July 2024 NS&T Highlights

September 2024

Addison M. Arave

Changing the World's Energy Future

INL Idaho National Laboratory

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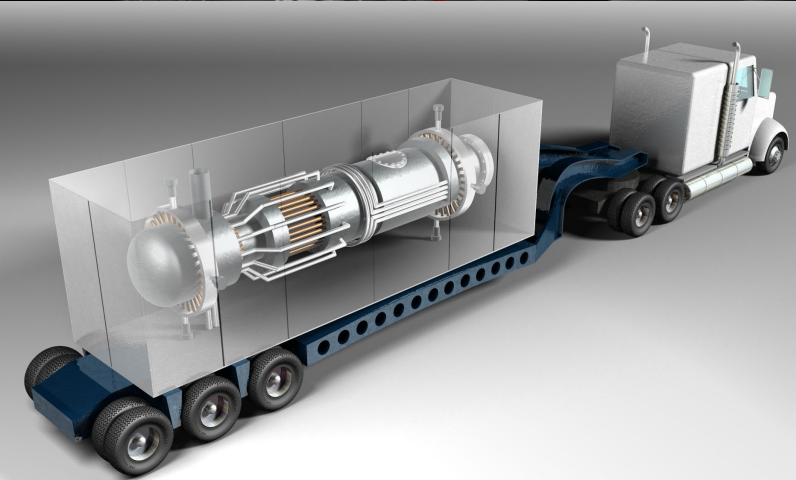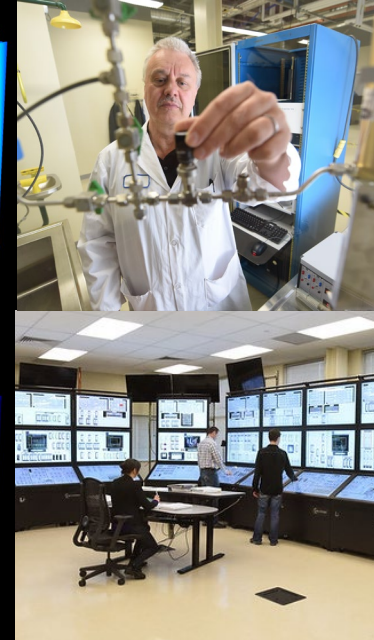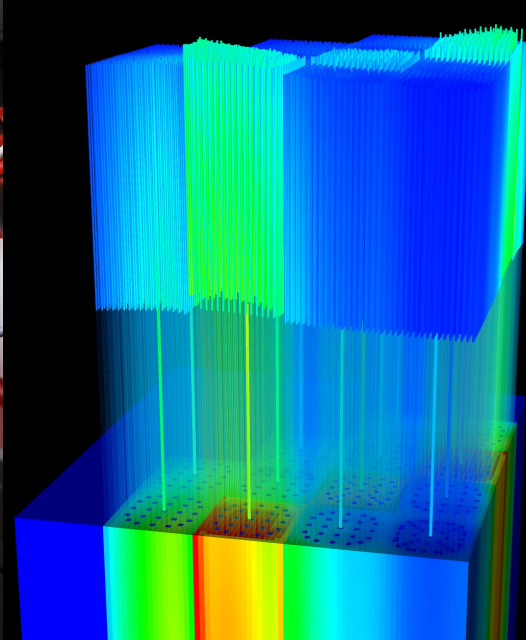
Nuclear Science & Technology

July 2024 Highlights

Idaho National Laboratory

High School Interns Demonstrated Reactor System Cyber Control using Raspberry Pi and Arduino Micro-Controller Kits

- High school interns Quentin Kester, Dee Tucker, Michael Clegg, and Karlie Purser worked in the Thermal Fluid Systems Methods & Analysis department, learning from Research & Development Staff Scientist Palash Bhowmik and Nuclear Engineer Kenneth Fossum.

- The interns worked on:
  - A hardware-based demonstration of reactor system remote monitoring, operation, control and cyber-attack scenarios.
  - A python-based code for various levels of cyber attacks, including specialized monitoring, reduced reactor power, reduced power isolated reactor condition, and reactor SCRAM (emergency shutdown).

- Raspberry Pi and Arduino microcontroller kits including sensors, Internet of Things (IoT) devices, and Power Line Communication (PLC) kits are used to demonstrate the system configuration.

DOE-NE Microreactor Program

MARVEL Technical Overview Summarizes Cost and Scope Growth Through 90% Final Design

- A full report of MARVEL's evolution and lessons learned from project initiation through the planning and design phases has been prepared to:
  - Benefit advanced reactor developers in their own planning and design.
  - Identify the cause(s) of MARVEL's cost and scope growth.
  - Present an overview of DOE's independent project assessment of MARVEL.
  - Document lessons learned with special focus on the Primary Coolant Apparatus Test (PCAT).
  - Identify that more extensive planning can eliminate or reduce cost and schedule growth later in the project.
- The report can be viewed here.
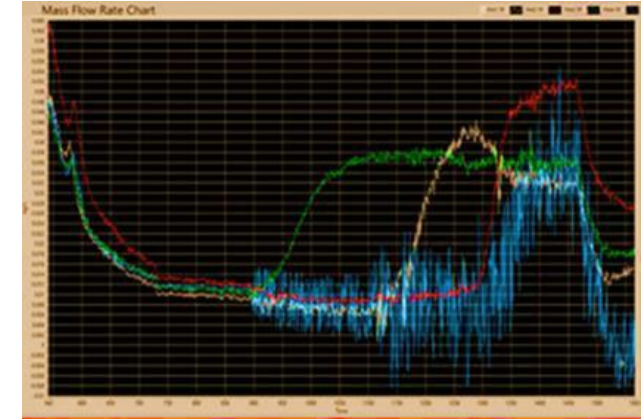
Screen shot showing the initiation of flow through 4 Stirling engines installed in PCAT
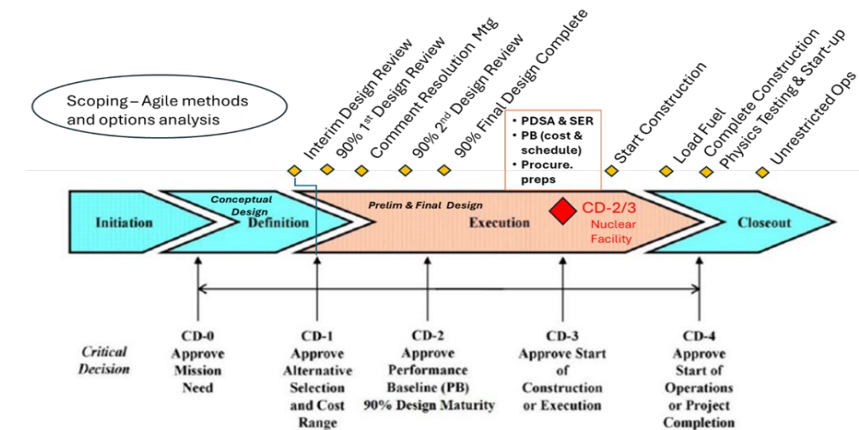
MARVEL project progression compared to DOE O 413.3B Phases and Critical Decisions

DOE-NE Integrated Energy Systems Program

Capability for Economic Parameter Uncertainty Quantification Added to Techno-Economic Analysis Tool

- The Framework for Optimization of Resources and Economics (FORCE) toolset now includes cost uncertainty within simulations.

- This new capability improves economic performance predictions for advanced reactors which have variance in projected costs.

- The Holistic Energy Resource Optimization Network (HERON) plugin within FORCE finds optimal sizes and operating strategies of integrated energy systems via stochastic, bi-level optimization.

- Uncertainty in market conditions is captured by simulating economic performance over multiple scenarios (e.g., electricity demand profiles, solar/wind availability) in the inner level.

- The new capability within the tool suite allows users to represent uncertainty in cost parameters (e.g., capital costs) as distributions which are now sampled in inner level (see top right figure).
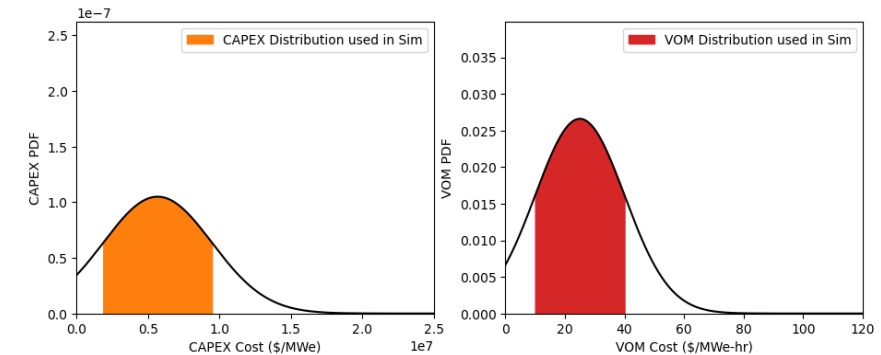
Uncertainty in capital costs (CAPEX) and variable operations & maintenance (VOM) costs as normal distributions in HERON.
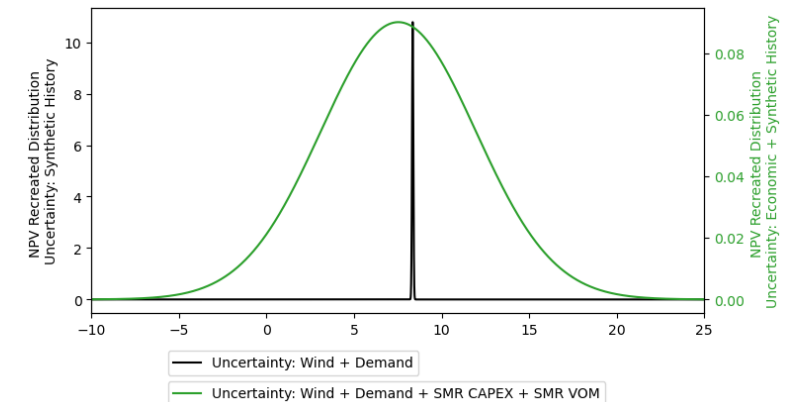
Net present value (NPV) distributions over two sets of N=50 samples: one with market uncertainty only ("synthetic histories") the other set with both market and cost uncertainty.

Automatic Reactor Control System Performs Successful Testing of Version 2.0 During Transient Reactor Test Facility Outage

- Upgrades in Automatic Reactor Control System (ARCS) v2.0 include:
  - Generic power segments to allow the segment to be defined by data points instead of two built-in spliced functions (i.e., ramps and periods = legacy methods), thus giving the capability to use any function in the definition.
  - Generic rod segments to extend the capability of ARCS to allow any rod movement to be defined instead of limiting to rod stops and rod drops.
  - Controlled shutdown to allow a "soft" shutdown to reduce downtime due to wear and tear on the rod drive systems.
  - New architecture to improved code efficiency for better determinism and to adapt for future changes.

Transient using the generic power segment to create the shape of Idaho.

George Mesina Elected as Chairman of the American Society of Mechanical Engineers Power Division

Dr. George L. Mesina was elected the Chairman of the American Society of Mechanical Engineers (ASME) Power Division and representative on the ASME TEC (Technical and Engineering Communities) Sector.

- The power division concerns itself with all aspects of power from modeling with thermal hydraulics and computational fluid dynamics fluid dynamics tools, to power production plants and maintenance, to prestigious awards, and everything in between including generative artificial intelligence, robots, and drones.

- As chairman, Mesina will:
  - Organize power division executive committee meetings.
  - Oversee the power division budget.
  - Expand power division membership, officer corps, and collaboration.
  - Review award applications and power conference papers.
  - Represent the power division in the ASME TEC sector.

Dr. George L. Mesina

Victor Coppo Leite Elected for Computational Fluid Dynamics Technical Committee in the American Society of Mechanical Engineers Fluids Engineering Division

Dr. Victor Coppo Leite will serve as secretary in the Computational Fluid Dynamics Technical Committee (CFDTC) in the American Society of Mechanical Engineers (ASME) Fluids Engineering Division (FED).

- The goal of the CFDTC is to develop, promote, coordinate, and disseminate computational fluid dynamics and related topics.

- As secretary, Leite will:
  - Assist in organizing and coordinating meetings and events.
  - Manage communication between the CFDTC and industry and research communities.
  - Propose strategies for engagement of participants in events.
  - Maintain records of decisions and activities of the CFDTC.

Dr. Victor Coppo Leite

Nuclear Regulatory Commission

INL Staff Delivers Training at Nuclear Regulatory Commission on Pebble Bed Reactor Modeling

- In May 2024, INL researchers conducted an invited training session for the Nuclear Regulatory Commission on modeling gas-cooled pebble-bed reactors to support the deployment of next-generation nuclear reactors.

- Training content included:

  - Neutronics and depletion modeling of pebble-bed reactors using Griffin.

  - Core thermal-hydraulics modeling with Pronghorn, featuring a detailed, step-by-step tutorial on code usage.

  - Integration of Pronghorn and SAM for multi-fidelity modeling of the reactor's primary loop.

  - Multiphysics coupling for enhanced core performance modeling.

HTR-PM Reactor Core Geometry

Tian, D., Shi L., Sun L., Zhang Z., Zhang Z., Zhang Z., "Installation of the graphite internals in HTR-PM", Nuclear Engineering and Design, 2020.
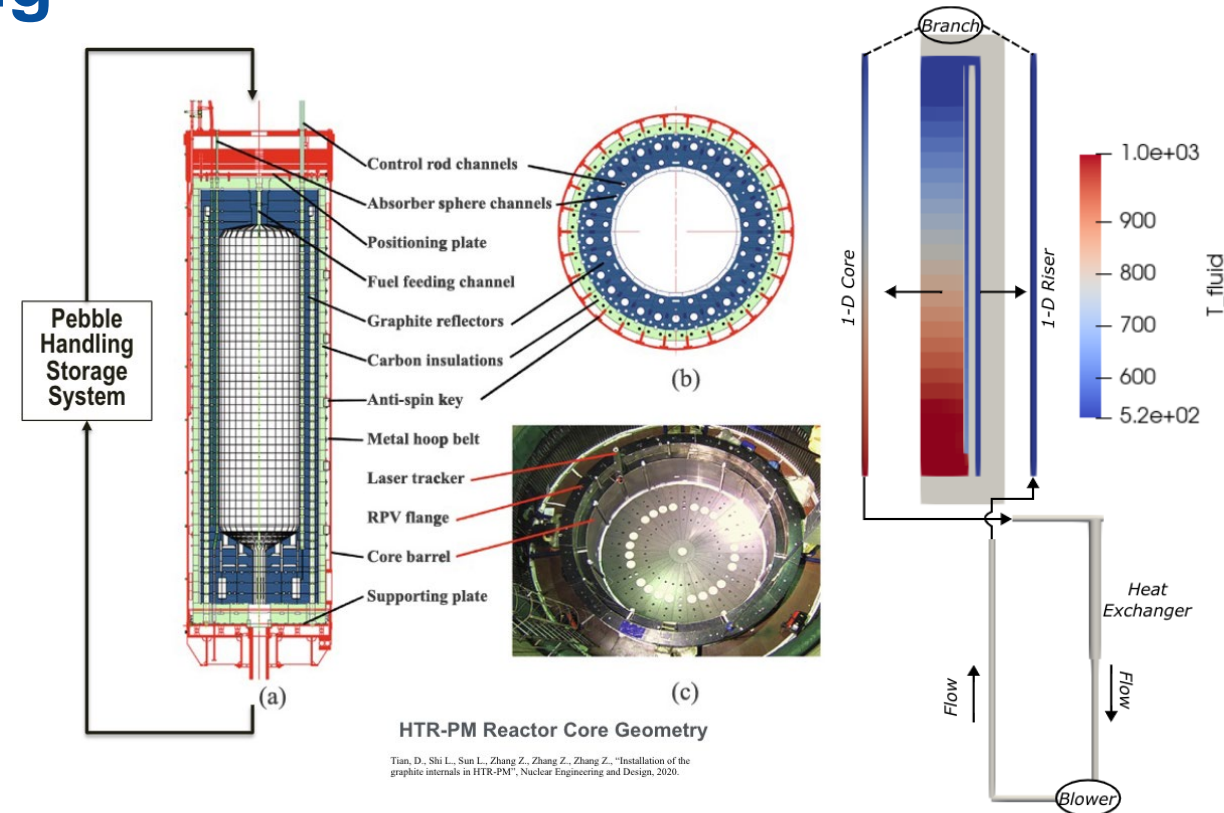
Left: High-Temperature gas-cooled Reactor Pebble-bed Module (HTR-PM) design.
Right: Coupled Griffin-Pronghorn-Systems Analysis Module multiphysics, multideity model of HTR-PM.

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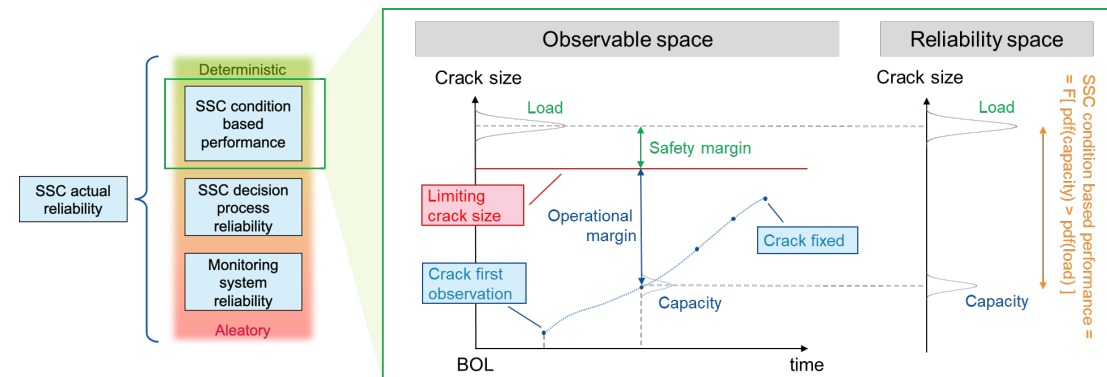
Nuclear Regulatory Commission

INL Presents at Nuclear Regulatory Commission Public Meeting on Advanced Reactor Risk Metrics and Data Analysis

- U.S. Nuclear Regulatory Commission (NRC) held a public meeting on July 18, 2024, to gather stakeholder feedback on development of risk metrics for non-light water reactors (NLWRs) and advanced reactor operating experience data, methods, and tools to support risk estimation.

- INL researchers, Dr. Sai Zhang and Dr. Diego Mandelli, presented INL perspectives on the advanced reactor risk and reliability parameter estimation and the intertwining of data, decisions, and reliability.

- The meeting solicited input and feedback to better prepare NRC staff for the upcoming NLWR license application reviews and help ensure smooth and timely review processes.

Public Workshop on Development of Risk Metrics to Support Implementation of Risk-Informed Programs for Advanced Reactors

July 18, 2024

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IDAHO NATIONAL LABORATORY

DOE-NE Light Water Reactor Sustainability Program

Ahmad Al Rashdan Gives Keynote Talk on AI Reliability and Common Misconceptions

- INL Senior Research & Development Scientist Ahmad Al Rashdan gave a keynote talk at the 2024 USA Nuclear Generator & Supplier Executive Summit on June 25–28 in Naples, Florida.

- He presented the Light Water Reactor Sustainability (LWRS) program's use of artificial intelligence (AI) to automate various aspects of nuclear power plant operations and maintenance, focusing on AI reliability and common misconceptions and emphasizing the need for high-quality AI solutions for successful deployment.

- The LWRS program is actively developing guidance and methods to address the broader challenges associated with deploying AI.

- LWRS Project Administrator Jodi Vollmer and Al Rashdan also networked with industry leaders at the event, strengthening the LWRS program's relationships with key stakeholders and opening doors for future partnerships or collaborations.

Nearly 450 attendees and guests from the industry came together to discuss "Nuclear Resilience in the Digital Revolution". Ahmad Al Rashdan (top-right).

DOE-NE Light Water Reactor Sustainability Program

Ahmad Al Rashdan Leads American Nuclear Society Efforts to Define AI Standards for the Nuclear Sector

- Ahmad Al Rashdan leads the American Nuclear Society (ANS) *ad hoc* committee developing artificial intelligence (AI) standards tailored for the nuclear industry and conducted a comprehensive survey among the ANS standards committee.

- The committee provided industry perspectives on AI applications in nuclear and highlighted strong support for developing standardized AI frameworks.

- Recommendations on AI standards will be submitted to the ANS standards board for consideration and adoption to help establish cohesive guidelines ensuring safe, effective and standardized integration of AI technologies across nuclear operations.

Ahmad Al Rashdan

DOE-NE Light Water Reactor Sustainability Program – Plant Modernization Pathway

Cost-Saving Strategies through Integrated Operations Presented to Nuclear Industry Leaders

- Thirteen nuclear utilities, vendors and research organizations attended the Light Water Reactor Sustainability (LWRS) Program's webinar on Integrated Operations in Nuclear (ION) on June 24.

- Participants received presentations detailing similarities between oil and gas and nuclear operations with the IO success criteria emphasizing the need for vertical and horizontal communication and collaboration through a data-centric model for faster and better decision-making.

- Three experts from the Institute for Energy Technology (Halden, Norway), with over 20 years of experience in Norwegian oil and gas IO transformation, shared valuable lessons applicable to the nuclear industry.

- Watch the full webinar recording here.
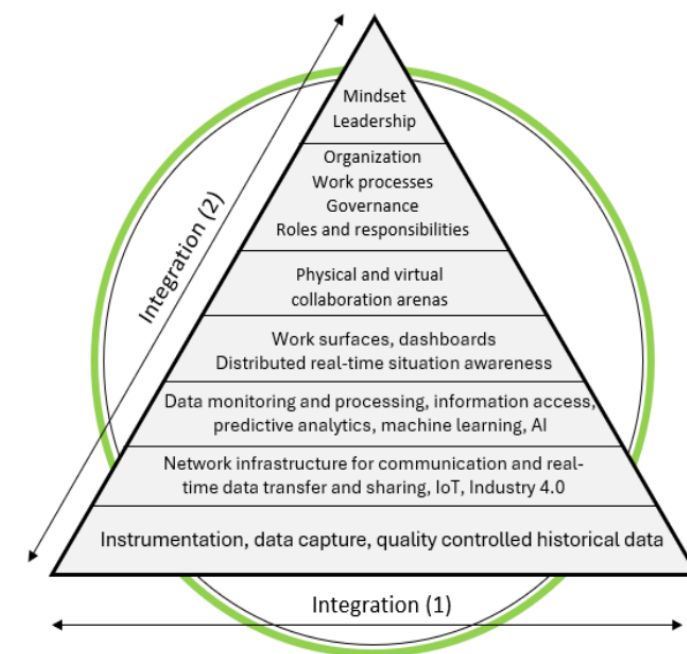
*Integrated operations criteria data-centric model for faster and better decision-making.*

DOE-NE Systems Analysis and Integration Program

Study Quantifies the Reduction in Capital Costs of Advanced Reactors Highlighted in a White House Press Release

- There are currently no committed orders for advanced reactors beyond the first-of-a-kind demonstrations (FOAK), and it is unclear how quickly their capital costs will reduce as more plants of the same kind are built.

- A Systems Analysis and Integration campaign funded study has developed an excel-based tool that quantifies the reduction in capital costs as more plants of the same kind are built through a committed order book.

- Four scenarios (ranging from optimistic to pessimistic FOAK project execution) were modeled to demonstrate the multiple potential paths to reach competitive costs.

- The study was highlighted in a White House Press Release in May and presented to the Organization for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) in June.
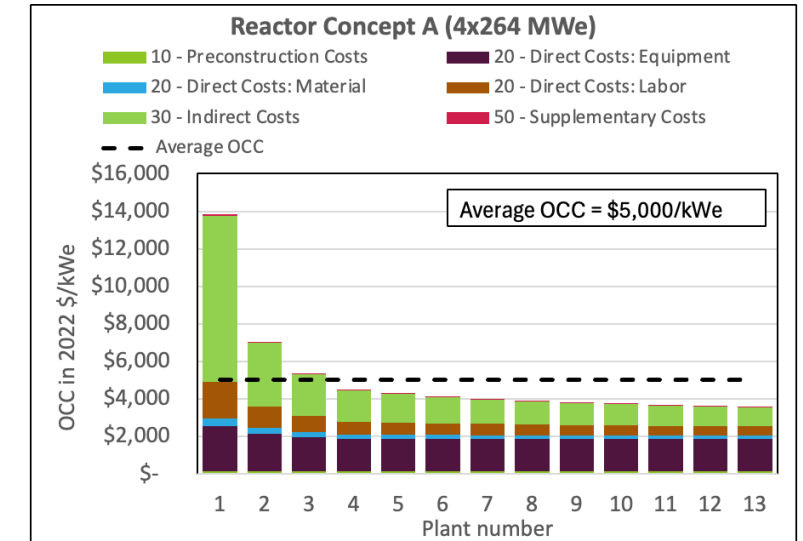
Reduction of overnight capital cost (OCC) as more plants of a reactor concept are built in a realistic scenario that starts with significant overruns in the FOAK plant. For an order book of 13 plants, the tool computes average cost of ~$5000/kWe and a final plant cost of ~$3600/kWe.

Title: Quantifying Capital Cost Reduction Pathways for Advanced Nuclear Reactors
Authors: Chandu Bolisetti, Abdalla Abou Jaoude, Botros Hanna, & Levi Larsen (INL), Jia Zhou (ANL), Koroush Shirvan (MIT)
Report Link: https://doi.org/10.2172/2361138
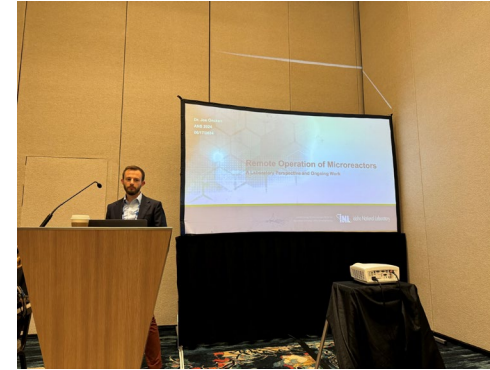**Tool Link**: https://inl.gov/content/uploads/2023/11/Nuclear-Reactor-Cost-Reduction-Pathway-Spreadsheet-Tool.xlsx

NUCLEAR RISK & REGULATORY RESEARCH | RISK PHENOMENA MODELING
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SA&i
SYSTEMS ANALYSIS
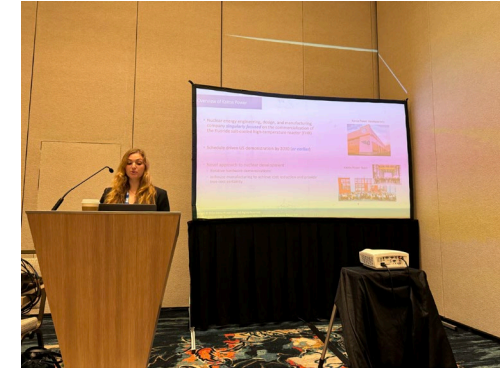AND INTEGRATION

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INL Organizes Remote Operation of Advanced Reactors Panel Discussion at American Nuclear Society Conference

- INL Researchers Vivek Agarwal and Joe Oncken hosted a panel session focused on Remote Operations for Advanced Reactors at the 2024 ANS Annual Conference in June featuring perspectives from across the nuclear industry.

- Many advanced reactor concepts incorporate some level of remote operations or monitoring into their design. This workshop was an opportunity for professionals from all corners of the nuclear industry to present their ongoing efforts in remote operations, and what actions need to be taken now to prepare for the deployment of remote operations.

- The workshop was organized after a need was identified to educate the nuclear community on the requirements, implications, and development needs to successfully bring remote operations to the industry.

Joe Oncken – INL

Clara Alivisatos – Kairos Power

Jesse Seymour – U.S. NRC

Stylianos Chatzidakis – Purdue University

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INL Program Development

INL Hosts Inaugural Workshop for Advanced Salt Based Technologies

- The workshop "Inaugural Molten Salt Technologies-Powering the Future" was held in May at INL.

- All five directorates at INL conduct work related to molten salt technology in support of INL's mission.

- Researchers and program leaders from national laboratories, private industries, and academic institutions met over a period of two days to share technical knowledge, research results, and opportunities for collaboration.

- Technology sectors including solar, geothermal, advanced nuclear energy, thermal transport, and rare-earth metals extraction were represented.

- This effort was the result of a working group at INL called Advanced Salt-Based Carbon Free Energy Technologies (ASCENT). The purpose of the working group is to provide a framework to connect numerous energy related research areas based on salt-based technologies to benefit stakeholders in industry, academia, and national laboratories.

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DOE-BES EFRC on Molten Salts in Extreme Environments

INL Researchers Invited to Organize Symposium at the 78th American Nuclear Society Northwest Regional Meeting

- The aim of the American Nuclear Society Northwest Regional Meeting was to promote communication between scientists and engineers from academia, industry, and government on interdisciplinary, multidisciplinary, and cross-disciplinary topics and studies in chemistry.

- INL researchers Ruchi Gakhar and Gregory Holmbeck joined Simerjeet Gill (Brookhaven National Laboratory) in organizing a symposium on *Exploring the Chemistry of Next-Generation Coolants and Solvents*, which involved 17 early-career and distinguished speakers.

- Contributing INL researchers included: Alejandro Ramos Ballesteros, Linu Malakkal, Maria Del Rocio Rodriguez Laguna, and Trishelle Copeland-Johnson.

NORM 2024 Symposium organizers and contributors (left to right): Alejandro Ramos Ballesteros, Trishelle Copeland-Johnson, Simerjeet Gill, Gregory Holmbeck, and Ruchi Gakhar.

FUEL CYCLE SCIENCE & TECHNOLOGY | CENTER FOR RADIATION CHEMISTRY RESEARCH
Gregory.Holmbeck@inl.gov and Ruchi.Gakhar@inl.gov

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ARPA-E

Michael Woods Receives ARPA-E Funding Award for Early-Career Researchers

- Dr. Michael Woods has been selected as an awardee in the initial cohort of the Advanced Research Project Agency-Energy (ARPA-E) Inspiring Generations of New Innovators to Impact Technologies in Energy (IGNIITE) program.

- This program is focused on early-career scientists and engineers converting disruptive ideas into impactful energy technologies and provides $500,000 for a two-year project.

- Dr. Woods's project will investigate the use of brazing for joining salt-facing materials for molten salt energy technologies, including molten salt nuclear reactors and thermal energy storage systems.

- His research at Idaho National Laboratory focuses on the corrosion of materials in molten salts and chemical processing for molten salt reactors and used fuel.

Dr. Michael Woods

National Reactor Innovation Center (NRIC) Submits Draft Environmental Assessment for DOME Experiments

- The submission of the draft environmental assessment to the Department of Energy Idaho Operations Office marks a major accomplishment to the effort of accelerating advanced reactor experiments within the Demonstration of Microreactor Experiments, or DOME test bed.

- The environmental assessment strategy uses a Plant Parameter Envelope that provides engineered and site parameters to advanced reactor developers.

- If applicable to their experiment, then no further National Environmental Policy Act analysis will be needed.

Tommy Fuerst Elected to Vice-Chair/Chair-Elect for the American Nuclear Society Fusin Energy Division

- Dr. Tommy Fuerst is a fusion scientist with expertise in tritium permeable membranes.

- The vice-chair position for the American Nuclear Society Fusion Energy Division must be elected from among previously serving Executive Committee members.

- After serving for a 2-year period, Dr. Fuerst will become the Chair for the Fusion Energy Division.

- The Fusion Energy Division of ANS hosts the Technology of Fusion Energy (TOFE) conference and promotes the development and timely introduction of fusion energy.
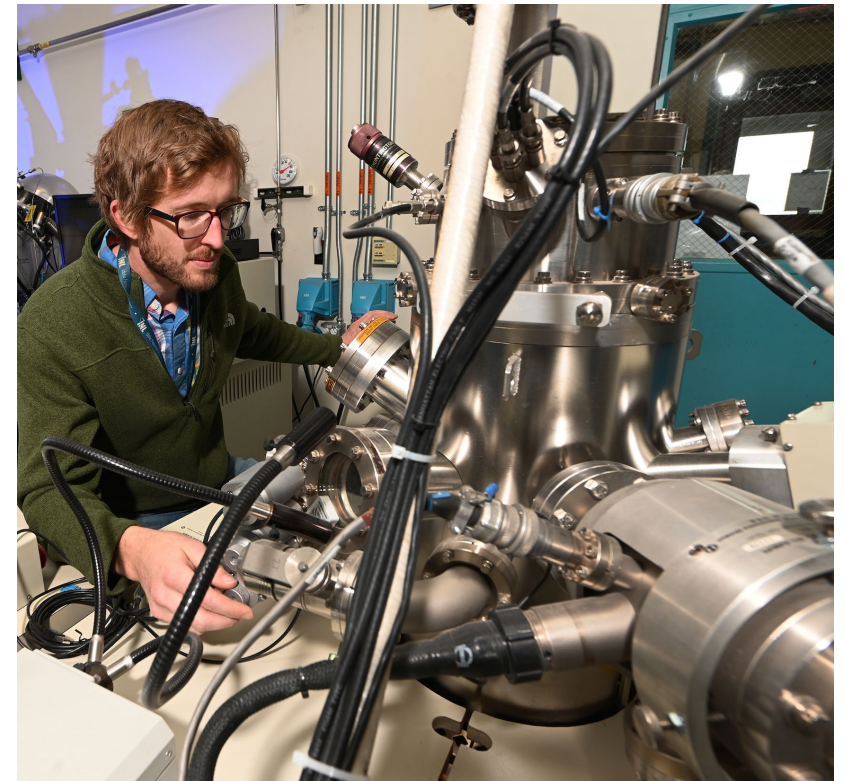
Tommy Fuerst analyzing fusion materials at the Safety and Tritium Applied Research (STAR) facility.

INL Researchers Provide Significant Contributions to the 26th Technology of Fusion Energy Conference

- The Technology of Fusion Energy Conference is the premier domestic event for fusion energy technology.

- It is organized by the Fusion Energy Division (FED) of the American Nuclear Society (ANS), and with over 400 participants, the 2024 gathering was one of the largest TOFE conferences to date.

- Researchers at INL contributed 12 technical oral presentations, two poster presentations, and four chaired sessions

- INL hosted an exhibitor booth where INL personnel engaged with students and researchers about the growing career opportunities in fusion energy at INL.

- ANS FED leadership from INL include: Thomas Fuerst as vice-chair, Pierre-Clément Simon on the executive committee, and Chase Taylor as webmaster.

INL personnel in front of the exhibitor booth at the conference. Left to right: Anthony Bowers, Masa Shimada, Casey Icenhour, PC Simon, Thomas Fuerst, Lane Carasik (VCU joint appointee), Ad Riet, Mike Worrall, Hanns Gietl, and Youssef Ballout.

Publications

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