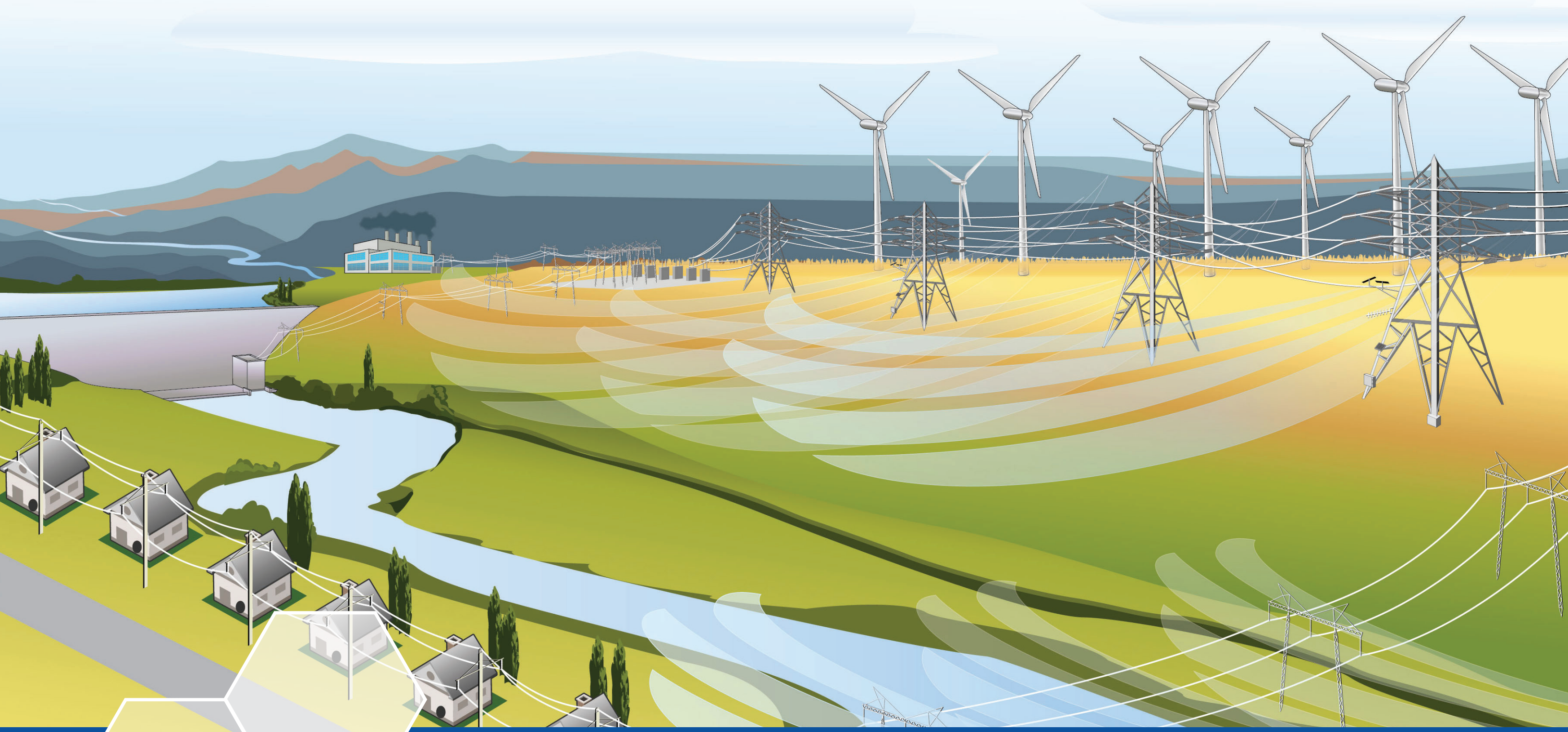


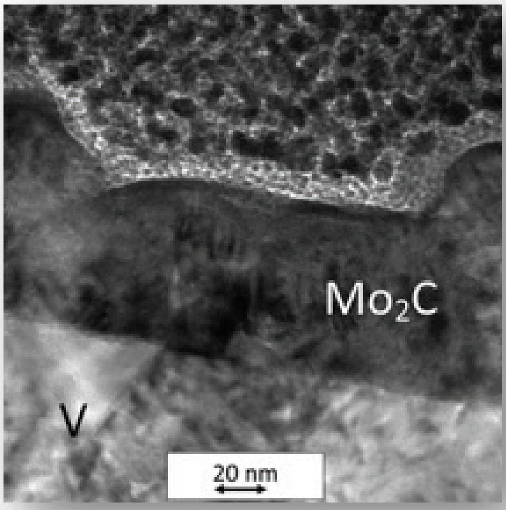
Advanced Research Projects Agency-Energy Research

A summary of INL's new and ongoing ARPA-E projects

LIQUID IMMERSION BLANKET RAPID ASSESSMENT (LIBRA)

This project will demonstrate high tritium breeding ratios in the salt within molten salt reactors. Successfully breeding tritium will be essential to meet the needs of larger-scale nuclear fusion reactors. INL's contribution will analyze pretest tritium transport to inform experiment designs and predict end-state tritium distribution. After the tests, INL will compare models and measured data, modifying these models as the data deems necessary. Finally, INL will support efforts to design a representative permeator tube or membrane and assist with its installation and commissioning. (Collaborator: MIT)

See Figure 1



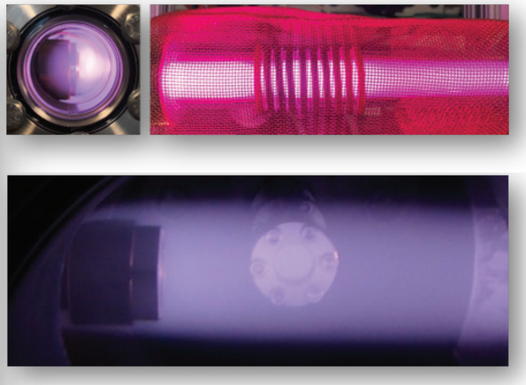


Figure 1.

Samples of how this membrane might appear. INL's capabilities in gathering tritium data are essential for this project's success.

Idaho National Laboratory

GEMINA, PROJECT "SAFARI" – Secure Automation for Advanced Reactor Innovation

Intelligent energy resources (IER) could reduce operations and maintenance costs while increasing autonomy in energy production. A key challenge is how to best accommodate the conflicting objectives and stringent constraints imposed on IER. INL researchers are introducing a novel architecture that autonomously learns and suggests policies for the optimal operability and maintenance of IER. Identifying the best operations and maintenance policies for specified missions. INL efforts represent a notable advance in integrating conventional IER methods with artificial intelligence techniques.

OPEN 2018 – Advanced Manufacturing of Embedded Heat Pipe Nuclear Hybrid Reactor

This project examines a unique microreactor, suggesting that the physics of the reactor ensures autonomous operation throughout the design lifetime. During off-normal conditions, the reactor will shut itself down and promptly dissipate the decay heat without operator intervention or control systems. The project will develop the conceptual basis for the microreactor to showcase its safety and establish that it does not require a safety-related instrumentation and control system. This is a transformative goal for a commercial nuclear power reactor. (Collaborators: Los Alamos National Laboratory, Westinghouse)

OPEN 2018 – Multimetallic Layered Composites for Rapid, Economical Advanced Reactor Deployment

This project will develop a new approach to creating corrosion resistance in structural materials, such as pipes. This involves combining an inexpensive structural material with a highly corrosion-resistant alloy. INL will develop models to predict the interface stability between the two layers. (Collaborators: Massachusetts Institute of Technology, University of Alabama)

TINA – NUCLEAR – Distributed Nuclear Reactor Core Monitoring with Single-Crystal Harsh-Environment Optical Fibers

The project will fabricate and test single-crystal optical fibers for distributed sensing inside molten salt-based nuclear reactor systems. The fibers will facilitate real-time temperature and strain measurements. INL will provide engineering assessments, modeling and analysis of the crystal fibers. (Collaborators: National Energy Technology Laboratory, MIT)

See Figure 2

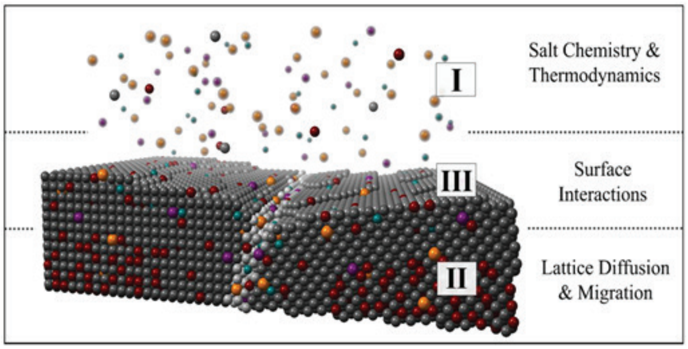


Figure 2.
Regions involved in the molten salt and solid surface interactions.

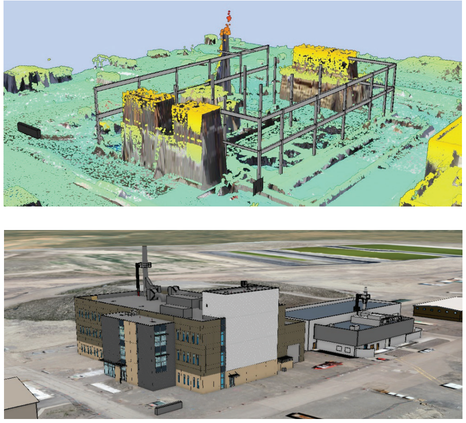


Figure 3.
Point cloud models of new INL construction based on INL images.

TINA – NUCLEAR – A Data-Driven Approach to High Precision Construction and Reduced Overnight Cost and Schedule

The nuclear construction industry has seen a massive uptick in construction and schedule delays. This is largely due to stringent nuclear safety and quality assurance standards, inexperience in managing and staffing according to these standards, excessive paperwork, and supply chain delays. This project will offer a novel virtual environment for modeling and simulating construction performance to lower fabrication and construction cost and time. The environment will enable virtual assembly of nuclear modular components that are fabricated off-site, ensuring their quality and compatibility before shipment.

See Figure 3

ELECTRO-HYDRAULIC FRACTURING

One key challenge with standard fracturing technology is short circuits that decrease efficiency. This project will develop electro-hydraulic fracturing (E-HF) technology, to eliminate these short circuits. E-HF technology uses electric joule heating with thermal shock followed by hydraulic fracturing at lower pressure than traditional methods. The team will use INL's Multiphysics Object Oriented Simulation Environment

See Figure 4

GEMINA, BUILD-TO-REPLACE – A New Paradigm for Reducing Advanced Reactor O&M Costs

This project will encourage capital investments in advanced reactor technology by reevaluating current operations and maintenance strategies. The team will analyze whether shorter design life for major components and systems could optimize both investments and operations. The project evaluates the implications of short versus long design life for cost competitive nuclear plant licensing, construction, operation and decommissioning. More frequent component replacement would enable deployment of emerging technologies that can improve plant efficiency, provide greater functionality, and further protect worker safety and the environment.

Two-Step Chloride Volatility Process for Reprocessing Used Nuclear Fuel from Advanced Reactors

This project will advance a novel two-step chloride volatility process to separate used nuclear fuel species while minimizing waste. The team will exploit their volatility differences in chloride form. Used nuclear fuel is chlorinated in two steps. The first involves hydrogen chloride, and the second, chlorine gas. Then, the reusable fuel components are separated and can be converted to multiple new nuclear fuel forms with minimal waste. (Collaborator: Brigham Young University)

Traveling Molten Zone Refining Process Development for Innovative Fuel Cycle Solutions

This project will develop innovative fuel cycle solutions by considering metallic spent fuel constituents. When spent metallic fuel melts or solidifies, it creates three distinct layers. The team will develop a thermal treatment process to rapidly extract actinides from spent metallic fuels, using knowledge of the fuel behavior in these layers. Successful execution will lay a cornerstone for a transformative economics and safeguards process path for used metal fuels.

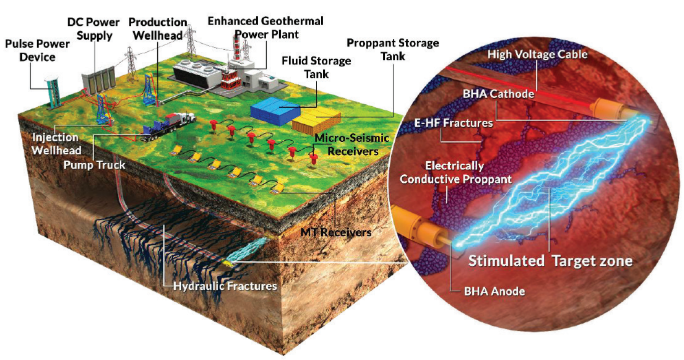


Figure 4.

Graphic representation of the Electro-Hydraulic Fracturing concept.

Interfacial-Engineered Membranes for Efficient Tritium Extraction

More efficient tritium processing enables safe and economical future fusion reactors. Membranes provide a continuous, efficient and low-maintenance method of tritium processing for fuel cycle components. This project will develop and demonstrate advanced membranes for tritium extraction and purification. INL's contributions will include gas-phase hydrogen permeation, tritium extraction, plasma-driven permeation of hydrogen and deuterium, membrane testing and characterization, and model development. (Collaborator: Colorado School of Mines)

Enabling the Near-Term Commercialization of an Electrorefining Facility to Close the Metal Fuel Cycle

This project will commercialize a state-of-the-art nuclear fuel recycling facility within the next few years. The facility will produce fuel for Oklo's metal-fueled reactors, closing the advanced reactor fuel cycle. INL will support the molten salt research aspect. Molten salt will be used as the electrochemical recycling medium for the used nuclear fuel. Over time, the molten salt becomes laden with used fuel constituents such as fission products. INL will demonstrate and optimize, in a remote nuclear facility hot cell, a fractional crystallization unit operation for concentrating and removing fission products from molten salt. After treatment with fractional crystallization, the clean salt can be reused in the proposed recycling process. (Collaborator: Oklo)

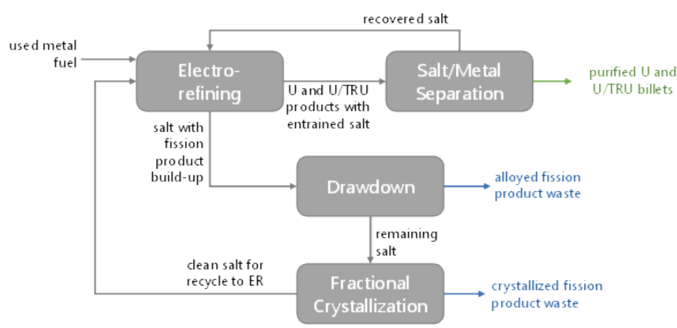
See Figure 5

Non-Neutron Transmutation of Used Nuclear Fuel

This project will develop a transformational technology for fission products with long half-lives. The goal is to use non-neutron particles, such as photons and protons. This could substantially reduce disposal impacts of recovered wastes from used nuclear fuels by eliminating the need for a geologic-time-scale repository in which nuclear wastes have to be interred for several hundred thousand years. The proposed technology also poses no criticality issue or proliferation risk because it would not involve any actinides. It would also limit the management of used fuel to short-term storage sites.

Chloride-Based Volatility for Waste Reduction and/or Reuse of Metallic-, Oxide-, and Salt-Based Reactor Fuels

This project will develop a method to recover uranium from used nuclear fuel using the volatility of chloride salts at high temperatures. Chloride-based volatility treatment could enable removal of bulk uranium. This uranium could then be recycled or disposed of at a lower cost, compared to other isotopes that need to be stored in geologic repositories. This approach could reduce the waste entering a repository by a factor of 10 or even 20, while also reducing the total cost of disposal. (Collaborator: Savannah River National Laboratory)



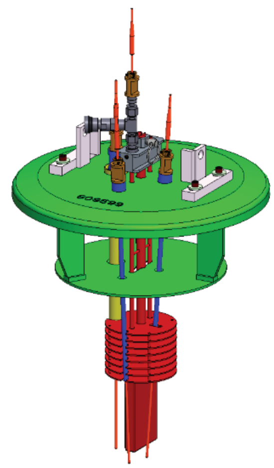


Figure 5.

A simplied flowsheet detailing unit operations, product streams, and waste streams to be examined by this project (above) and a rendering of INL's melt crystallizer (left).

FOR MORE INFORMATION

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