Molten Salt Reactor PROGRAM

MSR Fuel Cycle Chemistry Workshop

Held September 19-21, 2023 at Argonne National Laboratory

Argonne NATIONAL LABORATORY
INL Idaho National Laboratory
Los Alamos NATIONAL LABORATORY
OAK RIDGE National Laboratory
Pacific Northwest NATIONAL LABORATORY
Sandia National Laboratories
U.S. DEPARTMENT of ENERGY Office of Nuclear Energy

Motivation

- Establish a supply chain for molten salt fuels
- Develop a recycle or disposition pathway for used molten salt fuels
- DOE Office of Materials and Chemical Technology (NE-43) supports development of fuel cycle technologies for oxide, metal, and coated fuels.
- NE-43 seeks to develop MSR fuel cycle technologies by adapting existing technologies to molten salt fuels and develop any necessary new technologies.

MSR fuels are unique and require unique fuel cycles:

- **Enable on-line fuel conditioning**
- **Must be protected from contamination during synthesis, delivery, and use**
- **Online, at-line, and offline options are all possible.**

Goals of the Workshop

- Identify technological gaps, specific research needs, and future research directions in the following areas:
  - Synthesizing, purifying, and supplying molten salt fuels
  - Recovering and recycling resource materials from used fuel
- Identify existing fuel cycle-related technologies that could be applied to molten salt fuels

Develop a set of separation, synthesis and purification technologies that MSR developers can draw upon to build their fuel cycle strategies.

Brought together representatives from two offices of DOE, NRC, National Labs, Universities, Reactor Developers and Fuel Salt Suppliers for a robust discussion.

Rose, Melissa A. and Ezell, Dianne. "Molten Salt Reactor Fuel Cycle Chemistry Workshop Report." ANL/CFCT-23/50. Sep. 2023.

Topics Covered

- *Session 1: Conversion of fuel sources to salt*
- *Session 2: Fresh fuel salt purification technology*
- *Session 3: Scale-up of fuel synthesis, packaging, and delivery*
- *Session 4: Fuel salt characterization and qualification*
- *Session 5: Technologies for recovering actinides*
- *Session 6: Used fuel salt purification for recycle*
- *Session 7: Recovery and transmutation of long-lived isotopes*
- *Session 8: Noble metal and insoluble fission product recovery*
- *Session 9: Safeguarding approaches for liquid fuels and fuel cycle facilities*

Questions participants sought to answer:

- Can the industry synthesize and supply MSRs with an adequate volume of high-quality fuels?
- Who should be synthesizing and supplying these fuels?
- How and by whom is fuel quality determined?

Questions participants sought to answer:

- What does the fuel cycle for an MSR look like?
- What species should be removed from the salt to prolong its lifetime?
- What technologies will be required?

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Session Outcomes

In each session two technical talks were given by experts on the topic and a robust discussion among the participants identified the technological gaps, research needs and their impact on deployment of MSRs. These were exhaustively tabulated in the workshop report and discussed in session reports.

Main Themes:

- Synthesizing molten salt fuels at scale would develop a robust supply chain of molten salt fuel in advance of the deployment of MSRs.
- Understanding the impact of contaminants on fuel performance will allow developers to set the fuel specifications and optimize fuel synthesis processes to meet these requirements without undue cost.
- Purification technologies will enable the production of high-purity salts for use in measuring salt properties and synthesizing fuel salts.
- Recovery of actinides, removal of fission products and understanding the behavior of insoluble species in used molten salts will allow the reuse of the fuel elements, enable the drawdown of fission products, and minimize salt waste.

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Identified Future Research Directions

1. Develop and Demonstrate Efficient and Scalable Synthesis Processes
2. Understand the Impact of Impurities on Molten Salts
3. Optimize and Demonstrate Separation Technologies for Removing Impurities from Molten Salts
4. Develop Salt Chemistry Monitoring and Control Technologies
5. Adapt and Optimize Actinide Separation Technologies to Chloride and Fluoride Salts
6. Develop Technologies to Remove Fission Products from Chloride and Fluoride Salts
7. Understand the Behavior of Insoluble Fission Products in Molten Salts

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Impact of Workshop

- FRDs were used by DOE to develop the FY25 NEUP call under Topic Area 4- Fuels

- Revisit the discussion in 2026
  - Discuss advances in technology
  - Identify new technological gaps and refine research needs

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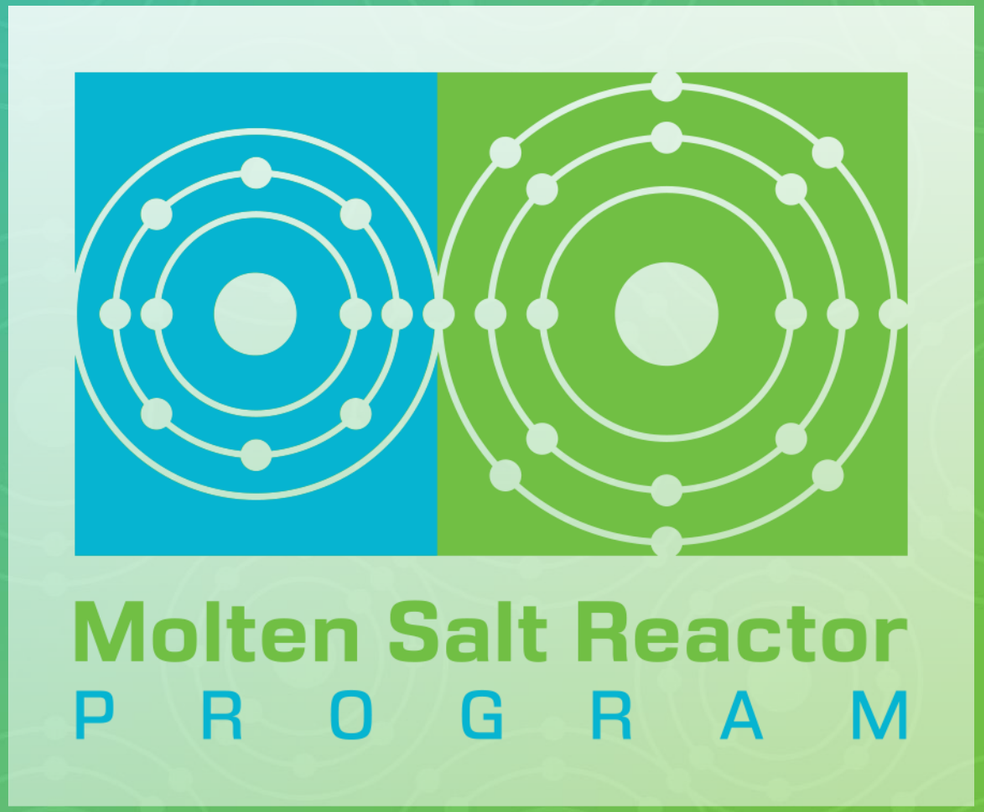
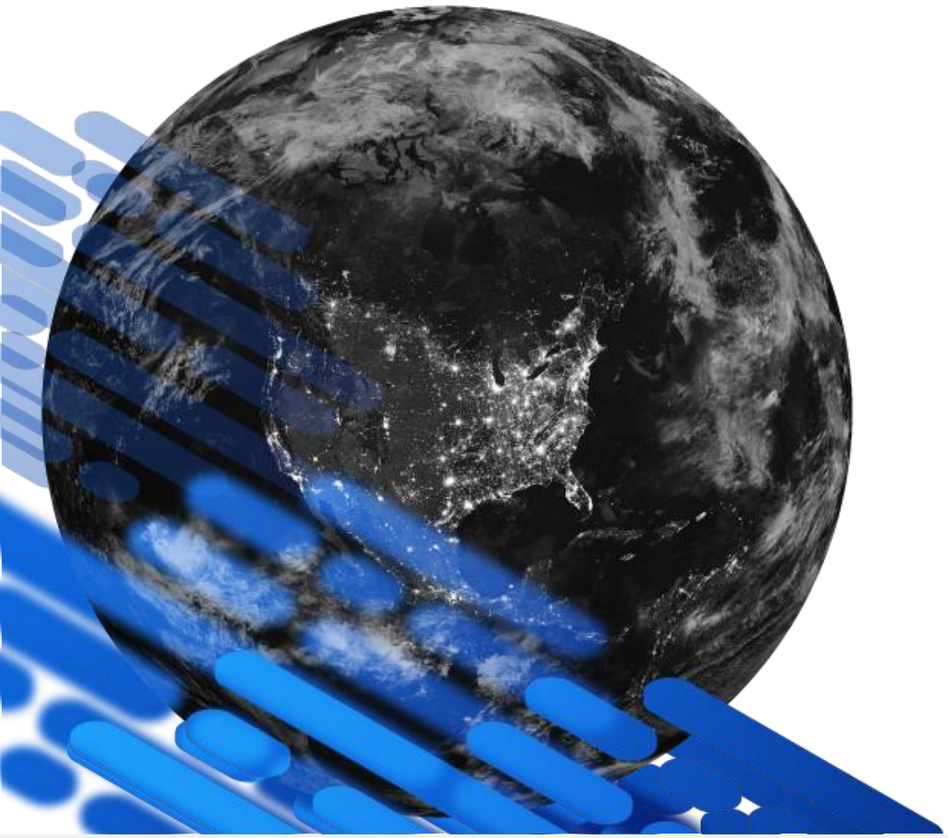
Thank you

Marose@anl.gov



AR Fuel R&D Workshop 2025



Objective

Identify & prioritize remaining R&D gaps with AR fuels with a focus on licensing, operation, and optimization.

Discuss opportunities for collaboration and acceleration of fuel qualification and deployment.

Who should attend

Open to all AR fuel R&D stakeholders:
reactor developers, fuel suppliers, utilities, DOE, regulators, NEI, national laboratories, universities, and other industry experts.

Location & Date

EPRI offices in Charlotte, NC
June 3-5, 2025

Aaron Totemeier
Principal Technical Leader
Nuclear Fuels
atotemeier@epri.com

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