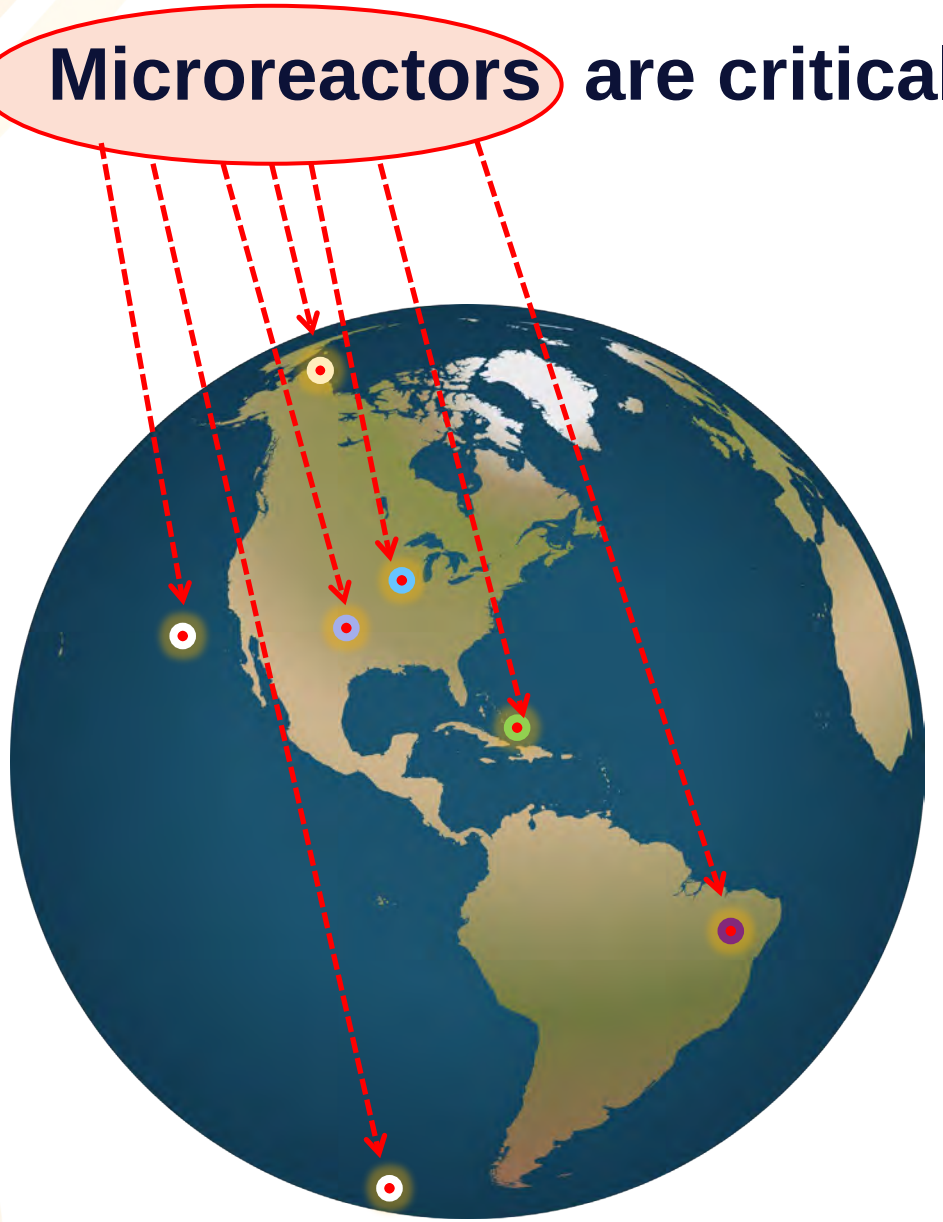
Microreactors are critical to energy and national security



Potential applications include:

- Offshore and floating nuclear power plants (etc., shipping, oil & gas)
- University microgrid, combined heat and power
- Arctic and Antarctic communities
- Mining and trona
- Island power
- Emergency response and recovery operations
- US export and global economic development

How to ensure Nth-of-a-Kind (NOAK) Success?

- Demonstrated economic viability
- Regulatory framework that enables novel operational regimes
- Flexible operations, tools, technologies, and capabilities that can address emerging challenges and new risks

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Scope

- **Systems Integration & Analysis (SIA)** – This scope will identify the needs, applications and functional requirements for microreactors through **market analysis** which will be used to drive future focus of the Microreactor Program toward **improving economics and/or viability of microreactors**. It will seek understanding of the microreactor design space by investigating innovative microreactor technology supporting concepts and will **perform regulatory research** to help develop the regulatory basis for microreactor deployments.

- **Recent work products and deliverables:**
  - BlueCRAB and MELCOR microreactor eVinci-like heatpipe microreactor model and code comparison to FATE (Westinghouse tool)
  - Microreactor transportation emergency response planning challenges and recommendations
  - Manufacturing license and factory-fueling regulatory challenges and recommendations

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How Systems Integration and Analysis Meets Program Objectives

Identifying regulatory challenges unique to microreactor applications

- Provide licensing recommendations on factory fabrication and new construction approaches
- Enable transportation of both self-contained fresh and operated fuel between sites and the factory
- Build a framework for future licensing and regulation of novel microreactor systems and applications

Assessing economic viability and paths for design optimization

- Provide industry with real microreactor cost estimates
- Develop new approaches to lower construction costs by leveraging advances in safety and security

Investigating analysis tools to support design and safety evaluations

- Enable core and system designs which increase fuel efficiency and enhance safety
- Reduce site boundary and emergency planning zones
- Lower safety uncertainty and risk associated with novel applications

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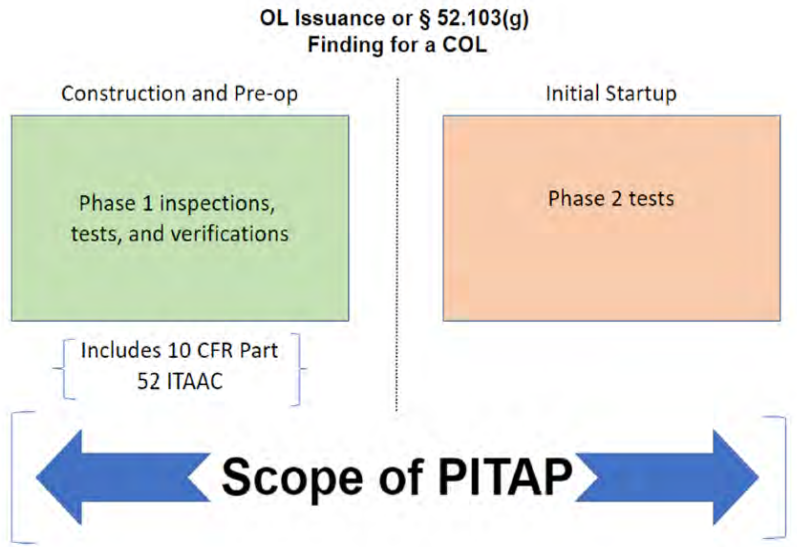
FY25 Work and Milestones

Research Area	WP Title	Key Questions being Investigated	Milestones
Analysis Tools and Approaches	Risk Assessment of Low Power Physics Testing for Factory Fueled Microreactors ★	• Identify what fission products and hazards are present as a result of low power testing at the factory • What is the existing licensing approach to this? • What approach *should* be used?	M3 – Report, due 3/30/25
Efficient Regulations	Microreactor Transportation Emergency Planning Challenges	• Building upon FY24 work, what elements of a transportation safety program are needed for microreactors? • Are there any unique elements and analyses that are needed to support transportation? • What revisions to the N14.24 standard are needed?	M4 - MARVEL cost estimates, due 3/30/25 M3 – Status update, due 6/30/25 M2 – Report, due 9/30/25
Economic Viability	Complete a bottom-up microreactor cost estimation tool to support developers and investors	• Using MARVEL costs, can a real microreactor (e.g., MARVEL-like or variant) be cost comparable to existing nuclear and other energy sources?	M4 – Draft report, due 3/30/25 M3 – N14.24 revisions, due 7/30/25 M2 – Report, due 9/30/25

★ Next slide

Risk Assessment of Low Power Physics Testing for Factory Fueled Microreactors

- The section XI of appendix – B to 10 CFR Part 50 and 10 CFR Part 52.47 (b)(1) mandates the establishment of a test program to verify the satisfactory performance of SSCs
- Scope of ITPs/PITAP:
  - The tests contained in the ITP/PITAP can be grouped into two phases:
    1. Phase – 1: Pre-operational Inspection, Testing and Analysis.
    2. Phase – 2: Initial start-up testing:
       1. Initial fuel loading and pre-criticality
       2. Initial Criticality Testing
       3. Low Power Testing
       4. Power Ascension Testing
  - Important characteristics confirmed by measurement are:
    1. Core reactivity
    2. Reactor shutdown
    3. Reactivity Control
    4. Power, temperature and flow distribution



From DANU-ISG-2022-06

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Goals for Microreactor Startup Testing

- **Primary goal is of this effort is to initiate discussion** around fuel loading and startup testing with a nuclear license that is commensurate with the hazard and risk to the health and safety of the public.
- The intent of a microreactor manufacturing and startup testing facility is **to not generate appreciable power**
- During startup testing, the fundamental safety function to be met is reactivity control. **Heat removal** and **containment of fission products** may not be of a similar level of importance during the startup testing of a microreactor since the power/heat level is significantly low, and "negligible" amounts of fission products are generated after startup testing.
- Therefore, the nature of the facility's license could be like a criticality experiment and not as a power reactor or a research reactor.
- Current model being proposed or recognized by NRC is that microreactor testing could be achieved with a non-power reactor license.

Next step: Quantitative analysis to support the stated goals

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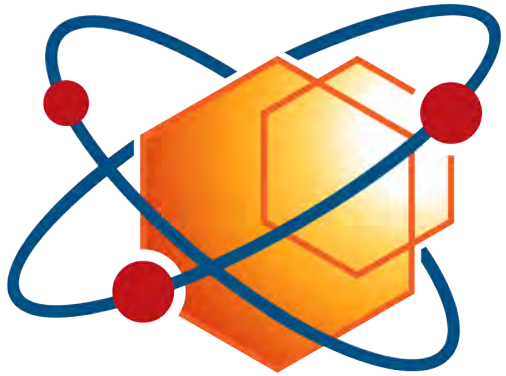

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