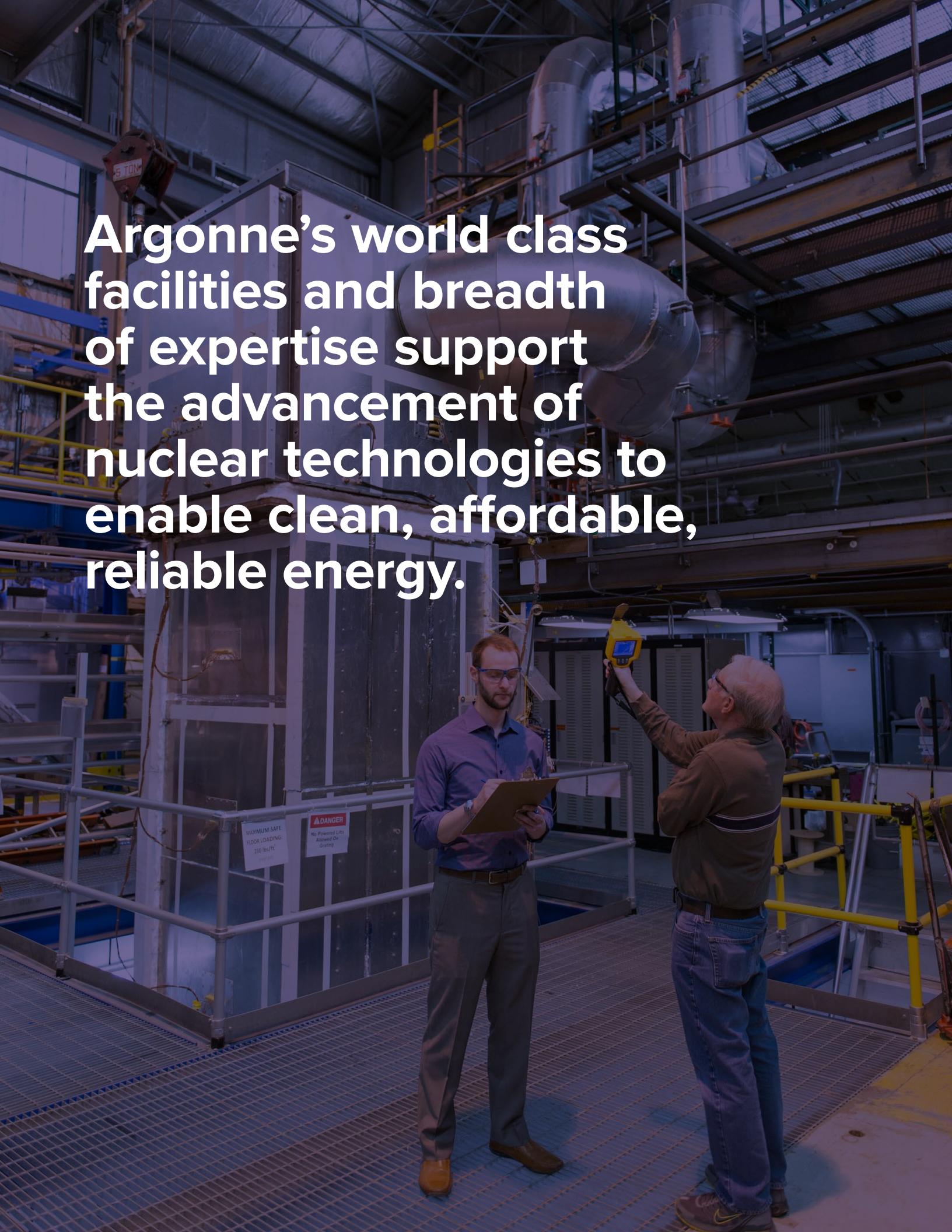


SUPPORTING ADVANCED REACTOR DEMONSTRATION

Via the Nuclear Reactor Innovation Center (NRIC)



Argonne's world class facilities and breadth of expertise support the advancement of nuclear technologies to enable clean, affordable, reliable energy.

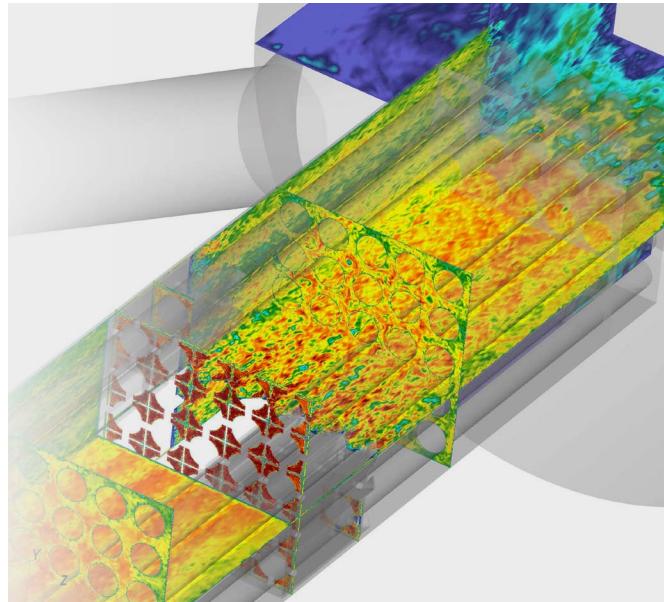
PROPOSED ARGONNE ROLES IN NRIC DEMONSTRATION PROJECTS

- 1 Contribute unique fast reactor expertise in support of industry-led fast reactor demonstration projects:** core design; fuel cycle; safety analysis; licensing; instrumentation and controls (I&C); materials discovery and qualification; NEPA, more.
- 2 Provide selective support to industry for demonstrations of other types of advanced reactors:** specific aspects of core design and modeling; safety analysis including probabilistic risk assessment (PRA) and source term; licensing support; spent fuel management; waste forms; and NEPA.
- 3 Test and validate performance capabilities of specific systems or components using unique experimental facilities at Argonne, particularly for liquid metal reactors (LMRs)** and for specific phenomena/systems for other reactors (e.g., using Argonne's NSTF Facility, engineering development laboratories, and radio-chemical engineering laboratories). These facilities also support safety analysis methods development and validation.

ARGONNE EXPERTISE MAPPED TO THE NRIC'S PLANNED EFFORTS TO SUPPORT THE NUCLEAR INDUSTRY

FOCUSED PROGRAMS THAT ENABLE INNOVATOR NEARING DEMONSTRATION STAGE

- Expertise in various engineering processes and applications that span the entire reactor lifecycle:
 - Reactor physics design and fuel cycle analysis,
 - Materials testing and discovery for advanced fuel types and related structures,
 - Systems monitoring, diagnostics, and controls,
 - Plant dynamics and safety analysis,
 - Advanced power conversion cycles,
 - Licensing,
 - Waste form and repository performance analysis, and
 - Decontamination and decommissioning.
- Computational modeling of neutronic, thermal-hydraulics, and thermo-structural behavior of advanced reactor systems, including molten salt-fueled reactors and heat pipe-cooled micro reactors, using state-of-the-art methods in nuclear engineering and high-performance computing (HPC).
- Unique expertise in radio-chemical engineering applicable to molten salt reactors (salt properties, reactions, on-line or off-line treatment) and post-irradiation treatment of diverse fuel types. Comprehensive expertise and handling and management of chemical hazards related to molten salts as well as sodium and other liquid metals.
- Extensive participation in GAIN voucher and DOE Office of Technology Transitions Technology Commercialization Fund projects demonstrates effectiveness in meeting focused needs of innovators that are pursuing the commercialization of their technologies by leveraging Argonne's extensive research and development (R&D) portfolio.



Predicted velocity distribution in the turbulent flow field inside a light water reactor rod bundle.

ACCESS TO SITES, REQUIRED UPGRADES, SITE SERVICES, AND DEMONSTRATION PROCESS SUPPORT

- Unique facilities (described on next pages) are available or can be adapted for support of demonstration projects.
- Argonne's site and existing buildings can accommodate additional experiments of varying scale for tests of thermal hydraulics, materials behavior, radio-chemistry of actinide-bearing molten salts, scaled prototypes/components, and sensors/detectors.

Our vision is the realization of nuclear energy as a sustainable, carbon-free energy source to support economic growth and prosperity worldwide.

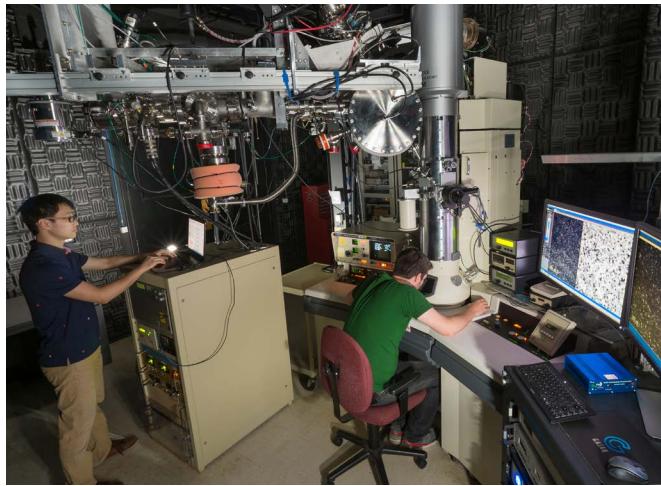
REGULATORY ASSISTANCE RELATED TO DEMONSTRATION

- Development and qualification of design and safety analysis software methods in accordance with current regulatory requirements:
 - Expertise in multi-physics and multi-scale methods in areas of fast reactors physics, fuel management, and safety analysis.
 - Validation experience includes use of high-fidelity and systems-level models, legacy data/measurements, and newly designed experiments.
- Support development of the Safety Analysis Report
 - Core, heat transport systems, and ex-vessel systems (e.g. fuel handling) design
 - Thermal-hydraulic analysis of all heat transport systems and components
 - Transient sequence identification — design basis accidents (DBAs), beyond design basis accidents (BDBAs), etc.
 - Probabilistic risk assessment using conventional and modern methods (risk-informed approaches, Licensing Modernization Process, etc.)
 - Source term modeling and calculations
 - Criticality safety analysis
 - Sodium fire analysis
- Experimental facilities for technology testing and/or validation of computational models:
 - *Natural convection Shutdown heat removal Test Facility (NSTF)*: State-of-the-art, large-scale laboratory for evaluating performance and validating computational models of passive safety systems (e.g., reactor cavity cooling system (RCCS), reactor vessel auxiliary cooling system (RVACS), etc.) that employ natural circulation to cool the reactor vessels.

- Liquid-metal facilities that provide unique capabilities for experimental work directly with sodium coolant, other liquid metals, or surrogate fluids at prototypic conditions:
 - *Mechanisms Engineering Test Loop (METL)*: Facility for testing of diverse components of advanced SFRs in liquid sodium under prototypic conditions. Performance data for advanced equipment, components or instruments can provide assurance of performance and reliability prior to use in a demonstration SFR.
 - *Thermal Hydraulic Experimental Test Article (THETA)*: Provides integral testing of components and systems during flow transients in liquid metal pool-type reactors. The test article, scaled to represent prototypic domestic pool-type designs, is highly configurable and contains all primary components of a typical pool-type liquid metal reactor (representative core heater, pump, IHX, DRACS).
 - SNAKE: Facility designed to examine effects of S-CO₂ leakage into sodium under prototypic Brayton cycle conditions.
 - Plugging phenomena loop utilized to investigate effects of plugging of narrow sodium channels that are prototypic of compact printed circuit heat exchangers.



Mechanisms Engineering Test Loop (METL) Facility



Intermediate Voltage Electron Microscopy (IVEM)-Tandem Facility

- Radio-chemical laboratories for development and testing of used-fuel processing techniques (for actinide recycle, or conversion to forms suitable for extended storage).
- Materials test capabilities for light water reactor (LWR), high temperature gas-cooled reactor (HTGR), and sodium-cooled fast reactor (SFR) technologies using finite element and AI-based predictive modeling testing design:
 - Mechanical and Environmental Testing Laboratory (METLab), a suite of testing capabilities used for evaluating mechanical performance of structural materials under various loading, temperature, and environmental conditions. The METLab consists of a number of autoclave systems, servo-hydraulic and screw-driven mechanical testing frames specially designed for evaluating environmentally assisted cracking, tensile behavior, creep, fatigue, creep-fatigue, and fracture toughness of structural materials in simulated reactor environments. A well-established testing procedure is followed to ensure ANL quality assurance equivalent to NQA-1.
 - Sodium Materials Testing Loops in the Argonne Liquid Metal Experiment (ALEX) Facility which are used to evaluate the sodium compatibility of materials in two forced-convection sodium loops.

- IVEM-Tandem Facility with in situ ion irradiation and ion implantation radiation damage studies.
- In-situ PIE with High-Energy Synchrotron X-rays in the eXtreme Materials beamline (XMAT).
- Irradiated Materials Laboratory (IML) which maintains four hot cells and supporting equipment. The beta-gamma hot cell facilities can be used for studies of activated structural materials (non-fueled), among other technologies.
- Metal additive manufacturing facility.
- Melt Coolability and Materials Interactions (MCCI) Facility: Provides unique severe accident (core melt coolability) testing of large-scale corium/concrete interaction experiments to support development and validation of severe accident code models and develop accident management practices to limit their consequences.
- Molten salt technology development facilities that support molten salt chemistry and process development, including inert atmosphere glove boxes (pilot- and bench-scale), chemical processing equipment (pilot-scale), and property measurement capabilities.
- Argonne national user facilities: Advanced Photon Source (APS), Center for Nanoscale Materials (CNM), Argonne Tandem Linac Accelerator System (ATLAS), and Argonne Leadership Computing Facility (ALCF).
- **NEPA support activities including work on Construction/Operation License (COL) and Early Site Permit (ESP) applications, uranium enrichment facilities, and reactor license renewals.**
- **Evaluation of the design certification/authorization application or documentation.**
- **Evaluation of ASME code cases for advanced reactors.**

FACILITATE NRC OBSERVATION/LEARNING

- Train NRC staff in advanced reactor physics, engineering, and safety (and in associated computational modeling and validation).

ADVANCING NUCLEAR ENERGY SYSTEMS

Argonne's Nuclear Science and Engineering division focuses on the advancement and operation of nuclear energy systems. Learn more at www.anl.gov/nse.

ARGONNE NATIONAL LABORATORY

- U.S. Department of Energy research facility
- Operated by the University of Chicago
- Midwest's largest federally funded R&D facility
- Located in Lemont, IL, about 25 miles (40 km) southwest of Chicago, IL (USA)
- Conducts basic and applied research in dozens of fields
- Unique suite of leading-edge and rare scientific user facilities

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