Idaho National Laboratory’s Nuclear Energy Research & Development Mission

Nuclear Energy Tribal Working Group

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The U.S. Department of Energy’s Idaho National Laboratory Site

DOE oversees contractors who are performing three major missions at the Idaho Site:

- **Energy (INL)**: Initially focused on the nation’s lead lab for nuclear energy research, development, and demonstration, but now conducting work such as advanced nuclear reactor development, renewable energy, and subsurface science.
- **National & Homeland Security (INL)**: Initially focused on weapons development, now conducting work related to power and cyber security, nuclear proliferation, non-proliferation, and antimissile technology.
- **Cleanup (ICP & AMWTP)**: Work includes decommissioning and decontamination of buildings, facilities, and equipment.

We Maintain:
- 250 square miles
- 111 miles of electrical transmission and distribution lines
- 376 buildings
- 172 miles of paved roads
- 14 miles of rail/road lines
- 3 reactors
- Spent & used fuel
- Mass transit system
- Security

INL’s history, expertise, and facilities focused on reactor fuels, materials, and safety made it a natural choice as DOE’s lead laboratory for nuclear energy research and development.

On June 1, 2016, Fluor Idaho, LLC, will take over most of the cleanup contract work.
Most of INL’s Nuclear Energy R&D capabilities are focused on three primary site areas

- Advanced Test Reactor Complex
- Materials and Fuels Complex
- Research and Education Campus
INL capabilities help answer BIG questions for DOE and America’s clean energy future

- How can current reactors be operated for 80 years? 100 years?
- How can we extract more energy from used nuclear fuel AND reduce the radiotoxicity?
- How can we make fuel that is accident tolerant?
- How can we license it?
- How can we model fuel and material behavior at the atomic scale?
- How can we build reactors that are more efficient than current reactors?
INL’s nuclear energy research facilities, equipment and expertise

- Advanced Test Reactor and ATR National Scientific User Facility (ATR NSUF includes the Test Train Assembly Facility)
- Transient Reactor Test Facility (TREAT)
- Fuel Conditioning Facility (FCF)
- Fuels and Applied Science Building (FASB)
- Hot Fuel Examination Facility (HFEF)
- Experimental Fuels Facility (EFF)
- Irradiated Materials Characterization Lab (IMCL)
- Electron Microscopy Lab (EML)
- Analytical Chemistry Lab (AL)
- Radiochemistry Lab (RCL)
- Microscopy and Characterization Suite (MaCS)
- Multiphysics Object Oriented Simulation Environment (MOOSE)
- Human Systems Simulation Lab (HSSL)
- Material Science Labs
- Wireless Testing Labs
Status of DOE’s Small Modular Reactor Licensing Technical Support Program

**NuScale Power**
- December 2013 Selection of NuScale announced
- May 2014 Cooperative Agreement signed
- DOE to fund up to $217 M for NuScale SMR development
- **February 2016 Site Use Permit signed** that enables the Utah Association of Municipal Power Systems (UAMPS) to study possibly locating a NuScale-designed SMR facility at INL site
- Government-to-government consultation with Shoshone-Bannock Tribes
- Facility will require National Environmental Policy Act compliance and a U.S. Nuclear Regulatory Commission license

**B&W mPower America**
- 2013 Cooperative Agreement established with team consisting of B&W, Bechtel, and Tennessee Valley Authority
- Initial DOE commitment of $101 M through March 2014
- B&W announced in 2014 that they would reduce funding to up to $15 M/year
- March 2016 BWX Technologies, Inc. and Bechtel announced agreement for accelerated development
- Facility will require National Environmental Policy Act compliance and a U.S. Nuclear Regulatory Commission license
What is a NuScale Power Module?

- A NuScale Power Module (NPM) includes the reactor vessel, steam generators, pressurizer and *containment* in an integral package that eliminates reactor coolant pumps and large bore piping (no LB-LOCA).
- Each NPM is 50 MWe and *factory built* for easy transport and installation.
- Each NPM has its own skid-mounted steam turbine-generator and condenser.

- Each NPM is installed below-grade in a seismically robust, steel-lined, concrete pool.
- NPMs can be incrementally added to match load growth - up to 12 NPMs for 600 MWe gross (~570 net) total output.
What is a Site Use Permit?

- The INL Site Use Permit signed by DOE and UAMPS allows UAMPS to access the INL site to analyze environmental, safety, and siting conditions.
- UAMPS is currently working to identify potential locations at INL that may be suitable for building the UAMPS Carbon Free Power Project (CFPP) for further characterization and analysis.
- The inclusion of the Shoshone-Bannock Tribes’ input is underway and will continue through the process.
- Site characterization activities will be conducted in accordance with all established INL site stewardship protocols to include environmental protection, and historic and cultural resource preservation.
- A Use Permit grants the Holder (UAMPS) the right to use the INL as its location for a SMR under the permit’s terms and conditions, if DOE approves the location.
- It is not a lease or a transfer of real property.
- DOE retains ownership of the real property.
- DOE retains its stewardship responsibilities for the property, including cultural resource protection and CERCLA institutional controls.
National Environmental Policy Act compliance is an important part of the UAMPS Carbon Free Power Project

- DOE will request that the U.S. Nuclear Regulatory Commission (NRC) be the lead agency for the Environmental Impact Statement (EIS)

- The EIS is part of the NRC licensing process

- DOE will consider the NRC final EIS in its NEPA decision related to the SMR location at INL

- Issuance of the license signals NRC’s final NEPA decision
INL’s history of supporting nuclear power in the U.S.

- **Materials Test Reactor** – 1953
  - First testing on what types of materials would work to build reactors
- **Engineering Test Reactor** – 1957
  - Began testing materials in a reactor core vs. external to core
- **Advanced Test Reactor** – 1967; full power in 1969
Purpose of the Advanced Test Reactor

- **What do we do?**
  - We produce neutrons
  - Materials testing time machine
  - Medical isotope production

- **For whom?**
  - U. S. Navy
  - Universities
  - Nuclear industry worldwide
  - Medical applications

- **Why?**
  - U. S. Navy fleet sustainability
  - Advancement of nuclear energy technology
  - Cancer treatment
Instruments installed at IMCL this year will include:
- Electron Probe Micro Analyzer (partly installed)
- Focused Ion Beam (partly installed)
- Scanning Electron Microscope
- Transmission Electron Microscope

These instruments in shielded enclosures allow microstructural characterization of highly irradiated nuclear materials

These studies will allow scientists and engineers to better understand the performance of these materials in nuclear environments
Nuclear Fuels development is a high global priority for multiple reasons

- Fukushima: Resulted in Congressional mandate for more accident tolerant nuclear fuels.
- World Health: World wide alone over 1 Million people die per year from air pollution related to coal fueled electricity generation; a cleaner option is required including new design nuclear plants.
- Greenhouse Gas Minimization: Wind and solar are not stable base loads; nuclear power plants must qualify fuel for load follow operation to allow better utilization of these alternative power sources.
Nuclear Fuels development requires transient testing for design development and qualification.

Nuclear fuel tends to fracture during use or when exposed to a power burst, it is important for the fuel to retain reasonable structural integrity.

During a transient test, fuel is intentionally exposed to a power-to-cooling mismatch, driving the fuel to high temperatures.

Transient testing fuel and crash testing cars have a lot in common: **Design and test for high safety standards**.
Transient Reactor Test Facility (TREAT) reactor

- Designed to conduct transient testing of fuels and structural materials
- Operated from 1959 to 1994 (construction completed in November, 1958)
- Several major bldg. and system upgrades, most recently in 1988
- Reactor has performed 6604 reactor startups, 2884 transient irradiations
- In 2014, a NEPA Environmental Assessment for resumption of transient testing in TREAT was completed
The Need for Transient Testing in the TREAT reactor

- The mission driver for resuming operations at TREAT is to support the development of new fuel types. Deployment of new fuel systems will require the full suite of qualification testing, including transient testing.

- The schedule is being driven by the Accident Tolerant Fuels (ATF) program. In order to have a Lead Test Assembly ready for insertion into a commercial reactor by 2022, transient testing is required in 2018.

- Other potential customers, domestic and international, are also showing interest.
Reactor cores present extreme environments for materials and fuels

Although modeling and simulation are becoming more sophisticated, behavior under irradiation is complex, and irradiation testing is required

INL is unique in its nuclear fuel and material development capability (ATR + MFC + Modeling and Simulation)

INL plays an important role in sustaining current nuclear energy infrastructure and in developing the basis for new nuclear energy systems

Research & Development work at INL improves the safety and longevity of existing reactors, and contributes to the advancement of new reactor and fuel designs for clean, safe, economical baseload electricity that doesn’t emit greenhouse gases
TREAT Overview

- Air-cooled reactor, walk-away facility
  - Negligible decay heat
  - No emergency cooling or residual heat removal required
  - Low fission product inventory
  - Emergency power – not required
- Self-limiting
  - Near instantaneous large negative temperature coefficient – safely shuts the reactor down
  - Reactor Trip System – not required for safety
- Reactivity Control and Operation
  - Three independent Control Rod Drive types
  - Steady state up to 120kW
  - Prompt critical operation – normal mode
  - Transients from remote Control Room
  - Self-contained experiment in center of core
## Roadmap for Transient Testing

### Maturity Curve

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<tr>
<td>✓ Establish Transient Testing Technical Advisory Board including key stakeholder communities</td>
<td>• Establish multi-year Industry consortium project (comparable to Halden and Studsvik)</td>
<td>• Broad user base established that includes DOE, industry programs, and university sponsored programs</td>
<td>• Routinely conduct transient testing in support of safety and performance studies for Industry, NRC, and DOE programs as well as scientific studies for university and DOE programs</td>
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<td>✓ Select and develop pilot test program</td>
<td>• Flowing water and Na loops available to support safety testing on prototype scale fuel systems (complemented by a water loop in ATR for pre-irradiation and operational transient testing)</td>
<td>• Establish multi-environment platform that offers a broad suite of experiment conditions (coolant, pressure, temperature neutron spectrum, etc.) for experiments</td>
<td>• Establish comprehensive user facility for reactor fuels and material safety testing (ranging from in-pile and out-of-pile capabilities for severe accidents to operational transients)</td>
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<td>✓ Develop state-of-the-art reactor testing models to support experiment design and interpretation at all relevant length and time scales (m to μm, min to ms)</td>
<td>• Remote device assembly and checkout station established in HFED for full length test loops</td>
<td>• Establish Capability to remanufacture and instrument fuel pins for transient testing</td>
<td>• Develop and deploy a set of special purpose devices and scientific instruments for in-situ monitoring of nuclear phenomena occurring over a wide range of length and time scales (m to nm, min to ms)</td>
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<td>✓ Re-capture ability to conduct drop-in capsule experiments on irradiated fuel samples including a suite of device designs and remote assembly capability</td>
<td>• Install advanced fuel motion monitoring capability</td>
<td>• Establish irradiated materials library to use as source material for experiments (may be a multi-national consortium)</td>
<td>• Routine use of goal oriented, science based experimentation to develop and qualify modern modeling and simulation tools for nuclear fuel and materials applications</td>
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<td>✓ Implement industry standard instrumentation technologies for experiment monitoring, including reactivation of the fast neutron hodoscope for bulk fuel motion monitoring</td>
<td>• Establish internationally relevant instrumentation development organization</td>
<td>• Establish capability to transport ‘small’ experiment samples internationally for collaborative experimenting and PIE</td>
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<td>✓ Initiate work on new generation of real time fuel motion monitoring instruments and controlled sample environments</td>
<td>• Demonstrate integration of multi-scale modeling and simulation with high fidelity nuclear fuel experimentation (i.e. through MOOSE based applications)</td>
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<td>✓ Explore development of advanced scientific instruments for in-situ monitoring of nuclear materials behavior</td>
<td>• Select and install first in-situ instrument for nuclear fuel behavior monitoring</td>
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