

# Science **Technology** OVERVIEW



As the nation's nuclear energy laboratory and a leader in cyber-physical security and resiliency, INL's expertise spans 15 of the 25 DOE-recognized core capabilities, delivering innovative outcomes through INL's five intersecting science and technology (S&T) initiatives to advance its mission to discover, demonstrate and secure innovative nuclear energy solutions, other clean energy options and critical infrastructure. Fundamental research coupled with direct applications in science and engineering enables INL to deliver immediate impact and groundbreaking technologies through the five S&T initiatives addressing clean

energy and critical infrastructure challenges. Nuclear Reactor Sustainment and Expanded Deployment along with Integrated Fuel Cycle Solutions are foundational initiatives to INL's nuclear capabilities, both of which enable the new paradigm of Integrated Energy Systems to create a clean energy future. Advanced Materials and Manufacturing for Extreme Environments supports these three initiatives, all of which are encompassed by Secure and Resilient Cyber-Physical Systems. These five initiatives leverage INL's core capabilities, comprised of our world-leading facilities, specialized equipment, and expert teams.

## INL'S CORE CAPABILITIES

- Advanced computer science, visualization, and data
- Chemical and molecular science (emerging)
- Cyber and information sciences
- Large-scale user facilities/R&D facilities/advanced instrumentation
- Nuclear engineering
- Applied materials science and engineering
- Chemical engineering
- Decision science and analysis
- Mechanical design and engineering
- Power systems and electrical engineering and integration
- Biological and bioprocess engineering
- Condensed matter physics and materials science (emerging)
- Environmental subsurface science
- Nuclear and radiochemistry
- Systems engineering and integration

## Nuclear Reactor Sustainment and Expanded Deployment

As DOE's nuclear energy laboratory, INL is creating and defining the next phase of nuclear energy. INL advances global competitiveness by sustaining and extending the safe and efficient operation of existing reactors and by pioneering

advanced reactor technologies for future deployment. INL focuses research, development, and demonstration of innovative technologies to improve the performance of existing and future nuclear energy systems. Under this initiative,

INL uses its core capabilities to strengthen the domestic commercial nuclear energy enterprise, enable U.S. technological leadership in global nuclear energy markets, and expand and deploy national nuclear energy strategic infrastructures.



## Integrated Fuel Cycle Solutions

INL's extensive facilities and expertise in nuclear fuels and materials creates vital integrated fuel cycle solutions to sustain the current reactor fleet, support the demonstration and deployment of new advanced reactors, and facilitate the management and disposition

of existing and future radiological waste materials. By exploring fuel cycle technologies for advanced reactor demonstration and deployment, INL focuses on a fuel cycle with inherent process transparency, reducing proliferation risk and including safeguards

and security by design. INL utilizes its core capabilities to advance the availability of special nuclear material and strategic isotopes, manage radiological waste materials and used nuclear fuel, reduce proliferation risk, and develop RD&D test beds.



## Integrated Energy Systems

Through research and demonstration, INL delivers technologies advancing integration of energy generation, storage, and delivery needed for a net-zero energy future. INL develops multigeneration energy systems incorporating nuclear heat with all forms of electricity generation, including renewables and natural gas

with carbon capture and sequestration, capable of producing products ranging from food to electronic devices as well as power for heating. By innovating methods to harness electricity and heat to produce hydrogen and other industrial products, INL is accelerating the creation of an economy based on clean energy while enhancing

grid reliability, resilience, and affordability. INL leverages its core capabilities to demonstrate high-efficiency thermal energy use, enable a sustainable, resilient, and reliable clean energy grid, develop novel chemical and industrial processes, and enhance tools and approaches to optimize integrated energy systems options.



## Advanced Materials and Manufacturing for Extreme Environments

Building on existing expertise in materials research and development for extreme environments with innovation in advanced manufacturing, INL is shifting the paradigm from design-build-test to digital design and manufacturing for nuclear fuels, lightweight materials, and advanced

survivability materials. Advanced manufacturing enables simultaneous fabrication with process monitoring and control, and supports all INL mission area needs. Under this initiative, INL uses its core capabilities to accelerate innovation by developing advanced manufacturing process-

informed material design, expand advanced manufacturing process development, enable rapid material characterization and testing designed for advanced manufacturing, and integrate comprehensive data analytic and modeling and simulation techniques.



## Secure and Resilient Cyber-Physical Systems

Relying on its world-class R&D capabilities and unique assets, INL secures our nation's critical civilian infrastructure and military systems against complex and dynamic cyber threats while increasing resiliency to a variety of hazards and environmental changes. INL advances

transformational approaches addressing true risks throughout critical system lifecycles. INL's core capabilities facilitate efforts to formalize and scale cyber-informed science and engineering, strengthen all-hazards physical and cyber critical infrastructure resilience, innovate

for enduring control systems cybersecurity, establish a secure resilient digital supply chain for critical infrastructure, and secure wireless communications and spectrum use as a key enabler to critical systems.



## Building toward a net-zero energy future

INL is leading by example to transform its campus to reach net-zero carbon emissions by 2031. In coordination with DOE, INL and three other national labs are partnering to demonstrate clean energy solutions that will lead the nation to net-zero carbon emissions. INL is well positioned to utilize its capabilities to develop science and technology that enables a net-zero energy future by integrating innovative nuclear with a variety of other clean energy technologies. INL's unique site and operational activities make it an ideal platform to demonstrate proof-of-concept for net-zero technologies that can be deployed domestically and throughout the world. Each science and technology initiative leverages its capabilities to facilitate INL's transformation to a net-zero campus.

