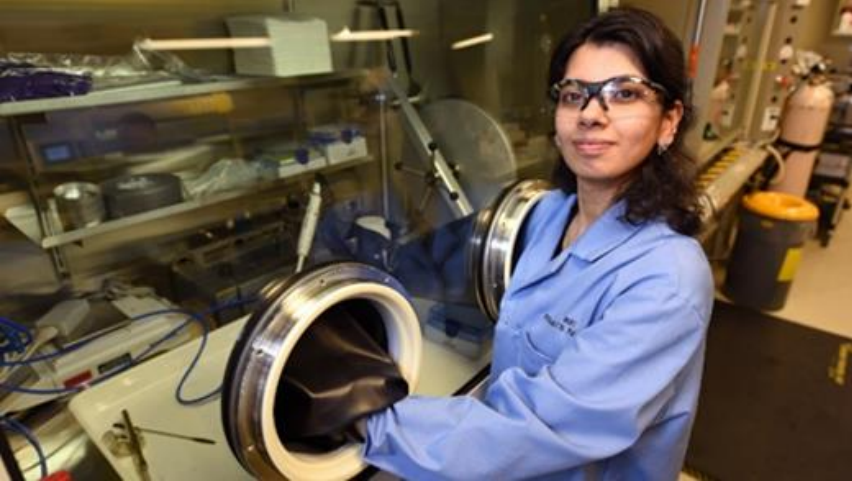


May 12, 2021

Dr. Jess Gehin

Associate Lab Director, Nuclear
Science and Technology

Jess.Gehin@Inl.gov



Nuclear Science & Technology Overview

Leadership in Nuclear Energy Commission

Jess C. Gehin, PhD

Associate Laboratory Director for NS&T

- **Education:**
 - B.S. Nuclear Engineering, Kansas State, 1988
 - M.S. Nuclear Engineering, MIT, 1990
 - Ph.D. Nuclear Engineering, MIT, 1992
- **Oak Ridge National Laboratory, 1992-2018**
 - High Performance Research Reactor Design and Operation
 - Disposition of Plutonium in Russian Reactors
 - Nuclear Fuel Cycle Analysis
 - Advance Reactor Technologies
 - Modeling and Simulation, CASL Director
- **Idaho National Laboratory, 2018-present**
 - Chief Scientist for Nuclear Science & Technology
 - Microreactor program, national technical director
 - Associate Laboratory Director for NS&T
- **Fellow, American Nuclear Society**



INL is addressing the world's most challenging problems



Nuclear S&T

- Nuclear fuels and materials
- Reactor systems design and analysis
- Fuel cycle science and technology
- Nuclear safety and regulatory research
- Advanced Scientific Computing



Advanced Test Reactor

- Steady-state neutron irradiation of materials and fuels
 - Naval Nuclear Propulsion Program
 - Industry
 - National laboratories and universities



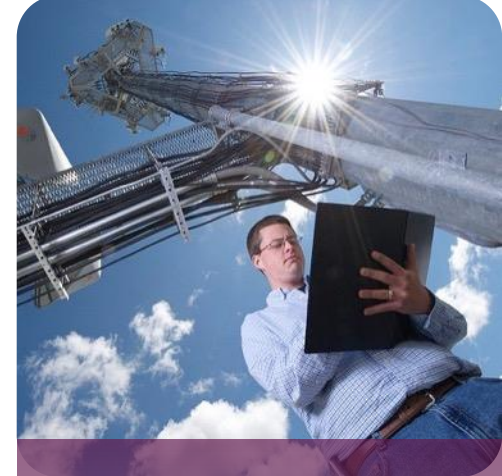
Materials & Fuels Complex

- Transient testing
- Analytical laboratories
- Post-irradiation examination
- Advanced characterization
- Fuel fabrication
- Space nuclear power and isotope technologies



Energy & Environment S&T

- Advanced transportation
- Environmental sustainability
- Clean energy
- Advanced manufacturing
- Biomass

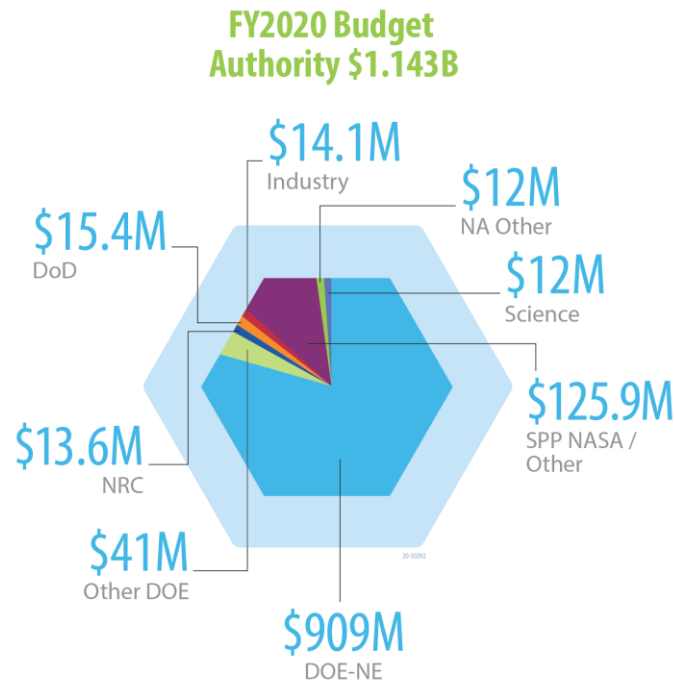


National & Homeland Security

- Critical infrastructure protection and resiliency
- Nuclear nonproliferation
- Physical defense systems

Nuclear RD&D Team at INL

1,632 staff working to revive, revitalize, and expand nuclear energy, enabled by unique research facilities, infrastructure, & capabilities



Nuclear Science & Technology

Change the world's energy future by advancing nuclear energy.

- Nuclear fuels and materials
- Nuclear systems design and analysis
- Fuel cycle science and technology
- Nuclear safety and regulatory research
- Advanced Scientific Computing

510 Employees • **144 Ph.D.** • **81 Bachelor**
73 Master • **37 Postdocs**

Materials & Fuels Complex

Experiments and engineering that drive the world's nuclear energy future.

- Transient testing
- Analytical laboratories
- Post-irradiation examination
- Space nuclear power and isotope technologies
- Fuel Fabrication
- Advanced characterization

710 Employees • **54 Ph.D.** • **222 Bachelor** • **3 Postdocs**
92 Master • **88 Associates**

Advanced Test Reactor

Provide unique irradiation capabilities for nuclear technology research and development. Steady-state neutron irradiation of materials and fuels.

- Naval Nuclear Propulsion Program
- National laboratories and universities
- Industry

412 Employees • **2 Ph.D.** • **133 Bachelor**
48 Master • **46 Associates**

Unique Research Facilities and Infrastructure/Foundational Enablers

Nuclear Science & Technology Vision, Mission, Priorities



Our Vision:

Change the world's energy future by advancing nuclear



Our Mission:

Enable nuclear energy expansion through innovation



Our Priorities for Nuclear Energy:

- Continued operation of the existing fleet
- Replacement and expansion of existing fleet
- Management and disposition of spent fuel

Nuclear Science and Technology



NS&T Associate Laboratory Director
Jess Gehin

NS&T Chief Scientist
Vacant



NS&T Chief Operations Officer
Pete Wells



International Programs
Bonnie Hong



Strategic Planning
Steve Aumeier



Naval Reactors Programs
Casey Stengel



**Gateway for Accelerated
Innovation in Nuclear (GAIN)**
Christine King



NE Senior Technical Advisor
Jon Carmack



**Nuclear Safeguards, Security,
& Nonproliferation Strategies**
Aaron Weston



Integrated Fuel Cycle Solutions
Monica Regalbuto



**Reactor Systems Design
& Analysis – C100**
Youssef Ballout, Director



**Nuclear Safety
& Regulatory
Research – C200**
Curtis Smith, Director



**National Reactor
Innovation Center
(NRIC) – C300**
Ashley Finan



**Fuel Cycle Science
& Technology – C400**
Michael Norato, Director

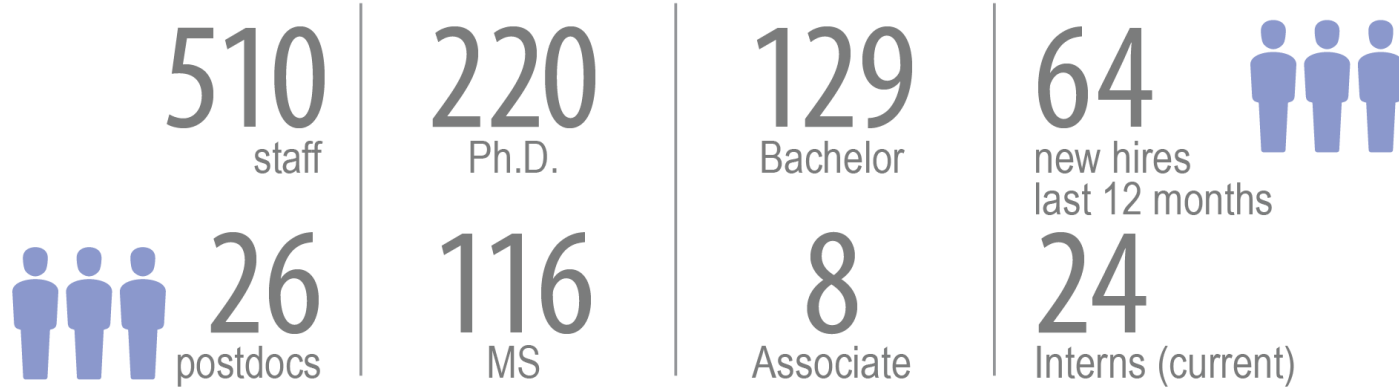


**Advanced Scientific
Computing – C500**
Eric Whiting, Director



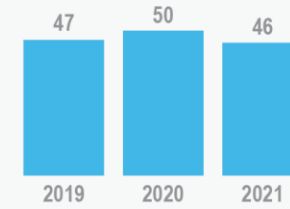
**Nuclear Fuels
& Materials – C600**
Steven Hayes, Director

Nuclear S&T Directorate

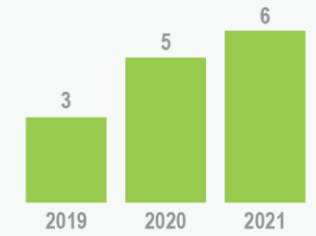


DATA BY FISCAL YEAR

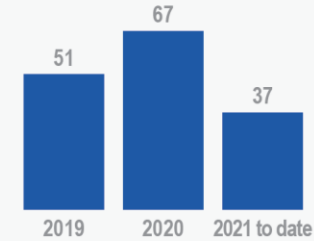
Invention & Software Disclosures



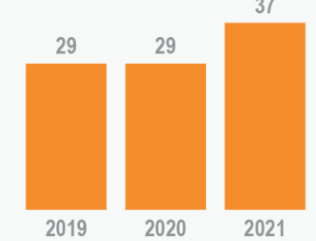
United States Patents Granted



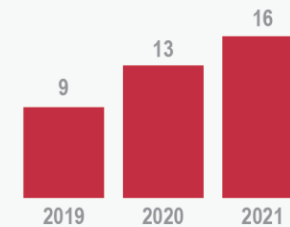
New Hires



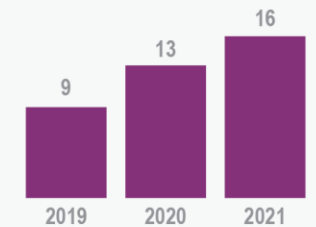
Post Docs



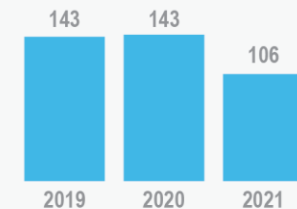
Grad Fellows



Visiting Researcher



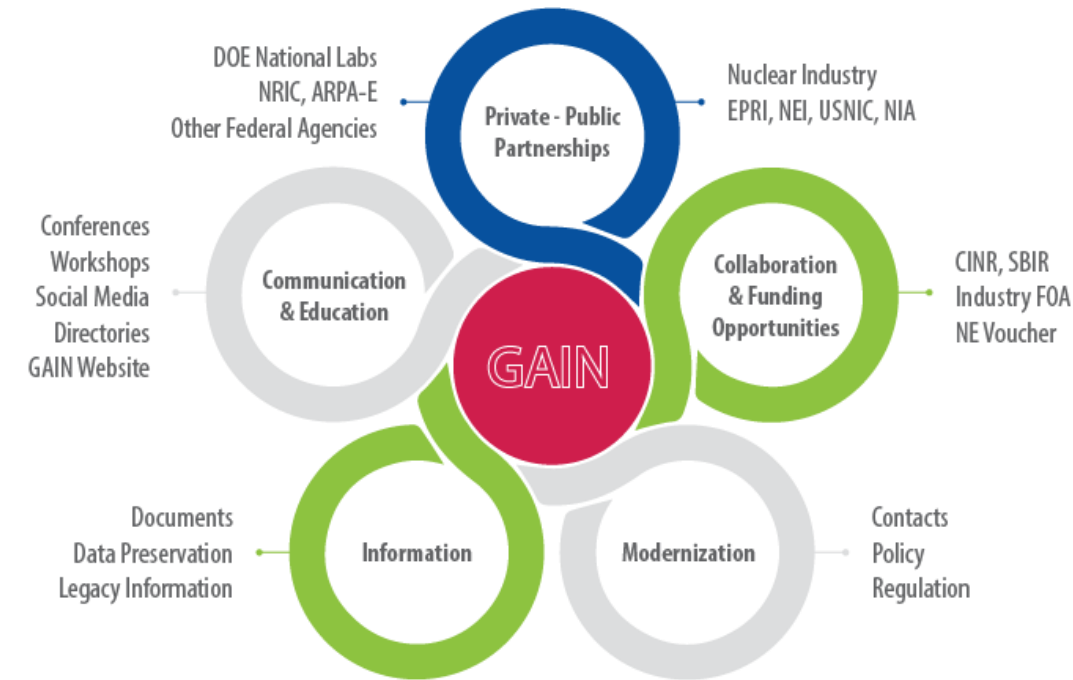
Interns



Gateway for Accelerated Innovation in Nuclear – Functions and Goals



- 1. Provide nuclear industry entities access** to financial support opportunities and national laboratory capabilities
- 2. Work with industry** to identify gaps, gather needs, and develop viable paths forward to inform DOE research programs and remove barriers for industry.
- 3. Complete the key portions of a modernized** risk-informed regulatory framework enabling deployment of advanced nuclear energy technologies.
- 4. Facilitate the advanced nuclear industry's access** to information to support their technology commercialization efforts.
- 5. Contribute tailored, factual information** to key stakeholders to motivate the integration of clean nuclear energy for long-term success.



Light Water Reactor Sustainability

Enhancing the safe, efficient, and economical performance of our nation's nuclear fleet, and extend their operating lifetimes

Plant
Modernization

Enable plant efficiency improvements through a strategy for long-term modernization

Flexible Plant
Operation &
Generation

Enable diversification of light-water reactors to produce non-electrical products

Risk Informed
System Analysis

Develop analysis methods and tools to optimize safety, and economics

Materials Research

Understand and predict long-term behavior of materials

Physical Security

Develop technologies to optimize physical security

DOE's Program for LWR RD&D

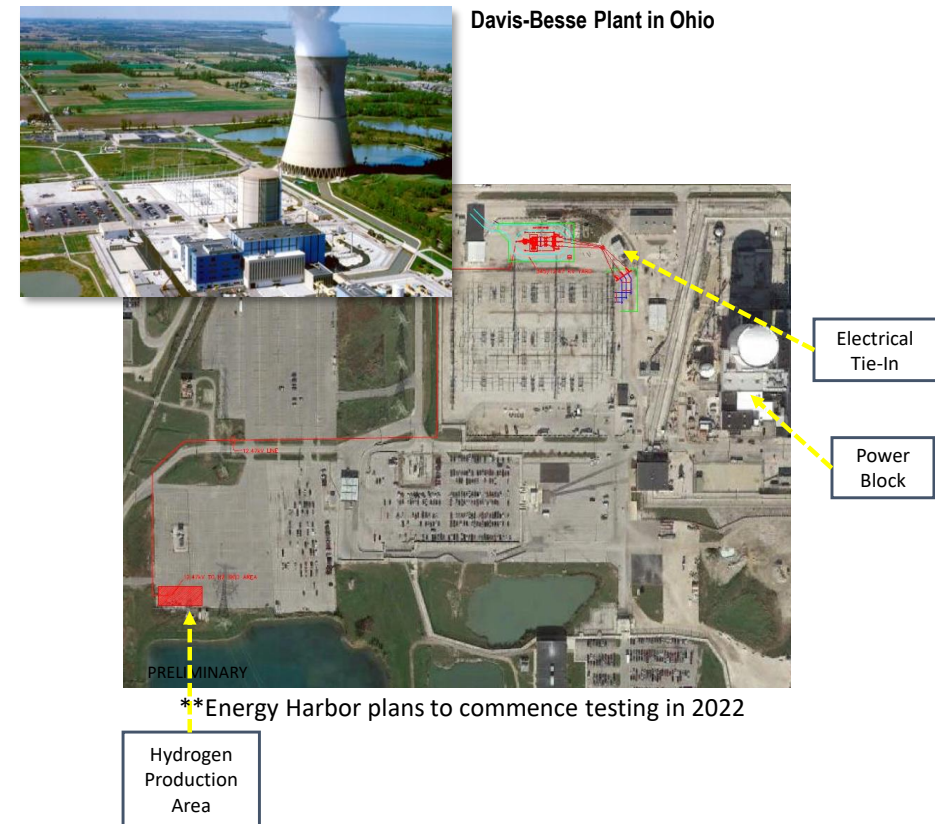


Nine Mile Point (Courtesy of Exelon)

LWRS - Products Beyond Electricity Markets

Increase the value from nuclear power plant by developing approaches for hybrid plant operations

- **Goal:** Operation of an LWR to produce non-electrical products by 2025–2030
- **Needs:**
 - Technical & Economic Assessments
 - Front-End Engineering and Design, Demonstration, and Deployment
 - Probabilistic Risk Assessment and Possible License Approaches
 - Stakeholder Engagement
- **DOE FOA awards:**
 - FOA awards: **Exelon, Energy Harbor, Xcel Energy, Arizona Public Services**



National Reactor Innovation Center

Enabling Reactor Demonstrations

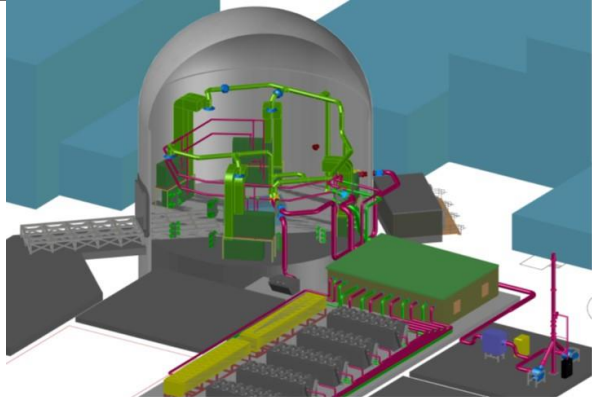


- **Established in 2019 with the purpose to provide the capabilities to support development and demonstration of advanced reactors**
- **Objective 1: Enable demonstration of two advanced reactors by the end of 2025**
 - Make available infrastructure, sites, materials, expertise
 - Provide regulatory support
 - Best practices in public engagement
- **Objective 2: Prepare DOE/labs for continuing innovation and demonstration**
 - Develop best practices for planning/construction/demonstration of nuclear projects
 - Develop enduring infrastructure and expertise
 - Establish methods for efficient coordination among laboratories

NRIC-DOME Test Bed

(Demonstration of Operational
Microreactor Experiments)

- Test bed for microreactors less than 20 MWt
- Reestablish capabilities of existing infrastructure



NRIC-LOTUS Test Bed

(Laboratory for Operations and
Testing in the United States)

- Experimental test bed with 500kW heat rejection system



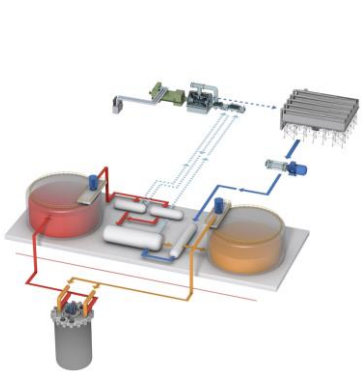
MARVEL – Microreactor Applications Research, Validation & Evaluation Project

- DOE project to develop a small scale (100 kWt) microreactor to aid R&D on the unique operational aspects of these new reactors and integrating them with end-user applications.
- Rapid development timeline: planned operation by early 2023
- Provides experience in developing, constructing and operating a new nuclear reactor that can be leveraged by other developers
- Currently engaging interested end users for testing activities including:
 - Microgrid integration
 - Remote power and heat for computing, water, buildings, etc.

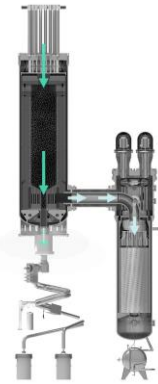


DOE has selected the Advanced Reactor Demonstration Program and ARC-20 Projects

ARDP Demonstration Projects

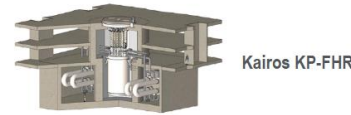


TerraPower Natrium sodium-cooled fast reactor



X-energy's Xe-100 high-temperature gas-cooled reactor concept

ARDP Risk Reduction Projects

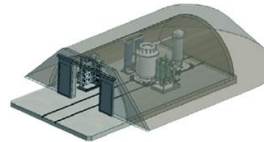


Kairos KP-FHR

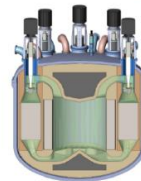
WEC eVinci



BWXT BANR

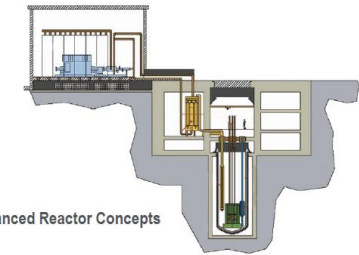


Holtec SMR-160

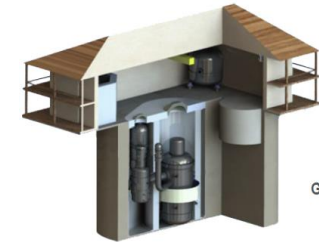


TerraPower MCFR

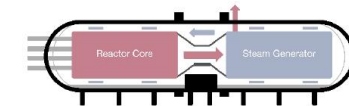
ARC-20 Projects



Advanced Reactor Concepts



General Atomics



MIT

INL is a partner on all ARDP Projects and ARC and GA ARC-20 Projects

Integrated Energy Systems

Maximizing energy utilization, generator profitability, and grid reliability and resilience through systems integration

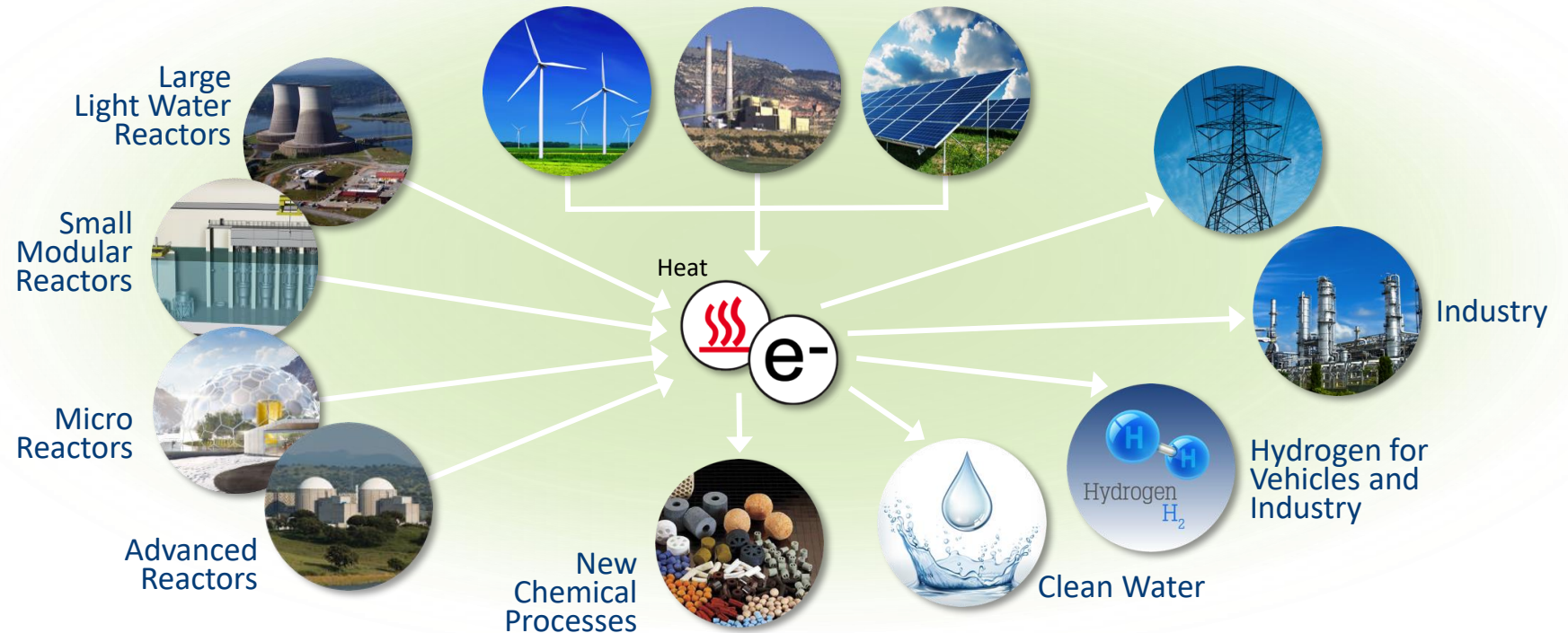
Today

Electricity-only focus



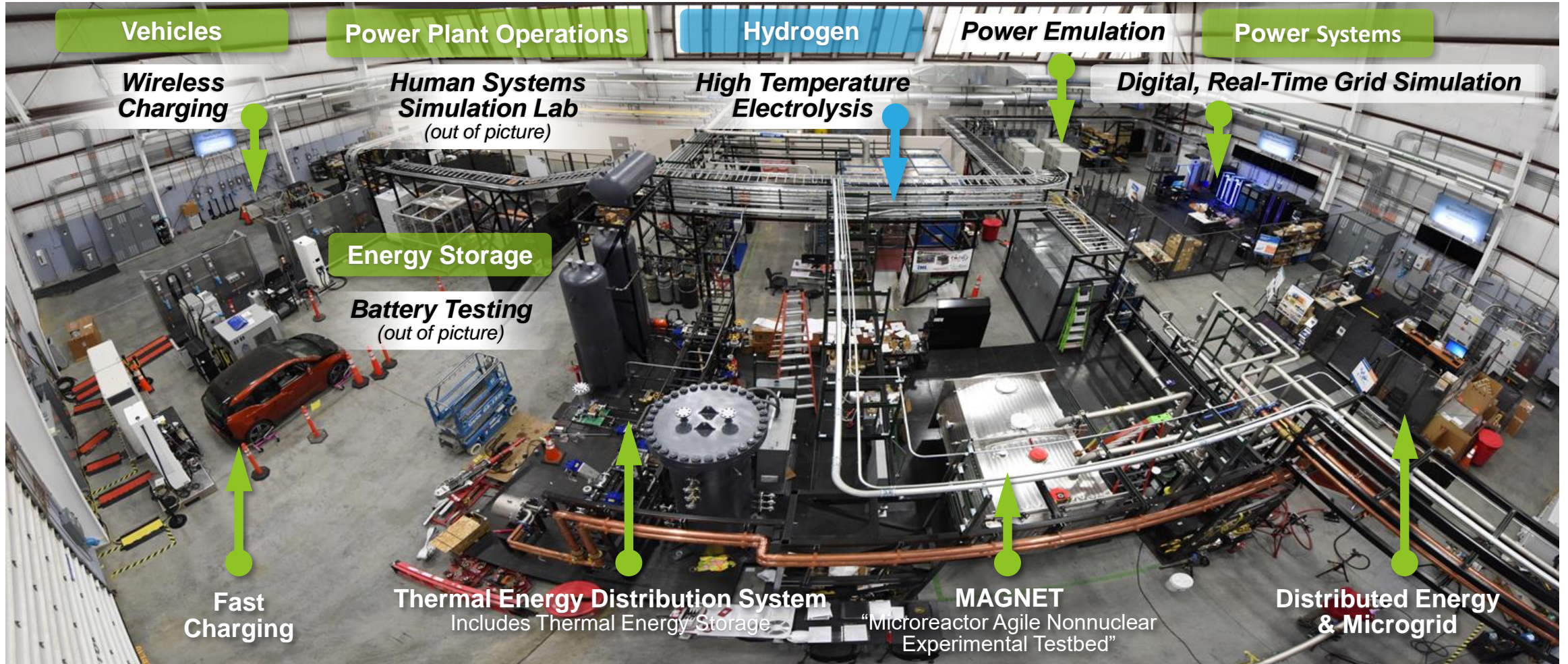
Potential Future Energy System

Enhanced energy system leverages contributions from low emission energy generation for electricity, industry, and transportation



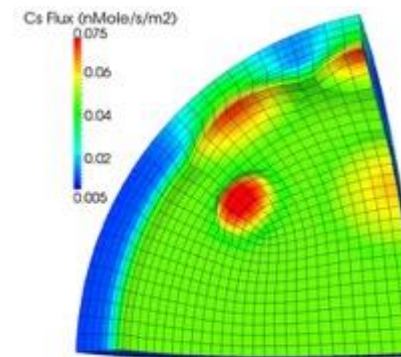
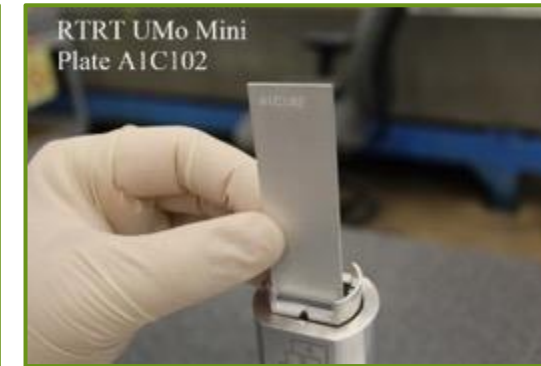
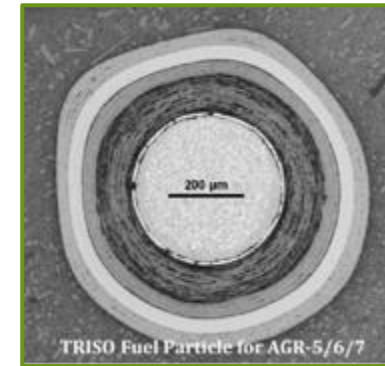
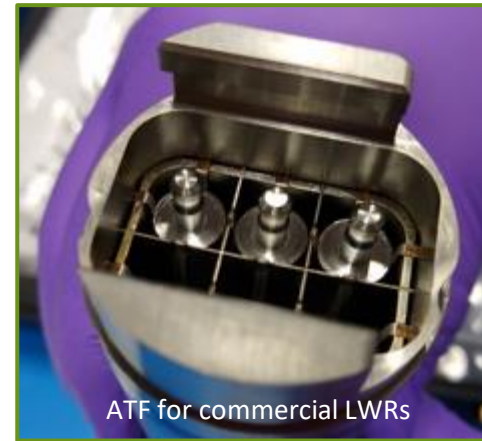
Flexible Generators ❖ Advanced Processes ❖ Revolutionary Design

Foundational laboratory capabilities for integrated energy systems

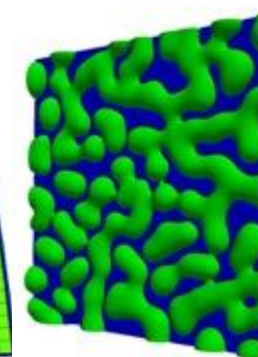


Nuclear Fuel Research and Development

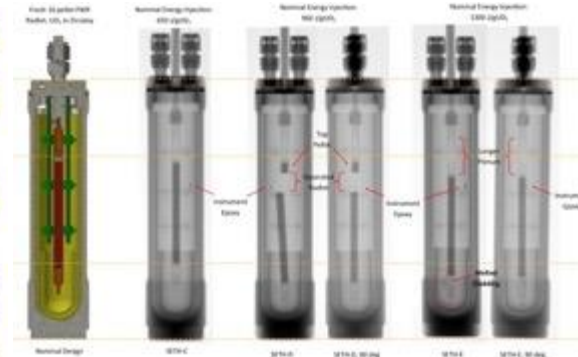
- **Advanced Fuels Campaign (AFC)**
 - Accident Tolerant and High Burnup Fuels (ATF)
 - Fuels for Advanced Reactors
- **TRISO Fuel and Graphite Qualification (AGR)**
- **High Performance Research Reactor (HPRR) Fuel Development and Qualification**
- **Nuclear Materials Discovery and Qualification Initiative (NMDQi)**
- **Nuclear Energy Advanced Modeling and Simulation (NEAMS)**
- **Other Significant Programs**
 - TREAT Transient Testing (ATF, NASA, Industry)
 - Versatile Test Reactor Fuel Design/Qualification
 - Fusion Safety Program (materials & ^3H performance)
 - Fuel testing to support multiple ARDP awards



BISON



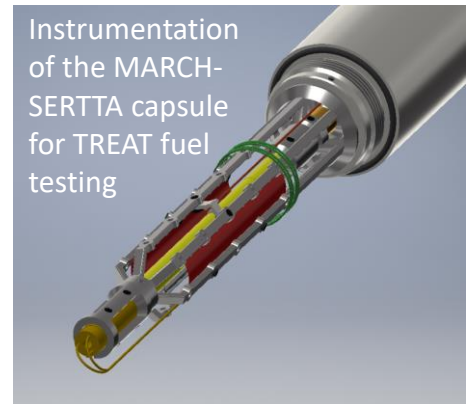
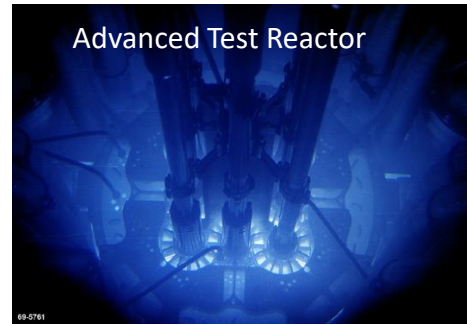
MARMOT



TREAT Fuel Safety Limit Testing

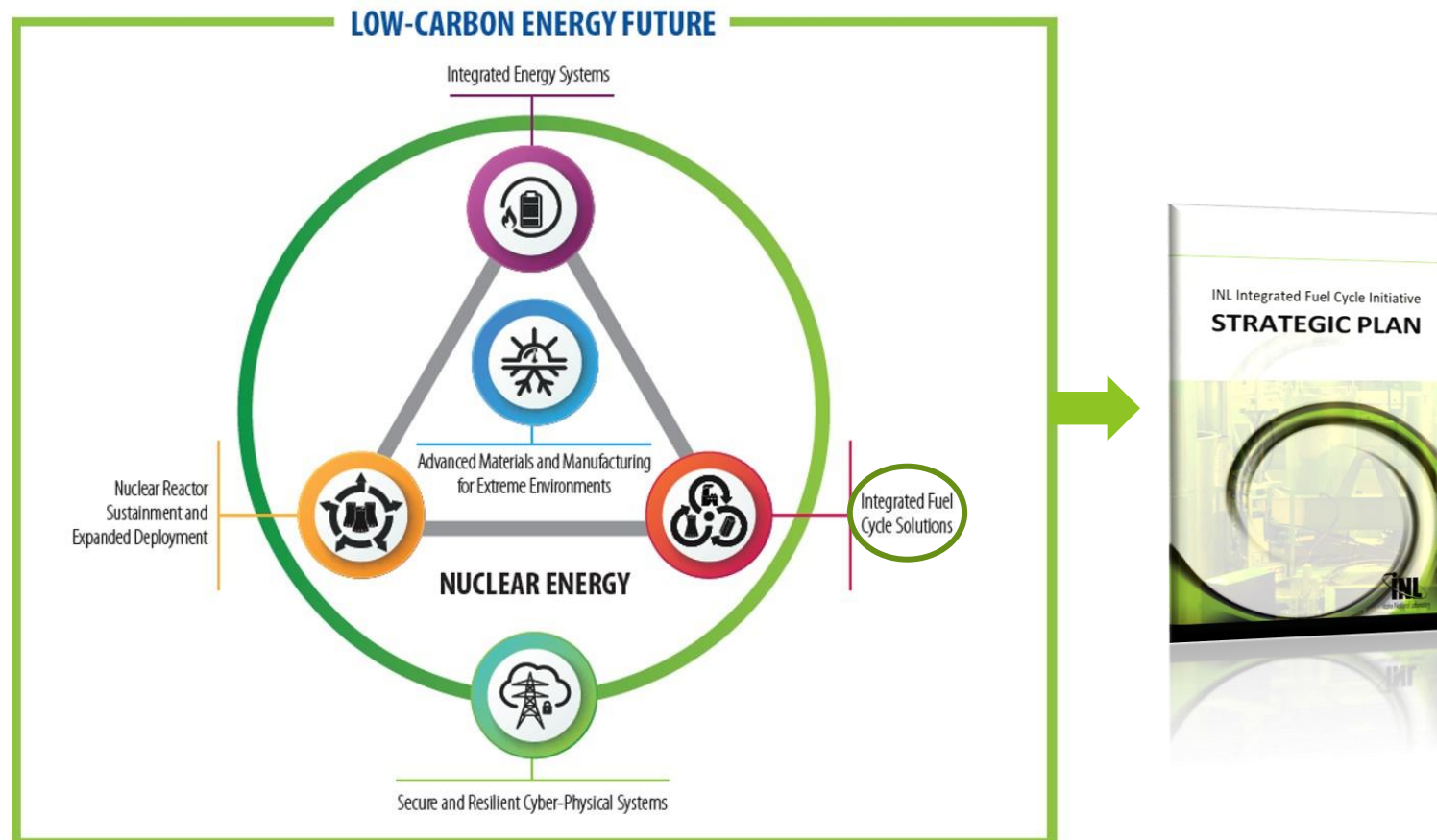
Activities Supporting Fuels and Materials Programs

- **Nuclear Science User Facilities (NSUF)**
 - Experiments awarded competitively to university, industry, and laboratory researchers in nuclear facilities at 20 partner institutions, including ATR, TREAT, HFIR, MITR, and BR2 reactors
- **Advanced Sensors and Instrumentation (ASI)**
 - Development/implementation of instrumentation for irradiation experiments and in-reactor applications
- **ATR I-Loop Project**
 - Expand PWR/BWR steady-state and ramp testing in ATR
- **Advanced Fuel Testing Capabilities**
 - Loss-of-Coolant-Accident (LOCA) test train for TREAT
 - Irradiated fuel rod re-fabrication/re-instrumentation capability to support LWR fuel safety testing in TREAT
 - Accelerated fuel testing methodologies (FAST)



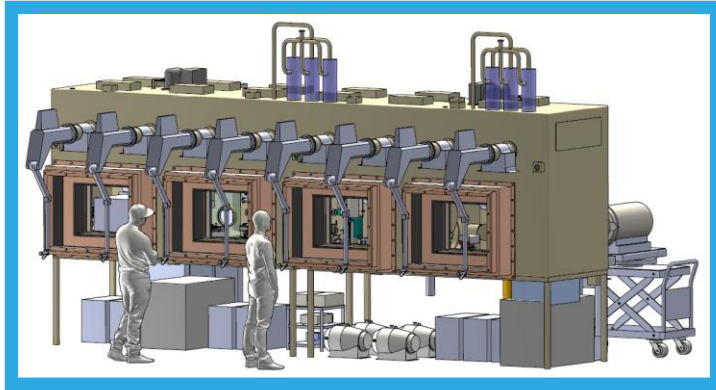
Integrated Fuel Cycle Solutions

INL supports the safe, secure, and economic management of nuclear fuel from inception to final disposition



- Supports **sponsor diversification** by capitalizing in growing NNSA, NHS, DTRA, and AI-Data Science initiatives and budgets
- Provides an integrated **civilian nuclear fuel cycle test bed capability** not available at any other national laboratory
- Develops **key infrastructure** that supports RD&D of **national security solutions** for the evolving civilian nuclear fuel cycle
- **Develops new scientists** to support fuel cycle and nonproliferation objectives

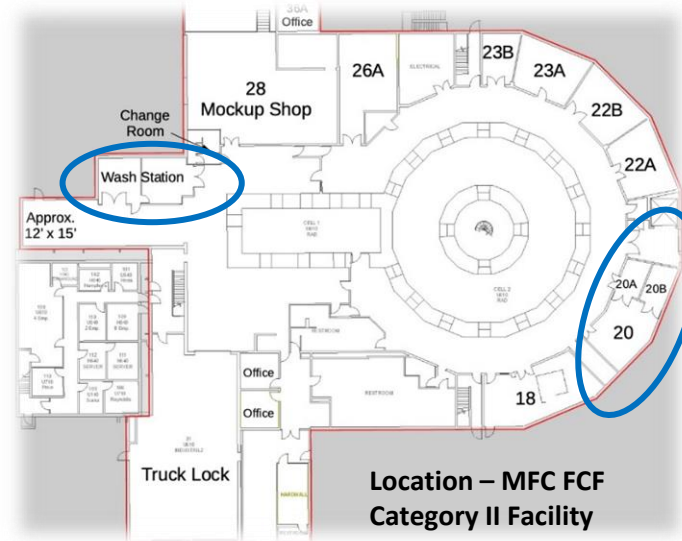
Integrated Fuel Cycle Solutions Test Beds



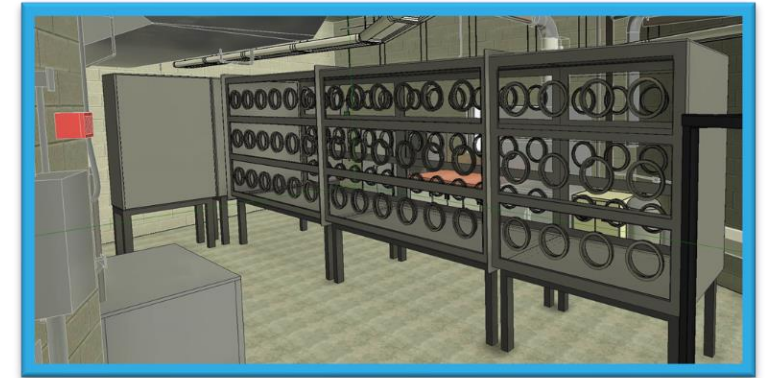
Molten Salt Thermophysical Examination Capability (MSTEC)

Objective – Provide critical data needed to **design, demonstrate, license, and operate a molten-salt reactor**

- Properties include viscosity, density, heat capacity, thermal conductivity, melt temperature, vapor pressure, and redox chemistry
- Supports development of salt purification methods



Location – MFC FCF
Category II Facility



Beartooth – SNM Test Bed

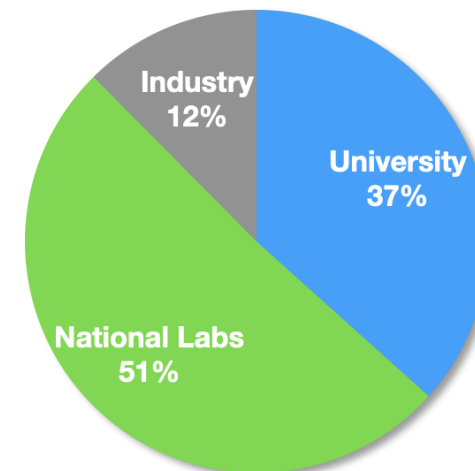
Objective – Provides an integrated civilian nuclear fuel cycle test bed capability for **testing new nonproliferation technologies**

- Platform for instrumentation development supporting tracking and accounting of special nuclear material and proliferation detection of the evolving nuclear fuel cycle
- Develops new AI and ML methods to inform nonproliferation decision making

Advanced Scientific Computing

Collaborative Computing Center is Living Up to its Name

- Facility opened in October 2019
- Four supercomputers fully operational and available for use by DOE, university, and industry
- Sawtooth is INL's flagship computer - 48th fastest computer in the world as of Nov 2020
- Falcon Supercomputer – strategy is being developed for transition to Idaho university operations and management
- Nuclear Computational Resource Center established to facilitate access to INL computing resources and software



Utilization of INL High Performance Computers

Nuclear Science & Technology...

- **Advancing nuclear energy technologies through broad R&D leadership and impactful outcomes**
- **Using and developing unique INL nuclear R&D capabilities for the nation**
- **Partnering with private sector to enable advanced reactor development, demonstration, and deployment**



Idaho National Laboratory