U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Molten Salt Reactor PROGRAM

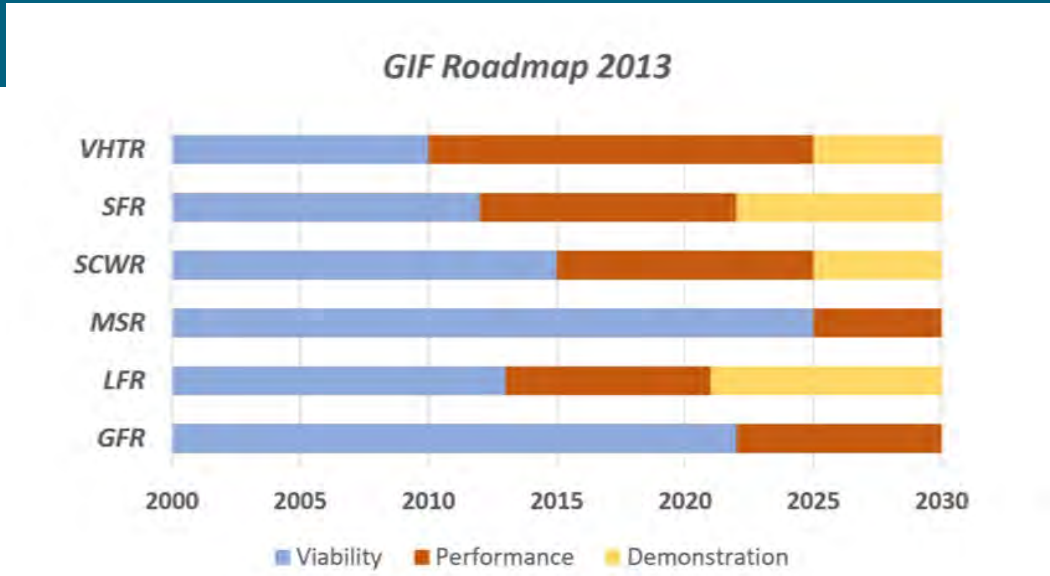
The U.S. Molten Salt Reactor Program

16 April 2024

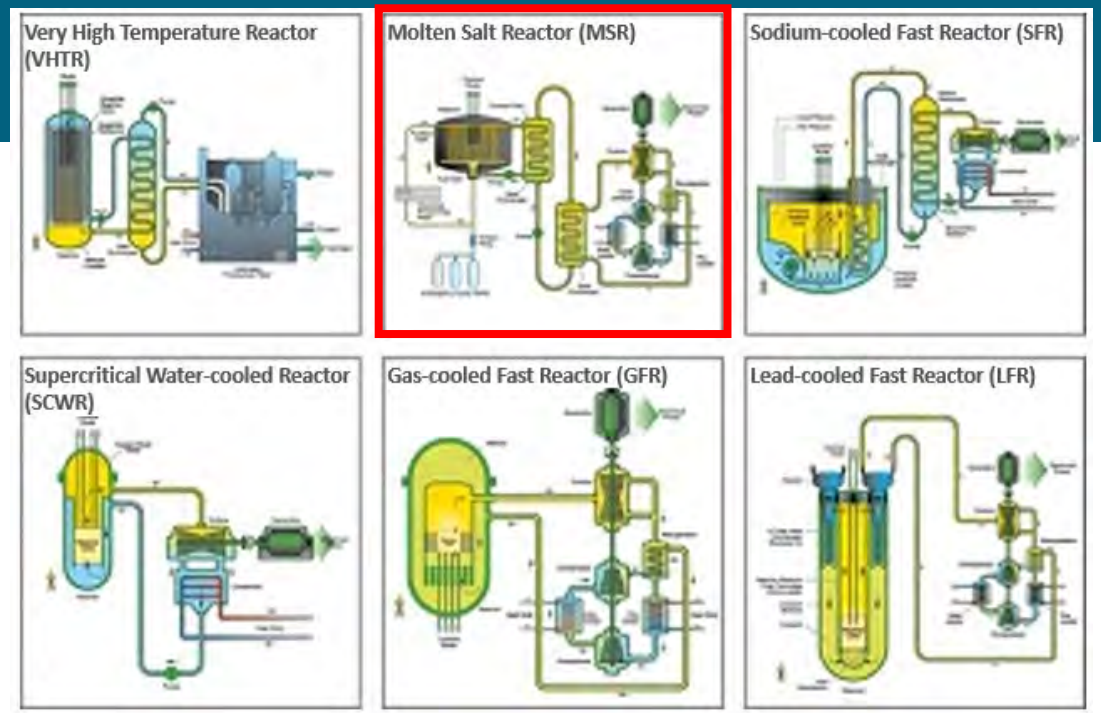
Dr. Patricia Paviet
National Technical Director
Dr. Michael Stoddard
MSR Federal Manager

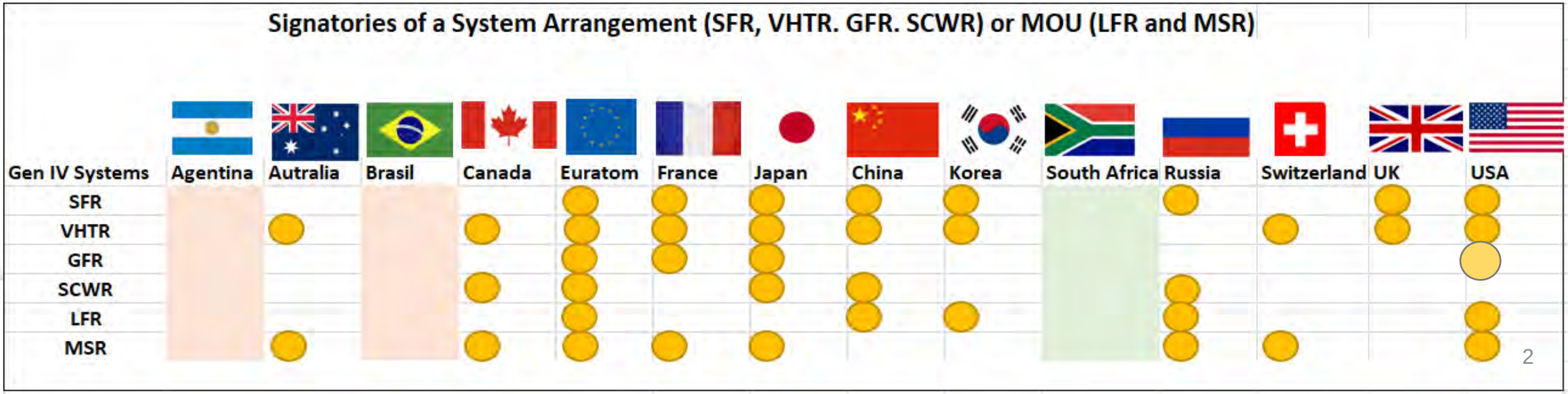
PNNL-SA-197208

Six Gen IV Reactor Systems with Common Attributes



https://www.gen-4.org/gif/jcms/c_9342/framework-agreement





International R&D on Molten Salt Reactors, Molten Salt Chemistry, Materials, Mod&Sim

IAEA

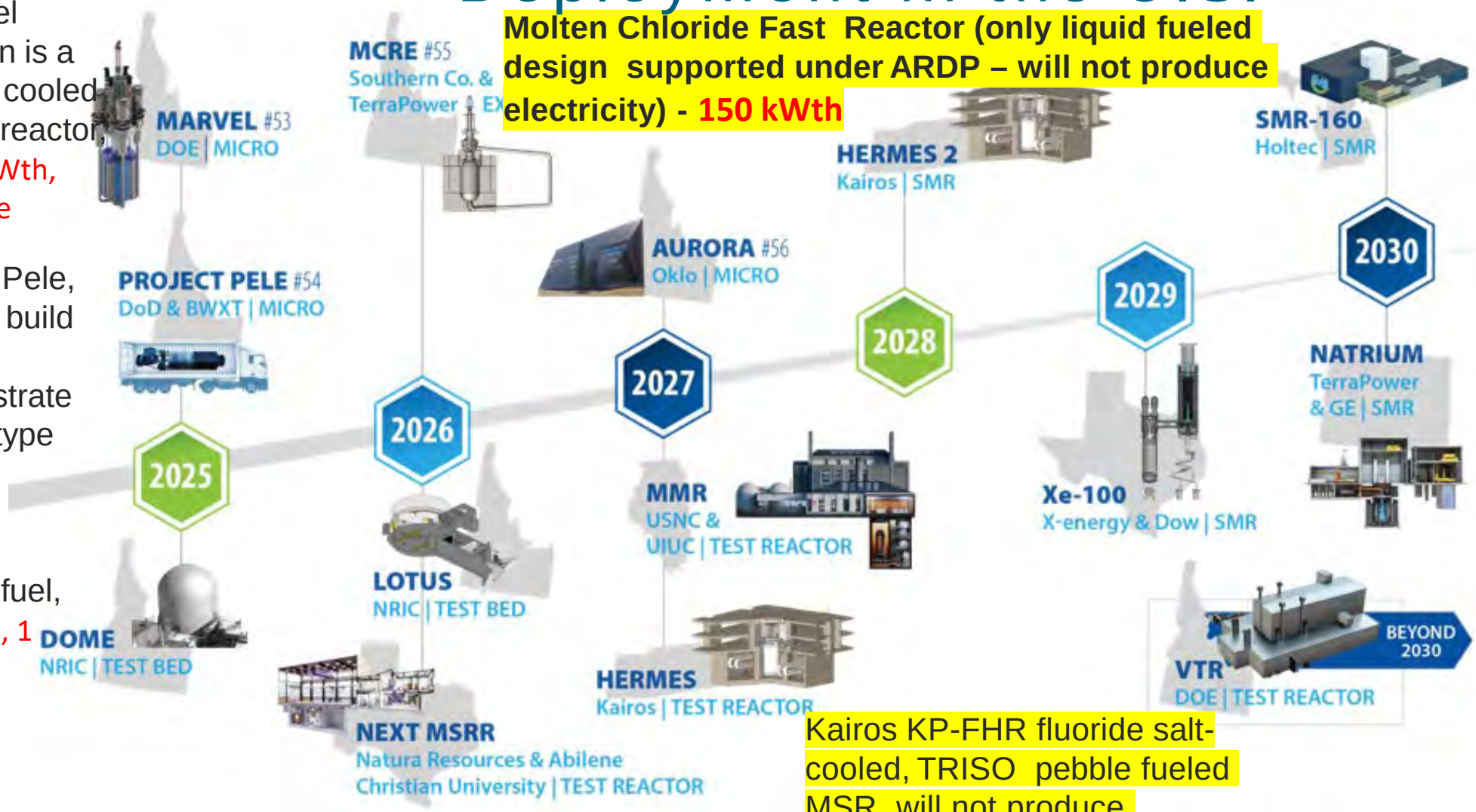
NEA
NUCLEAR ENERGY AGENCY

GEN IV International Forum
Expertise | Collaboration | Excellence

Accelerating Advanced Reactors Demonstration & Deployment in the U.S.

Marvel design is a Na-K cooled microreactor, 100 kWth, 20kWe

Project Pele, design, build and demonstrate a prototype mobile nuclear reactor, TRISO fuel, 5 MWth, 1 MWe



Molten Chloride Fast Reactor (only liquid fueled design supported under ARDP – will not produce electricity) - 150 kWth

MCFR Full commercial operation – 500-1200 MWe

Natrium – 840 MWth, 345 MWe (variable output (up to 500 MWe short-term with molten salt storage) – ARDP award

Kairos KP-FHR fluoride salt-cooled, TRISO pebble fueled MSR, will not produce electricity, 35 MWth

MSRR, Low power (up to 1 MWth, to support academic research)

Technical Areas of Strategic R&D

Oak Ridge National Laboratory

Pacific Northwest National Laboratory

Thermophysical and Thermochemical Properties of Molten Salts – Experimentally and Computationally

Salt Chemistry

Mission : Develop the technological foundations to enable MSRs for safe and economical operations while maintaining a high level of proliferation resistance.

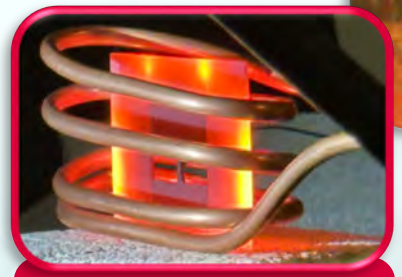
Technology Development

Off-Gas Management
Radionuclide Release Monitoring, Sensors & Instrumentation
LSTL & FASTR

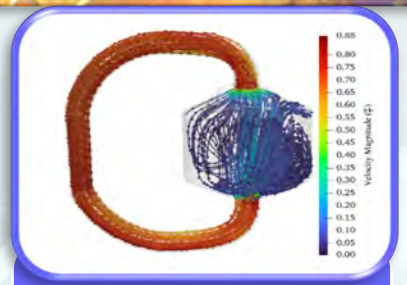
Argonne National Laboratory

Los Alamos National Laboratory

Development of Materials Surveillance Technology
Graphite/Salt Interaction
Materials/Salt Interaction



Advanced Materials



Mod & Sim

MSR Radioisotopes

Developing new Technologies to Enrich & Separate Radioisotopes of Interest to the MSR Community

INL Idaho National Laboratory

Sandia National Laboratories

Resolve technical gaps related to mechanistic source term (MST) modeling and simulation tools.
Modeling radionuclide transport from a molten salt to different regions of an operating MSR plant

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Molten Salt Reactor PROGRAM

AMMT ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGIES

- **MSR Structural Materials R&D will be transitioning from the MSR program to the Advanced Materials and Manufacturing Technologies starting 01 OCT 2024**
- **Working closely with Dr. Meimei Li and the other Gen IV reactors National Technical Directors for a smooth transition**
- **Meeting with MSR developers to understand the needs they have**

  Terrestrial USA

  Flibe Energy

  TerraPower and Southern (01 May 2024)

Integration with Universities

FY 2020 Integrated Research Project Awards			Prof. Charles Forsberg
Molten Salt Reactor Test Bed with Neutron Irradiation	Massachusetts Institute of Technology	$4,800,000	Researchers will build and operate a flowing liquid salt loop with heated and cooled sections where the salt is irradiated with neutrons from the MIT research reactor. The loop will (1) enable understanding the behavior of tritium, noble metal fission products, and other radionuclides in a salt environment , (2) testing of instrumentation and (3) be a prototype for future loops at other universities and in DOE test reactors. The salt can include uranium that generates fission products.

FY 2022 Integrated Research Project Awards			Prof. Max Fratoni
Bridging the gap between experiments and modeling to improve design of molten salt reactors	University of California, Berkeley	$2,998,545	The scope of this project is to improve our understanding of the role of impurities and fission products on the operational performance of MSRs as well as potential impact on accident scenarios. A key target is to contribute to the development of MSRs solving real world issues and for this reason we will work closely with two MSRs vendors representing the two different categories: liquid fuel and solid fuel MSRs.

NEUP 2019 R&D Award Abstracts			Prof. Adrien Couet
NEUP Project 19-16954: Innovative In-Situ Analysis and Quantification of Corrosion and Erosion of 316 Stainless Steel in Molten Chloride Salt Flow Loops	University of Wisconsin-Madison	$800,000	Researchers will use a thin-layer activation technique for the first time in molten salts, on 316H samples placed in natural convection and forced flow loops. The individual and synergistic effects of corrosion, irradiation and thermo-mechanical treatments will be evaluated in-situ to predict component service lifetimes and design limits. The effects of molten chloride flow velocity will also be assessed.

Integration with Other Offices

Los Alamos National Laboratory to lead study of molten-salt nuclear reactor materials

$9.25 million DOE nuclear energy research program aims to improve safety and efficiency of sustainable nuclear energy

AUGUST 15, 2022

Dr. Laurent Capolungo, LANL

"This program powerfully brings together experts from basic and applied sciences with multiple world-class research facilities to enable discovery," said **Kathryn Huff, Assistant Secretary for Nuclear Energy**. "These partnerships promise to advance our understanding of material phenomena essential to designing and demonstrating safe and efficient advanced nuclear reactors."

Brookhaven National Laboratory

Laboratory Staff

U.S. DEPARTMENT OF ENERGY

James F. Wishart

Director, Molten Salts in Extreme Environments Energy Frontier Research Center; Distinguished Chemist, Electron- and Photo-induced Processes (EPIP) Group, Chemistry Division

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

NEA
NUCLEAR ENERGY AGENCY

International Workshop on the Chemistry of Fuel Cycles for Molten Salt Reactor Technologies

2 – 6 October 2023

Ref. No.: EVT2205115

Hybrid Event

Kicking off the nuclear week in Brussels with an important workshop:
Putting Science into Standards for Molten Salt Reactor technologies

Together with #CEN and #CENELEC #JRC carries out its annual foresight on standardisation
- what could be more topical than
#SMR small modular reactors and in particular #MSR molten salt reactors
See my colleague Ondrej Benes explaining his work on molten salt

https://lnkd.in/esuTPMiC

EU Science, Research and Innovation Bernard Magenhann Stephen Quest Jolita Butkevičienė Fabio Taucer Andreas Jenet

“Putting science into standards for MSR technologies” 18-19 March 2024

OAK RIDGE National Laboratory

Molten Salt Reactor Workshop
5-7 NOV 2024
Oak Ridge, TN

SAVE THE DATE

Workshop on Measurement and Analysis of Thermochemical & Thermophysical Properties of Molten Salts

Under the auspices of the *ad hoc* Molten Salt Thermal Properties Working Group

Hosted by the University of South Carolina
The meeting will be solely virtual

Date and Time: 10 AM – 3 PM Eastern US Time, July 16-17, 2024

The purpose of the workshop is to exchange information on standards and best practices for obtaining and analyzing thermal and physical property data. The goal is to help assure that values generated for ultimate inclusion in databases and for use in applications are as accurate as possible with the uncertainties understood and reported.

Organizers: Ted Besmann, University of South Carolina
Tony Birri, Oak Ridge National Laboratory

NEAMS
R ENERGY ADVANCED MODELING & SIMULATION PROGRAM

OAK RIDGE National Laboratory

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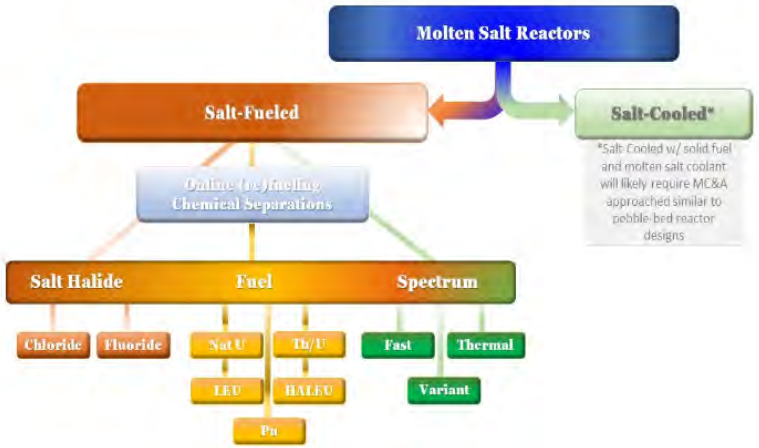
The DOE-NE MSR program serves as the hub for addressing the technology challenges for MSRs to enter the commercial market.



The breadth of the MSR design space presents a substantial challenge to the completeness and broad applicability of any technology development planning activity. Dozens of design concepts are currently in some state of development, nearly all have been introduced in the past decade, and it is not currently possible to reasonably evaluate which designs will eventually be successful. Nevertheless, MSRs have common characteristics and many technology development issues are broadly applicable to most MSRs

Contacts

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Announcements
November 5-7, 2024

- A Molten Salt Community Framework for Predictive Modeling of Critical Characteristics
- Understanding the Interfacial Structure of the Molten Chloride Salts by in-situ Electrocapillarity and Resonant Soft X-ray Scatter (RSoXS)
- Nuclear Material Accountancy During Disposal and Reprocessing of Molten Salt Reactor Fuel Salts
- Optical Basicity Determination of MoltenFluoride Salts and its Influence on Structural Material Corrosion

FY22 SciDAC Award

- Los Alamos National Laboratory to lead study of molten-salt nuclear reactor materials

MSR Annual Campaign Review

- May 2-4, 2023
- April 26-27, 2022
- June 17, 2021

MSR Course

Molten Salt Thermal Properties Database (MSTDB)

- University of South Carolina - College of Engineering and Computing -- MSTDB
- Oak Ridge National Laboratory -- MSTDB

Molten Salt Thermal Properties Working Group

Presentations on Molten Salt Chemistry

Reports

- Chemistry
- Off Gas Management
- Modeling and Simulation
- Materials

GIF Webinars

https://gain.inl.gov/SitePages/MSR_Program.aspx

Promoting the future leaders of tomorrow through the Gen IV International Forum – Education and Training Working Group

GEN IV International Forum
Expertise | Collaboration | Excellence

Education and Training Working Group

Webinar Invite

Join us on April 17, 2024, 8:30 a.m. EST (UTC-4)

Multiphysics Depletion & Chemical Analyses of Molten Salt Reactors

Molten Salt Reactors (MSRs) are an innovative Generation-IV reactor concept which use nuclear fuel dissolved in a high temperature liquid salt and allow for enhanced safety and economic performance. The liquid fuel feature also entails several multiphysics effects that can complicate reactor design. One primary effect, coined here as depletion-driven thermochemistry, is the changing chemical redox potential of the fuel salt due to chemical composition changes driven by depletion. As the fuel is consumed and fission products are formed, the redox potential of the fuel salt shifts toward a more oxidizing state. Without active control, the changing chemistry can have multiple effects on the multiphysics behavior of the reactor that are important for both steady state operation and for accident scenario transients.

A new multiphysics framework capability developed at Idaho National Laboratory can now simulate these coupled processes occurring in MSR systems during depletion including neutron transport, nuclide generation, thermal hydraulics, thermochemical equilibrium, chemical species transport, corrosion, and active chemistry control. The application of this work includes modeling source term, decay heat removal, reactivity transients, corrosion, chemistry control, and safeguards analyses. Future work focuses on validation efforts by defining a thermochemical benchmark against the Molten Salt Reactor Experiment (MSRE) and future digital twins of near-term experiments.

Free webcast!

April 17, 2024
8:30 am EST (UTC-4)

Register NOW at:
https://attendee.gotowebinar.com/register/3263652212604349019

Who should attend:
policymakers, managers, regulators, students, general public

Dr. Samuel Walker is an R&D Staff Scientist in the Advanced Reactor Technology & Design Department of Idaho National Laboratory (INL). He earned his Ph.D. in Nuclear Engineering from Rensselaer Polytechnic Institute in 2021 where he worked developing mass transfer modeling approaches for insoluble fission product transport in Molten Salt Reactor (MSR) systems. His graduate work was funded by a Department of Energy Nuclear Energy University Program (DOE NEUP) Fellowship that he was awarded in 2017. His current work at INL focuses on coupling Nuclear Energy Advanced Modeling and Simulation (NEAMS) tools for multi-scale and multi-physics analysis of advanced reactors with a heavy focus on MSR multiphysics. His expertise lies in modeling chemical species transport phenomena in molten salts used in fission and fusion systems. Applications of his work include source term and safety analyses, multiphysics core and system design, chemistry control system modeling, and novel MSR safeguard approaches.

Upcoming Webinars

22 May 2024, GIF/IAEA panel discussion on Regulatory Activities in support of SMRs and Advanced Reactor Systems

05 June 2024, Directed Energy Deposition Process of Corrosion Resistant Coating for Lead-Bismuth Eutectic Environment, Gidong Kim, UNIST, Korea

31July 2024, On-line Monitoring Development in Support of the Nuclear Fuel Cycle, Samantha Lines and Sam Bryan, PNNL, USA

For more information, please contact Patricia Paviet at patricia.paviet@pnnl.gov or visit the GIF website at www.gen-4.org

www.gen-4.org


T. Fuerst
T. Besmann
M. Rose
Z. Huber
M. Thuong NGuyen
V. Glezakou
D. Holcomb
S. Thomas
M. Tano
K. Robb
A. Lines
M. Harris
P. Thallapally
H. Felmy
B. McNamara
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H. Andrews
A. Abou Jaoude
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Thank you

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