System Integration and Analysis Technical Area Overview

March 5th, 2024

Alex Huning, ORNL

Schedule

10:25	**System Integration and Analysis Overview**	**Alex Huning (ORNL)**
10:40	Microreactor cost basis	Abdalla Abou-Jaoud (INL)
11:10	CRAB/MELCOR code to code comparison	Jason Christensen (INL)
11:30	Emergency planning for transportation	Steve Maheras (PNNL)
12:00	(NEUP) Evaluation of microreactor requirements and performance in an existing well-characterized micro-grid	Caleb Brooks (UIUC)
12:25	(NEUP) Development of the technical bases to support flexible siting of microreactors based on right-sized emergency planning zones	Saya Lee (PSU)
12:35	Wrap up	Alex Huning

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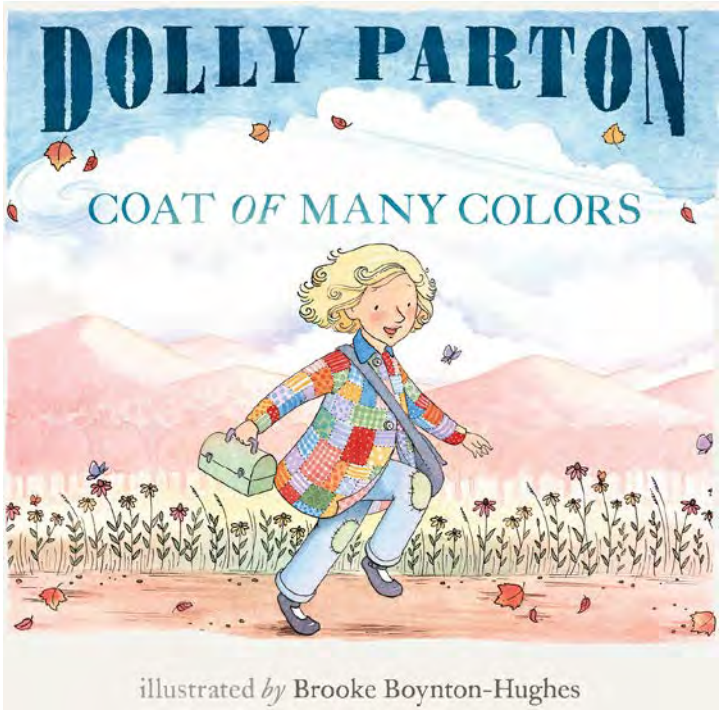
We cannot direct the wind, but we can adjust the sails



Find out who you are and do it on purpose

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National Laboratory Team FY24**

- Alex Huning
- Steven Arndt

- Jason Christensen
- David Shropshire
- Abdalla Abou Jaoude
- Stefano Terlizzi
- Rodrigo de Oliveira

- Steve Maheras
- Harold Adkins

- Jim Scobel*
- Patrick Kopfle*
- Sung Jin Lee*

*No cost peer-consultant

**May have excluded a few on accident, feel free to chime in to be represented

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.

- **Key SIA areas of research:**

Efficient Regulations

Economic Viability

Analysis Tools

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Efficient Regulations

- Microreactor regulatory challenges identified in 2019 by NEI and others
  - Sufficiently “unique” from many other advanced and small modular reactors
- Focus of SIA has been on these “unique” (low-to-mid TRL) regulatory challenges
  - Manufacturing, Transportation, Emergency planning
- Proposed NRC Advanced Reactor Construction Oversight Process (ARCOP) will apply for microreactors, in addition to other non-LWRs
  - Various options being considered to establish reasonable assurance of safety and security of the public and environment
- SECY-24-0008 – Technical, Licensing and Policy Considerations for Factory-Fabricated Microreactors, (February 2024)
  - Near term strategies and next steps for licensing novel regulatory challenges
  - No NRC plans to address mobile microreactor regulatory challenges
- MRP is well equipped to **support industry** in understanding and applying these new regulations and guidance, and to **recommend improvements** to regulatory processes based on scientific and technical evidence

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Economic Viability

- Many of the regulatory challenges tie directly to economic viability (transportability, remote operations, review cost and licensing, etc.)
- Geography and regional conditions highly influence microreactor economic viability
- Combined heat and power will be essential for economic viability (“No heat should be wasted”)
- Transportability of nuclear reactors offers unique advantages for other industries
  - Mining
  - Trona (chemical processing)
- University campuses exploring and planning for microreactor operations (ACU, UIUC)
- DOD and NASA interest in space applications for small nuclear power systems
  - Large organizations facing similar concerns as other interest buyers
- MRP can support industry economic viability by identifying methods or new/novel technologies to reduce economic cost uncertainty

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Analysis Tools

- Many thermal hydraulic, neutronic, fuel performance, and other nuclear engineering analysis tools exist for design purposes… **MRP SIA focus is on tools which support safety and regulatory analysis** (reduces licensing uncertainty and accelerates deployment)
- Critical that all accident phenomena associated with the safety of the plant be modeled with **uncertainties appropriately documented and quality supporting data**
- Gaps and high uncertainty regions may necessitate additional data gathering (experiments)
  - Critical to identify these gaps and uncertainties in the design phase rather than during licensing
- Given the wide range of microreactor developers, technology experience levels, guidance on code usage, integration between codes, and application of the codes to safety analysis **will provide compounding benefits for these companies going into licensing**

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FY24 Tasks

Research Area	Task	Description
Analysis Tools	1. Integrated BlueCRAB and MELCOR Heat Pipe Microreactor Model for Source Term Analysis Lead Labs: INL and ORNL	(1) Develop a BlueCRAB and MELCOR heat pipe microreactor for source term calculations. (2) Identify coupling challenges, potential gaps, and develop recommendations. (3) Compare the model and results with the Westinghouse FATE code.
Efficient Regulations	2. Emergency Planning for Transportation Lead Lab: PNNL	Following on recommendations from FY23, this task will focus on the use of hazardous materials in microreactor designs. Continue to interface with the NTSF and Tribal Radioactive Materials Transportation Committee.
Economic Viability	3. Develop a robust bottom-up cost estimate for a commercial microreactor Lead Lab: INL	(1) to provide detailed basis for the ultimate expected costs of microreactors, (2) to provide a comprehensive frameworks for evaluating microreactor costs, and (3) identifying pathways towards reducing these costs

Activity for FY24

1. Analysis Tools
   Efficient Regulations
   Economic Viability

TITLE: Expand on FY23 scope to apply CRAB/MELCOR framework to generic microreactor and perform code-code comparison with FATE

SCOPE: Extending upon the MELCOR and BlueCRAB task performed during FY23, this task will develop a **complete working heat pipe microreactor model in MELCOR with interfaces to the BlueCRAB** suite of tools for integrating realistic power and temperature profiles within the core and vessel structures as a starting point for source term transport under hypothetical accident conditions. This model will then be used to assess modeling uncertainties and where additional experimental or other data is needed to better characterize offsite dose consequences and ensure deployment under unique conditions for which many microreactor developers are proposing (e.g., urban siting, multiple site operations, etc.). The scope will leverage reactor physics, thermal hydraulic, and other core analyses performed under the SA&I campaign to better inform and identify gaps in the engineering analyses necessary for licensing and other microreactor regulatory applications.

POCs: Jason Christensen – INL, Alex Huning – ORNL

M2: Complete initial CRAB/MELCOR code to code comparison with FATE to provide a valuable confirmatory calculation of source term for a generic heat pipe reactor (Sept, 2024)

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Activity for FY24

Analysis Tools

Efficient Regulations

Economic Viability

2.

TITLE: Transportation of Emergency Planning Challenges for Microreactors

SCOPE: Continue to develop and refine the transportation emergency planning challenges associated with the transportation of a microreactor containing its irradiated fuel. **One area of emphasis this year will be on the use of hazardous materials in microreactor designs and how this might change transportation emergency planning.** Continue to interface with the National Transportation Stakeholders Forum and the Tribal Radioactive Materials Transportation Committee on the emergency planning challenges associated with the transportation of a microreactor containing its irradiated fuel.

M3: Assessment of Transportation Emergency Response Planning Challenges (Sept, 2024)

POC: Steve Maheras – PNNL

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Activity for FY24

Analysis Tools

Efficient Regulations

Economic Viability

3.

TITLE: Development of a bottom-up cost estimate for a commercial microreactor

SCOPE: The long-term goal of this project is threefold: (1) to provide detailed basis for the ultimate expected costs of microreactors, (2) to provide a comprehensive frameworks for evaluating microreactor costs, and (3) identifying pathways towards reducing these costs. In FY24, the work will focus on laying the foundation for this broader scope by developing a detailed cost estimate for a commercial-like microreactor. To do so, the technical analysis will be performed to define cost ranges and evaluate tradeoffs for a representative microreactor (e.g., type of reflector/fuel material, forced/natural convection, power conversion cycle). MARVEL cost data will be leveraged where applicable with the design modified to represent commercial concepts. The work will leverage cost equations developed by the Systems Analysis & Integration (SA&I) campaign, follow the SA&I 'economics-by-design' framework, and leverage previous SA&I-MRP joint work on factory fabrication models for microreactors.

POC: Abdalla Abou Jaoude – INL

M3: Complete Detailed Bottom-up Estimate and Technoeconomic Evaluation of a Microreactor (Aug. 2024)

Thank you, and next up:

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