INL/MIS-23-73234-Revision-0

Nuclear Science & Technology May 2023 Highlights

July 2023

Addison Marie Arave

Changing the World's Energy Future

Idaho National Laboratory

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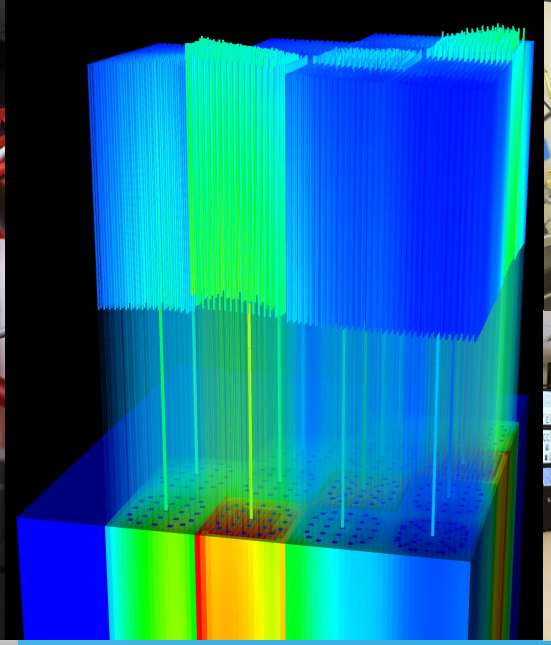
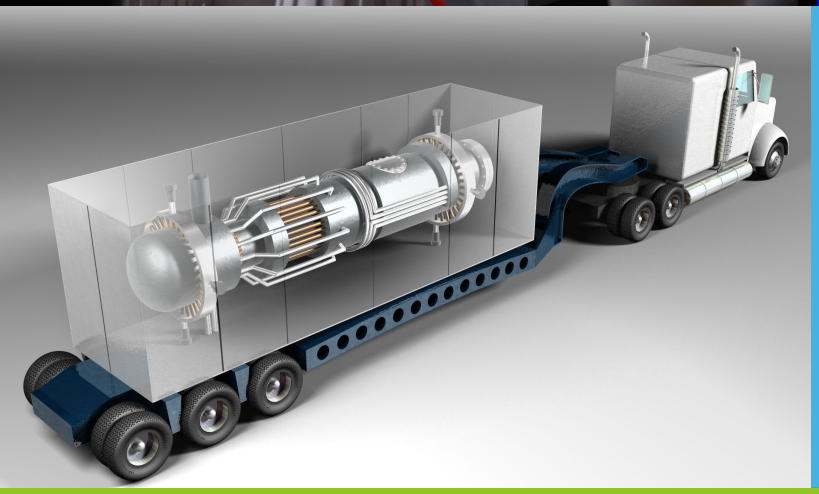


Nuclear Science & Technology

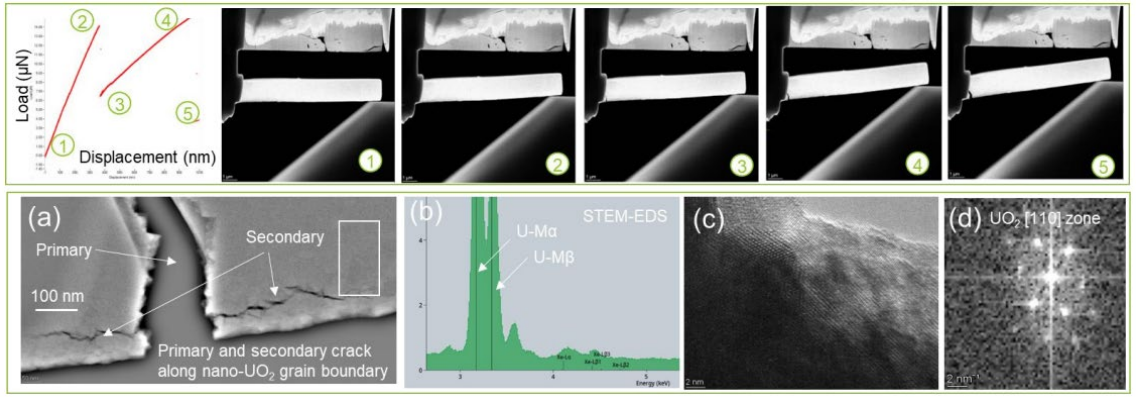
May 2023 Highlights

Idaho National Laboratory

DOE-NE Nuclear Science User Facilities

Research Team Observes Fracture Behavior of Xe-irradiated Nanograined UO_2

- A research team at the Materials and Fuels Complex (MFC) performed in situ cantilever bending tests in the Idaho National Laboratory (INL) Irradiated Materials Characterization Laboratory's Titan transmission electron microscope (TEM) with a PI 95 picoindenter to examine the fracture behavior of Xe-irradiated nanograined UO_2.
- The experimental study revealed multiple cracking stages during the fracture process (shown below – top row). The team characterized the post-fracture crack region via various TEM-based techniques (shown below – bottom row).
- This capability directly enabled the study of mechanical behavior and was used on an ultrafine-grained ion-irradiated sample to support the mechanistic understanding of fracture behavior.
- This research was prompted after a completed Rapid Turnaround Experiment.



Top: Load versus displacement under various fracture stages.

Bottom: Post-fracture crack region characterization by (a) high-angle annular dark field image; (b) Scanning/transmission electron microscope energy dispersive spectroscopy spectrum; (c) High-resolution TEM image; and (d) fast Fourier transform of image c showing the crystal structure of UO_2 grains next to the primary crack.

Nuclear Science User Facilities

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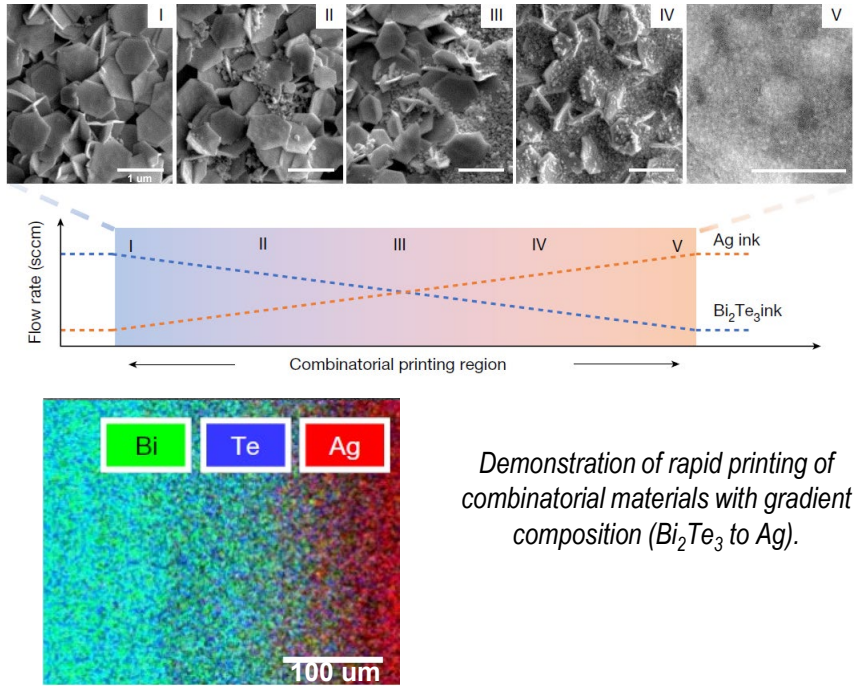
DOE-NE Advanced Sensors and Instrumentation Program

Researchers Develop a High-Throughput Method to Create New Advanced Materials

- INL collaborated with the University of Notre Dame to develop an aerosol jet printing technique capable of creating graded compositions and fabricating materials at small resolution.
  - This capability has applications in material discovery studies and sensors and instrumentation applications for multi-modal sensors and advanced passive sensors.
- This in situ mixing and printing method facilitates real-time tweaks on the ratio of mixed materials, which is an important feature unavailable in most conventional multi-material printing methods, such as those using feedstocks in liquid–liquid or solid–solid phases.
- INL contributed to a Nature publication on this work led by the University of Notre Dame. This was one of a small handful of papers on additive manufacturing published in Nature.
  - The new method outlined in this paper promises the development of compositionally complex materials inaccessible via conventional manufacturing approaches.
  - INL worked directly with the University of Notre Dame for this work, though other contributors also collaborated with Notre Dame.



Demonstration of rapid printing of combinatorial materials with gradient composition (Bi_2Te_3 to Ag).

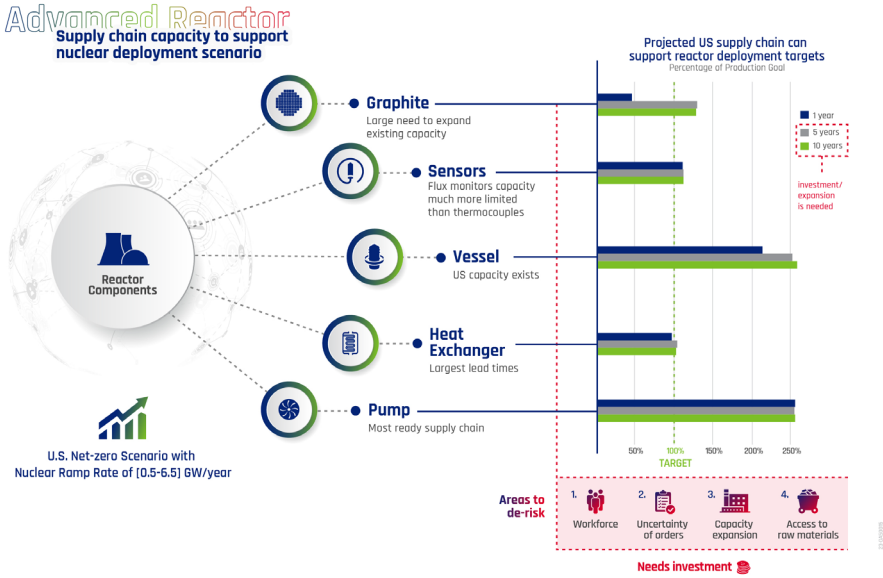
Title: High-throughput printing of combinatorial materials from aerosols
Authors M. Zeng, Y. Du, Q. Jiang, N. Kempf, C. Wei, M. Bimrose, A. Tanvir, H. Xu, J. Chen, D. Kirsch, J. Martin, B. Wyatt, T. Hayashi, M. Saiedi-Javash, H. Sakaue, B. Anasori, L. Jin, **M. McMurtrey**, Y. Zhang
Journal: Nature
Link: DOI: 10.1038/s41586-023-05898-9

Research Highlight

DOE-NE Gateway for Accelerated Innovation in Nuclear

Advanced Reactor Supply Chain Assessment Identifies Nuclear Deployment Needs within 5 to 10 years

- Gateway for Accelerated Innovation in Nuclear (GAIN) and contributors at Idaho National Laboratory produced an Advanced Reactor Supply Chain report released on May 19. This report assesses the needs for advanced nuclear deployment. The focus was specific to:
  - Vessels, nuclear graphite, pumps, heat exchangers, and sensors.
- GAIN surveyed 20+ companies on current capacities and projections for 5–10 year timeframes.
- For initial deployment, there is a domestic supply chain and companies are willing to ramp up production assuming the following hurdles can be overcome:
  - Workforce issues
  - Increased capacity to meet 5 year and 10 year targets (investment will be needed)
  - Companies are unwilling to invest without certainty of orders or other items that will secure that investment
  - Some companies need access to raw materials
- This information builds on prior United States Department of Energy (DOE) supply chain work but does not necessarily reflect the views of DOE.



Overview of the advanced reactor supply chain assessment for the various components considered in this study.

Title: Advanced Reactor Supply Chain Assessment
Authors: Christopher Lohse (GAIN), Abdalla Abou-Jaoude (INL), William D. Jenson (INL) and Ian Prado (INL)
Journal: U.S. Department of Energy Office of Scientific and Technical Information
Link: https://www.osti.gov/biblio/1973747

GATTEWAY FOR ACCELARATED INNOVATION IN NUCLEAR
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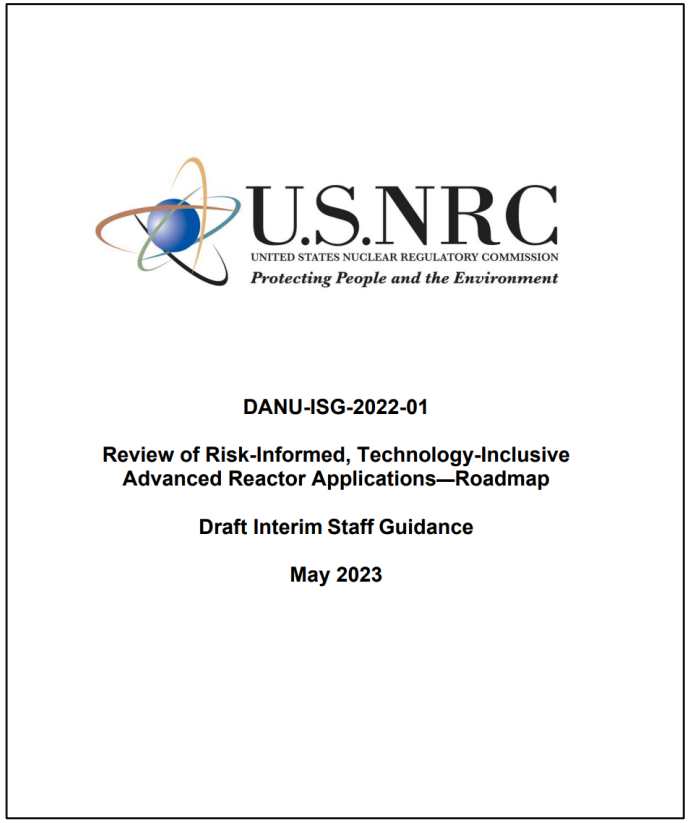
Nuclear Regulatory Commission Advanced Reactor Content of Applications Program

First-Ever Complete Technology-Neutral Advanced Reactor Licensing Guidance Released for Public Comment

- The industry-led, Department of Energy-funded, Technology-Inclusive Content of Applications Project (TICAP) built on the Licensing Modernization Project's (LMP) risk/consequence-based approach. This approach is to develop portions of an advanced reactor application under 10 Code of Federal Regulations Parts 50 and 52.
- For the last two years, INL and the Nuclear Regulatory Commission (NRC) have reviewed industry TICAP proposals and drafted the remaining application guidance documents needed for licensing under the Advanced Reactor Content of Application Project (ARCAP).
- The NRC has issued the draft ARCAP roadmap regulatory guide as interim staff guidance (ISG) to support near-term applications. This includes the DOE's two Advanced Reactor Demonstration awardees. NRC also issued 8 additional ISGs to inform advanced reactor applications.
- The draft NRC regulatory guide that formally endorses TICAP was also issued, completing the guidance for a 12-chapter Safety Analysis Report that utilizes the LMP methodology.


U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

DANU-ISG-2022-01

Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications—Roadmap

Draft Interim Staff Guidance

May 2023

Draft Regulatory Guide issued as Interim Staff Guidance.

NUCLEAR SAFETY & REGULATORY RESEARCH | REGULATORY SUPPORT
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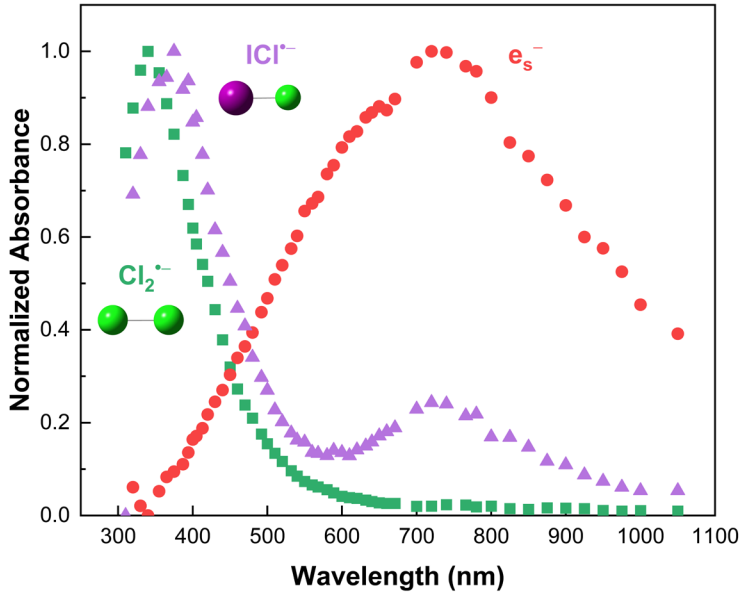
DOE Office of Science Basic Energy Sciences, Chemical and Materials Sciences to Advance Clean Energy Technologies and Low-Carbon Manufacturing

Researchers Measure Radiation-Induced Interhalogen Chemistry in Molten Salts for the First Time

- A new ionic compound species, iodine-chlorine radical anion (ICl•–), has been identified for the first time in a molten salt eutectic.
- The fundamental understanding of iodine species in molten salts is essential to the deployment of next generation molten salt reactor technologies.
- Pulsed electron irradiations using the Brookhaven National Laboratory Laser Electron Accelerator Facility were employed to investigate the impact of iodide ions on the fundamental radiation chemistry occurring in molten chloride salt mixtures.
- This study determined that the new interhalogen species (ICl•–) exhibited a lifetime on the order of microseconds and likely has significant implications for the transport and accumulation of iodine in molten salt reactor environments.



Normalized, deconvoluted transient spectra from the electron pulse irradiation of molten KI (10 wt.%) in LiCl-KCl eutectic at 400 °C. (ICl•– = iodine-chlorine radical anion, $Cl_2^{\bullet-}$ = dichlorine radical anion, and e_S^- = solvated electron).

Title: Impact of Iodide Ions on the Speciation of Radiolytic Transients in Molten LiCl-KCl Eutectic Salt Mixtures
Journal: Physical Chemistry Chemical Physics
Authors: Jacy K. Conrad, Kazuhiro Iwamatsu, Michael E. Woods, Ruchi Gakhar, Bobby Layne, Andrew R. Cook, and Gregory P. Horne
Link: https://doi.org/10.1039/d3cp01477k

NUCLEAR SCIENCE & TECHNOLOGY | CENTER FOR RADIATION CHEMISTRY RESEARCH
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Research Highlight

DOE-NE Nuclear Energy Advanced Modeling and Simulation Program

New TimeStepper System Enables Arbitrary Transient Simulation Time Complexity in MOOSE

- Multiphysics simulations rely on numerical time stepping methods to discretize simulation of transient phenomena in time.
- The TimeStepper in MOOSE (Multiphysics Object Oriented Simulation Environment) determines the time steps during transients. Various basic regimes for stepping through the simulation were available, but only one could be used at a time.
- The new TimeStepper System supports composing multiple stepping regimes and customized activation of time steppers during the simulation.
- This capability simplifies the workflow for complex time stepping in Multiphysics simulations, provides more flexibility for customized time stepping regimes, and better supports the modeling of engineering scale Multiphysics simulations.

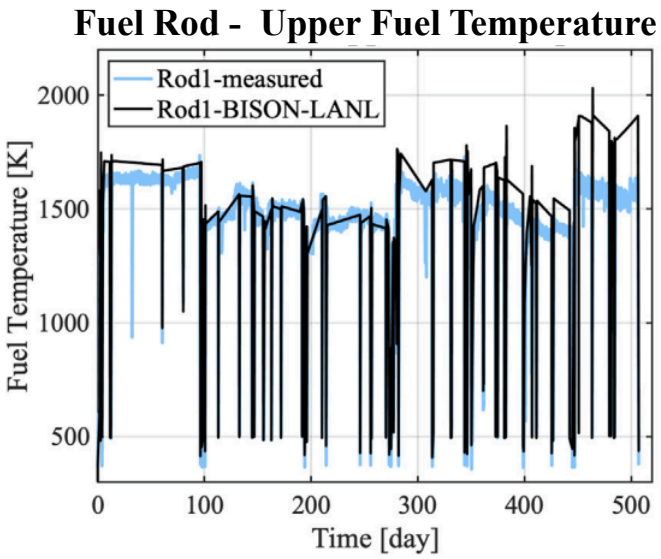

Fig.1: Example of time history in fuel performance simulation[1]. The TimeStepper system will provide a simple solution to follow such complex time stepping in transient fuel temperature modeling.

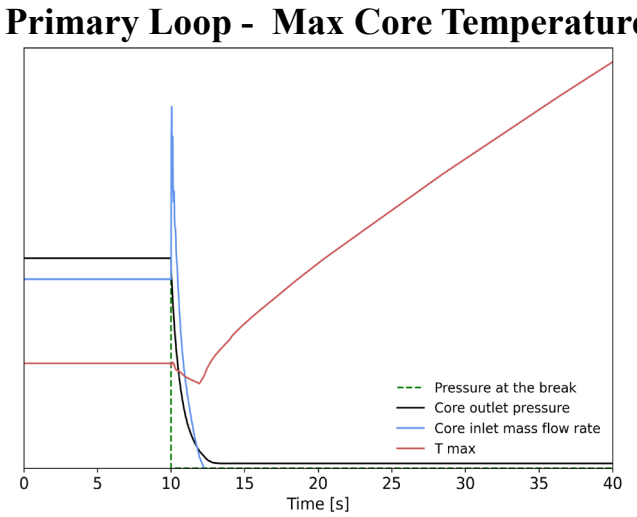

Fig.2: Example of a full primary loop simulation with a hot leg break (credit to Lise Charlot). The TimeStepper system can support a small step at the break to capture the rapid change physics and another time stepper for the slowly increase temperature in the fuel.

Title: Application of Kriging and Variational Bayesian Monte Carlo method for improved prediction of doped UO2 fission gas release
Authors: Yifeng Che, Xu Wu, Giovanni Pastore, Wei Li, Koroush Shirvan
Journal: Annals of Nuclear Energy
Link: https://doi.org/10.1016/j.anucene.2020.108046

ADVANCED SCIENTIFIC COMPUTING | COMPUTATIONAL FRAMEWORKS
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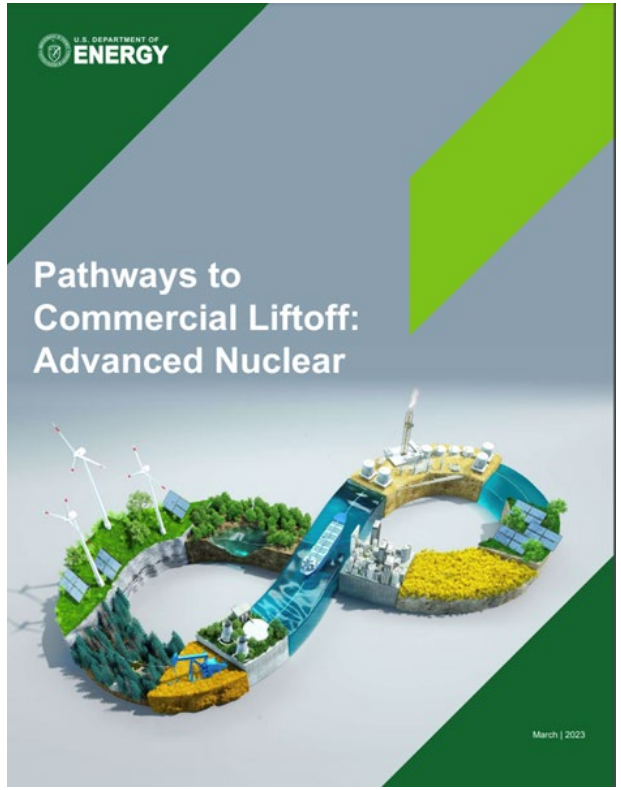
MOOSE

IDAHO NATIONAL LABORATORY

Department of Energy

Department of Energy Releases Report on Pathways to Commercial Liftoff of Advanced Nuclear

- This report is designed to help industry, investors, and stakeholders make decisions about the emerging technologies that are needed to slash greenhouse gas emissions by highlighting possible solutions to overcome barriers and achieve widespread commercialization.
- U.S. domestic nuclear capacity has the potential to scale from ~100 GW in 2023 to ~300 GW by 2050—driven by deployment of advanced nuclear technologies.
- Advanced nuclear includes a range of proven and innovative technologies.
- Advanced nuclear provides a differentiated value proposition for a decarbonized grid.
  - Nuclear energy generates carbon-free electricity, provides stable power that complements renewables, has low land-use requirements, and has lower transmission requirements than distributed or site-constrained generation sources.
- An initial order book of 5–10 (likely) Generation III+SMRs by 2025 would catalyze follow-on growth of the advanced nuclear industry.
- Andrew Foss, currently on detail assignment from INL to the DOE Office of Policy, worked closely with DOE colleagues to prepare the report.



Title: Pathways to Commercial Liftoff: Advanced Nuclear
Authors: DOE Loan Programs Office, Office of Technology Transfer, Office of Nuclear Energy, Office of Clean Energy Demonstrations, Office of Policy, and Argonne National Laboratory
Link: doi.org/https://liftoff.energy.gov/wp-content/uploads/2023/03/20230320-Liftoff-Advanced-Nuclear-vPUB.pdf

REACTOR SYSTEMS DESIGN & ANALYSIS | INTEGRATED ENERGY & MARKET ANALYSIS
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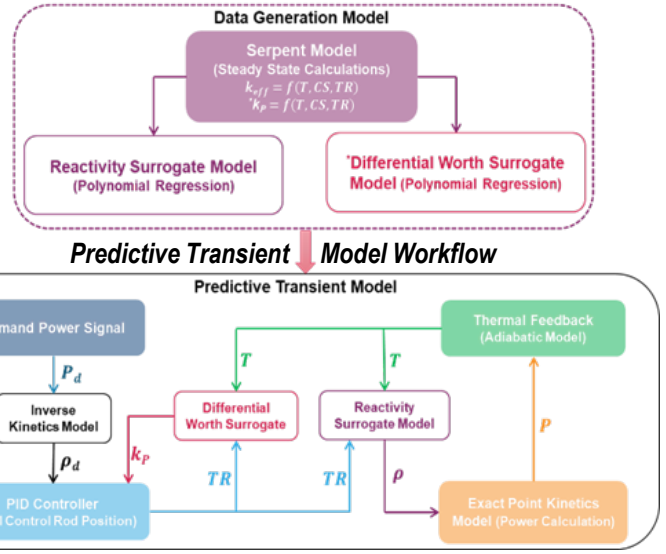
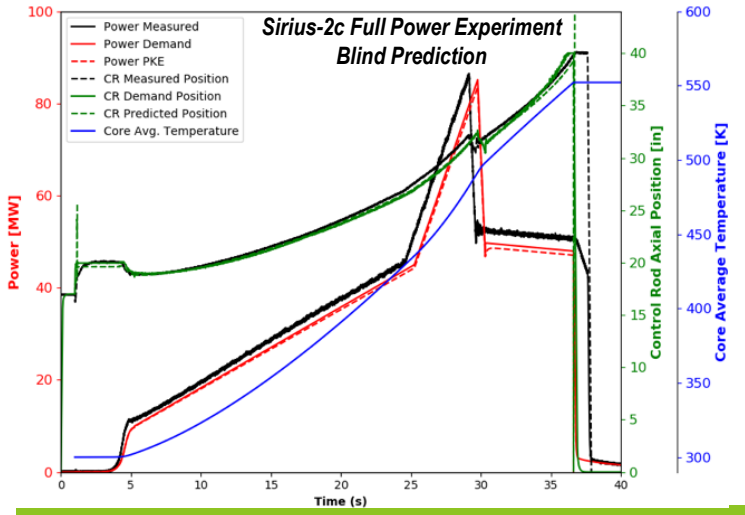
Research Highlight

NASA Space Nuclear Propulsion Project

Researchers Develop Predictive Transient Model for TREAT-Sirius Experiments

- An improved predictive transient model was developed to support analysis for the National Aeronautics and Space Administration (NASA)-sponsored Sirius experiments in the Transient Reactor Test Facility (TREAT).
- The model relies on two surrogate models based on MOOSE stochastic tools and steady state Serpent calculations to predict the control rod axial position and its corresponding reactivity during a transient.
- The model has the following components:
  - **Data Generation:** Performs steady state analysis using Serpent code to generate reactivity data points and differential worth coefficients as a function of control rod axial positions and fuel average temperature.
  - **Inverse Kinetics:** Converts the demand power signal into a reactivity signal.
  - **Differential Worth Surrogate:** Predicts the differential rod worth coefficients based on Serpent calculations.
  - **Proportional Controller:** Determines the equivalent-reactivity control rod axial position.
  - **Reactivity Insertion Surrogate:** Calculates the inserted reactivity from axial control rod movements and core average temperature.
  - **Adiabatic Feedback:** Determines average fuel temperature at each time point.
  - **Point Kinetics:** Calculates the total reactor power with given reactivity and kinetics parameters during the transient.
- The model was validated against Sirius-1 experimental data and utilized to perform Sirius-2c blind prediction.
- The model contributes to the long distance nuclear thermal propulsion (NTP) mission by providing a critical capability for NTP modeling.





REACTOR SYSTEMS DESIGN & ANALYSIS | REACTOR PHYSICS METHODS & ANALYSIS
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DOE-NE Advanced Reactor Technologies - Gas Cooled Reactors Program

Database Constructed for High-Temperature Gas-Cooled Reactor Thermal-Hydraulic Experimental Facilities

- A total of 33 projects focused on high-temperature gas-cooled reactor (HTGR) research have been funded by the U.S. Department of Energy (DOE) under the Nuclear Energy University Program (NEUP) since 2009, representing an investment of $26 million. The data and detailed results obtained for these experiments are, in most cases, still located at the universities and cannot be publicly accessed.
- To improve access to this valuable HTGR validation dataset and optimize the return on the significant investment made by DOE, the Advanced Reactor Technologies (ART) - Gas Cooled Reactors (GCR) program has started a survey of current and completed HTGR NEUP projects to develop a public-access database. This database can be used to retrieve computational fluid dynamics and system code validation data.
- The published INL report provides an overview of the research projects and identifies validation knowledge gaps still existing in HTGR thermal-fluid research. The HTGR database development is aimed to guide future NEUP-funded research and promote the use of existing high-quality data in future code verification and validation matrices.

FINISHED NEUP PROJECT # in RED / ONGOING NEUP PROJECTS # in BLUE			SCENARIOS				
			NORMAL OPERATION	PRESSURIZED LOSS OF FLOW	DEPRESSURIZED LOSS OF FLOW	LOAD CHANGE (TRANSIENT)	STEAM GENERATOR TUBE BREAK
PHENOMENA	PLENUM MIXING / JET IMPINGEMENT	LOWER PLENUM	12-3582, 15-8627	16-10244	16-10244		
		UPPER PLENUM	12-3759	18-15058	18-15058		
		PLENUM TO PLENUM	13-4953, 16-10509	20-20074	20-20074		
	INGRESS	AIR INGRESS		15-8205, 20-19896	09-784, 15-8205, 13-4884, 17-13115, 14-6435, 20-19896		14-6786, 19-17183
		STEAM/WATER INGRESS		18-15058	18-15058, 21-24111		14-6786
	CONJUGATE HEAT TRANSFER (CORE)	FORCED CONVECTION	09-771, 21-24104, 11-3081, 21-24287, 16-10509	11-3218, 21-24104, 21-24287	11-3218, 21-24156		
		NATURAL CONVECTION	14-6794, 16-10509	14-6794	14-6435, 21-24156		
	RCCS PERFORMANCE		09-781, 13-4953, 09-817, 20-19896, 11-3079	20-19896	20-19896	09-781, 11-3079, 09-817, 13-5000	
	CORE BYPASS FLOW		09-830, 15-8627, 20-19968	15-8205	09-840, 15-8205		
	FLUID STRATIFICATION				14-6435		
	MULTI-PHYSICS (FISSION PRODUCT, SAFETY ANALYSIS, THERMAL-MECHANICAL, ETC.)		20-19896, 22-26607	20-19896	19-17037, 21-24111, 20-19896, 21-24156	22-26607	

Thermal-fluids phenomena summary (FY09-22) for HTGR-related NEUP projects.

Title: High-Temperature Gas-Cooled Reactor Research Survey and Overview: Preliminary Data Platform Construction for the Nuclear Energy University Program
Authors: Sunming Qin & Gerhard Strydom, Cam Binh T Pham, Minseop Song, Stefan H. Vietz, Mitchell A. Plummer
Link: https://doi.org/10.2172/1887092

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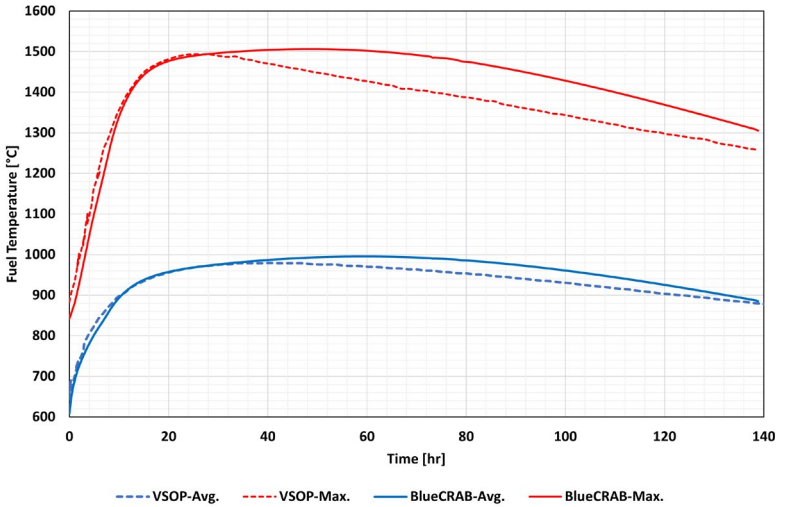
Nuclear Regulatory Commission Advanced Nuclear Reactor Modeling Project

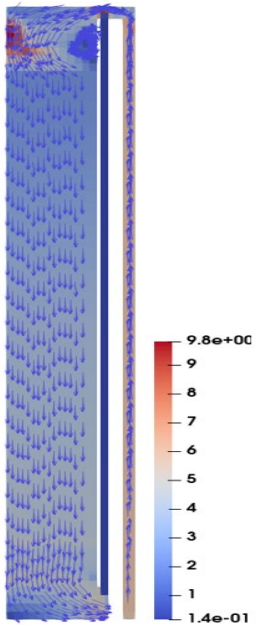
Researchers Model Depressurized Loss-Of-Forced-Cooling Event of High-Temperature Gas-Cooled Reactor - Pebble-Bed Module

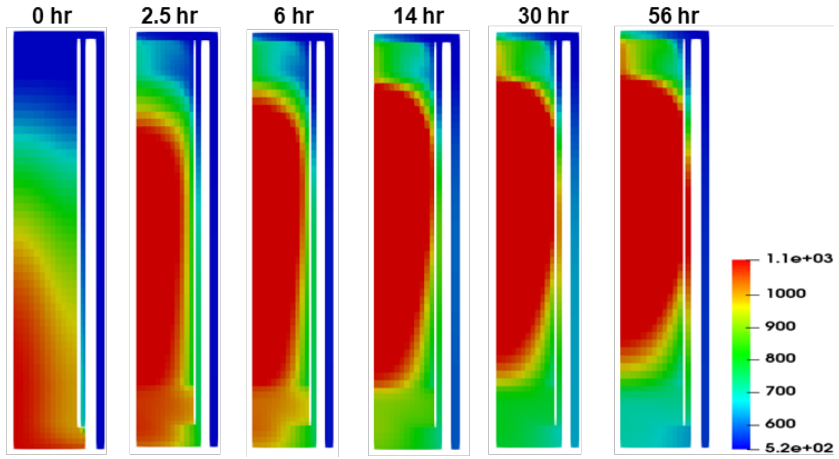
- To support the Nuclear Regulatory Commission's (NRC) efforts to develop and model support for advanced non-light water reactors, an equilibrium full core model was developed for the reference High-Temperature Gas-Cooled Reactor - Pebble-Bed Module (HTR-PM) reactor.
- The model couples the following codes to perform Multiphysics analysis:
  - **Griffin:** Solves reactor physics parameters including equilibrium core depletion and transient solutions.
  - **Pronghorn:** Solves porous medium equations for the fluid regions and conduction in the solid regions.
  - **BISON:** Solves thermal conduction problems for pebbles in the pebble-bed core to provide fuel and moderator spatial temperature fields.

Fuel Temperature Evolution during DLOFC Transient Scenario.



Velocity Field





Fluid Temperature Evolution During DLOFC Transient Scenario.

- The developed model of the HTR-PM was used to perform equilibrium core steady state calculations and depressurized loss of forced cooling accidents.
  - Numerical test results show very good agreement with published Very Superior Old Programs results.
  - Steady state solution: eigenvalue within 150 pcm, power peaking factor within 0.2%.
  - Transient solution: average and maximum temperatures are within 1%.
- The model contributes to the NRC mission of licensing Pebble-Bed Reactors by providing the necessary capabilities for Multiphysics modeling and simulation.

REACTOR SYSTEMS DESIGN & ANALYSIS | REACTOR PHYSICS METHODS & ANALYSIS
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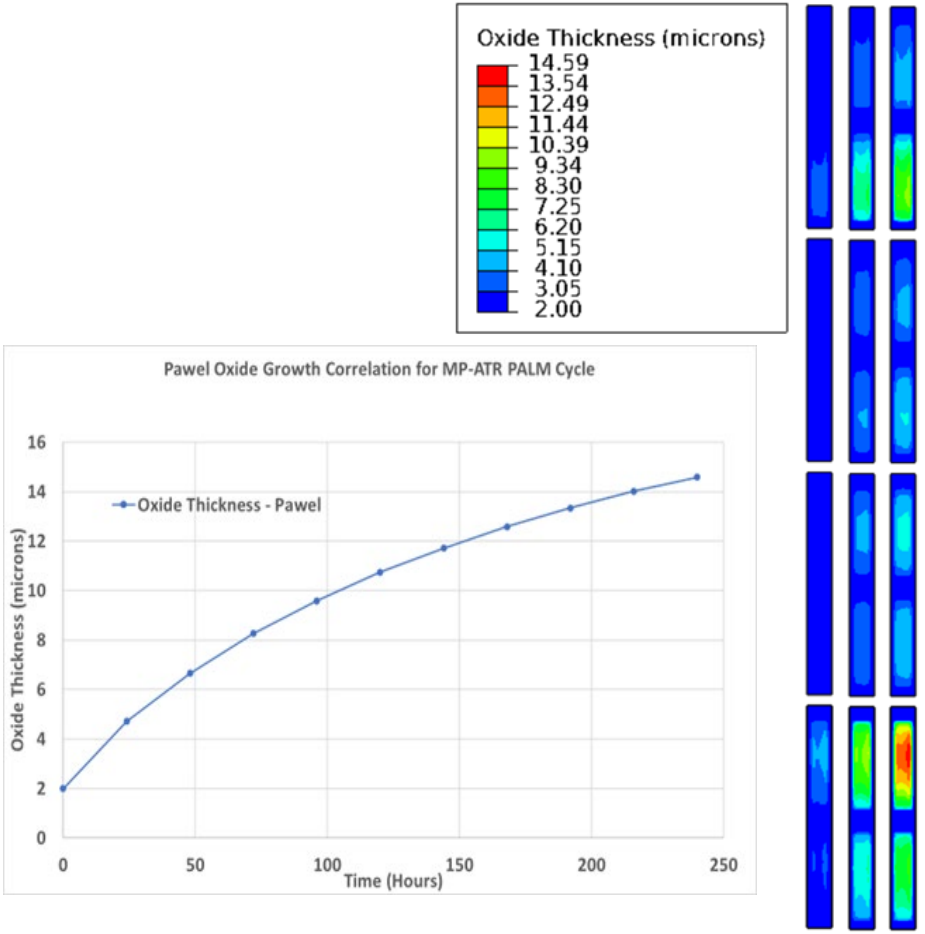
NNSA Material Management and Minimization Reactor Conversion Program

Oxide Growth Implemented During an Advanced Test Reactor Powered Axial Locator Mechanism Cycle

- Mini-Plate-ATR (MP-ATR) is a fueled experiment being irradiated during a high-power Advanced Test Reactor (ATR) Powered Axial Locator Mechanism (PALM) cycle.
- A PALM cycle occurs when the irradiation cycle utilizes the PALM to change the axial position of different experiments to simulate different reactor conditions.
- A PALM cycle in ATR typically is run at higher reactor power and increased reactor coolant pressure than normal cycles.
- The MP-ATR high-power experiment required the use of the Pawel correlation, which predicts oxide growth on aluminum-clad fuel plates with high surface heat flux and surface temperature conditions. This is due to it having a built-in sensitivity to heat flux and the ability to accommodate higher heat flux ranges than other correlations.
- This work resulted in increased confidence in using the Pawel correlation for predicting oxide for aluminum-clad fuel plates during an ATR PALM cycle for the MP-ATR experiment.



Oxide thickness for the MP-ATR experiment at 24 hours, 120 hours, and 240 hours.

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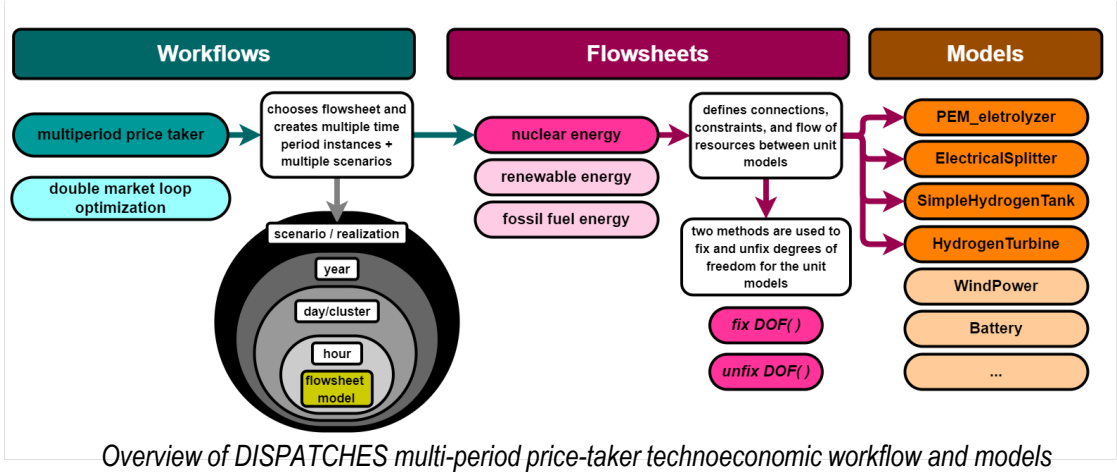
DOE-NE Integrated Energy Systems Program

Researchers Enhance Technoeconomic Analysis by Integrating with Additional Software

- The open-source Framework for Optimization of Resources and Economics (FORCE) tool suite, developed at INL, enables technoeconomic simulations of integrated energy systems under market uncertainty.
  - Grid portfolio optimization is implanted using the Holistic Energy Resource Optimization Network (HERON) plugin via stochastic, bi-level optimization.
  - HERON uses simple linear physics models.
- The Design Integration and Synthesis Platform to Advance Tightly Coupled Hybrid Energy Systems (DISPATCHES) software uses the Institute for the Design of Advanced Energy Systems (IDAES) platform to create steady-state algebraic models which describe plant components.
  - For example, hydrogen storage tank and turbines for combustion, electrolyzer, wind turbine.
- New capability integrates DISPATCHES algebraic models within HERON and solves using a single optimization level. This provides:
  - Higher fidelity analysis with steady-state plant component models
  - Computationally efficient solution while still using physics models
  - New HERON workflow, which currently implements nuclear-hydrogen case (*see right*).



Overview of DISPATCHES multi-period price-taker technoeconomic workflow and models within nuclear energy flowsheet.

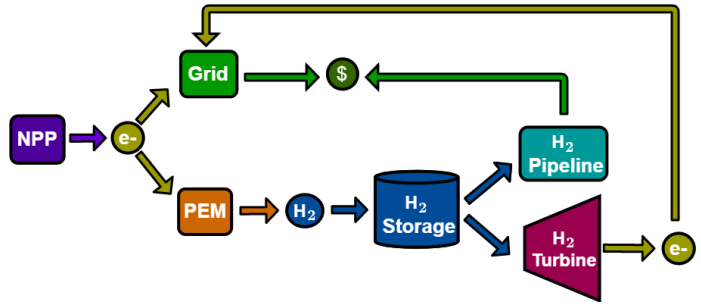


Diagram of the Nuclear Energy Case with Hydrogen production and combustion.

Title: FORCE-DISPATCHES Integration - Initial Demonstration (INL/RPT-22-69033)
Authors: Gabriel J. Soto, Paul Talbot
Link: doi.org/10.2172/1891636

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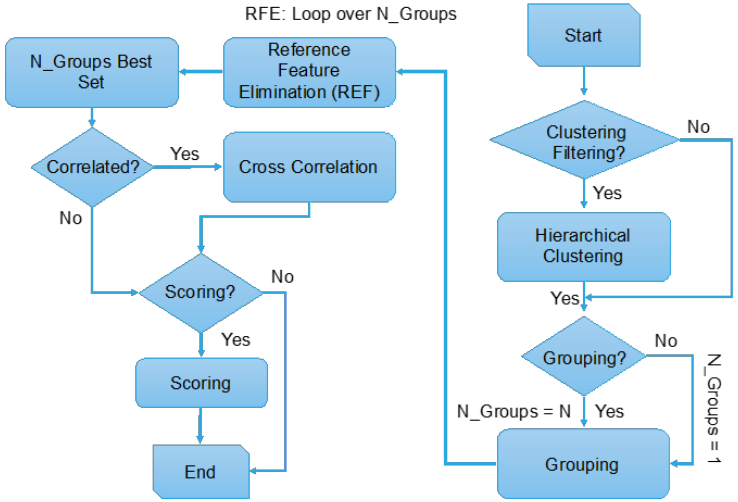
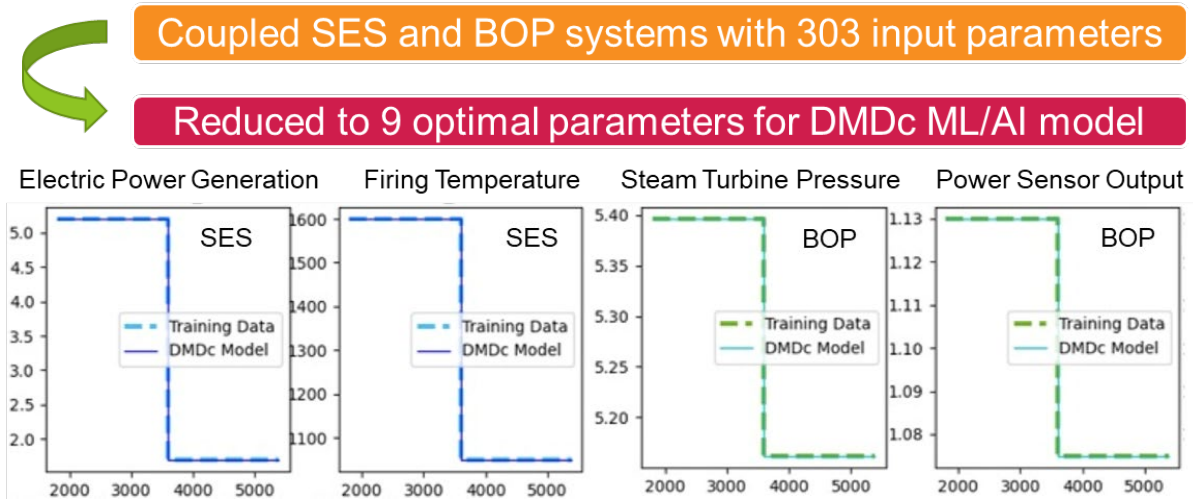
DOE-NE Integrated Energy Systems Program

New Capability Developed for RAVEN to Optimize and Minimize Input Parameters for Accelerated Analysis with Similar Accuracy

- The RAVEN team, in collaboration with Argonne National Laboratory, and with contributions from Ultra Safe Nuclear Technologies (USNC-Tech), recently deployed a fully integrated system for the automated selection of optimal input parameter space. This is specifically designed for construction of Machine Learning/Artificial Intelligence (ML/AI) models to represent physics-based models.
- The integrated feature selection framework is aimed to identify the most relevant features for maximizing the accuracy of ML/AI models using a blend of supervised learning techniques and recursive feature elimination (RFE) methods.
- This development represents a key contribution in the effort to quickly deploy ML/AI models, optimally constructed for deployment in modeling and simulation, digital twin applications, etc.



RAVEN Advanced Optimal Input Parameter Space Search Scheme.



SES: Secondary Energy Source System, BOP: Balance of Plant System, DMDc: Dynamic Mode Decomposition with Control.

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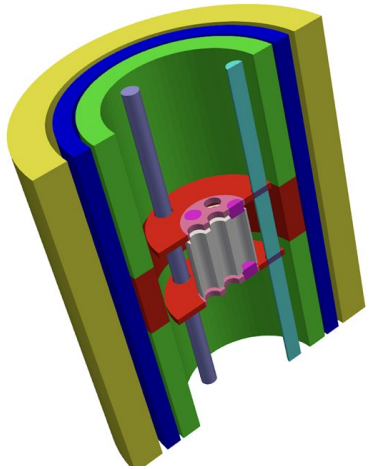
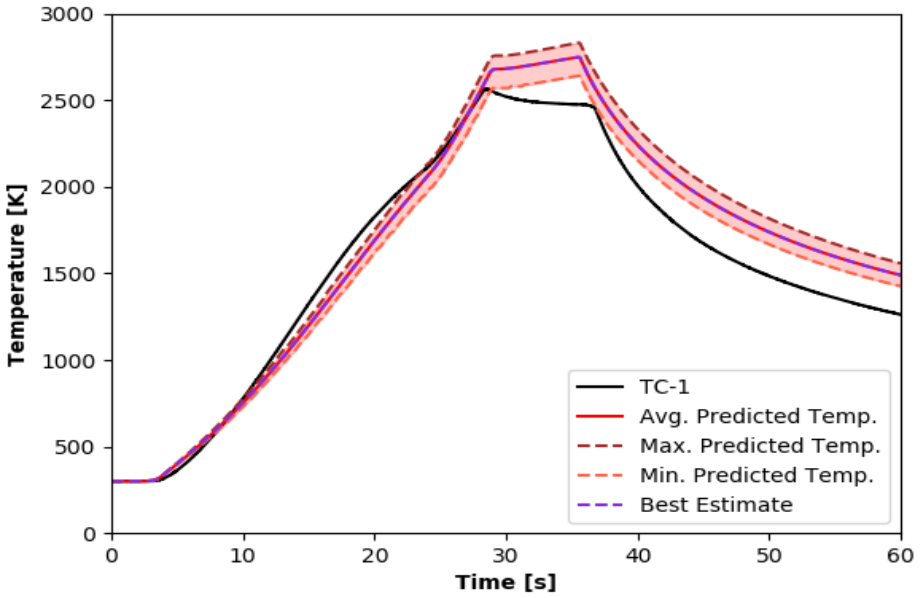
Research Highlight

BlueCRAB Models Used to Predict Temperatures of Sirius-2C Full Power Experiment

- The objective of Sirius experiments is to examine the performance of Nuclear Thermal Propulsion (NTP) fuels when subjected to temperature ramp rates that are prototypical of NTP system startup.
- These tests will determine whether operational temperature conditions will result in detrimental performance phenomena.



Depiction of the current Sirius-2c model for thermal analysis.



Comparison of predicted and measured temperature profile of Sirius-2C full power experiment. TC1 indicates the thermo-couple measurement.

- The Sirius-2C test specimen were irradiated in the Transient Reactor Test (TREAT) Facility with irradiation startup ramp rates that are prototypical of a potential reactor's ramp rate.
  - A blind prediction of the Sirius-2C was performed with the Comprehensive Reactor Analysis Bundle (BlueCRAB) MOOSE suite of tools.
  - The prediction demonstrates that the BlueCRAB MOOSE tools can do predictive and bounding analysis for experiments inside TREAT.
  - The predictions contribute and enable the successful and safe operation of NTP rockets for long range space missions.

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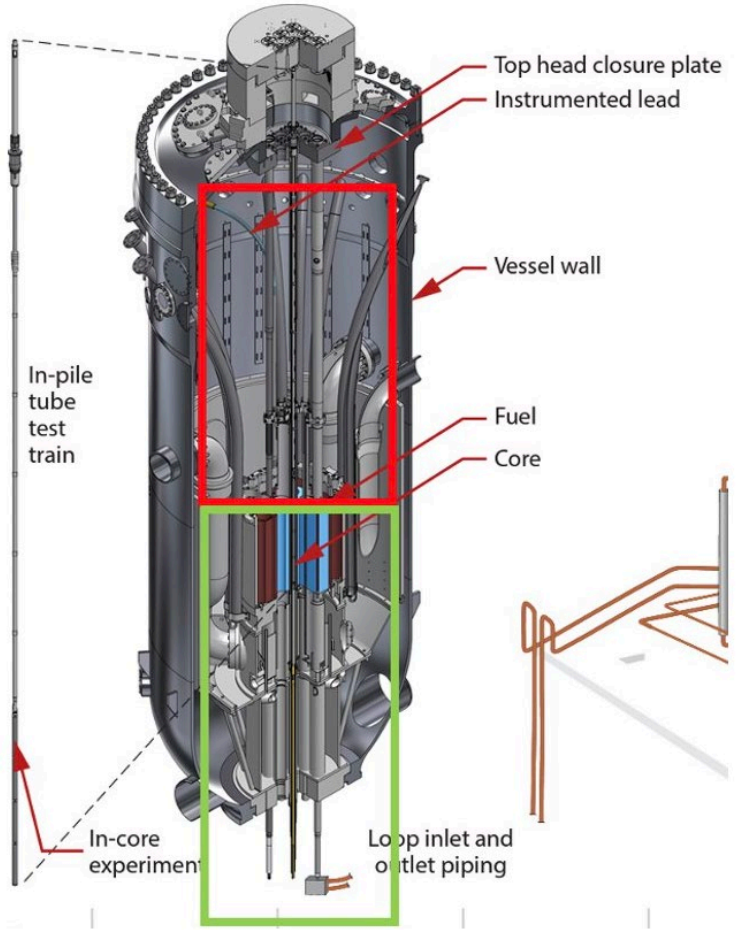
Thermal Hydraulics Analysis Code Training Provided to Increase Modeling Capabilities for ATR Irradiations

- The Irradiation Experiments Thermal Hydraulics Analysis department performs thermal analyses of irradiation experiments in the Advanced Test Reactor (ATR).
- ATR thermal hydraulics predictions are performed using a validated version of the RELAP5-3D code.
- The team requested RELAP5-3D training to increase their understanding of existing RELAP5-3D ATR models and increase thermal hydraulics modeling capabilities for ATR.
- The RELAP5-3D training included an overview of ATR-relevant input models and a discussion on modeling natural convection driven flow inversion.
- Future training and discussions will be provided to INL staff on advanced models for ATR and the Transient Reactor Test Facility (TREAT).
- The purpose of this training series is to provide INL staff with industry standards for system analysis code modeling.



ATR Components found in RELAP5-3D Model.

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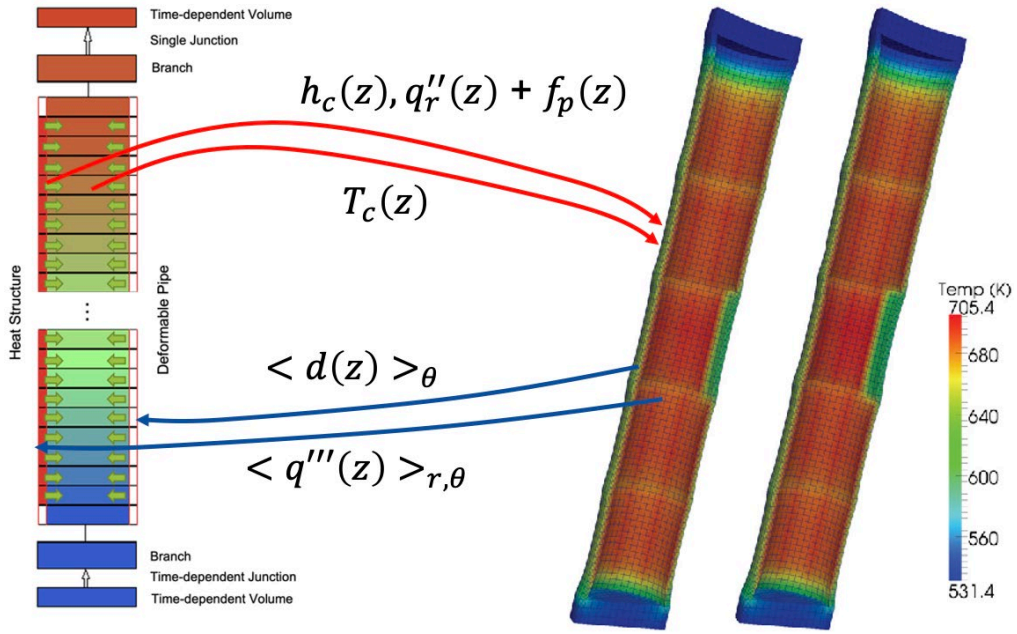
DOE Office of Technology Transitions Technology Commercialization Fund

INL Completes Kickoff Meeting to Model Fuel Rod Ballooning Transient

- The Electric Power Research Institute (EPRI) is sponsoring a Technology Commercialization Fund (TCF) project on the development of a Loss-of-Coolant Accident (LOCA) analysis tool.
- INL and EPRI are jointly developing an assessment tool that supports deployment of higher burnup light-water reactor (LWR) fuel.
- INL's assessment tool couples BISON for nuclear fuel performance predictions with RELAP5-3D for thermal hydraulic predictions.
- The INL tool will allow modelling of Fuel Fragmentation, Relocation, and Dispersal (FFRD) during simulated LOCAs.
- EPRI identified the FFRD modeling as a need of the nuclear industry.
- The Kickoff Meeting occurred on May 11 in INL's Collaborative Computing Center auditorium and included presentations by representatives from EPRI and INL experts.



Representation of RELAP5-3D Coupling with BISON.

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Radioisotope Power Systems

Thermal Analysis Group Qualifies Pu-238 Production in the Advanced Test Reactor for Use in Current and Future NASA Space Missions

- INL has taken a significant step in supporting the domestic restart of Pu-238 production to power technology for deep space missions.
- This goal of this collaboration with DOE and NASA is to produce ~1.5 kg of heat source material annually at the domestic level.
- The thermal analysis team expedited qualification of the new ATR-Gen-1 targets for insertion into several irradiation positions at the Advanced Test Reactor (ATR).
- The team ensured that safety requirements were met, aided in the shipment and receipt of irradiation targets, and configured equipment for reactor insertion and extraction.
- Qualification efforts will produce ~200g of heat source material, positioning DOE targets ahead of schedule.

RPS program leads and thermal analysis team (left to right) Andrew Zillmer, Joshua Fishler, William Green, Stacey Wilson, Jason Barney, Austen Fradeneck and Piyush Sabharwall.

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DOE-NE Integrated Energy Systems

Over 100 Participants Attend Training on Framework for Optimization of ResourCes and Economics (FORCE) Tool Suite

- The Integrated Energy Systems (IES) program, hosted a hands-on training session for its modeling and simulation tool suite “Framework for Optimization of ResourCes and Economics” (FORCE) on April 4–6.
- The training primarily targeted people who are new to energy systems modeling and informed participants of the FORCE framework’s possible applications.
  - FORCE allows researchers to analyze interconnected energy-related sources and the associated techno-economics of the integrated energy systems.
- The hybrid event was hosted both in-person and remotely.
  - It attracted more than 100 participants from national laboratories, academia, industry and international organizations.
- Presentations are available online from the IES website.

FORCE training participants during the event.

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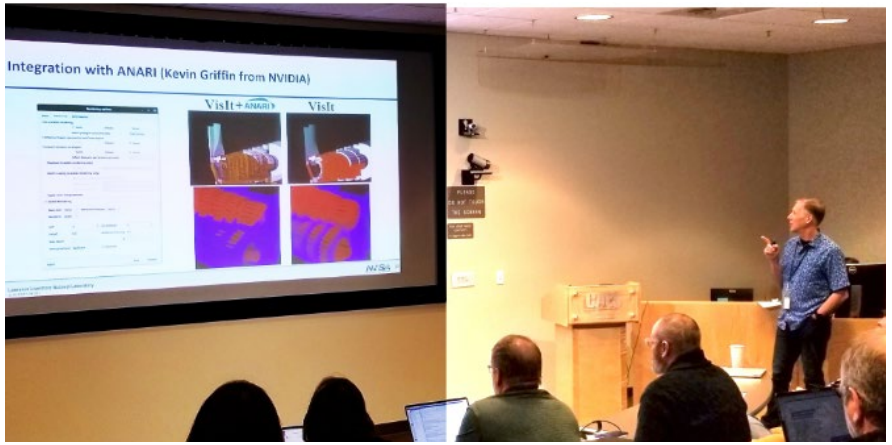
Applied Visualization Laboratory Hosts Department of Energy Computer Graphics Forum

- The DOE Computer Graphics Forum (DOECGF) is an annual event that first began in the 1970s. This meeting is intended to allow government-sponsored computer graphics/scientific visualization scientists, engineers, and practitioners to have the opportunity to share recent research, development, and deployment results.
- From April 25–27, the Applied Visualization Laboratory hosted the annual DOECGF at the Center for Advanced Energy Studies.
  - There were 55 attendees (33 in person, 22 online).
  - There were 23 participating institutions including DOE National Laboratories, Department of Defense, military, other federal agencies, universities, and industry.
- Discussions covered institutional capabilities, technical talks, and future needs in the field of visualization.
- The Applied Visualization Laboratory was heavily utilized and allowed attendees to conduct demonstrations of capabilities.



A presenter at DOECGF giving a technical talk.

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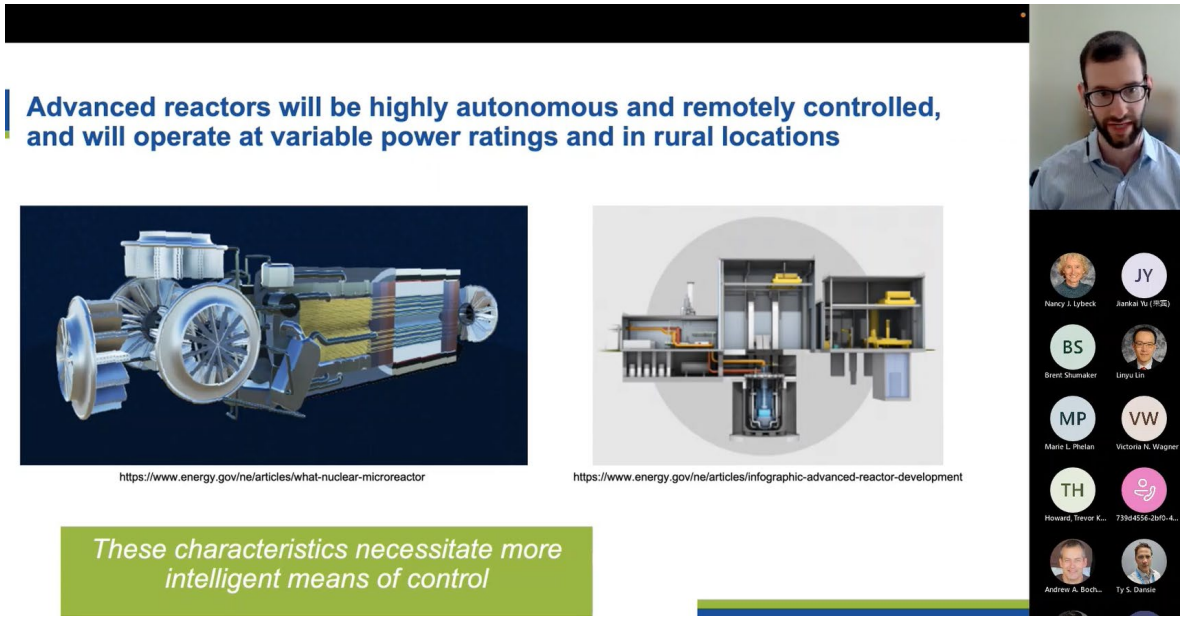
INL Hosts 11th Artificial Intelligence and Machine Learning Symposium

- INL held its 11th Artificial Intelligence and Machine Learning (AI/ML) Symposium on April 27.
- The focus was on AI/ML in instrumentation, control, and automation.
- The virtual symposium was attended by researchers and practitioners from a variety of organizations within the nuclear community.



Screenshot of a presentation during the virtual symposium.

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DOE-NE Nuclear Science User Facilities

Nuclear Science User Facilities Awards Approximately $1.74M for Rapid Turnaround Experiments

- Nuclear Science User Facilities (NSUF) has awarded 28 proposals to support advancing nuclear science and technology.
- This is the second award for FY 2023.
- The awards total is approximately $1.74M.
- These awards went to 19 principal investigators from universities and nine from national laboratories.
- NSUF selected these projects from a competitive pool of quality Rapit Turnaround Experiment (RTE) proposals submitted during the solicitation period.
- The NSUF team evaluates proposals based on various factors, including technical approach, mission relevance and scientific-technical merit.
- Find current and past awards here.

Awards totaling approximately $1.74M have been approved to support the advancement of nuclear science and technology.

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NSUF Nuclear Science User Facilities

DOE-NE Advanced Fuels Campaign

Advanced Fuels Campaign Hosts Metallic Fuels Workshop

- Advanced Fuels Campaign (AFC) leads the Department of Energy (DOE) objectives for metallic fuel, which is the primary advanced fuel technology for planned sodium fast reactor (SFR) deployment.
- Presentations from national metallic fuel stakeholders highlighted their organization's status and needs regarding metallic fuel.
- Reviewed the DOE Advanced Fuels Campaign (AFC) research and development (R&D) goals.
- Attended by representatives from industry (Oklo, ARC Clean Energy, TerraPower, Global Nuclear Fuel, Lightbridge, Westinghouse, Dominion Engineering, Tokamak Energy), Department of Energy Office of Nuclear Energy HQ, Department of Energy Idaho, the Nuclear Regulatory Commission (NRC), and 5 National Laboratories.

Nuclear Fuels and Materials Division Director Steve Hayes welcomes metallic fuel stakeholders to the AFC workshop (top). Representatives from DOE, NRC, reactor startup companies, and national laboratories pose with metallic fuel technology leaders and pioneers (seated): Doug Porter (INL) and Leon Walters (ARC).

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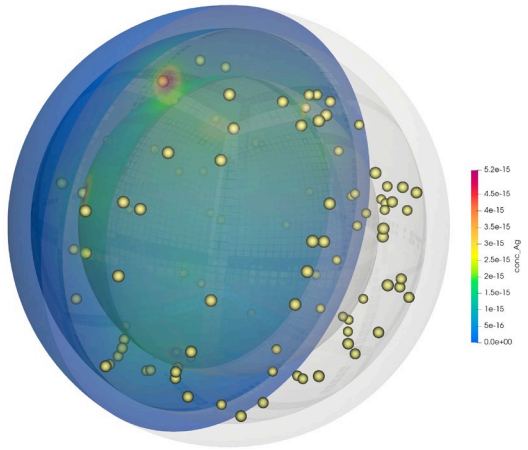
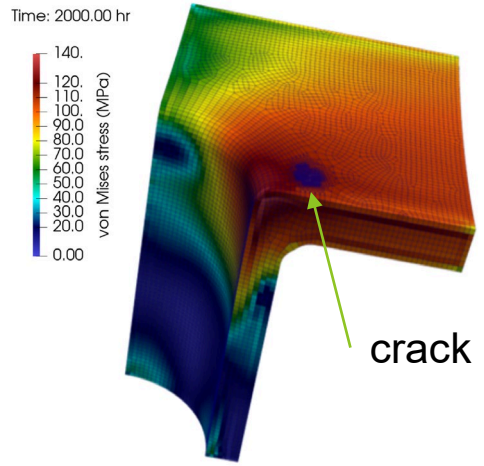
DOE U.S. Industry Opportunities for Advanced Nuclear Technology Development

INL Supports Accelerated Qualification of Kairos Power Reactor through Simulation

- INL recently completed a multi-year project supported by the Department of Energy U.S. Industry Opportunities for Advanced Nuclear Technology Development in partnership with Argonne National Laboratory, Los Alamos National Laboratory, and Kairos Power, LLC (KP).
- Through this project, INL enhanced modeling and simulation tools to support accelerated qualification of the KP fluoride-salt-cooled high temperature reactor (KP-FHR) in two major areas:
  - Improvement and validation of the models for fission product transport and failure prediction in TRISO fuel in the BISON code.
  - Qualification support for the KP-FHR vessel by integrating models for high-temperature creep and creep-fracture of alloy 316H into the Grizzly code.
- INL's contribution was instrumental in helping KP submit a topical report on TRISO fuel analysis to the United States NRC and resulted in 6 journal publications (published and in-review).



Simulated diffusion of silver originating from a small subset of the fuel particles within a fuel pebble (shown), which are assumed to fail in this demonstration BISON calculation.



Stress concentration near a postulated crack in a Grizzly simulation of a prototypical 316H reactor vessel.

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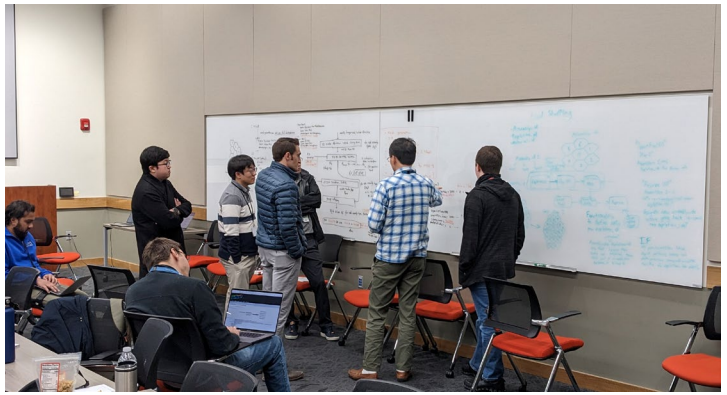
DOE-NE Nuclear Energy Advanced Modeling and Simulation Program

Nuclear Energy Advanced Modeling and Simulation Team Participates in the Reactor Physics Technical Area Meeting at INL

- Members of the Nuclear Energy Advanced Modeling and Simulation (NEAMS) reactor physics technical area met at INL on May 9–10.
- Four Argonne National Laboratory, five Oak Ridge National Laboratory and nine Idaho National Laboratory researchers discussed implementation plans for the Griffin (deterministic) and Shift (Monte Carlo) computer codes.
- The meeting, which took place in the auditorium of the INL Collaborative Compute Center (C3), was designed to:
  - Encourage brainstorming
  - Provoke collaboration between researchers
  - Allow flexibility in idea generation.
- The primary outcomes were the clear understanding of reactor physics workflows and detailed implementation needs to support:
  - Fast reactor cross sections preparation for homogenized and duct-heterogeneous geometries
  - Pebble bed reactor online cross section preparation
  - Pebble bed reactor startup and burning-in phases.

Members of the Griffin and Shift teams collaborate on assigned tasks during this hands-on meeting



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DOE-NE Light Water Reactor Sustainability Program

Light Water Reactor Sustainability Program Hosts Halden Reactor Project Human Technology Organization Annual Board Meeting

- The yearly Halden Reactor Project Human Technology Organization (HTO) board meeting met on May 9–10. Research program directors from various countries associated with Halden convened at INL.
- Key topics of discussion included artificial intelligence systems for operations and maintenance, human and organizational factors methods, cyber and human factors, digital instrumentation, and control with probabilistic risk assessment and plant modernization.
- Halden's team of experts possess extensive knowledge and expertise in various areas of nuclear science and technology. This collaboration fosters innovation and supports the growth of the United States nuclear industry.
- Bruce Hallbert, chairman of the Halden HTO Program Review Group and INL employee, emphasized the current focus on control room-related work.

Halden Project Annual Board meeting participants from 19 countries, both virtually and in-person.

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LWRS LIGHT WATER REACTOR SUSTAINABILITY

DOE-NE Light Water Reactor Sustainability Program

Light Water Reactor Sustainability Program Hosts Halden Project's International Workshop on Simulators for Future Operational Concepts

- The Halden Project Board meeting concluded with a two-day workshop, May 11–12, chaired by Dr. Ron Boring from INL.
- The workshop focused on the importance of human factors simulation facilities for developing future control room concepts.
- Significant key topics of discussion were uses of simulators to support plant modernization and to develop control rooms for advanced reactors.
- Simulators like INL's Human Systems Simulation Laboratory (HSSL) support control room design and operator-in-the-loop evaluations for engineering and licensing purposes.
- Over 30 international on-site and virtual participants joined INL researchers to discuss emerging control room topics, such as artificial intelligence, automation, and cybersecurity.
- The workshop highlighted the value of international collaboration in human factors research, the need for complementary simulators to support different research needs, and emerging simulator requirements for advanced reactors.

Simulator workshop attendees.

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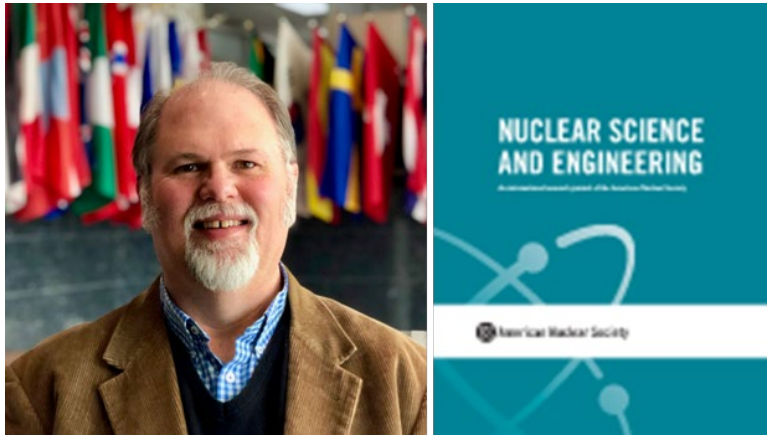
LWRS LIGHT WATER REACTOR SUSTAINABILITY

DeHart to Serve on Nuclear Science and Engineering Editorial Advisory Board

- Mark DeHart has joined the Editorial Advisory Board for Nuclear Science and Engineering (NSE), an international research journal of the American Nuclear Society (ANS).
  - Board members are notable leaders in relevant technical areas who volunteer to advise, guide, and assist the Editors in the production of the journal.
  - Members serve a number of functions through regular meetings or teleconferences, including:
    - Elicitation of high quality technical and review paper submissions
    - Identifying topics and recruiting guest editors for special issues of NSE
    - Identifying and recruiting manuscript reviewers
    - Participate in annual meetings of the NSE Editorial Advisory Board at ANS meetings.
- NSE is the oldest peer-reviewed journal in its field, publishing since 1956.
  - Its focus is on the fundamentals of nuclear systems, theoretical physics, mathematical treatments, advanced computational methods, nuclear data improvements, and uncertainty analysis & quantification.
  - NSE publishes technical papers, technical notes, critical reviews, rapid communications, book reviews, and letters to the editor.



Newest member of the Editorial Advisory Board for Nuclear Science and Engineering, Mark Dehart.

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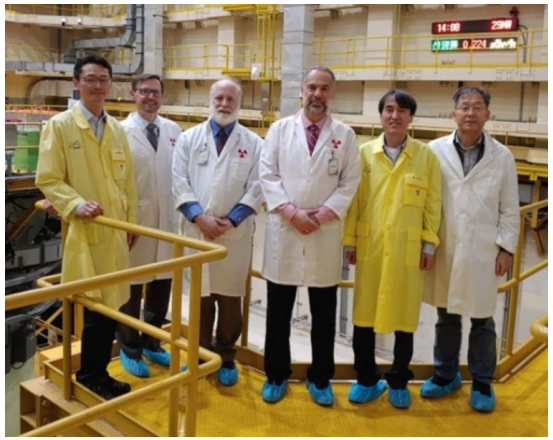
INL Staff Tour Korea Atomic Energy Research Institute Facility and the Wolsung Nuclear Power Plant

- From April 23–27, representatives from INL attended the International Conference on Advances in Nuclear Power Plants (ICAPP 2023).
  - Nuclear Science and Technology was well represented by Division Director Jess Gehin, Youssef Shatilla, Mark DeHart, William Phillips, and James King.
- Dr. Han Gyu Joo, President of the Korea Atomic Energy Research Institute (KAERI), arranged special tours and social time after the conference for Idaho National Laboratory, Argonne National Laboratory, and Oak Ridge National Laboratory leadership. The tour included:
  - Wolsung Nuclear Power Plant and the Shin Wolsong-1 OPR-1000 reactor
  - New KAERI advanced reactor research site under construction at Gimpo near Gyeongji, S. Korea
  - Main KAERI campus in Daejon, S. Korea and the High-Flux Advanced Neutron Application Reactor (HANARO).

Dr. Jess Gehin discussing advanced reactors during a morning plenary session.

A visit to the new KAERI facility under construction near Gyeongji, Korea.



Tour of KAERI headquarters HANARO reactor at Daejon, Korea.

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Curtis Smith Presented with the Idaho State University 2023 Professional Achievement Award for the College of Science and Engineering

- Dr. Curtis Smith, Director of the Nuclear Safety and Regulatory Research Division at INL, was awarded two awards:
  - The Idaho State University (ISU) 2023 Professional Achievement Award for the College of Science and Engineering
    - This award recognizes individuals who have made a significant impact in the science and engineering profession, community, and at ISU.
  - The American Nuclear Society 2023 Fellow Award
    - This distinction of Fellow is awarded to American Nuclear Society members for outstanding accomplishments in the area of nuclear science and engineering.
- Smith has dedicated 33 years of service to INL in a variety of positions.

Award winner Curtis Smith.

Curtis Smith's Professional Achievement Award from Idaho State University.

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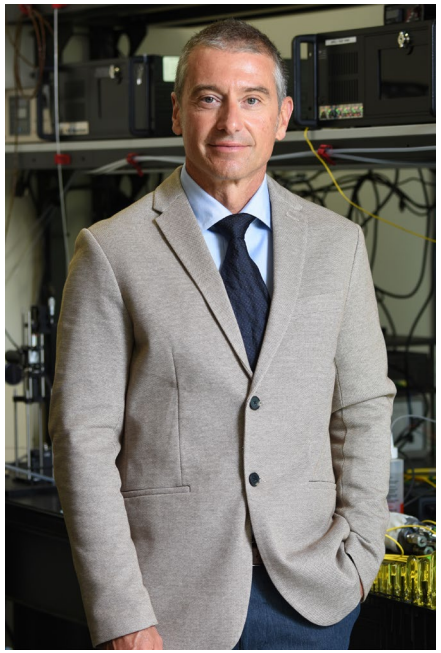
Pattrick Calderoni Nominated as United States Technical Advisor for the International Atomic Energy Alliance Technical Working Group on Nuclear Power Plant Instrumentation and Control

- The International Atomic Energy Agency (IAEA) Technical Working Group on Nuclear Power Plant Instrumentation and Control (TWG-NPPIC) is a group of experts from IAEA member states nominated by their governments and appointed by the IAEA Deputy Director General.
- Experts advise the IAEA and support the program implementation in the area of instrumentation and control (I&C) and human-system interface technologies.
- In May 2023, Pattrick Calderoni was nominated as United States Technical Advisor:
  - Pattrick Calderoni is the National Technical Director (NTD) for the DOE-NE Advanced Sensor and Instrumentation (ASI) program.
  - Only two representatives were nominated nationwide.
  - Calderoni's ASI NTD nomination reflects the growing interest in I&C technologies for advanced reactor concepts.

IAEA
International Atomic Energy Agency



U.S. IAEA TWG-NPPIC Technical Advisor Nominee Pattrick Calderoni.

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INL Hosts the 46th Actinide Separations Conference

- INL welcomed scientists and engineers to the Actinide Separations Conference. This is an annual conference to discuss the latest research related to recovery, isolation, and purification of actinide elements.
- The conference was held May 16–18 at INL Meeting Center.
- INL hosted 152 attendees representing 7 national laboratories, 14 universities, and 8 countries.

Group photo of 46th Actinide Separations Conference attendees.

AQUEOUS SEPARATIONS & RADIOCHEMISTRY | FUEL CYCLE SCIENCE & TECHNOLOGY
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DOE-NE Nuclear Science User Facilities

Nuclear Science User Facilities Director Brenden Heidrich Joins Editorial Board for Open-access Research Journal

- Brenden Heidrich, the Nuclear Science User Facilities (NSUF) director, has been appointed to the editorial board of a new open-access journal of the American Nuclear Society (ANS).
- The soon-to-be-launched publishing platform Nuclear Science and Technology Open Research (NSTOR) is an exciting joint initiative between the ANS and publisher F1000.
- The new platform aims to publish academic works on all areas of nuclear research and will focus on some areas not represented in their current technical journals.
- Through the Department of Energy's Office of Nuclear Energy, the NSUF is committed to providing easy access to data. This journal:
  - Maximizes the potential for research to be have real-world impact.
  - Accelerates research progress, meaning new insights and innovations will be available to those who need them more rapidly.
  - Facilitates collaboration, engagement and research dialogue through open data sharing, transparency and attribution.

NSUF Director Brenden Heidrich.

NSUF Nuclear Science User Facilities

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