August 2021

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Environment Science and Technology

Energy, Environment, Science & Technology

Program Overview

Idaho National Laboratory

INL is uniquely capable of addressing challenges to the nation's energy and security future

INL Values

Excellence, Inclusivity, Integrity, Ownership, Teamwork, and Safety

INL Vision

INL will change the world's energy future and secure our critical infrastructure.

INL Mission

Discover, demonstrate and secure innovative nuclear energy solutions, clean energy options and critical infrastructure.

Overview

- Integrated Energy Systems
- Resilient Energy Systems
- Manufacturing
- Feedstocks for a Circular Economy

Integrated Energy Systems

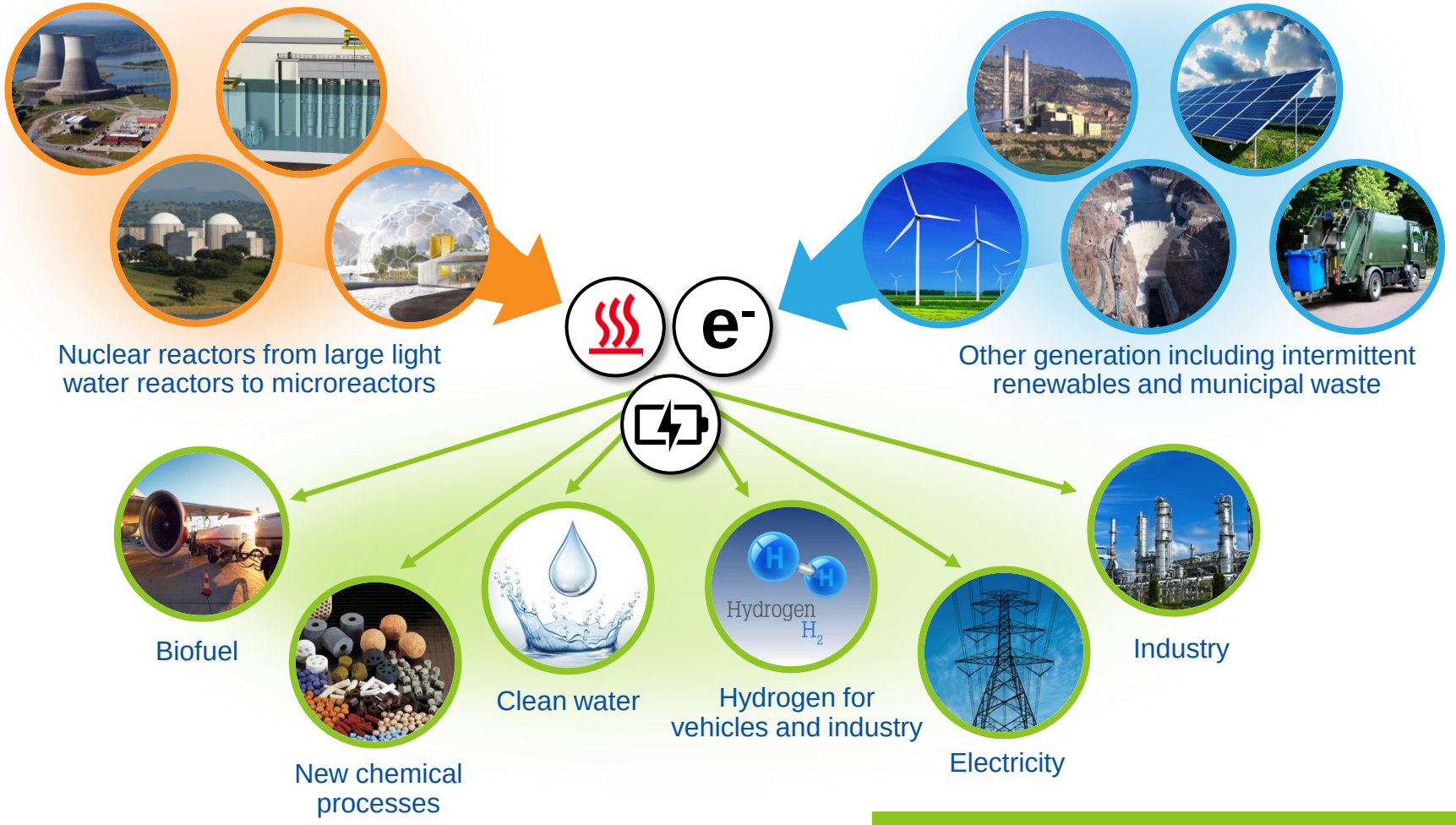
Transforming the energy paradigm

Today

Electricity-only focus

Future Energy System

Integrated grid system leverages contributions from nuclear fission beyond electricity



Joint EERE-NE H_2 Production Demonstration Projects

Four projects have been announced for demonstration of hydrogen production at nuclear power plants

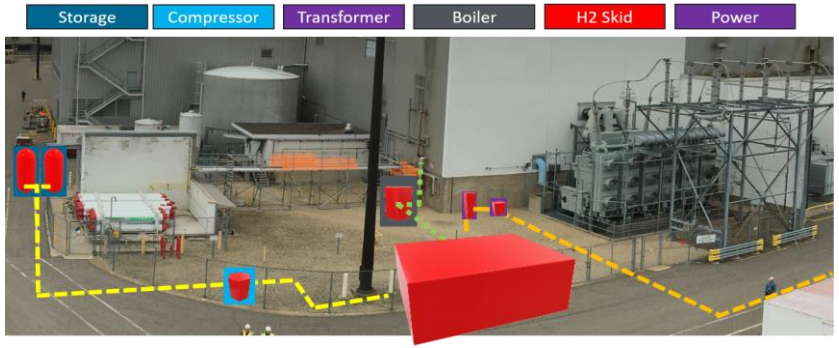
- Demonstrate hydrogen production using direct electrical power offtake from a nuclear power plant for a commercial, 1-3 MWe, low-temperature (PEM) and high temperature steam electrolysis modules
- Acquaint NPP operators with monitoring and controls procedures and methods for scaleup to large commercial-scale hydrogen plants
- Evaluate power offtake dynamics on NPP power transmission stations to avoid NPP flexible operations
- Evaluate power inverter control response to provide grid contingency (inertia and frequency stability), ramping reserves, and volt/reactive control reserve
- Produce hydrogen for captive use by NPPs and first movers of clean hydrogen

H2@Scale U.S. Department of Energy

LWRS LIGHT WATER REACTOR SUSTAINABILITY

Davis-Besse Nuclear Power Plant

Thermal & Electrical Integration at Xcel Energy Nuclear Plant



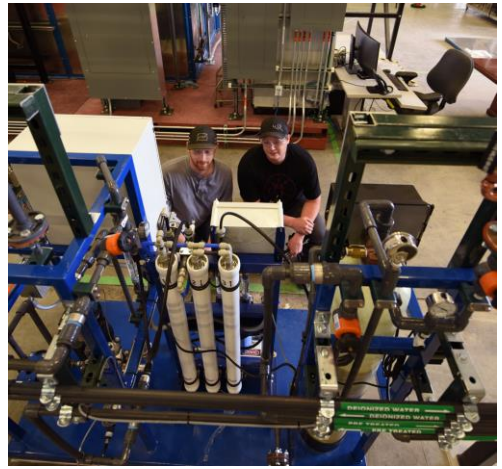
High Temperature Electrolysis – Hydrogen Production

Program Overview

- High temperature electrolysis (HTE) systems produce hydrogen using heat and electricity with ultra-high efficiency.
- INL's 25 kW HTE Station (pictured right) verifies durability and performance of solid oxide cells that are used to produce hydrogen with high efficiency.

Example Projects

- High Temperature Steam Electrolysis modules testing: Bloom Energy, FuelCell Energy, OxEon



Impact/Opportunity

- Establish Idaho as a leader in a Western United States Hydrogen Hub to produce hydrogen using nuclear power.

Hydrogen Production - Partners

Program Overview

- INL has teamed with several industry partners to demonstrate hydrogen production at nuclear power plants.

Partnerships

- Bloom Energy has manufactured a 100kW HTE to be installed and tested at INL in September.
- INL will install a 150 kW HTE system at Xcel Energy Nuclear Power Plant to demonstrate high-efficiency hydrogen production using nuclear power.
- FuelCell Energy is developing a 250kW HTE to be tested by INL in early 2022.
- OxEon is manufacturing a reversible solid oxide cell system that will operate in either electrolysis mode to produce hydrogen from electricity and water, or in fuel cell mode to produce electricity from hydrogen.

Energy Storage

Program Overview

- INL's battery facilities provide 20,000 square feet and can test hundreds of batteries at the same time.

Example Projects

- Battery500: The team has developed long life batteries with two times the energy of previous state of the art commercial batteries.
- Machine Learning: INL is reducing time needed to validate technologies.
  - From 18 months to 2 weeks, the team can now predict performance and cell failure 36 x's faster.

Impact/Opportunity

- Idaho's cobalt deposits provide opportunity to understand how critical metals can be a part of advanced battery development.

Transportation Electrification

Program Overview

- Provide data, tools and expertise to help the public and private sectors plan the fueling/charging infrastructure necessary to support widespread electric and fuel-cell vehicle adoption.

Example Projects

- White House national EV charging network planning team
- INL Netzero
- Technical assistance to Idaho OEMR, DEQ for EV charging infrastructure program using Volkswagen settlement funds

Impact/Opportunity

- INL motorcoach fleet electrification will provide a blueprint for other Idaho fleets.
- Helping to shape state-wide EV charging infrastructure network and program that will bring more funding to Idaho.

Electric Vehicles & the Grid

Program Overview

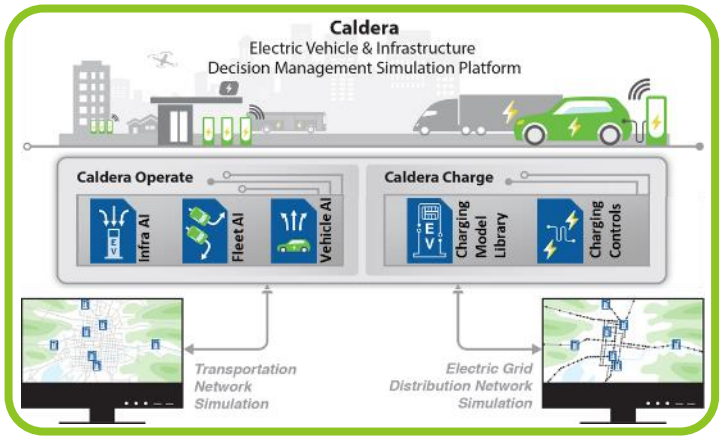
- Developing technology to integrate EV charging and hydrogen fueling into the broader energy system.
- Our research includes data collection, modeling and simulation, cybersecurity, and real-world demonstrations.

Example Projects

- Caldera: a tool for evaluating EV charging impact on the electric grid
- Cybersecurity: EV charging as critical infrastructure must be secure to protect transportation and the grid
- Studying in-road wireless charging could remove the need for large, bulky batteries.

Impact/Opportunity

- Partnerships for Technical Collaboration with Rocky Mountain Power, Valley Regional Transit, Mountain Rides and Republic Services



Hydropower

Program Overview

- Advancing hydropower's ability to balance the regional grid and maximizing the value of this renewable resource for communities.

Example Projects

- Hydro+Storage: developing tools to design hydropower hybrids.
- Irrigation Modernization: decision tool for irrigation districts.
- Hydropower + Hydrogen: generating green hydrogen.

Impact/Opportunity

- Working with Minidoka irrigation district to investigate upgrade opportunities.
- Teamed with Idaho Falls Power to show how hydropower plants can be used to serve critical community electric loads during emergency outage.
- Working with Idaho Power on viability of producing green hydrogen at one of their facilities; oxygen biproduct would be injected into river to improve water quality.

Resilient Energy Systems

Microgrids

Program Overview

- INL's microgrid test bed system allows researchers to study and demonstrate their uses and component capabilities prior to real-world application.

Example Projects

- Net-zero microgrids R&D initiative, with potential to incorporate and integrate advanced storage, renewable energies, no/low-carbon fuels, and small modular/micro reactor technologies.
- R&D on relocatable microgrid systems with outage relief benefits for end users.

Impact/Opportunity

- Microgrid use increases clean energy resource developments, integration, and resiliency improvement potential.
- Consulted with Idaho Power and Idaho Falls Power to develop microgrid technologies that fit their needs.

Manufacturing

Electric Field Assisted Sintering Technology (EFAST)

Program Overview

- EFAST is a system that can manufacture advanced components made of metals and ceramics that can withstand extreme conditions.

Example Projects

- The new DCS-800 EFAST under construction at INL (pictured right) is the world's largest and can manufacture materials at industrially relevant scales.

Impact/Opportunity

- INL houses the world's only capability to engage in all stages of R&D in a single site, from basic science through bench scale demonstration and digital engineering, to pilot scale production demonstration.

Digital Engineering

Program Overview

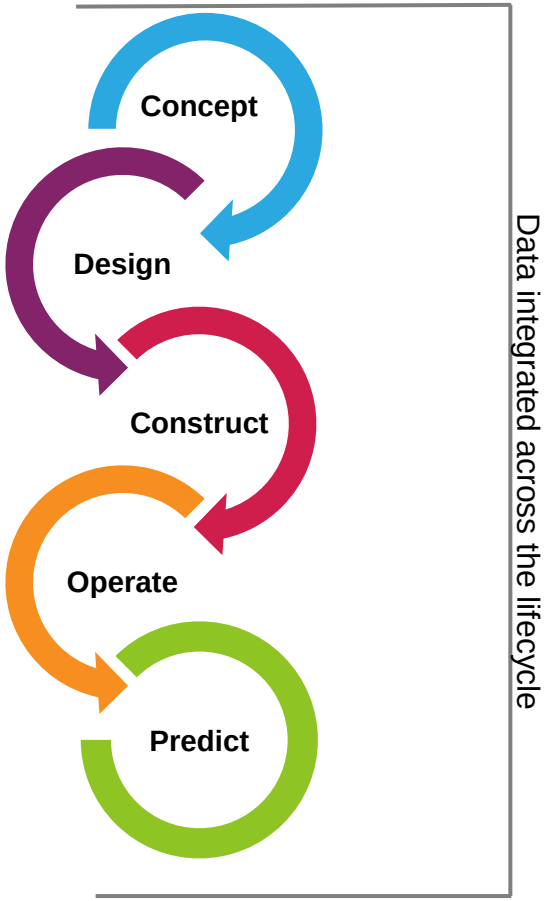
- Digital Engineering (DE) uses artificial intelligence and real-time integrated data to coordinate engineering, construction, procurement, and facility operations.
- DE keeps costs down through integrated design and work on track while dramatically reducing overall program risk.

Example Projects

- Digital Engineering Design Ecosystem for Nuclear Reactors.
- Digital Twins for Non-Proliferation.
- Integrated Hybrid Cloud / High Performance Computing Platforms.

Impact/Opportunity

- DE initiative is working to secure funding on new renewable energy digital twins (ex. Water Irrigation which will have significant impact on the snake river plain water system).



Feedstocks for a circular economy

Biomass Feedstock National User Facility

Program Overview

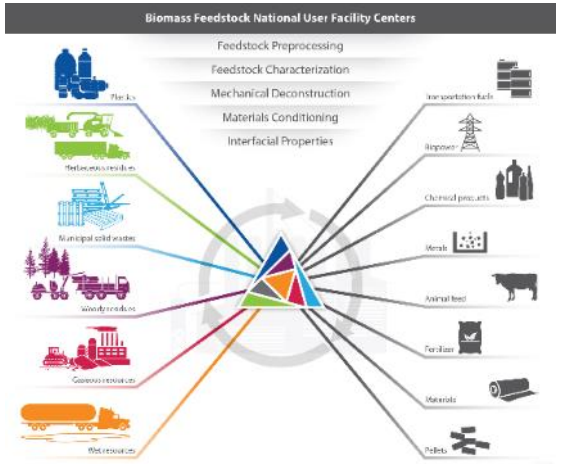
- At the Biomass Feedstock National User Facility researchers focus on R&D associated with key technical barriers facing the U.S. bioenergy and manufacturing industry.

Example Projects

- DARPA: mobile waste processing systems for remote locations.
- Waste fractionation to produce insulation or compounds for auto parts.
- New project on improving soil health with cover crops and biochar.

Impact/Opportunity

- New scope to develop STEM curriculum on MSW and recycling strategies for Shoshone Bannock Tribe.
  - INL will work with this community to conduct waste surveys and collect materials for characterization and preprocessing.
- New market exploration enabled by fractionation, formulation, and merchandising.



E-RECOV

Program Overview

- Electrochemical Recycling Electronic Constituents of Value (E-RECOV) is a method that uses an electrochemical cell to efficiently recover valuable metals from discarded electronics.

Example Projects

- Supporting industry partner Quantum Ventura Inc., to build a demonstration plant with capacity to process over 7 kg/day of electronic waste

Impact/Opportunity

- Idaho's primary renewable energy generation makes it a suitable place to implement electrochemical powered technologies in the manufacturing sector.

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Example Projects

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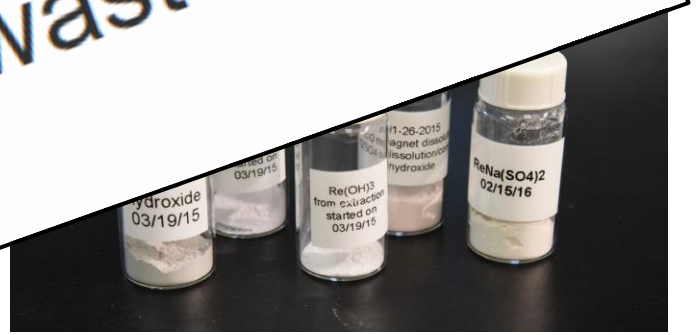
INL research studies use of potato wastewater in reclaiming rare-earth elements



Questions?