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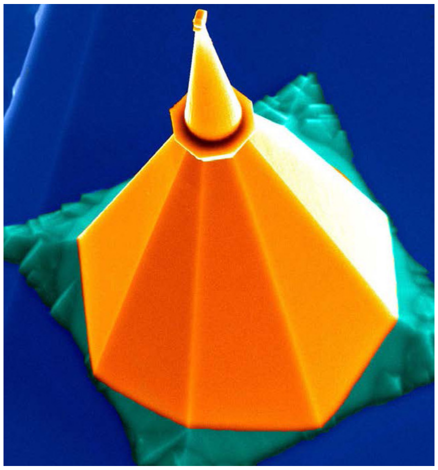
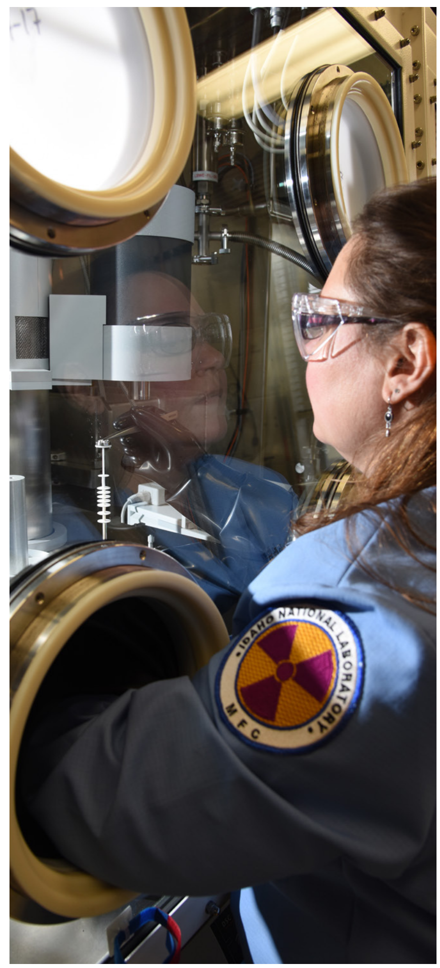
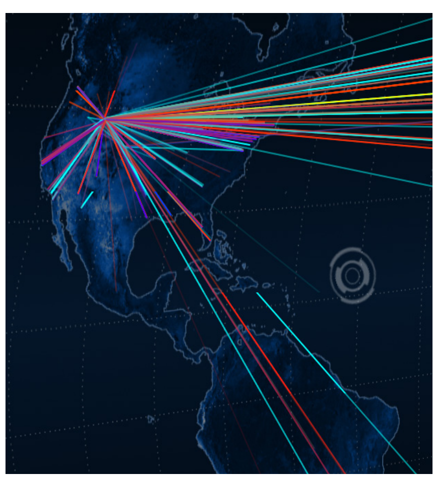
INL VISION AND STRATEGY 2015



Changing the World's Energy Future and Securing our Critical Infrastructure

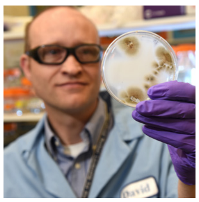




Idaho National Laboratory

Exciting Future

Fuel on Coupon Pillar



David Reed, Critical Materials Institute

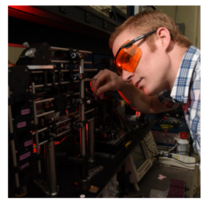
Battery Test Lab

Grid Security

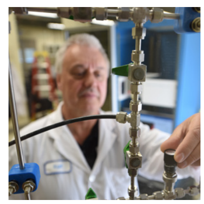
MFC

Sophia

Grid Security

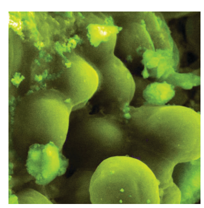


NEUP Fellow



High Temperature Test Lab

ATR reactor top



Fuel From Algae

The best ideas with the best capabilities

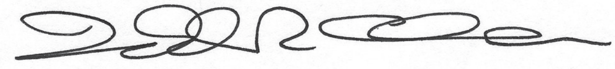
Idaho National Laboratory (INL) is the Department of Energy Office of Nuclear Energy lead laboratory. Our mission is to discover, demonstrate, and secure innovative nuclear energy solutions, other clean energy options, and critical infrastructure with a vision to change the world's energy future and secure our critical infrastructure.

Over its 890 square miles, INL holds a combination of energy system performance and demonstration capability unmatched in the nation. This includes facilities to support innovation across all aspects of nuclear energy, including security and non-proliferation; co-located facilities to understand wireless spectrum use and electrical energy transmission and distribution; first responder training facilities; energy system dynamics capability; transportation system performance; and an explosives test range used to develop systems for protection of physical assets. We like to think of the Laboratory as a well-characterized city/region that is reconfigurable to analyze, optimize, and demonstrate energy system performance and security. These energy system performance facilities are made impactful through the efforts of the key national thought leaders in our 11 areas of impact described in this Laboratory vision and strategy document. We have the people and capabilities, and have formed the partnerships to lead the nation in 21st century energy security.

Enabling the use of the capability to researchers, including industry, academia, and national laboratories, beyond INL is a necessary and proper use of the facilities entrusted to INL. To optimize the use of precious national resources, INL embraces the user facility model where we not only host the capability, but also make it available to researchers across the nation. Pairing the best ideas with the best capabilities must be our goal.

Todd Allen
Deputy Laboratory Director
Science & Technology

This Laboratory vision and strategy presents INL's vision and strategy for the Laboratory and is our introduction to a special place dedicated to improving our nation's energy security future.



Todd R. Allen
Deputy Laboratory Director, Science & Technology
Idaho National Laboratory

Acronyms

AL	Analytical Laboratory
ANL	Argonne National Laboratory
ATR	Advanced Test Reactor
ATRC	Advanced Test Reactor Critical
BEA	Battelle Energy Alliance, LLC
CAES	Center for Advanced Energy Studies
CETT	Collaboratory for Energy Transitions Transformations
CFA	Central Facilities Area
CITRC	Critical Infrastructure Test Range Complex
CMI	Critical Materials Initiative
DOE	Department of Energy
EM	Office of Environmental Management
EML	Electron Microscopy Laboratory
EPRI	Electric Power Research Institute
FASB	Fuels and Applied Science Building
FCF	Fuel Conditioning Facility
FORGE	Frontier Observatory for Research in Geothermal Energy
FMF	Fuel Manufacturing Facility
FY	fiscal year
HES	hybrid energy systems
HEFE	Hot Fuel Examination Facility
IMCL	Irradiation Materials Characterization Laboratory
GEM	Global Energy Innovation and Manufacturing Institute
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IRC	INL Research Center
LANL	Los Alamos National Laboratory
LDRD	laboratory-directed research and development
LWR	light water reactor
MFC	Materials and Fuels Complex
MOOSE	Multiphysics Object-Oriented Simulation Environment
NASA	National Aeronautics and Space Administration
NE	Office of Nuclear Energy
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NSUF	Nuclear Science User Facilities
ORNL	Oak Ridge National Laboratory
R&D	research and development
RCL	Radioanalytical Chemistry Laboratory
RD&D	research, development, and demonstration
RDD&D	research, development, deployment, and demonstration
REC	Research and Education Campus
RISMC	Risk Informed Safety Margin Characterization
RML	Radiation Measurements Laboratory
RWMC	Radioactive Waste Management Complex
SMC	Specific Manufacturing Capability
SNM	special nuclear material
SPL	Sample Preparation Laboratory
SPP	Strategic Partnership Programs
SSPSF	Space and Security Power Systems Facility
STAR	Safety and Tritium Applied Research Facility
STEM	Science, Technology, Engineering, and Math
TAP	temporal analysis of products
TREAT	Transient Reactor Test Facility
UNF	used nuclear fuel
ZPPR	Zero Power Physics Reactor Building

Contents

Laboratory Overview

Location: Idaho Falls, ID

Type: Multiprogram laboratory

Contractor: Battelle Energy Alliance, LLC (BEA)

Responsible DOE Field Office: Idaho Falls Office

Web site: https://www.inl.gov/

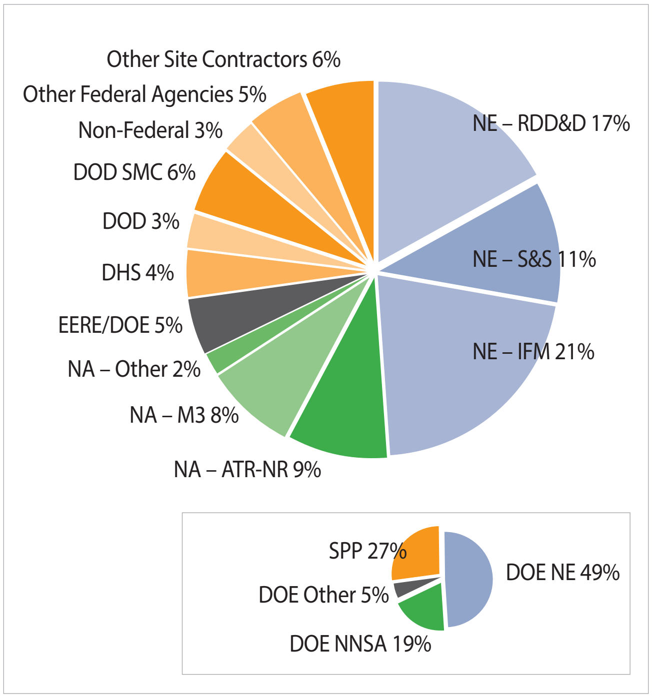
INL Site: INL resembles a "well characterized city/region" where energy and security questions can be addressed at scale, including:

- 890 square miles
- 111 miles of electrical transmission and distribution lines
- 492 buildings
- 117 miles of paved roads
- 14 miles of railroad lines
- 3 nuclear reactors
- 2 spent nuclear fuel pools
- Mass transit system
- Security
- Museum
- Waste disposal facilities
- 300 metric tons of used fuel
- Education and research partnerships: Center for Advanced Energy Studies

Fiscal Year 2015 Human Capital:

- 3,890 total full-time equivalent
- 18 joint faculty
- 36 postdoctoral researchers
- 89 graduate students
- 167 undergraduate students
- 16 high school interns
- 130 user facility participants

FY 2015 Research Funding: $924M, nuclear energy RD&D (accounting for 49% of all work)



FY 2015 Funding by Source: (Cost data in $M)

1. Mission, Vision, and Overview

The mission of Idaho National Laboratory (INL) is to discover, demonstrate, and secure innovative nuclear energy solutions, other clean energy options, and critical infrastructure, and in doing so to execute INL's vision to change the world's energy future and secure our critical infrastructure. To achieve its vision, INL is

- Focusing research, development, deployment, and demonstration (RDD&D) on grand challenges in energy and national security (Appendix A)
- Designing, building, and operating world class and unique research, development, and demonstration (RD&D) infrastructure (Appendix B)
- Working towards creating a global nexus of world-class scientific talent pool
- Building and sustaining global strategic partnerships.

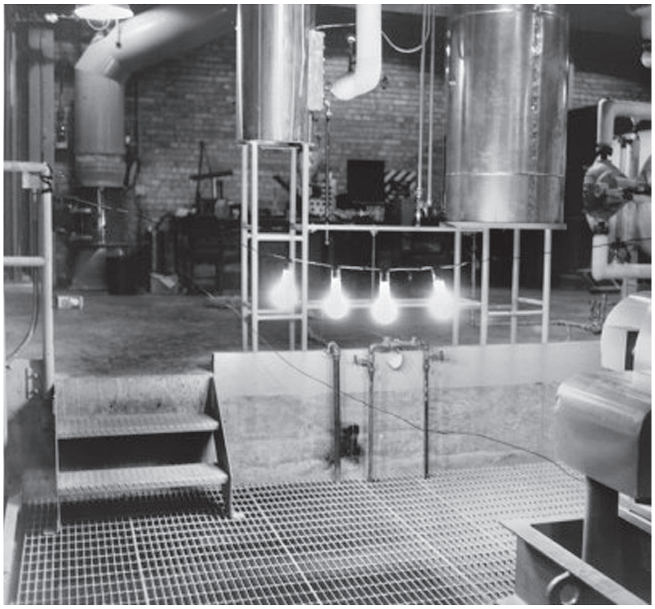
To execute this mission, INL integrates and applies distinctive core capabilities (Appendix C) combined with unique RD&D facilities that provide signature strengths in nuclear energy, clean energy deployment, and modernizing and securing critical infrastructure. The outcome will be transformational innovations in energy and security concepts.

INL Core Capabilities

- Nuclear fuels and materials science and technology
- Applied materials science and technology
- Energy systems design and analysis
- Critical infrastructure protection
- Engineering research, performance, validation, and demonstration
- Nuclear nonproliferation
- Industrial control systems
- Environmental systems surveillance
- Chemical and materials separation science
- Materials science and energetics
- Defense systems
- Enabling infrastructure

Operating since 1949, INL is the nation's leading RD&D center for nuclear energy including nuclear non-proliferation and physical and cyber-based protection of energy systems and critical infrastructure, and integrated energy systems RDD&D. INL is managed and operated by Battelle Energy Alliance, LLC (BEA), a wholly-owned company of Battelle, for the Department of Energy (DOE) since 2005. BEA is a partnership of Battelle, BWX Technologies, Inc., AECOM, the Electric Power Research Institute (EPRI), the National University Consortium (Massachusetts Institute of Technology, Ohio State University, North Carolina State University, University of New Mexico, and Oregon State University), and the Idaho University Collaborators (University of Idaho, Idaho State University, and Boise State University).

Created as the National Reactor Testing Station, INL pioneered nuclear-generated electricity to power the first American community and demonstrated the Navy's first nuclear propulsion systems. INL is where several of the nation's best and brightest researchers come to advance the promise of nuclear energy, the most reliable and cost-effective energy source that will enable national objectives for addressing climate change. Since its creation, INL's research and development (R&D) portfolio has broadened with targeted programs supporting national missions in advancing nuclear energy, enabling clean energy deployment, securing and modernizing critical infrastructure. INL's RD&D capabilities, resources, and unique geography enable the integration of scientific discovery, innovation, engineering, operations, and controls into complex/large-scale testbeds for discovery, innovation, and demonstration of transformational clean energy and security concepts strengthening INL's leadership as a demonstration laboratory.

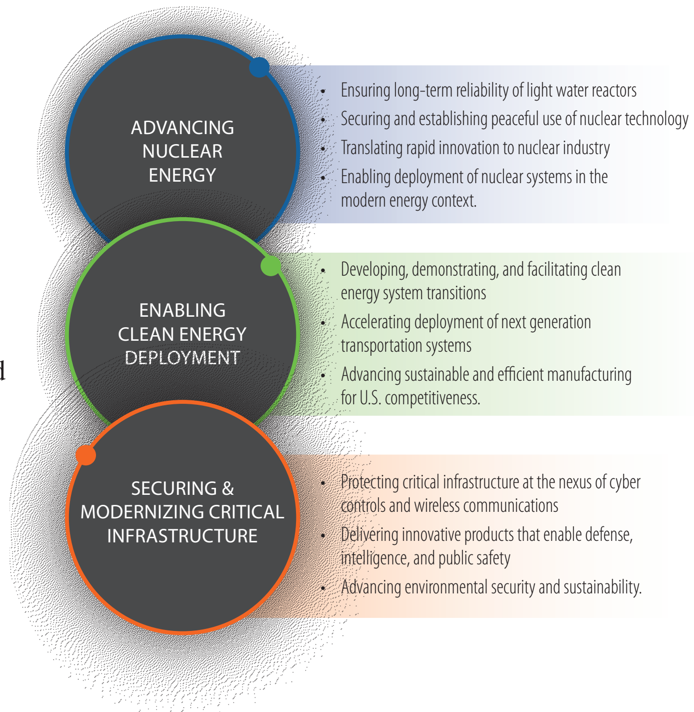


EBR-I became the first power plant to produce electricity using atomic energy on December 20, 1951.

Today, INL is the lead national laboratory for nuclear energy RDD&D supporting the long-term operations of commercial light water reactors (LWRs), developing advanced nuclear reactors and associated fuel cycles, and developing nuclear fuels. INL is home to some of world's most unique and premier facilities that support innovations across all aspects of nuclear energy and national security. INL's world premier research facilities include the Materials and Fuels Complex (MFC) that hosts the nation's leading post-irradiation examination facility (which supports the National Aeronautics and Space Administration's [NASA's] missions in addition to fundamental nuclear fuels and materials research) and the Advanced Test Reactor (ATR) Complex that facilitates fuels and materials testing for use in nuclear reactors.

In addition to nuclear energy, INL is a globally-recognized RDD&D leader in control systems cybersecurity and makes important contributions to secure and modernize the nation's critical infrastructure. INL's 890-square-mile laboratory and testing complexes represent a synergistic integration of co-located and networked nuclear and national security facilities. INL hosts unparalleled assets such as a utility-scale electric power grid for improving grid reliability and security; a wireless communications testbed supporting commercial and government-sponsored research; key capabilities for performing cyber and control system research, explosives and ballistic threat analysis, and armor development; and safe and secure locations for accelerating protective solutions development and testing, and facilitating first responder training experiences in nuclear forensics, real-world contamination scenarios, and incident response. Combined with INL's internationally-recognized critical infrastructure protection and nuclear nonproliferation scientists and engineers, the Laboratory resembles a reconfigurable region where challenging energy and security questions can be answered.

To facilitate transitions of discoveries and innovations to advance energy and security technology and enable clean energy deployment, INL is addressing energy production challenges. INL has made significant contributions in renewable energy grid integration and transportation system transformation. INL is addressing challenges in water utilization, energy-critical materials, biomass feedstock assembly, and optimizing the efficiency of advanced manufacturing processes. INL is increasing the balance,



1. Mission, Vision, and Overview (continued)

Nuclear Science User Facilities

diversity, efficiency, affordability, and acceptability of domestic sources of energy and supporting national transition to industrial competitiveness through energy security.

Each year, INL collaborates with regional, national, and international leaders in academia, industry, and government. INL hosts hundreds of facility users and visiting scientists that perform work at various INL user-facilities and support the transition of world's energy future and critical infrastructure security. INL leads DOE's Nuclear Science User Facilities (NSUF) that provides research teams with no-cost access to nuclear energy research state-of-the-art facilities. NSUF[1] advances nuclear energy RD&D by uniting facilities and technical expertise from a diverse mix of affiliated university, national laboratory, and industry partners across the country. INL's biomass feedstock processing capability is also designated as a national user facility that empowers researchers to collaborate with producers of biomass feedstock and bioproducts to reduce variability and produce high-quality feedstock from grass, wood, and agricultural residues. INL's Wireless Testbed is the INL's third designated user facility and enables government, industry, and academic researchers to collaborate and address some of the nation's most pressing wireless communications challenges.

INL's expansive customer base supports missions of DOE, other federal agencies, universities, and industry by using and leveraging INL's distinctive capabilities. In addition to DOE funding, INL strategically pursues funding from non-DOE sources through Strategic Partnership Programs (SPP) and uses discretionary investments to deliver on mission outcomes. Appendix D provides a listing of INL funding sources and benefits.

1. NSUF offers extensive state-of-the-art nuclear capabilities to support unparalleled research opportunities for nuclear energy researchers. Users are provided no-cost-access to world-class nuclear research facilities, technical expertise from experienced scientists and engineers, and assistance with experiment design, assembly, safety analysis, and examination.

2. Delivering INL Vision

Accomplishing the INL mission requires building leadership and simultaneous excellence in RD&D, which includes building next-generation research staff, signature strengths, and partnerships; laboratory operations; and exemplary stakeholder and community relations.

2.1 Strategy for the Future: Excellence in RD&D

To produce transformational innovations in energy and security, INL has established 11 focused initiatives that drive specific impacts that will develop, extend, and translate INL's distinctive leadership positions into discovery and innovations for advancing nuclear energy, deploying clean energy, and securing critical infrastructure. These initiatives help advance the goals and objectives of DOE's Office of Nuclear Energy (NE), National Nuclear Security Administration (NNSA), Office of Energy Efficiency and Renewable Energy (EERE), Office of Science, and non-DOE federal agencies supported by INL including NASA, Department of Defense (DoD), Department of Homeland Security (DHS), Nuclear Regulatory Commission (NRC), and Department of Interior.

Major INL Initiatives
1. Enable long-term reliability of LWRs
2. Facilitate long-term interim nuclear fuel storage and transshipment missions
3. Enable the cost effective integration of nuclear energy into the modern energy system
4. Facilitate the timely deployment of novel, market adapted, nuclear technologies
5. Protect national and international nuclear facilities from cyber and physical attacks
6. Lead advancement of nonproliferation technologies to enable the expansion of nuclear energy
7. Develop solutions to the complex challenges facing the nation's critical infrastructure
8. Ensure U.S. technical superiority in materials science and armor-related defense systems
9. Reduce barriers to advanced transportation technology deployment
10. Provide U.S. manufacturers a competitive advantage through focused scientific and engineering advancements
11. Identify and mitigate impacts of energy activity and energy-water issues on the environment

Delivering major initiative impacts requires INL to develop partnerships with other laboratories, universities, and industry to support INL mission objectives, expand capacity, complement capabilities and expertise, and accelerate advances in technology deployment. Expansion of INL's capabilities and expertise will increase the availability of distinctive research facilities to the national and international RD&D user community.

2.1.1 Enable Long-Term Reliability of Light Water Reactors

Embracing INL's heritage, scientists, engineers, and technicians are helping the U.S. achieve nuclear-enabled energy security. One transition strategy is to sustain the current nuclear-based power generation assets in a safe, reliable, and efficient working condition.

Nuclear power has safely, reliably, and economically contributed almost 20% of electrical generation over the past two decades. Nuclear power remains the primary low-carbon asset (exceeding 60% non-greenhouse-gas-emitting electric power generation contribution). U.S. Domestic demand for electricity is growing (29% from 2012 to 2040), while operating nuclear power plants reach the end of their operating license. The strategic intent is to keep these nuclear power plants operating beyond their current operating license, while new nuclear plants are quickly built to provide low-carbon electricity generation alternatives to meet increasing demand without increasing the carbon foot print. R&D supporting current plants' long-term operation is a primary objective of DOE's 2010 Nuclear Energy

2. Delivering INL Vision (continued)

Dr. Curtis Smith

Under the direction of Dr. Curtis Smith, the RISMC pathway has seen a greatly expanded impact and enhanced recognition. An example of this recognition includes the inclusion of the RISMC approach as one of the key topics involved in the U.S.-Japan Bilateral Commission on Civil Nuclear Cooperation. Dr. Smith also has been asked to represent DOE on several international activities including the International Atomic Energy Agency 19th Meeting of the Technical Working Group on Advanced Technologies for Light Water Reactors.

Roadmap.[2] In addition, a close working relationship with the nuclear industry is essential to help prioritize R&D activities, transfer technology development and innovations for industry adoption, and deliver impact.

To address long-term operations objective for the current commercial nuclear reactor fleet, INL's research is organized in four technical research pathways, aligned with DOE's LWR Sustainability Program: (1) R&D in materials aging and degradation to develop the scientific basis for understanding and predicting long-term environmental degradation behavior of materials in nuclear power plant, providing key input to regulators and industry, (2) R&D in risk-informed safety margin characterization supported by validated multiscale, multiphysics safety analysis tools to develop and deploy approaches to support the management of uncertainty in safety margins quantification to improve decision-making for nuclear power plants (3) R&D in advanced instrumentation, information, and control systems technologies to address long-term aging and modernization of current instrumentation and control technologies for more automated and reliable plant operations, and (4) R&D reactor safety technologies to aid in developing mitigating strategies and improving severe accident management guidelines for the LWR fleet. The research will address challenges and provide solutions for managing the aging of plant systems, structures, and components so that nuclear power plant lifetimes can be extended and the plants can continue to operate safely, efficiently, and economically; and implementing industry technology to exceed the performance of the current labor-intensive business model.

INL's expertise in data and analysis capabilities enable the establishment of the life extension technical basis of the existing commercial nuclear reactor fleet beyond 60 years. The Laboratory's dedicated ATR LWR test loop can leverage world class, crack-growth rate testing capabilities and atomic-scale characterization techniques to support material aging studies. INL's Multiphysics Object-Oriented Simulation Environment (MOOSE) tools[3] support Risk Informed Safety Margin Characterization (RISMC).

INL is closely collaborating with EPRI to understand industry needs and priorities. INL also supports a multi-laboratory and university partnership to bring the expertise and capabilities needed for success and delivery of initiatives critical outcomes of this initiative.

Life extension of existing NPP fleet to 80 years or more – If the data and analyses enable industry to establish the technical basis for the life extension, it delays more than $500 B replacement cost beyond 2050.

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2. *DOE-NE, 2010, Nuclear Energy Research and Development Roadmap, Report to Congress, U.S. Department of Energy Office of Nuclear Energy, April 2010, http://energy.gov/sites/prod/files/NuclearEnergy_Roadmap_Final.pdf, Web page visited September 2015.*

3. *MOOSE is a finite-element, multiphysics framework primarily developed by INL. MOOSE provides a high-level interface to some of the most sophisticated nonlinear solver technologies. MOOSE is one of INL's R&D 100 winning technologies.*

Dr. Joshua Daw

Dr. Joshua Daw is executing the first ultrasound-based sensor under development. The ultrasonic thermometer is a small diameter multi-point probe capable of providing temperature profile data within harsh environments with high spatial resolution. Specialized versions of the sensor are in development for high accuracy and resolution measurements in high flux, high temperature irradiation tests conducted in ATR, TREAT, and for monitoring used fuel storage casks.

Mr. Justin Coleman

Mr. Justin Coleman, NS&T structural analyst, developed conceptual layout for a full-scale high burnup fuel rod normal condition of rail transportation hot cell test. The test will demonstrate the ability of high burnup fuel cladding to maintain integrity during normal condition of rail transportation, which will provide data that will be used to validate multi-physics numerical codes.

2.1.2 Facilitate Long-Term Interim Nuclear Fuel Storage and Transshipment Missions

To deliver a sustainable nuclear-based national energy security outcome, it is critical to address the challenge of spent nuclear fuel long-term storage. Consolidated interim storage is recognized as key to addressing the challenge for management and disposal of used nuclear fuel (UNF) at the back end of commercial nuclear fuel cycle.[4] To address this challenge and DOE's strategy[5] for transformational change, DOE launched a used fuel storage and transportation R&D program called the Used Fuel Disposition Campaign.[6] Three main program objectives include development of technical bases to support (1) the continued safe and secure dry storage of UNF for extended period; (2) the safe and efficient retrieval of UNF after extended dry storage; and (3) the safe transport of high-burnup fuel, as well as low- and high-burnup fuel storage.

INL's fuel performance knowledge and analysis expertise can address and support the critical objective outcomes by leveraging the Laboratory's advanced instrumentation for casks, full-scale fuel performance analysis capability in MFC's Hot Fuel Examination Facility (HFEF), and small-scale separate effects testing and analysis capabilities. INL has also built validated multiscale, multiphysics fuel and cask modeling and simulation tools that will support objective outcomes. INL partners with Oak Ridge National Laboratory (ORNL), Argonne National Laboratory (ANL), Los Alamos National Laboratory (LANL), and Sandia National Laboratory to bring expertise and capabilities needed to address DOE's used fuel disposition objectives.

Safe and secure extended storage of UNF (> 100 years) – Data and analysis to establish the technical basis for extended dry storage and transportation of UNF for a range of burnup and environmental conditions of interest today and in the future.

4. *BRC, 2012, Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy, January 2012, http://energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf, Web page visited September 2015.*
5. *DOE, 2013, Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste, January 2013, http://www.energy.gov/sites/prod/files/Strategy%20for%20the%20Management%20and%20Disposal%20of%20Used%20Nuclear%20Fuel%20and%20High%20Level%20Radioactive%20Waste.pdf, Web page visited September 2015.*
6. *FCRD, 2011, Used Fuel Disposition Campaign Disposal Research and Development Roadmap, FCR&D-USED-2011-000065, Rev. 0, March 2011, http://energy.gov/ne/downloads/used-fuel-disposition-campaign-disposal-research-and-development.*

2.1.3 Enable Cost-Effective Integration of Nuclear Energy into a Modern Energy System

In support of President Obama's[7] clean energy goal for the nation (80% electricity from clean energy sources by 2035), the U.S and DOE's strategy is to continue developing and deploying a full range of clean, affordable, domestic energy sources with nuclear power as a key component of the portfolio. This means tighter coupling of nuclear and renewable energy to meet both grid demand and thermal energy needs in the industrial sector. Increasing the integration with intermittent energy resources (such as wind and solar) will maintain grid stability, resilience, and promote competitive cost structures. Integrating intermittent energy resources will require increasing the flexibility of other power generation assets, increasing grid-scale energy storage, or developing a more effective demand response to manage generation-load balance. Current technology and deployment paradigms, intermittent energy sources, and other electricity generation assets necessary to balance energy resource intermittency create market inefficiencies and non-optimal use (waste) of capital assets resulting in high cost and regulatory deficiency. The strategy for overcoming market inefficiencies and non-optimal use is coupling energy production and manufacturing.[8] Significant research is required to reduce development risk for advanced energy systems.[9,10] INL has advanced the idea of coupling diverse energy systems through foundational research that began approximately 5 years ago. The objective is to assess how to efficiently and cost-effectively coordinate energy exchange over the electricity grid, transportation system, and industrial manufacturing as the nation reinvents and rebuilds the energy infrastructure[11] with increased integration of intermittent energy sources (also referred to as hybrid energy systems [HES]). INL's R&D in HES integrates two or more energy resources to generate two or more products including an energy commodity (i.e., electricity transportation fuel). The proposed HES could incorporate a small modular reactor concept (currently under development) or consider a retrofit to a currently operating large-scale LWR. The understanding of a modern grid and the capability to optimize integrated systems grow from the history and geography of the Laboratory.[12] This advanced

7.*The White House, 2011, "Remarks by the President in State of Union Address," https://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address, Web page posted January 25, 2011, Web page visited September 2015.*

Dr. Shannon Bragg-Sitton

The importance of ensuring reliable, stable, and economic energy systems in the future is punctuated by invitations for Dr. Bragg-Sitton to speak at key industry meetings, including the 2015 Small Modular Reactor Summit in April 2015 and the 2015 Technology Innovation Summit, which will be held in October 2015 and is sponsored by EPRI. Dr. Bragg-Sitton was invited to become a member of the EPRI Technical Advisory Group for Flexible Operation of NPPs and a consultancy on the same topic conducted by IAEA.

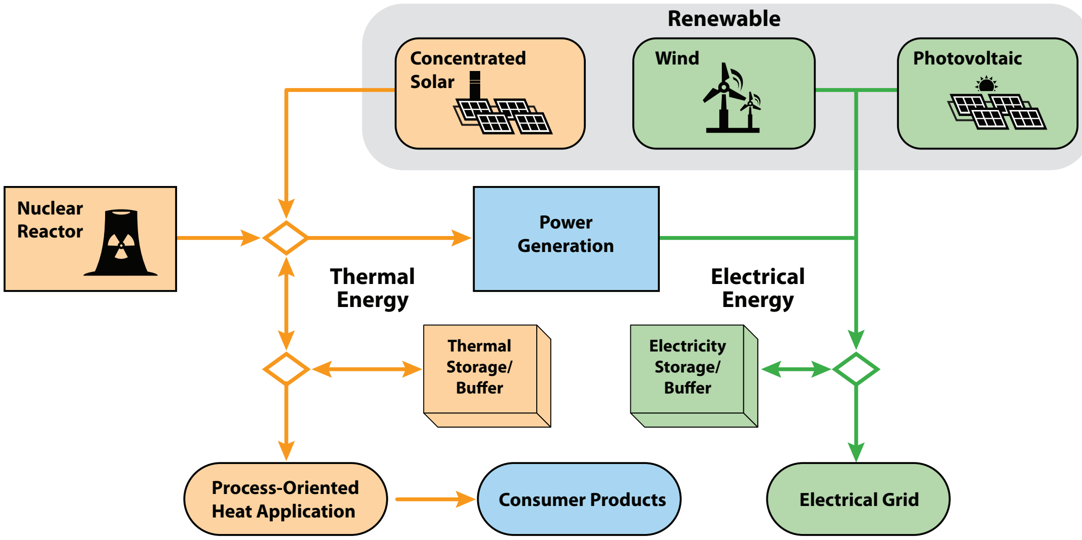
8.*Koningstein R. and D. Fork, 2014, What it would really take to reverse climate change: Today's renewable energy technologies won't save us. So what will?, http://spectrum.ieee.org/energy/renewables/what-it-would-really-take-to-reverse-climate-change. Web page posted November 18, 2014, Web page visited September 2015.*

9.*Bragg-Sitton, S. M., et al., 2014, "Rethinking the future grid: Integrated nuclear-renewable energy systems," Proceedings of the Ninth Nuclear plants current issues symposium: Moving forward, December 2014.*

10. *NREL, Integrated Nuclear-Renewable Energy Systems: Foundational Workshop Report, INL/EXT-14-32857 Rev 1, NREL/TP-6A20-62778, August 2014.*

11. *DOE, 2015, Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure, Department of Energy, April 2015, http://energy.gov/epsa/downloads/quadrennial-energy-review-full-report, Web page visited September 2015.*

12. *INL was designated the National Reactor Testing Station in 1949 and hosted 52 different reactors as the country developed commercial nuclear energy systems. Support to these reactors required the establishment of a supporting electrical grid. INL operates a 61 mile, 138kV dual-fed power loop complete with seven substations, portions of which can be isolated for independent, real-time testing. Combined with the INL's Wireless National User Facility, real-time digital simulation computers, and microgrid, the Laboratory has a deep understanding of the challenges of complex modern energy production, transmission, and distribution systems. This understanding of modern energy systems provides a deeper context for developing nuclear energy concepts that thrive amongst the complexity.*



A generic nuclear-renewable energy system

understanding leads the strategic intent to position INL as the science and technology leader in advanced HES concept development. This initiative has five critical outcomes (1) understanding if integration will increase the overall value over traditionally-independent system components; (2) developing innovations in safety, subsystem interfaces, instrumentations, and control technologies; (3) creating innovations in business models; (4) addressing regulatory challenges; and (5) developing integrated technologies within the timeframe established for achieving clean energy and emissions goals. To achieve demonstration of prototype nuclear-renewable energy systems, INL is collaborating with National Renewable Energy Laboratory, ORNL, ANL, and Pacific Northwest National Laboratory (PNNL); industry partners NuScale and TerraPower; university partner University of Idaho; Wyoming business council; and the International Atomic Energy Agency (IAEA). National laboratories and universities provide expertise in computational modeling, energy system design, nuclear and renewable energy, energy conversion, power generation, and the experimental testing associated with each of these areas. Early engagement with industry, regulators, and the business council will help address the deployment constraints critical to achieve successful adoption of technology innovations.

2.1.4 Facilitate the Timely Deployment of Novel, Market-Adapted Nuclear Technologies

As a leading nuclear laboratory, the strategic intent is to support the nation's "all of the above" energy strategy. This strategy includes developing and making available the nuclear energy option and support transition to a secure, clean energy system. INL aims to recapture and maintain the U.S.'s eroding historical leadership in nuclear energy. A key goal is achieving a significant reduction of the costly and lengthy process for new technologies on the path to commercial readiness (addressing the two valleys of death).[13] A critical outcome of this R&D initiative is developing innovations to advance nuclear energy technologies to commercial readiness level for quicker market adoption.

A key component to quick market adoption is establishing a public-private partnership with supporting testbeds to evaluate and demonstrate multiple stages of technology readiness level and overcoming technology's multiple

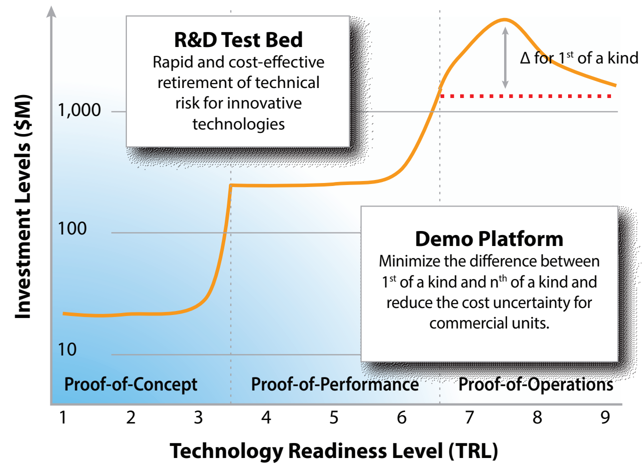
13. Pasamehmetoglu, K., Icenhour, A., and Peters M., 2015, "White Paper on Nuclear Energy Test Bed," Idaho National Laboratory, July 2015

The MOOSE team

The MOOSE team is composed of six highly talented computer scientists and software engineers, Cody Permann (lead), David Andrs, John W. Peterson, Andrew Slaughter, Brian Alger, and Derek Gaston (currently serving an out-plant assignment at MIT). MOOSE framework use has increased since obtaining open source software status and receiving an R&D 100 award.

valleys of death. In addition, advanced modeling and simulation tools in conjunction with smaller-scale, phenomenon-specific experiments informed by theory is required to reduce the need for large, expensive integrated experiments. Key critical initiative outcomes are to (1) develop a research paradigm that reduces the RDD&D phase of technology readiness for commercialization to 10–12 years with limited large scale prototyping and (2) accelerate the development of advanced reactors and fuel cycles by leveraging the Laboratory's capabilities with the National Nuclear Knowledge and Validation Center by expanding multiphysics, multiscale coupled applications under the MOOSE framework for effective coupling among different physical models and collaborations

Reduction in RD&D time for commercial readiness of innovative technologies to 10–12 years – An RD&D paradigm and associated licensing paradigm to reduce the time and cost of readiness for deployment of advanced technologies retires technical risk faster and attracts private investment, and enables rapid return on investment.



among teams focusing on different physics; expanding the NSUF concept to other unique and expensive facilities (beyond just the nuclear/radiological facilities) to provide researchers an effective access mechanism to unique nuclear research facilities; building virtual design capabilities with RISMC to advance reactor system design, fabrication, regulation, and operation; performing anticipatory regulatory research with NRC; and developing a licensing paradigm consistent with RDD&D. INL is working with ORNL, ANL, and LANL to gather the expertise and capabilities needed to address these critical outcomes.

2.1.5 Protect National and International Nuclear Facilities from Cyber and Physical Attacks

INL employs the foremost cyber and industrial control systems security experts in the world. When integrated with INL's nuclear energy capability, INL can lead the international nuclear community in understanding cyber and physical security risks and in developing mitigation strategies and techniques to meet the unique nuclear requirements of network and operational environments. INL's 60-year history with securing special nuclear materials and safely conducting nuclear research along with expertise in industrial control system cybersecurity provides an unprecedented environment to focus on the integration of cyber and physical security in

Mr. Bob Anderson and **Mr. Rob Hoffman**

Mr. Bob Anderson's and Mr. Rob Hoffman's technical thought leadership in the security of cyber-physical systems is fundamentally changing how the world addresses these challenges. Their strategic vision, research leadership, and consultative services have led to new technical frameworks driving the formal security guidance issued to the international nuclear energy community.

nuclear facilities. The strategic intent, as a leader in national and homeland security and nuclear energy, is to make nuclear facilities resilient and assure continuous, safe, reliable, and efficient operations while these facilities are becoming more connected with information and wireless communications. By leveraging INL's expertise and capabilities, the Laboratory has assumed the leadership role within the international nuclear community in understanding cyber and physical security risks and in developing mitigation strategies and techniques to meet the unique nuclear requirements of network and operational environments. Critical outcomes include integrating control system and wireless cyber security to deliver defense-in-depth solutions, responding to real-time cyber events and conducting anticipatory intelligence analysis that provide leadership with public-private shared actionable information that accelerate the deployment of security solutions proven through modeling and full-scale infrastructure testing. INL is serving in leadership assignments with NNSA's Cybersecurity Task Force and in support of NE plans focused on initiating a research field in nuclear energy-cyber security. INL intends to achieve a long-term vision for a reliable, secure, and cost-effective future for nuclear energy by expanding (1) strategic contributions to national RD&D plans; (2) talent base through strategic hires, increased investments in transformational-researcher initiated R&D concepts; innovative cooperative agreements for fluid transition of researchers between government, military, industry, academic, and entrepreneurial work environments; and (3) INL's experimental laboratories and training capabilities to incorporate nuclear power digital instrumentation and control systems, safeguards and IAEA inspector equipment, integrated modeling and simulation tools for safety, security, and cyber risk analyses and table top exercises; and (4) INL's partnership with other national laboratories, IAEA, and nuclear security professional organizations to combine complementary capabilities and investments.

2.1.6 Lead the Advancement of Nonproliferation Technologies to Enable Nuclear Energy Expansion

While supporting national and global deployment of nuclear technologies, INL's strategic intent is to simultaneously reduce the potential risks of nuclear and radiological threats. INL's unique and world-renowned nuclear energy and fuel cycle expertise, operational nuclear research facilities, accessibility to special nuclear materials, and integrated multiple test ranges provide the Laboratory with an unparalleled environment to work with government agencies, industry, and academia in developing, testing,

Dr. David Chichester

Dr. David Chichester is the Applied Radiation Measurements and System group leader in INL's Nuclear Nonproliferation Division. His research focuses on developing and using advanced radiation measurement methods to detect, locate, and characterize nuclear and hazardous materials – research that supports nonproliferation treaty verification and emergency responders. Dr. Chichester has spearheaded research collaborations with academia, industry, and national laboratories, and he is the principal investigator for multiple research grants.

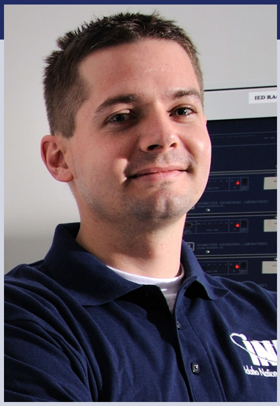
deploying, and training specialists in new technologies and methods that protect this nation and the world. The Laboratory's expertise and facilities allow for applied engineering and research that support national and international technology challenges. Key critical outcomes are to (1) deter and prevent the proliferation of nuclear weapons by securing and replacing high risk vulnerable nuclear and radiological materials with effective substitute materials; (2) discover preemptive proliferation programs and forensic-based attribution t or illicit trafficking of nuclear or radiological devices; (3) leverage the Laboratory's expertise and facilities to address technology challenges in enhancing confidence in nation-state compliance with nuclear nonproliferation treaties and technical information exchange agreements; (4) train first responders communities with field deployable technologies in realistic exercises; (5) prepare IAEA inspectors with advanced preparation tools for understanding diversion pathways, increased confidence in distance monitoring and surveillance and effective on-site visits; and (6) work with government, industry, and academia in developing, testing, deploying, and training specialists in new technologies, and methods that protect this nation and the world. To maintain leadership and critical expertise, INL capabilities must expand through internal investments or through strategic collaborations/partnerships. Specific capabilities to create include advanced methods in isotope production for standards and references materials for the nuclear forensics community and the Comprehensive Test Ban Treaty organization; state-of-the-art mass spectrometry and radiation detection to improve the certainty of detection methods for nonproliferation and safeguard verification; advanced methods in manufacturing and testing low enrichment; high burnup fuels to continue low-enriched uranium reactor technologies; and superior testing and training facilities and ranges that support the development of nuclear material measurement technologies and preparation of first-responder training.

2.1.7 Develop Solutions to Complex Challenges Facing the Resilience of the Nation's Critical Infrastructure

The strategic intent of this initiative is securing the nation's critical infrastructure to improve its resiliency even as the critical infrastructures are becoming more instrumented and are continuously connected to information and wireless communication systems. INL has the unique combination of expertise and infrastructure to become the premier organization to address control system cybersecurity and national power grid security challenges. By leveraging INL's power grid testbed and advanced modeling and simulation capabilities, the Laboratory provided seminal results to discover and demonstrate the fundamental principles and eventual consequences of security threats against the national power grid. This first-of-its-kind experimental data is being used to build and validate models and influence R&D to build solutions that assure infrastructure resilience.

INL's expertise in cellular, radio frequency, internet protocol networks, telecommunications protocol, and its unique research infrastructure for testing in

Mr. Jonathan Chugg



Mr. Jonathan Chugg is part of the Cyber Security R&D Department control systems security research team focused on identifying and mitigating vulnerabilities in computer systems responsible for efficient and resilient operation of U.S. critical infrastructure.

Ms. Rita Foster

Ms. Rita Foster is the Energy Sector Infrastructure Security Strategic Advisor for critical infrastructure protection and nationally recognized for research leadership in control-system cybersecurity and control-system development. Ms. Foster's 25 years of control-system integration and analysis provides a solid background for research and strategic direction in protecting the U.S. power grid and other critical U.S. infrastructure.

indoor and outdoor environments fill critical national security, emergency preparedness, and economic gaps. INL's research and technology experts support the U.S. Department of Homeland Security Industrial Control Systems Cyber Emergency Response Team with conducting infrastructure site assessments, publishing cyber vulnerability advisories, training and educating federal and industry leaders on cyber security and protective technologies applications, and consulting in fly-away team events to resolve cyber-attacks against strategic U.S. infrastructure facilities. INL's unique infrastructure, such as the Electric Grid Reliability Testbed and the Wireless Testbed, validate models-at-scale that support advances in sciences and innovations in security technologies.

INL demonstrates the attributes of critical power and control infrastructure through (1) an isolatable, industry-scale electric power grid, (2) an independent fiber-optic system for monitoring and control (Supervisory Control and Data Acquisition [SCADA] INL electrical power consumption computerized system), (3) commercial "carrier-grade" wireless technology systems spanning 2G to 4G and beyond, and (4) cross-functional testing capabilities (e.g., power, cyber, control systems). The Laboratory's infrastructure and capabilities are similar to what is found in a small city; enabling holistic solutions and mitigations of technology and infrastructure interdependencies.

2.1.8 Ensure U.S. Technical Superiority in Materials Science and Armor-Related Defense Systems

The strategic intent of this initiative is to maintain, combine, and expand 30 years of expertise and capabilities in highly specialized manufacturing techniques, armor materials and design, and advanced modeling and simulation that continues to address the survivability needs of the U.S. Department of Defense. Critical outcomes are to (1) enhance warfighters protection, (2) enhance U.S. economic growth and job creation, and (3) leverage the advances in armor-related technologies for uses in physical protection of critical infrastructure and incident management personnel and equipment. Since 1984, INL has delivered the Army's Abrams tank heavy armor that protects U.S. war fighters. The armor protects against foreign ballistics or blast threats. The armor design and manufacturing is a one-of-a-kind capability and integrates a safe and secure facility, unique materials processing equipment and processes, and national experts in the production of this product. INL's Specific Manufacturing Capability (SMC) is designated by the U.S. Army as an Abrams

Dr. Henry Chu

Dr. Henry Chu is the Armor Technical lead supporting RDD&D of INL's Specific Manufacturing Capability and Materials Technologies Department. Dr. Chu's focus is on R&D of new materials and processing technologies to improve materials for defense-related and critical infrastructure protection applications, as well as advanced characterization methods for dynamic properties of armor materials.

Mr. Greg English

Mr. Greg English conducts vulnerability assessments for the protection of DOE's special nuclear materials and high-consequence assets as part of INL's Physical Security Analysis team. With extensive experience leading and training tactical response forces, as well as security design and protective force operations, Mr. English provides unmatched expertise in protecting U.S. personnel and critical assests.

Armor Center of Excellence. Combining SMC with INL's expertise in modeling and simulation and energetics and ballistic protection provides the unique capability to increase the foundational science in materials and armor protection.

2.1.9 Reduce Barriers to Advanced Transportation Technology Deployment

The strategic intent of this initiative is to support 15% greenhouse gas emissions reduction, support 50% oil import reductions, improve electric/hybrid vehicle cost-parity by 2020, and help meet the 54.5 mpg CAFÉ standard by 2025. INL hosts the Biofeedstock National User Facility and Battery Performance Laboratory. These facilities and the Laboratory's performance-science expertise can be leveraged to deliver critical outcomes including (1) battery performance assessment and establishment of U.S. and international testing and performance standards to address challenges associated with wide deployment and adoption of electric vehicles, (2) addressing biomass feedstock systems performance and process engineering to enable deployment of biomass-based fuels and chemicals, and (3) research and innovations in fuel cells and hydrogen systems as alternatives for energy storage technologies.

INL has established leadership in performance science and is recognized as an independent, third-party testing and analysis laboratory for DOE vehicle technologies, batteries, other components. The test data informs regulators, policy makers, manufacturers, and others on how to proceed as the U.S. moves from fossil-fueled vehicles to all-electric and hybridized automobiles. The Laboratory assists with developing uniform standards for electric vehicles charging infrastructure that will affect the adoption and implementation of this technology. The tools and information developed by INL is guiding the best placement of electric vehicle charging infrastructure and educating utilities of impact this technology will have on U.S. power supply and electric grid. INL's work in battery performance is leading to the development of longer-lasting, more powerful batteries that can operate in a wider variety of climate and other conditions.

INL's work in biomass enables researchers to develop customized biomass feedstocks, as well as characterize their energy and storage potential—critical traits for biofuels. INL's R&D innovation in fuel cells and hydrogen systems provides alternatives for energy storage technologies. Increases in electric vehicles, fuel cells, and hydrogen systems will drive the need for

Mr. Richard "Barney" Carlson

Richard "Barney" Carlson leads INL's efforts to evaluate and characterize conductive and wireless charging infrastructure for electric vehicles and develop codes and standards for this new technology and equipment. Mr. Carlson and his team test and evaluate charging infrastructure for energy efficiency, electrical power quality, electro-magnetic field emissions, cyber security vulnerability, and integration with renewable resources.

carbon-free electricity production including nuclear-based electricity production. INL collaborates with Lawrence Berkley National Laboratory, DuPont, U.S. Council for Automotive Research, and the California Environmental Protection Agency to deliver successful outcomes of this initiative.

2.1.10 Provide U.S. Manufacturers a Competitive Advantage through Focused Scientific and Engineering Advancements

The strategic intent of this initiative is to address critical resource availability using chemical and materials separations science, creating technology advancements needed for net-zero waste in manufacturing, reducing energy consumptions of key energy-intensive industries by 50%, and reducing manufacturer water consumption. INL researchers are world-renowned for developing novel catalytic processes that use far less energy and water than conventional methods as well technologies to recycle and treat industrial waste streams or harvest valuable waste stream products. INL's background in nuclear energy builds leadership capabilities and expertise in separations and membranes sciences, process chemistry, materials for high-temperature and harsh environments, control systems, and systems engineering/diagnostics.

These capabilities will be leveraged to deliver critical outcomes including (1) technologies to recover, reuse, remanufacture, and recycle to reduce waste more than 50% (2) develop a secure, sustainable domestic supply of critical materials to allow the invention, manufacturing, and deployment of clean energy technologies; and (3) R&D to achieve more than 50% life-cycle energy reductions in energy-intensive industry within 10 years (by 2025). To help achieve the energy-reduction goals, INL invested in new equipment, invested in research initiatives, and hired leading industry scientists. INL researchers are using a cutting-edge temporal analysis of products (TAP)[14] reactor to develop catalytic processes that consume far less water and energy and produce little or no waste. INL's TAP reactor is located at the Center for Advanced Energy Studies (CAES) (a public research facility) providing accessibility for INL researchers, academia, and industry.

INL also plays a pivotal role in DOE's Critical Materials Initiative (CMI)[15], leading in recycling

14. TAP reactors enable the examination of catalytic process in real-time to understand why and how this reaction occurs, which then enable the design and optimization of better catalysis for specific products or chemicals.

15. DOE, 2011, U.S. Department of Energy's Critical Materials Strategy,

Dr. Anne Gaffney

Dr. Anne Gaffney leads the Process Science and Technology Division within INL's Energy and Environment Science directorate and in building advanced manufacturing expertise and capabilities. She is a Lab Fellow and was the first female to receive the Houdry Award from the North American Catalysis Society. The award recognizes individuals who develop new and improved catalyses and processes that have a significant industry impact.

and recovery efforts. INL works on biological and geochemical approaches to improve extraction of critical elements from ores and waste streams, and also contributes to environmental research related to waste water processing and in economic analyses of processes developed through this initiative. INL co-invented new technology to aid in the recycling, recovery, and extraction of rare earth minerals, which has been licensed to U.S. Rare Earths, Inc.

INL's emerging advanced manufacturing initiative is designed to support the goal of reducing life-cycle energy consumption of manufactured goods and also support the DOE mission[16] to develop processes that reduce energy use and improve production that can be applied at scale across the diverse manufacturing sector. By leveraging historical material performance expertise in harsh environments and membrane science, INL researchers have developed and patented a R&D 100-winning, forward osmosis technology to treat wastewater sources. Advanced experimental, computational and visualization capabilities are important to achieving this initiative. INL collaborates with Ames Laboratory, University of Wyoming, CMI, and Porifera to deliver successful outcomes of this initiative.

2.1.11 Identify and Mitigate Impacts of Energy Activity and Energy-Water Issues on the Environment

The strategic intent of this initiative is to increase efficiency in the use of water and minerals and identify regional climate change impacts and allow mitigation of environmental emergencies and threats. INL has long and storied expertise in the areas of geosciences (particularly subsurface geomechanics), systems engineering, sensing, measurement and data sciences, power and energy systems, and environmental analysis to solve critical challenges surrounding the energy-water nexus. By leveraging these capabilities and partnering with Sandia National Laboratory, Idaho State University, and Boise State University, the Laboratory will deliver the following critical outcomes (1) assist improved decision-making on energy and water use by collecting data and employing multiple modeling techniques and analytical approaches to extract meaningful information, (2) assess ecological and economic impacts of energy on water resources development by leveraging INL's Water Security Testbed, and (3) reduce adverse impacts to environmental and ecological systems. INL is leveraging its Switchable Polarity Solvents Forward Osmosis (a R&D 100-winning technology) to treat and recycle wastewater more efficiently and with less energy than other methods. INL researchers are applying this technology to wastewater produced during energy production and other industrial processes.

Dr. Aaron Wilson

Dr. Aaron Wilson led the team that developed INL's Switchable Polarity Solvent Forward Osmosis method, a patented technology that won an R&D 100 Award in 2013. The method extracts freshwater from wastewater by having a more concentrated switchable polarity solvent on the other side of a fine membrane. This method can be used to treat various industrial waste-water streams. A California company is using the technology to treat wastewater from coal-fired power plants.

Department of Energy, http://energy.gov/epsa/initiatives/department-energy-s-critical-materials-strategy, December 2011, Web page visited September 2015.

16. DOE, 2015, Advanced Manufacturing Office, http://energy.gov/eere/amo/advanced-manufacturing-office, Web page visited September 2015.

2.2 Supporting the Laboratory Mission

INL is continually committed to enhancing its global leadership by building exceptional staff, providing world-class facilities to support emerging RDD&D challenges, creating strategic partnerships to expand scientific reach and access, and implementing effective and efficient management and operations of programs and services to enable transformational innovations in energy and security.

2.2.1. Next Generation RDD&D Staff

INL's workforce has expanded with budget growth over the last couple of years from approximately 3,789 employees in 2013 to an estimated 3,890 employees in 2015. However, given the anticipated staff retirements and expected program growth, INL is anticipating significant workforce turnover that may likely define INL into the early 21st century. Approximately half of the workforce at INL is expected to change in the next five years, which provides an opportunity for INL to shape its workforce for the next 5–10 years. INL must determine the characteristics of the workforce required to support core capabilities and deliver on the RDD&D mission and impacts to ultimately achieve the INL vision. Over the next several years, INL plans to make key investments in knowledge transfer, workforce development, and employee total rewards to shape its technical, operational, and professional workforce talent to meet evolving mission needs for recruiting, retaining, and developing talent.

INL's strategy for making the Laboratory the best place to work includes ensuring that INL has the scientific tools to support compelling science, improve and modernize quality of work environment, upgrade information services and data access to support modern science, provide modern technology and communication services, invigorate internal communications, practices, and tools, and create a positive, inclusive, and supportive work culture. INL's goal is to forge and maintain powerful connections between personal and organizational values to foster individuality and cultural strength simultaneously.

INL is committed to helping local and regional education leaders improve the quality of K-12 learning, especially enhancing Science, Technology, Engineering and Math (STEM) programs and diversity of students pursuing STEM education. INL's STEM focus and resources will be prioritized to meet Idaho's need. INL's university partnership program will promote close collaboration between INL and universities to enable the attraction and retention of talent through R&D projects, internships, postdoctoral assignments, joint appointments, and employee education.

To create leadership talent, INL will cultivate leadership skills through formal programs that develop, assess, and mentor current and potential leaders across INL. INL also invests in managerial leadership development through INL's leader and manager development program, formal and informal mentoring and coaching, and action learning assignments.

2.2.2. World-Class RDD&D Infrastructure

INL resembles a well-characterized "reconfigurable city/region" where energy and security questions can be addressed at scale. INL real-property infrastructure includes 492[17] NE-owned and operating real property assets[18] with a total replacement value of $3,260 million. These assets include 286 operating buildings (totaling 2.4 million gross ft^2) and 207 nonprogrammatic other structures and facilities. The facilities accommodate approximately 3,890 people on a daily basis, including employees, facility users, subcontractors, and others.

INL maintains and operates the majority of NE's essential nuclear energy R&D capabilities, which represents the core of the federal government's national nuclear energy R&D infrastructure. RDD&D activities associated with advancing nuclear energy, clean energy deployment, and security takes place at several INL locations including (1) ATR Complex, (2) MFC, (3) Research and Education

17. 21 mission critical, 317 mission dependent, and 154 not mission dependent assets.

18. Buildings, trailers, utility systems, and roads.

Transient Test Reactor

Campus (REC), (4) Central Facilities Area (CFA), (5) Critical Infrastructure Test Range Complex (CITRC), (6) SMC, and (7) Transient Reactor Test Facility (TREAT). In addition to INL facilities, the INL Site also hosts three non-NE facility areas: (1) Idaho Nuclear Technology and Engineering Center (INTEC), (2) Naval Reactors Facility (NRF), and (3) Radioactive Waste Management Complex (RWMC). INL also invests in virtual R&D infrastructure to advance nuclear energy modeling and simulation and now HES for clean energy integration and deployment studies. Appendix B provides brief description of each of these facilities/capabilities.

The facilities at INL provide unique and unparalleled research opportunities to INL staff and to a growing user community of universities, industry, other national laboratories, and other research institutions throughout the world that when combined with deep domain knowledge will enable meeting mission goals and objectives. R&D capabilities supported by the ATR Complex facilities, the MFC facilities, the TREAT facilities, the REC facilities, the powerful MOOSE software platform, and the HES focus area will advance nuclear energy. R&D capabilities supported by REC, CAES, and CFA will enhance the development and deployment of clean energy innovations. R&D capabilities supported by MFC, CFA, CITRC, SMC, REC, and HES will help secure the nation's critical infrastructure.

To maintain relevant capability, gain strength to address global challenges, and create expanded leadership, INL's infrastructure strategy is guided by DOE's objective to developing and maintaining RDD&D framework and the Laboratory's vision and mission, which is captured in the INL Ten-Year Site Plan.[19] The strategic intent is to create capabilities for small-scale laboratory experiments to larger-scale prototypic demonstration to explore new technologies, and to facilitate increased coupling of theory with fundamental phenomenological testing and modeling and simulation. In the near-term, INL infrastructure investments will focus on MFC, ATR, and REC (specifically the INL Research Center [IRC]) to improve facility availability and reliability to support mission accomplishments, reduce deferred maintenance, enhance small-scale experiments aimed at observing isolated phenomena or measuring fundamental properties, and address specific analysis and demonstration capability gaps. Key infrastructure initiatives to expand existing capabilities are summarized in Table 2.

19. INL, 2015, *Idaho National Laboratory 2015-2025 Ten Year Site Plan*, DOE/ID-11528, July 2015.

Advancing nuclear energy

Table 2. Major RDD&D infrastructure initiatives to deliver strategy.	
Initiatives	**Impact**
Resuming TREAT	Anticipated to begin in fiscal year (FY) 2018, transient testing will screen advanced fuel concepts, including accident-tolerant fuels, by allowing for early identification of the limits of fuel performance. It will also focus on fuel development from various viable options, ultimately reducing the time and cost required to develop new fuels. TREAT is capable of conducting tests on full-size fast reactor fuel and 36-in. segments of LWR fuel. The NRC will use data from TREAT tests as part of the process for granting licenses for new fuel types. The data will also be important for the validation of multi-scale, multi-physics modeling and simulation tools
Enhancing MFC	Irradiation Materials Characterization Laboratory (IMCL) will allow for preparation of fuel samples for testing. Sample Preparation Laboratory will provide sample preparation and dedicated equipment for a broad range of mechanical testing capability for examining radioactive materials and will advance the understanding of nuclear fuel and materials behavior by providing world-class examination capabilities. Materials and Fuels Research Support Facility will increase access to MFC capabilities. As new state-of-the-art and unique capabilities are added, the plan is to increase access to these facilities to additional external users through NSUF. The support facility will include a research data visualization center and laboratory space for engineering and development of experiments and analytical capabilities. Implementation of the ZPPR documented safety analysis upgrade will increase the ventilation flow in the facility and significantly improve the safety and the storage of SNM and providing compliance with the new safety basis. HFEF is a heavily shielded nuclear facility designed to be the front-end of the post-irradiation examination capability. HFEF enhancements will improve facility availability and reliability to support mission accomplishment.
Performing ATR reliability improvements	Performing significant refurbishment to 50-year- old plant equipment which is failing at a higher rate. This will improve operational schedules and allow ATR to operate more reliably than it has in recent years.
Deploying the Advanced Reactor Technology Integral System Test (ARTIST)	ARTIST is a multifluid, multiloop thermal hydraulic test facility that will help evaluate performance of candidate heat exchangers (i.e., printed-circuit heat exchangers, characterize flow and heat transfer issues related to core thermal hydraulics in advanced helium-cooled and salt-cooled reactors, evaluate corrosion behavior of new cladding materials and accident-tolerant fuels for LWRs, demonstrate advanced instrumentation, and integrate co-located energy systems for characterization of dynamic behavior at prototypical conditions).
Transferring the Remote Analytical Laboratory	INL supports NE potential transfers from DOE Office of Environmental Management (EM) to NE of several facilities including the Remote Analytical Laboratory, a 13,000-ft^2 facility designed for a number of organic, inorganic, and radioanalytical capabilities.
Enhancing Remote-Handled Low-Level Waste disposal facility	NE with NR is constructing a replacement facility located adjacent to ATR Complex to provide up to 20 years of additional storage capacity for remote-handled low-level waste.

Table 2. (continued)

	Initiatives	Impact
Advancing nuclear energy (continued)	Expanding Nuclear System Testbed	Expanding an existing suite of facilities for fuel design, as well as nuclear system development, testing, and demonstration will prove viability of new technologies. Expansion will include facilities for proper scale nuclear demonstration, next generation demonstration and test reactors, knowledge centers, NSUF interface-modeling and simulation and validation facilities, and collaboration space.
	Repurposing IRC	INL has evaluated use options and developed a plan to repurpose space in IRC that will meet nuclear energy, environmental, and energy security multiprogram R&D needs in the near term, while planning for significant investment needed to upgrade critical utilities systems.
Enabling clean energy deployment	Expanding Electric Grid	Expansion of the electrical grid is planned for installation near the CFA/CITRC area to provide a new reconfigurable test substation and several miles of transmission and distribution lines.
	Frontier Observatory for Research in Geothermal Energy (FORGE)	An EERE initiative focused on developing, testing and accelerating breakthroughs in enhanced geothermal system technologies and techniques to engage the geothermal community to conduct R&D on viable, clean, and domestic sources of energy. INL was selected as one of the Phase 1 teams that will complete mission-critical technical and logistical tasks that demonstrate site viability and show the team's capability of meeting plans for Phase 2. Phase 1 tasks include conceptual geologic modeling and the creation of comprehensive plans for data dissemination, intellectual property, environmental, health and safety information, communications and outreach, stakeholder engagement, R&D implementation, and environmental management.
	Establishing Real-Time Digital Simulation	Interconnecting geographically-distributed real-time digital simulation assets across other national laboratories, universities, and utilities and conduct dynamic and transient analysis of large power and energy systems will provide design and operational tools for dynamic analysis to address challenges in improving power quality and predicting transients under increasing penetration of hybrid systems consisting of distributed and renewable resources at regional and national level.
	Establishing the Collaboratory for Energy Transitions and Transformations (CETT)	The CETT research complex is expected house advanced computing and visualization capability, energy/manufacturing systems prototyping capability, and materials and chemical process research laboratory. CETT will be the focal point for manufacturing and aims to reduce the innovation-to-deployment cycle time through national laboratory, university, and industry collaboration built around collaborative applied computing and related research and prototype laboratories to (1) develop technologies to reduce energy consumptions of energy-intensive manufacturing industry, (2) drive toward net-zero waste in manufacturing leveraging INL's leadership in separations science, and (3) secure national critical materials supply chain.
Securing and modernizing critical infrastructure	Enhancing REC	Growth in DHS programs will require additional laboratories to be set up at REC. REC power loop will support the next-generation supercomputer and plan growth/co-location of many capabilities.
	Securing the Laboratory	Infrastructure is needed to accommodate expanding R&D programs in classified space for cyber and control systems R&D that will accommodate a public/private facility that engages industry in energy and advanced manufacturing innovations through collaborative computing and ensures adequate safeguards and security for appropriate materials controls and accountability.

In addition to experimental capabilities, INL's mission requires access to research quantities of SNM and capabilities to process and manage waste. The nuclear materials management infrastructure at INL, a unique asset, consists of facilities and capabilities to store and handle Safeguards Category I quantities of SNM. INL's strategy for nuclear materials management is to obtain/retain and make accessible materials needed to support R&D, dispose of unneeded materials to reduce liabilities, and ensure the safe and efficient handling and storage of nuclear materials. Waste management activities at INL use complementary infrastructure (supported by both NE and EM) for waste characterization, storage, and disposition, ensuring minimal duplication of infrastructure capabilities and investments.

In addition to expanding capabilities, critical investments are required to continually address base infrastructure needs (modernize, refurbish, maintain) as well enhance existing capability to build upon INL's status as a preeminent and comprehensive laboratory. To meet INL's mission needs, the Laboratory's information management infrastructure needs to be based on technology that is sustainable, agile, secure, reliable, and innovative in all aspects of information service delivery. Key near-term investments will focus on critical needs including upgrades to MFC and ATR's networking and communications infrastructure. Through institutional planning processes, INL identifies investments to maintain, upgrade, and improve support infrastructure through base, sustainment, and investment planning.

2.2.3 Strategic Partnership to Accelerate the Pace of Mission Delivery

Strategic intent is to (1) expand INL's capabilities and leadership; reduce risk of technology maturation, adoption, and use; and accelerate the pace of mission delivery through strategic partnerships (2) support DOE by enhancing collaboration (3) advance U.S. international civil nuclear energy priorities and objectives, and (4) integrate national RDD&D framework. Partnerships to consolidate research infrastructure resources of national laboratories, universities, and industry through the user facility model will help provide unparalleled research opportunities for advancing mission goals. While DOE provides support through RD&D ranging from fundamental nuclear phenomena to the development of advanced fuels, future consideration will require cost-sharing with industry for the design, construction, and licensing of advanced reactors. Partnership with industry (suppliers and users) of clean energy and security technology will enhance market knowledge, facilitate joint R&D investments, and help accelerate the pace of development and deployment pathways for advances in clean energy technologies. Partnership with government sector (national and international) will reduce the barriers for federal agencies to work with INL, leverage federal investments in R&D and facilities for advancing clean energy R&D, technology adoption and deployment, securing critical infrastructure, and advancing nuclear energy. Partnership and collaboration with universities (national and international) will help augment/enhance INL's capabilities through consolidating RDD&D capabilities through expansion of experimental and computational capabilities, joint appointments, and creating the next generation of scientists and engineers needed for clean energy and security RDD&D.

2.2.4 Enabling Services

Getting the basics right requires excellence in management and operations. Mission support has established a set of focused initiatives that drive specific impacts to mission accomplishment. These initiatives to improve core programs and services are listed in Table 3.

Improving staff work life requires addressing conditions that hinder research productivity. Mission support has established a set of focused initiatives to remove barriers to work, promote process modernization, create an inclusive workplace for a more diversified workforce, and innovate in services. These initiatives to improve the INL work environment are listed in Table 4.

Achieving the Laboratory strategy requires mission support to be aligned and fully supportive of the major research initiatives listed in Table 1. Mission support has established a set of focused initiatives to assure strategic mission outcomes are well supported with the capabilities, infrastructure, operations programs and services necessary to deliver on impact. These initiatives are listed in Table 5.

In FY 2016, INL will show progress across a number of these initiatives. Some initiatives will take years to achieve their impact and others are more likely to be impactful in 1–2 years.

Table 3: Major mission support initiatives to improve core programs and services.

Initiative	Impact
Operations Excellence	Mission is enabled through a strong organizational culture committed to the safe conduct of research and an effective and transparent contractor assurance system.
Enterprise Governance and Management	Mission is enabled through effective allocation of discretionary investments resulting from improved processes and practices for business intelligence, strategic planning, programming and budgeting.
Asset Revitalization and Modernization	Mission is enabled through increased reliability and availability of physical assets (facilities, networks, business systems, general purpose equipment).
Talent Acquisition and Retention	Mission is enabled through the implementation of market-facing programs to competitively compensate and benefit staff.
Partnerships and Outreach	Mission is enabled through collaborations, partnerships, and outreach that positively brand INL and expand its scientific reach and access to talent.

Table 4: Major mission support initiatives to improve work life environment.

Initiative	Impact
Process Modernization	Mission is enabled through a conduct of research-focused approach to process design and delivery.
Inclusion and Diversity	Mission is enabled through creation of a workplace that values staff diversity.
Technology-Adoption	Mission is enabled through broad use of technology to enhance staff productivity.
Staff Wellness	Mission is enabled through sustainable work practices that creates a welcoming environment and build staff resilience to injuries and illness.
Managed Services	Mission is enabled through delivery of a cost-effective, responsive, and agile suite of services managed by in-house or third party providers.

Table 5: Major mission support initiatives to deliver strategy.

Initiative	Impact
Campus Alignment	Mission is enabled through a strategy-aligned and creative approach to facility and capability acquisition that makes use of all available alternatives.
Enabling Regulatory Environment	Mission is enabled through regulatory programs that open not shut doors to strategic progress.
Talent Availability	Mission is enabled through better understanding of the talent marketplace and what INL can do to remain competitive to attract and retain its best.
Work Proposal and Acceptance	Mission is enabled through processes that allow the evaluation, capture, and acceptance of program work that supports the strategy.

3. Summary

This living document is INL's commitment to implement the discussed strategies and to periodically review and modify this document to align with future INL mission needs and evolving customer requirements. This document identifies major Laboratory aspirational directions intended to deliver on high-level and specific mission outcomes and associated support initiatives. This laboratory strategy identifies the key set of impacts and associated strategy that the Laboratory will employ to advance nuclear energy, clean energy technology deployment, and secure and modernize critical infrastructure. For the next five years, INL will focus on the 11 impact areas discussed in Section 2.1, build INL's critical human capital, strengthen INL's capabilities and leadership through infrastructure investments and strategic partnerships, and obtain operational excellence on support services as strategized in Section 2.2. INL will continuously improve its core capabilities, infrastructure, human capital, partnerships, operational excellence, and management systems while balancing investments, minimizing cost, and ensuring mission success now and into the future.

Appendix A: Grand Challenges in Energy and National Security

The U.S. is faced with difficult energy and national security challenges. INL is part of DOE-led energy collective–the world's best thinkers on energy and climate–that will help solve these challenges.[20] INL's response to the grand challenges require a cross-discipline approach supported by flexible R&D responses.

A.1 Climate Change

Energy infrastructure systems should be developed and managed in an environmentally responsible manner. This responsibility includes considering the imperatives of climate change and the societal costs and benefits of reducing or avoiding pollution and land-use impacts on a lifecycle basis to minimize their environmental footprint while enabling better and vast environmental performance for the energy system.

It is also important for policies to promote equity and avoid disproportionate impacts to any particular populations. Through basic and applied energy research, INL is studying different types of energy infrastructure systems and the direct or indirect impact climate change can have on them. This includes the changing costs associated with energy and water usage, diversifying energy supplies in regions with high energy costs, and the changing importance of critical infrastructure and energy transport and storage systems, which can become at risk from events such as drought, flooding, etc.

20. DOE, 2015, Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure, Department of Energy, April 2015, http://energy.gov/epsa/downloads/quadrennial-energy-review-full-report, Web page visited September 2015.

A.2 Energy Security

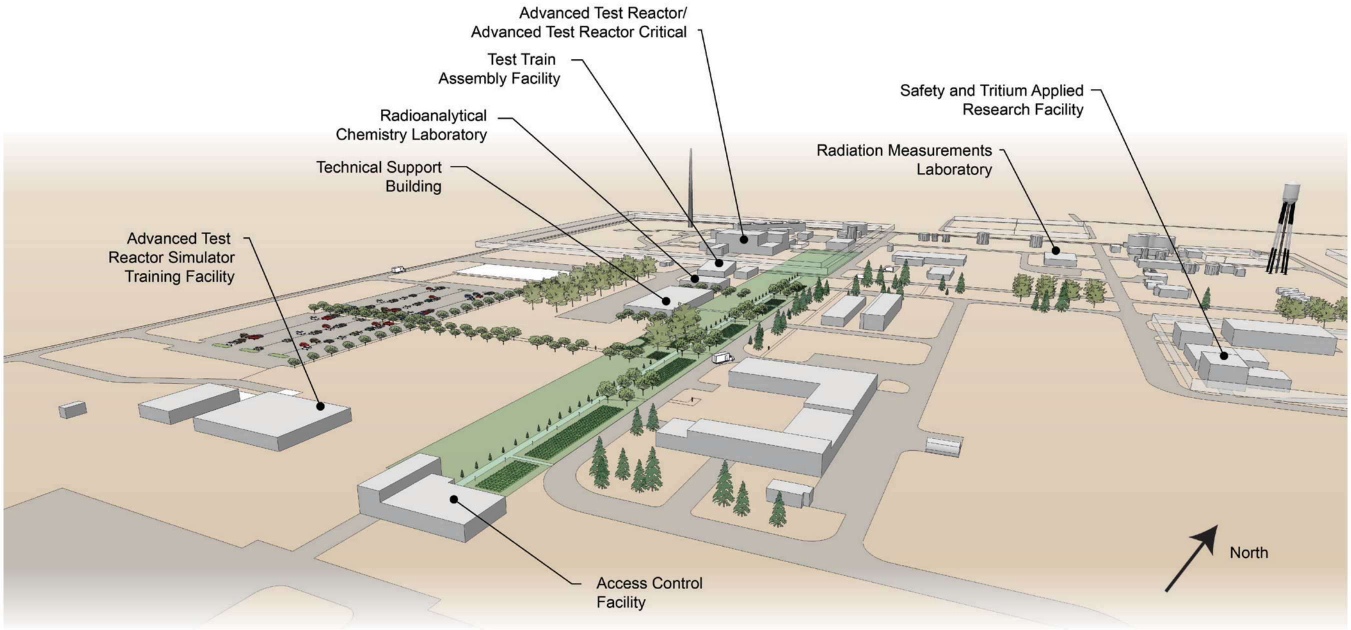
Vulnerabilities resulting from disruptions (cyber-attacks) to energy infrastructure and nuclear proliferation should be minimized. Cyber-attack to business and control systems is a serious risk because of the effect on the U.S. economic prosperity and well-being. The August 2003 east coast power blackouts underscored the susceptibility of interconnected networks not only to terrorist attacks, but to also to severe disruption. Nuclear weapons proliferation poses one of the greatest threats to international security today. Black market nuclear networks underscore the far-from-remote possibility that a terrorist group or a so-called rogue state will acquire weapons of mass destruction or materials for a dirty bomb. The problem of nuclear proliferation is global and any effective response must be multilateral. Overall, the existing global nonproliferation regime is a highly developed example of international law.

The goal is mitigating risks associated with disruptions in supply and nuclear proliferation. INL is a leader in conducting R&D associated with those physical or cyber-based energy systems considered essential to the minimum operations of the economy and government, and in providing thought leadership and expertise to help inform national policy and strategy to protect critical infrastructures from physical and cyber threats. If disrupted, the U.S. energy infrastructure should be able to recover quickly. INL expertise is also addressing an update to the current framework to effectively address today's proliferation threats. This includes supporting DOE in the oversight of civilian nuclear programs and dual-use technologies, ultratrace analysis and standards development and training, securing fissile material and nuclear arsenals, and establishing U.S. nonproliferation policy. Energy security is tightly integrated with overall national security and encompasses a collective approach to U.S. allies, other friendly nations, and trading partners. INL is solving some of the energy security challenges associated with vulnerabilities in energy sources and infrastructure; providing analysis, monitoring, and associated response teams; and scenario modeling and simulation analysis of the drivers of the U.S. and world economy associated with energy components.

A.3 Economic Competitiveness

Energy infrastructure should enable the U.S. to (under a level playing field and fair and transparent market conditions) produce goods and services that meet the test of international markets while simultaneously maintaining and expanding jobs and the incomes of the American people over the longer term. Energy infrastructures should enable new architectures to stimulate energy efficiency, new economic transactions, and new consumer services. Analysis and research at INL is focused on cost and stability of energy through advanced systems and technologies to produce cleaner energy, energy storage systems performance science; cost-effective integration of nuclear energy into a modern energy system, protecting and modernizing infrastructure, and innovative clean energy technologies in advanced manufacturing, which are all critical to developing sound policies; directing investment; and delivering secure, sustainable, and affordable energy.

Appendix B: INL RDD&D Infrastructure



RDD&D activities associated with advancing nuclear energy, clean energy deployment, and security takes place by leveraging capabilities available on INL site (includes both NE and non-NE facilities). These facilities range from those designed to develop foundational knowledge to those designed to demonstrate advanced concepts at scale. INL hosts hot cells, test reactors, radiological facilities, specialty engineering facilities, non-radiological laboratories, small- and large-scale test beds, standards development facilities, SNM storage facilities, and computing capability from desktop workstations to high performance computing infrastructure. INL has also pioneered HES for clean energy integration and deployment studies. In addition to RDD&D capabilities, INL maintains necessary supporting capacity for safety and security of infrastructure including those required to support nuclear RD&D. These capabilities are described briefly below.

Advanced Test Reactor (ATR Complex)

ATR Complex houses one of the world's most versatile materials test reactors ATR and associated Advance Test Reactor Critical (ATRC), Test Train Assembly Facility, Radioanalytical Chemistry Laboratory (RCL), Safety and Tritium Applied Research Facility (STAR), and Radiation Measurements Laboratory (RML). R&D at ATR assures the U.S. Navy's capabilities for strategic defense, the lifetime extension of the nation's commercial nuclear energy reactor fleet, and a pipeline of solution for future advanced nuclear reactors. ATR is not only a national resource to support research across our the nation's nuclear engineering educational complex, but is also a global resource supporting nuclear energy research in Europe, Canada, South Korea, South Africa, among other countries. ATR capabilities will help deliver impacts 2.1.1, 2.1.2, 2.1.3, 2.1.4, and 2.1.6. In addition, these facilities support NE R&D for NNSA, universities, industry, for international cooperation, and other federal agencies.

ATR is a water-cooled, high-flux test reactor, with a unique serpentine design that allows large power variations among its four separate core sections. It is part of NE's first and only user facility for nuclear energy researchers. Primary location to conduct thermal irradiation. ATR is a materials and fuels test reactor with thermal neutron fluxes of 1 × 1,015 neutron/cm^2-sec and maximum fast (E > 0.1 MeV) neutron fluxes of 5 × 1,014 neutrons/cm2-sec. These fluxes, combined with ATR's 77 irradiation positions, make ATR a mission-critical facility with a unique, versatile thermal irradiation capability. The reactor accommodates static, sealed capsule tests with passive instrumentation, tests with active instrumentation for measurement and control of specific testing parameters, and pressurized water loops that allow testing of materials and fuels under representative plant conditions (e.g., pressure, temperature, flow, and chemistry). A few experiments at ATR include doing fast neutron irradiations by filtering the thermal neutrons with cadmium. A hydraulic shuttle irradiation system allows for short-duration irradiation tests. ATR meets the irradiation testing needs of NE, NR, NNSA, and many other researchers.

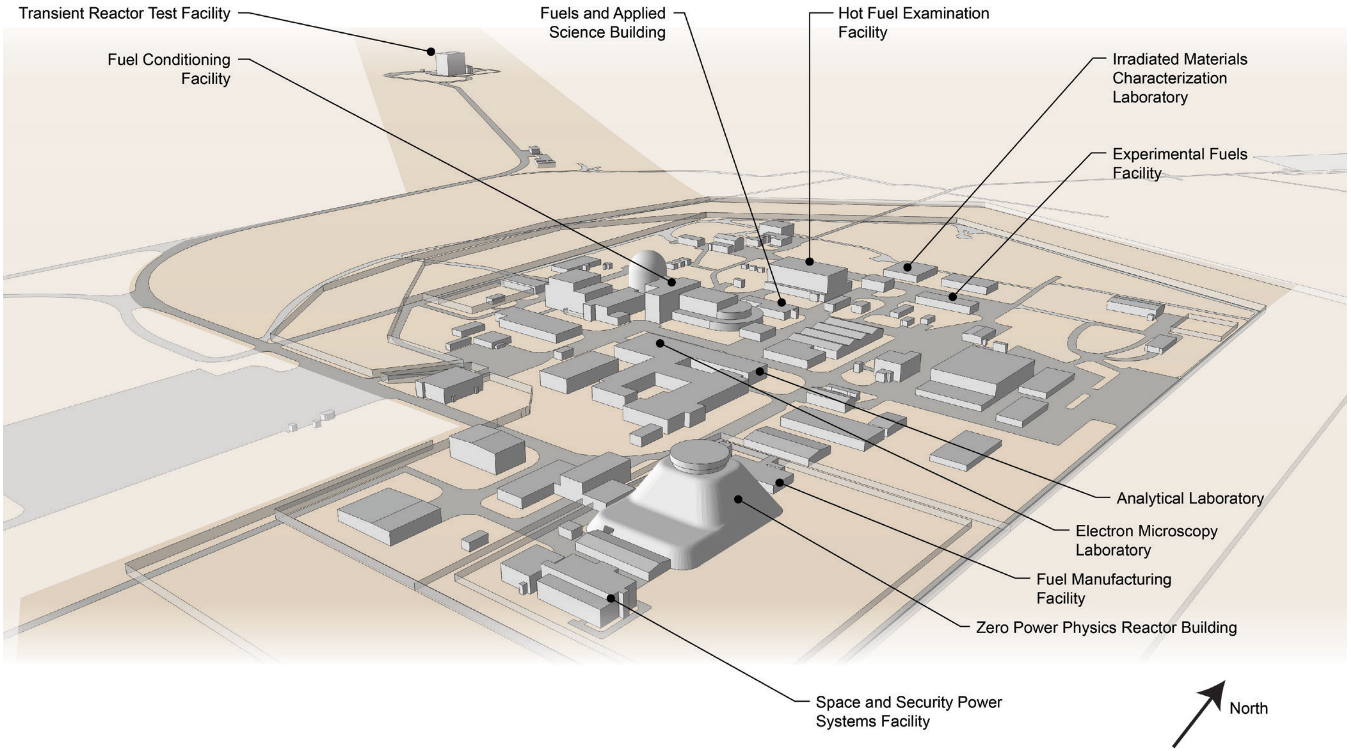
ATRC is a full-size, low-power, pool-type nuclear replica of ATR used to evaluate prototypical experiments before they take place in ATR. There is increasing demand for its use by researchers, and the ATRC is running for longer periods to accommodate experiments. Its normal operating power level is approximately 100 W, with a maximum power rating of 5 kW. Modernization of the instrumentation and control systems will provide enduring support for research.

Test Train Assembly Facility (4,200 ft^2) supports the precision work associated with experiment assembly for insertion in the reactor. A newly installed pressurized water reactor loop is currently in use by EPRI for LWR sustainability research. A low-temperature, pressurized, water-cooled reactor for steady-state irradiation.

RCL contains warm (radiotracers and glovebox work) laboratory/bench-scale testing and analytical capabilities to support aqueous separations research exist at RCL. At RCL, researchers can work to convert used nuclear fuel into more manageable waste forms.

Safety and Tritium Applied Research Facility (STAR) is located at the ATR facility at INL and is funded by SC, Fusion Energy Sciences and supports the mission of harnessing environmentally benign and safe fusion power. STAR facility is classified as less than Hazard Category 3 nuclear facility and is restricted to a facility total tritium inventory of less than 1.6 gram (15,390 Ci) to remain below Hazard Category 3 nuclear facility threshold. STAR supports many experiments performed in collaboration with national and international partners. The Tritium Plasma Experiment is the STAR's primary experiment for studying plasma-driven tritium retention and permeation, this is a US-Japan collaboration. The Tritium Gas Absorption Permeation Experiment (a U.S. and Japan collaboration) is a permeation apparatus for studying tritium behavior in disc-type metal sample and liquid blanket/breeder material (e.g., lead-lithium eutectic) at low tritium partial pressure region for the purpose of accurately measuring tritium permeation in fusion material at realistic tritium partial pressure condition. The test section can be modified to conduct tritium absorption test in solid and liquid blanket/breeder material.

RML is a modern, well-equipped radioanalytical laboratory specializing in qualitative and quantitative measurements of alpha, beta, gamma, and neutron radiation. Most of the RML capabilities are applied to the analyses related to reactor operations, reactor experiments, radioactivity effluent monitoring, environmental monitoring, environmental restoration monitoring, waste characterization monitoring, and radiological safety monitoring. In addition to these analyses, the RML performs measurements and analyses related to R&D programs that establish new capabilities for measurement techniques and the electronic and digital systems needed to apply R&D.



Material Fuels Complex (MFC)

Provides shielded hot cells to handle highly irradiated materials and gloveboxes to handle SNM. MFC houses one-of-a-kind hot cell capabilities and facilities that support world-class nuclear research. MFC includes HFEF, Fuel Conditioning Facility (FCF), Analytical Laboratory (AL), Fuels and Applied Science Building (FASB), Electron Microscopy Laboratory (EML) and co-located fuel fabrication glovebox lines, Space and Security Power Systems Facility (SSPSF), Zero Power Physics Reactor Building (ZPPR), IMCL, Fuel Manufacturing Facility (FMF), and Experimental Fuels Facility. Many of MFC's capabilities are part of NE's NSUF. The capabilities at MFC will help deliver impacts 2.1.1, 2.1.2, 2.1.3, 2.1.4, and 2.1.6. In addition, these facilities support NE R&D for NNSA, universities, industry, for international cooperation, and other federal agencies.

AL (part of NSUF) houses advanced instruments, including a state-of-the-art inductively coupled plasma mass spectrometer, two thermal ionization mass spectrometers, and instruments for determining the fundamental thermodynamic properties of actinide-bearing materials. These activities support various INL research programs, including advanced nuclear fuel design, waste management, environmental science, and nuclear nonproliferation and security missions. AL focuses on chemical and isotopic characterization of unirradiated and irradiated fuels and materials. A large percentage of INL research requires many of AL's capabilities. AL supports analysis of irradiated and radioactive materials via inductively coupled plasma mass spectrometry, optical emission spectrometry, X-ray diffraction, thermal ionization mass spectrometry, and thermal analysis including: thermogravimetric analysis, differential thermal analysis, differential scanning calorimetry, and laser flash analysis.

EML (part of NSUF) is a radiological facility containing optical, scanning, and analytical electron microscopes. It has focused ion beam capable of preparing and analyzing fresh and irradiated nuclear materials and fuels samples. EML houses a transmission electron microscope, dual-beam focused ion beam fitted with electron backscatter diffraction and microchemical analysis capabilities, and state-of-the-art scanning electron microscope fitted with a wavelength dispersive spectrometer with software that allows semi-quantitative analysis of heavy actinides. EML supports isotopic and nanometer-scale microstructural and microchemical analysis. In addition to supporting NE programs and NSUF, EML provides capability to support the High Performance Research Reactor Fuel Development Program.

Experimental Fuels Facility is a nuclear fuel fabrication facility where oxides, nitrides, carbides, silicides, and composite fuels and materials samples are fabricated for irradiation in research reactors such as ATR. The samples provide forms that may offer advantages over current commercial fuel technologies.

FCF has full capabilities for conducting engineering and pilot-scale electromechanical separations research and demonstrations and developing high-level hot fuel waste products. A mock-up area enables preparation, modification, and testing of sophisticated instruments prior to their installation in INL's hot cells to make sure they can be operated and maintained remotely. FCF's unique capabilities support treatment of DOE-owned sodium-bonded metal fuel, demonstrate the technical feasibility of pyro-processing technology for treating used nuclear fuel, and also support NNSA defense nuclear nonproliferation programs.

FMF supports laboratory-scale development and assembly of transuranic metal and ceramic fuels for the Advanced Fuel Cycle Initiative. Americium distillation and americium oxide reduction are being developed in FMF.

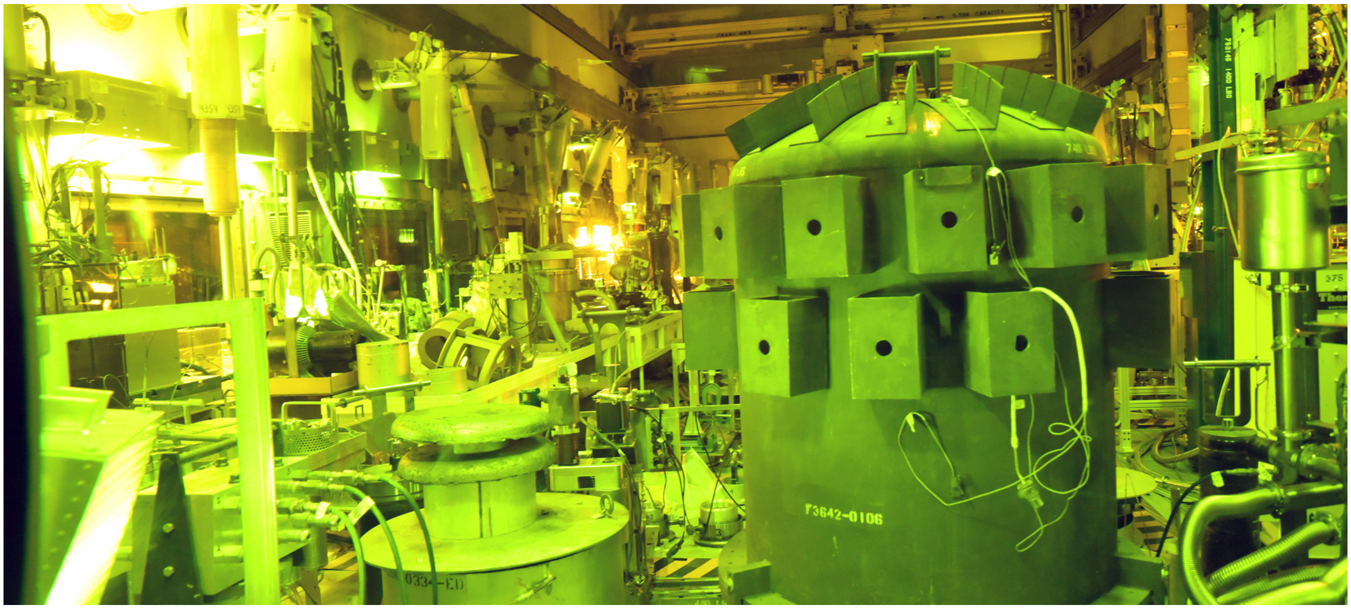
FASB (part of NSUF) has two heavily shielded irradiation-assisted stress corrosion cracking test rigs and instrumentation for lower level radiological thermomechanical property measurements. FASB provides the resources to perform fuel development, materials characterization, and irradiated materials testing. It houses a low-level, thermophysical properties laboratory outfitted with equipment for sample preparation, optical microscopy, electron microscopy, and thermodynamic properties determination. It is also equipped with a suite of lead-shielded gamma cells to conduct environmental crack-growth-rate and fracture-toughness testing on irradiated materials. This testing enables examination of larger specimens providing quantitative data on the effects of reactor environments upon which to build science-based determinations of reactor life extension. FASB houses unique uranium fabrication capabilities and is dedicated to characterization of fresh uranium fuel. It supports fuel R&D such as prototyping of transmutation fuel fabrication processes for fuel-cycle R&D. FASB also houses uranium glovebox lines for developing new fuel types for converting research and test reactors from highly enriched to low-enriched uranium fuel.

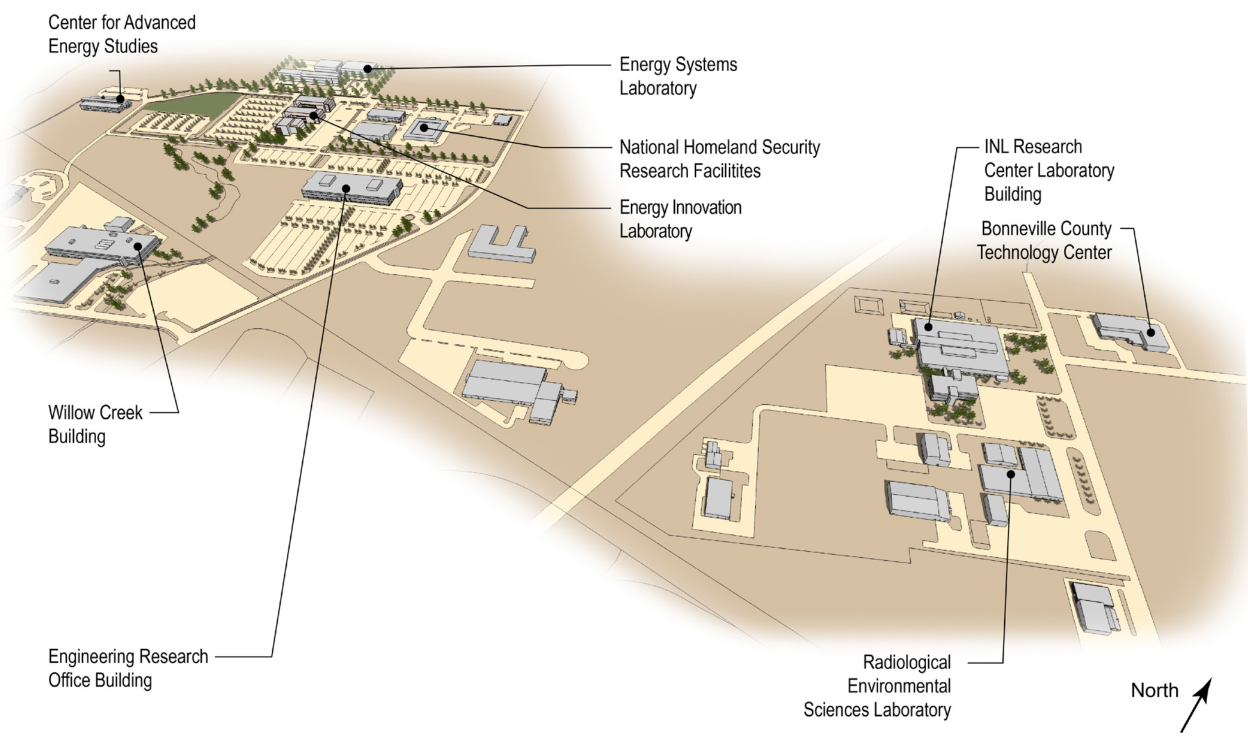
HFEF (part of NSUF) is a heavily shielded nuclear facility designed to be the front end of the PIE capability. It can receive and handle kilograms to hundreds of kilograms of nuclear fuel and material in almost any type of cask, including full-size commercial LWR fuel casks. The mission of HFEF is to receive material, conduct nondestructive and destructive examinations, and prepare material specimens for transfer to characterization laboratories for detailed analysis. HFEF also houses limited mechanical testing equipment and NRAD 250-kW Training, Research, Isotopes, General Atomics reactor for neutron radiography, bench-scale electrochemical separations testing, and engineering-scale waste-form development to support operations in FCF. HFEF also provides support to a variety of programs including R&D in nuclear fuel cycle, Generation IV, space nuclear, and home land security technologies.

IMCL (part of NSUF) is the newest nuclear energy research facility at MFC. It is a unique facility that incorporates many features designed to allow researchers to safely and efficiently prepare irradiated fuel and material samples for microstructural-level investigations. The many advanced capabilities slated for installation in the IMCL's reconfigurable 8,000-ft^2 research area will help INL continue research that provides a deeper understanding of fuel performance and behavior than ever before. IMCL's design incorporates vibration, environmental, and radiological isolation that enables advanced microscopy techniques requiring extremely sensitive equipment.

SSPSF provides one-of-a-kind capabilities for fueling, testing, and delivering radioisotope power systems. It has a unique collection of equipment and facilities for isotope production and power conversion system development, production capabilities for high temperature metals and components, and infrastructure for safe assembly, test, and transport of flight and terrestrial power systems. It houses three fueling glovebox lines, including one equipped to meet NASA planetary protection protocols. It also houses a vibration test apparatus to simulate launch pad scenarios, magnetic-moment measuring device, and mass-property-measuring device. Finally, there are two thermal vacuum chambers: one equipped to employ liquid nitrogen cooling for simulating space environments and one to assess power output. SSPSF's full delivery system is composed of two specially equipped trailers and three Type-B shipping containers for delivering final power systems to customer's location.

ZPPR building supports nuclear materials handling and packaging activities in the workroom and cell, and routine activities conducted in the ZPPR vault/workroom to monitor and maintain the integrity of the ZPPR fuel plates and other fissile materials in storage. The facility is also used to support the development, testing, and evaluation of nuclear material detectors and to train personnel.





Research and Education Campus (REC)

REC provides nonradiological laboratories and administrative facilities to support multiple Laboratory mission. REC is very conducive to collaboration with business and university partners, while providing diverse laboratories and office spaces. It includes Energy Innovation Laboratory (EIL), CAES, Energy Systems Laboratory (ESL), National Homeland Security Research Facilities, Energy Research Office Building, INL Research Center Laboratory (IRCL), Radiological Environmental Science Laboratory (RESL), Bonneville Country Technology Center, and the High Performance Computing Data Center. The capabilities at REC will help deliver impacts 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.6, 2.1.7, 2.1.9, 2.1.10, and 2.1.11. In addition, these facilities support NE R&D for NNSA, universities, industry, for international cooperation, and other federal agencies.

EIL (a 148,000-ft^2 laboratory commissioned in FY 2014) is the R&D showcase for INL. An award-winning, Leadership in Energy and Environmental Design Platinum-certified facility, EIL provides a state-of-the-art laboratory, office space, and a meeting center. This facility consolidates laboratories needed for fundamental R&D activities and centralizes key research functions at REC. Specifically, EIL supports chemical sciences, nanotechnology, water chemistry, advanced microscopy, control systems, high-temperature testing, thermal hydraulics, materials testing and characterization, separations technology, and advanced instrument training.

CAES (55,000 ft^2) fosters multi-institution, collaborative energy research programs important to the nation; attracts students and faculty to the Idaho universities; promotes informed energy policy dialogue across Idaho and the nation; and acts as a catalyst for technology-based economic development in Idaho. CAES houses (1) radiochemistry laboratory, (2) advanced materials laboratory, (3) analytical chemistry laboratory, (4) advanced transportation laboratory, (4) microscopy and characterization suite, (5) fluids lab, (6) advanced visualization laboratory, (7) analytical instrumentation laboratory, and (8) human performance simulation laboratory. These laboratories support materials science, advanced visualization and modeling, actinide sciences, analytical chemistry, and carbon management. These capabilities are made available to CAES partners through collaborative research activities in nuclear science and engineering, bioenergy, carbon management, energy efficiency, and advanced materials. CAES's MaCS is part of NSUF and is equipped to handle low-level radiological samples and nonradiological samples. MaCS include focused ion beam, local electrode atom probe, tomography, transmission electron microscope, scanning electron microscope electron backscattered diffraction.

ESL is a 91,000-ft^2 laboratory and office facility that began operations in FY 2013. It houses multiple research programs for advancing energy security and reducing risks that may be associated with new technologies. It expands current capabilities and provides state-of-the-art high bays and laboratory space. ESL enables R&D in bioenergy feedstock processing, advanced battery testing, and hybrid energy systems integration.

National Homeland Security Facilities house cyber security intelligence, security systems laboratory, critical infrastructure protection and resilience, and homeland protection facilities. These facilities contain collaborative research and laboratory areas that support federal agencies, national and international programs, and energy industry. R&D within these facilities focuses on materials analysis, energy systems resilience and reliability, industrial control systems cybersecurity, and critical infrastructure interdependencies.

Nanotrace Laboratory uniquely integrates its core capabilities with nuclear materials, separation science, analytical chemistry and detection science to support research and produce analyses and measurement standards for national ultratrace nonproliferation and forensics measurements. INL enables world-class experts with access to a unique inventory of nuclear and radiological materials, a series of clean rooms, cold and hot sample preparation laboratories, mass separators and mass spectrometers, and isolated alpha/beta/gamma/neutron measurement systems. These measurements and standards, deployed nationally and internationally, lead to discoveries in the physics and chemistry of elemental isotopes; increase the confidence in nonproliferation treaty compliance; assure environmental, safety and health stewardship of nuclear and radiological operations; and provide forensic capability to assign attribution after a radiological or nuclear event

Wireless Testbed applies extensive wireless expertise, laboratories and our full-scale wireless testbed to develop innovative, technical solutions to meet the emerging national wireless communications challenges that connect the nation's technology which drives our national economy and enables government, military, emergency and public safety operations. In addition to our integrated team of wireless experts from government, military, academia, vendors and telecommunication providers, our unique wireless infrastructure includes (1) multiple laboratories equipped with experimental transmission, receiving, and analysis systems and chambers; (2) an isolated geographical terrain with relatively radiofrequency-free environment; (3) authorization from the National Telecommunications and Information Administration to operate as an experimental radio station for testing advanced technology system performance, interference testing and training; (4) full-scale, deployed 2nd, 3rd, and 4th generation technology and networks for sophisticated signal, reliability and encrypted messaging research and testing; (5) multiple network operation centers for simultaneous testing of site and off-site communication systems; and (6) physics-based radiofrequency modeling and simulation. In addition to performing testing for multiple government organizations, with designation as a Wireless User Facility, this testbed is accessible for nonproprietary testing for industry, academia and national laboratories

IRC (280,000 ft^2) is a collection of laboratories that support advanced research, process development, and applied engineering in biology, chemistry, metallurgy, robotics, materials characterization, modeling and computational science, physics, and high-temperature electrolysis production of hydrogen for nuclear and non-nuclear energy applications. Its large footprint, including high bay areas for small-scale pilot plant research, enables advancement of basic research and bench-scale concepts into viable, integrated systems (e.g., hybrid energy systems). Recent addition of a unique accelerator mass spectrometer provides additional support for homeland security programs

RESL features analytical chemistry and radiation protection and serves as a reference laboratory for numerous performance evaluation programs. It provides technical support and quality assurance metrology, which is directly traceable to the National Institute of Standards and Technology. RESL also houses INL's whole-body counter and is a critical resource for DOE and Office of Environment, Health, Safety, and Security.

High Performance Computing Data Center is a 3,700 ft^2 facility, housed at the Energy Research Office Building. The data center provides essential support for modeling and simulation work and multiple program missions. The center houses the new installed current-generation supercomputer known as Falcon. INL upgrades its computing capabilities every 3 year.

Bonneville County Technology Center is a leased non-radiological facility with individual research high bays that support various INL experiments including geocentrifuge operations, spray forming research, fracture flow research and biomass energy whole crop utilization research.

Water Security Testbed Facility supports research, evaluations and testing over a topic range that includes persistence of contaminants in a municipal water system that include biological, chemical and radiological contamination. Additionally, evaluation and testing of sensors, detectors, materials, sampling methods, SCADA/cyber security and decontamination processes, efficacy and related technologies is conducted at the site.

Central Facilities Area (CFA)

The remoteness of CFA and other site locations, together with quiet radiofrequency spectrum and Scoville Power System, makes this area a unique and desirable location for wireless testbed and electric-grid power testing. CFA capabilities will help deliver impacts 2.1.5 and 2.1.7.

Critical Infrastructure Test Range Complex (CITRC)

CITRC is focused on critical infrastructure resiliency and nonproliferation testing and demonstration. CITRC activities include wireless test-bed operations, water security test-bed operations, power line and grid testing, unmanned aerial vehicle testing, accelerator testing, explosives detection, and radiological counter terrorism emergency-response training. CITRC capabilities will help deliver impacts 2.1.5 and 2.1.7.

Specific Manufacturing Capability (SMC)

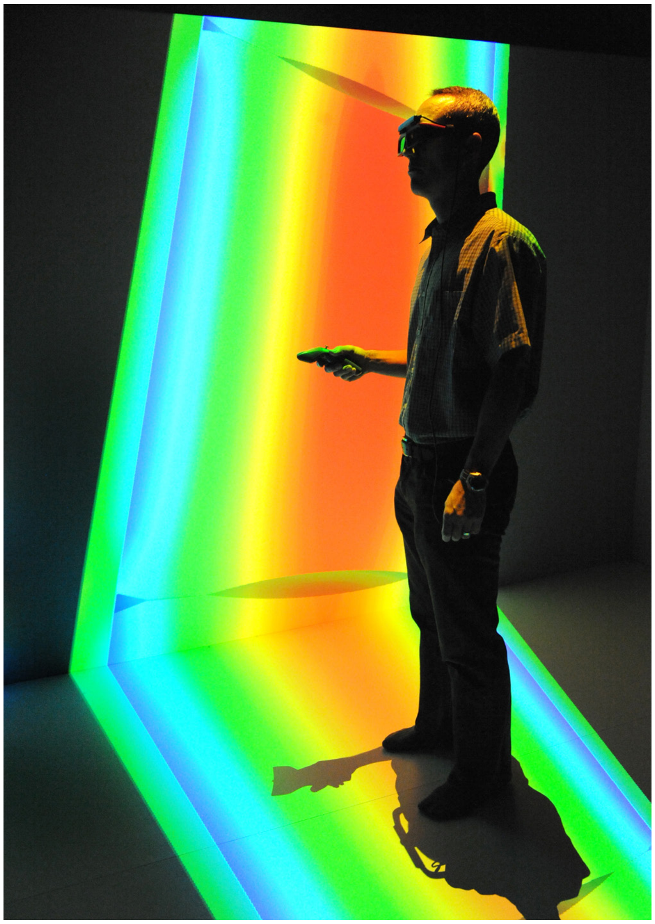
SMC manufactures armor packages for the U.S. Army Abrams main battle tank since 1984. This armor-manufacturing complex provides 320,000 ft2 of secure floor space and state-of-the-art equipment. SMC capabilities include light and heavy fabrication equipment and a modern metallurgical laboratory. SMC capabilities will help deliver impacts 2.1.8.

Transient Reactor Test Facility (TREAT)

Adjacent to the MFC complex, TREAT was specifically built to conduct transient reactor tests where the test material is subjected to neutron pulses that can simulate conditions ranging from mild upsets to severe reactor accidents. The reactor was constructed to test fast reactor fuels but has also been used for LWR fuel testing and other exotic special-purpose fuels (i.e., space reactors). TREAT capabilities will help deliver impacts 2.1.1, 2.1.3, 2.1.4, and 2.1.6. In addition, the facility supports NE R&D for NNSA, universities, industry, for international cooperation, and other federal agencies.

Multiphysics Object Oriented Simulation Environment (MOOSE)

MOOSE is a finite-element, multiphysics framework primarily developed by INL. It provides high-level interface to some of the most sophisticated nonlinear solver technology. MOOSE is one of INL's R&D 100 winning technologies. MOOSE makes modeling and simulation more accessible to a broad array of scientists and enables simulation tools to be developed in a fraction of the time previously required especially in the field of nuclear engineering, revolutionizing predictive modeling. It allows nuclear fuels and materials scientists to develop numerous applications that predict the behavior of fuels and materials under operating and accident conditions. MOOSE has bred a herd of modeling applications describing phenomena in nuclear physics (BISON, MARMOT), geology (FALCON), chemistry (RAT) and engineering (RAVEN, Pronghorn). MOOSE and its herd of applications are licensed for use by domestic and foreign laboratories, universities, and industry. MOOSE capabilities will help deliver impact 2.1.4. In addition, the capability supports NE R&D for universities, industry, for international cooperation, and other federal agencies.



Idaho Nuclear Technology and Engineering Center (INTEC)

Owned and operated by DOE-EM. Until 1992, INTEC operated to recover highly enriched uranium from used nuclear fuel from government reactors and to convert the resulting liquid high-level waste into a more stable, solid granular material suitable for long-term storage. Today, environmental cleanup of INTEC nearing completion, INTEC facilities are or will be surplus. The Material Security and Consolidation Facilities at INTEC and several surrounding buildings are used for the relocation of low-enriched uranium disposition products from a sodium-bonded spent nuclear fuel campaign. INTEC capabilities will help deliver impacts 2.1.2 and 2.1.7.

Naval Reactors Facility (NRF)

Operated by Bechtel Marine Propulsion Corporation under contract and direct supervision of Naval Nuclear Propulsion Program in support of U.S. Navy's nuclear powered fleet. NRF integrates the ATR's unique irradiation and test capabilities into its exclusive nuclear propulsion research program.

Radioactive Waste Management Complex (RWMC)

Stores legacy transuranic waste and mixed low-level waste. Beginning in 1970, approximately 65,000 m^3 of waste in 55-gal drums, boxes, and bins were placed on asphalt pads for interim storage at the RWMC Transuranic Storage area. This facility is operated by Idaho Treatment Group, LLC and the program, Advanced Mixed Waste Treatment Project (AMWTP) is funded by EM. AMWTP's mission is to retrieve characterize, treat, and remove the legacy waste from Idaho. RWMC capabilities will help deliver impacts 2.1.2 and 2.1.7.

Appendix C: INL Core Capabilities

The core capabilities are required to accomplish INL's multiprogram missions. Mission accomplishment encompasses a substantial combination of facilities and/or teams of people and/or equipment. These are unique and/or world-leading components at INL. These capabilities are relevant for delivering DOE, DHS, NNSA, NASA, NR missions and national needs. INL's core capabilities were approved by DOE on May 28, 2014.

Core capability	Description
Nuclear fuels & materials research Delivering impact on 2.1.1–2.1.4 2.1.8 2.1.9	The nuclear fuels and materials research capability includes INL's ability to conduct applied nuclear fuels and materials R&D for applications in electricity and/or process heat production, nuclear materials management (transmutation), research reactors, space technology, and radioisotope production. INL expertise includes development of fabrication processes for new fuels, characterization of fuel samples, irradiation testing, post-irradiation examination, out-of-pile testing, and modeling of fuel performance. Nuclear fuels and materials R&D encompasses fuel performance during normal reactor operations, behavior and failure modes during off-normal and accident conditions, and performance during extended storage and transport. Nuclear fuels and materials R&D encompasses fuel performance during normal reactor operations, behavior and failure modes during off-normal and accident conditions, and performance during extended storage and transport. The R&D relies on engineering driven science-based approach, which includes multi-scale, multi-physics modeling of fuel performance with phenomenological models at different length and time-scales.
Applied materials research and processing Delivering impact on 2.1.2–2.1.4 2.1.6 2.1.9	Applied materials research and processing capability includes INL's ability to determine properties and performance of materials (metals, polymers) applied to next generation energy systems particularly those involving aggressive operating conditions (temperature, pressure). Specific research expertise is applied to corrosion of materials in gases, aqueous media, and liquid metals, and adequate corrosion protection measures as well as materials studies for reactor safety. Similar expertise is also applied to the processing of biomass feedstock to enable consistent materials availability to bio refineries or other bioenergy programs.
Applied chemical separations Delivering impact on 2.1.1–2.1.4 2.1.7 2.1.8	Research development and demonstration capability in aqueous and electrochemical processing for recycle of used nuclear fuel are the focus of applied chemical separations. The capability enables the ability to conduct rare earth materials recovery and separation across life cycle of production (ore processing to recovery from consumer products) and to process industrial and process water for recovery and reutilization. INL includes expertise in radio chemistry, analytical chemistry, and physical analysis, actinide separations, and specialty equipment such as inductively coupled plasma atomic emission spectrometry, ion chromatography, gamma spectroscopy, liquid scintillation and alpha and beta counting equipment to analyze samples.
Energy systems design and analysis Delivering impact on 2.1.1–2.1.11	This capability includes ability to develop hybrid energy systems that enable tightly coupled nuclear, renewable and carbon based energy systems, which feed to next generation grid systems that are resilient, robust and flexible for both storage and delivery. Capabilities utilize state-of-the-art computational methods and modeling and simulation to couple multiple physics at different scales. This multi-physics, multi-scale approach, in turn, enables the development of best- estimate predictive models applied to energy systems such as advanced transportation, advanced nuclear reactor and fuel cycles, natural gas, space nuclear, grid, wind, and geothermal. Design and analyses capabilities extend to the fabrication and testing of radioisotope power sources used for space and homeland security applications. Design and analyses capabilities extend to the fabrication and testing of radioisotope power sources used for space and homeland security applications.

Core capability	Description
Engineering research, performance, validation & demonstration Delivering impact on 2.1.1–2.1.11	This capability includes leading-edge specialty research facilities and expertise used by universities, national laboratories and industry to carry out 'at-scale' testing and demonstration of technology, and conduct groundbreaking R&D activities that would otherwise not be possible. This requires the scientific and research expertise of multiple scientific disciplines, offers researchers access to unique and expensive equipment and expertise, and facilitates the collaboration of scientists and engineers. Provides a rich field for scientific investigation, through access to the world-class capabilities offered by the Advanced Test Reactor and post-irradiation examination facilities, and the variety of reactors, beam lines and instruments at partner facilities. Combined, these hubs, centers and national user assets form major centers for energy security technology development and demonstration.
Critical infrastructure protection Delivering impact on 2.1.5	This capability includes INL's ability to conduct research, development, testing and evaluation for the reliability and resilience of critical infrastructure systems. It integrates with industrial control systems including wireless and cyber security and includes capability for vulnerability assessment and threat prevention.
Nuclear nonproliferation Delivering impact on 2.1.1–2.1.4 2.1.6 2.1.7	This capability includes a full range of facilities, radiological and nuclear materials and expertise in monitoring, evaluating and preventing threats from nuclear proliferation. This includes the development of proliferation resistant fuels, technical support for reactor conversions, nuclear safeguards and security, nuclear cybersecurity, advanced detection and identification of nuclear and radiological materials and illicit activities, material signature identification and method development for nuclear forensics and ultra-trace detection. Capabilities and expertise exist for demonstration and training in real world environments using radiological and nuclear materials for emergency response. Test ranges exist that are permitted and support large scale outdoor contamination exercises and testing.
Industrial control systems Delivering impact on 2.1.5	This capability includes the ability to identify and reduce vulnerabilities in industrial control systems including supervisory control and data acquisition systems, distributed control systems and energy management systems. This includes expertise in the testing, R&D of industrial control systems cyber security.
Environmental system surveillance Delivering impact on 2.1.11	This capability utilizes unique expertise applied to understanding and mitigating the impact on environmental systems due to resource recovery, and consequences of energy production as well as threats to domestic water supplies.
Defense systems Delivering impact on 2.1.8	This capability includes INL's ability to provide independent technical evaluations and solutions to manufacturing, engineering, and material science challenges for a variety of non-nuclear weapons programs and customers in threat defeat and survivability solutions. This includes R&D of armor and physical protection of energy transmission and distribution systems using secure floor space complete with state-of-the-art equipment and a knowledgeable and security cleared workforce.
Enabling infrastructure Delivering impact on 2.1.1–2.1.11	This capability is INL's unique expertise, equipment and systems applied to supporting critical mission capabilities and facilities including HVAC, electrical, fire main, water, sewer, access, etc.

Appendix D: INL Funding Portfolio

Supporting Missions of DOE

As the NE national nuclear labortory, INL serves unique role in civilian nuclear energy research. Given its history and preeminance in reactor and fuel-cycle technology research, development, demonstration, INL stewards majority of DOE's nuclear energy R&D infrastructure. INL assists DOE in leading, coordinating, and participating in RDD&D performed by national laboratories, U.S. universities and industry, and collaborating with international research institutions. For EERE, INL is providing support in the areas of advanced vehicles, energy storage and battery testing, bioenergy and biofuels, geothermal energy, wind and water energy. For NNSA, INL

- Supports naval nuclear propulsion system research
- Supports development of solutions for converting high enriched uranium fueled research reactors to low enriched uranium fuel while retaining original reactor's performance
- Provides innovations in advanced radiation measurement methods and systems for ultratrace to weapon quantitites
- Supports development of unique production, separation and purification of fissionable materials and fission products resulting in the delivery of isotopic standards and reference materials that assure the accuracy of global measurement systems
- Supports enhancing physical and cyber security of nuclear facilities, recovering obsololete or uncontrolled radiation sources, reducing the proliferation pathways of nuclear energy technologies transferred within international agreements, and securing and accounting for inventories of nuclear materials
- Provides program management, expert staff, equipment and response coordination for support and security during high profile national events
- Provides physical and cyber security vulnerability assessments for nuclear facilities and laboratories
- Provides education, training, and exercise support for military, law enforcement, and state emergency responders, and international treaty inspectors.

Table D1 provides summary of projected FY 2015 DOE funding.

Strategic Partnership Programs to Achieve National-Scale Goals

SPP projects and partnerships have benefitted DOE projects and programs, help attact high-caliber scientific and technical talent. INL ensures that SPP programs are balanced with DOE programs and synergies exist within INL's leadership positions. This ensures that large reductions in SPP program will not significantly impact taff terminations and reassignments. The infrastructure needs of SPP programs are factored into INL's plans for continuing revitalization to enhance mission readiness.

SPP enables INL to support the public and private sector, consistent with DOE's goals of supporting the achievement of national-scale goals by providing access to its facilities, services, and technical expertise on a full cost-recovery basis. INL's SPP portfolio reflects and validates the leadership, excellence, and competitiveness of INL's core capabilities, it spans the breadth of its core capabilities, and supports new capabilities and capacity to be developed to support future research direction and sustain the Laboratory's core capabilities.

INL weighs benefits and risks to ensure that its SPP strengthens the Laboratory, sustains and builds on it core capabaility, builds leadership position, encourages innovations, and also benefits DOE. In managing discretionary resources, INL's first priority is to ensure sustainability and expansion of its ability to execute its mission by investing in and maintaining its infrastructure, funding support elements, and building science and technology capability to deliver mission outcomes. In the absence of programmatic support, INL may elect to invest in its key research infrastructure to improve availability, reliability, performance, high

Table D1. Projected FY 2015 DOE funding.						
	FY 2013		FY 2014		FY 2015 Projected	
AFCI (AF58)	58.1	7%	57.1	7%	62.1	7%
RC RD&D (RC)	58.9	7%	61.7	7%	53.8	6%
NE Other	53.6	6%	37.5	5%	40.0	4%
Subtotal NE – RDD&D	**170.6**	**20%**	**156.4**	**19%**	**155.9**	**17%**
IFM (AF02)*	142.0	17%	170.2	20%	189.3	20%
RH-LLW (NE)	0.0	0%	0.3	0%	4.3	0%
S&S (FS55)	85.4	10%	87.6	11%	101.6	11%
Subtotal NE – Infrastructure	**227.4**	**27%**	**258.2**	**31%**	**295.2**	**32%**
ATR – Naval Reactors	56.4	7%	55.6	7%	69.9	8%
RH-LLW (NA)	0.0	0%	1.4	0%	9.2	1%
NA-M3 (NN90)	87.7	10%	81.3	10%	76.3	8%
NA Other	17.3	2%	18.0	2%	21.1	2%
Subtotal NA	**161.4**	**19%**	**156.3**	**19%**	**176.5**	**19%**
EERE	28.8	3%	28.9	3%	33.8	4%
DOE Other	12.2	1%	10.6	1%	15.8	2%
Subtotal DOE Other	**41.1**	**5%**	**39.5**	**5%**	**49.6**	**5%**
Subtotal DOE	**600.5**	**72%**	**610.4**	**73%**	**677.2**	**73%**

standards of safety and mission readiness and to sustain core capabilities. SPP represents approximately 27% of Laboratory's budget and a major part of the way that INL fulfills DOE's mission.

Federal agencies, other than DOE, supported by INL include NASA, DoD, DHS, NRC, and the Department of Interior. This work involves the application of INL's nuclear energy capabilities (e.g., nuclear forensics, nuclear nonproliferation, and radioisotope power systems assembly and testing), while other work is an extension of INL's capabilities and expertise in analysis, testing, and validation and demonstration in areas such as critical infrastructure protection, clean energy systems, energy storage, and related enabling technologies. INL works closely with nuclear industry to help bring commercial perspective to R&D and to meet industry specific needs. In addition to the nuclear sector, INL supports industry partners in other segments of energy sector, automobile manufacturing, and agribusiness with engineering. Table D2 provides summary of projected SPP funding.

Discretionary Investments to Help Deliver Mission Impacts

INL's first priority in managing discretionary resources is to address the delivery of mission impacts with appropriate priority and risk mitigation. The Laboratory must sustain and expand its ability to execute its mission by investing in and maintaining its infrastructure; funding INL's support elements line operations management, business management, employee benefits, performance and risk management, financial management, etc. and maintaining and building science and technology capability and capacity. In the absence of appropriate programmatic support, INL will also elect to invest in its key multi-program research infrastructure to improve availability,

Table D2. Projected FY 2015 SPP funding.						
	FY 2013		FY 2014		FY 2015 Projected	
DHS	26.6	3%	28.1	3%	34.1	4%
DOD	37.6	4%	34.8	4%	31.3	3%
DOD SMC	74.2	9%	47.9	6%	53.6	6%
DOE	17.4	2%	16.7	2%	8.9	1%
Non-Federal	14.1	2%	23.1	3%	29.7	3%
NRC	8.4	1%	7.1	1%	8.3	1%
Oth Fed Agencies	24.3	3%	25.8	3%	27.8	3%
Oth Site Contractors	36.7	4%	38.4	5%	52.8	6%
Subtotal SPP	**239.2**	**28%**	**222.0**	**27%**	**246.5**	**27%**

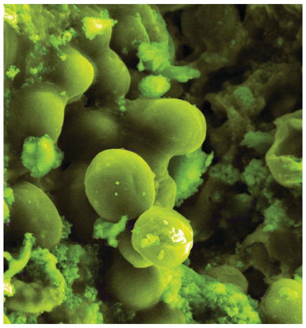
reliability, performance, high standards of safety and mission readiness and to sustain capabilities that has been threatened when programmatic support is not available. Within this process, INL also prioritizes and balances laboratory-directed research and development (LDRD) investments, program-directed opportunities, and conventional infrastructure investments with the goal to maximize Laboratory strategic value.

Discretionary funds for infrastructure are applied to reduce ES&H risks including studies to inform decisions on hardening of INL facilities to address seismic hazards, applied to deferred maintenance, repair, and replacement of real property, enterprise management to update and upgrade aging enterprise systems essential for INL business operations based on priority needs across the enterprise, improvement to quality of work life (aesthetics, amenities, and new acquisitions (base infrastructure, business systems, vehicles, etc.). Discretionary funds for science and technology infrastructure is focused on nuclear facilities MFC and ATR to ensure habitability, program readiness, and reliable operations and availability of the capabilities to support R&D. Investments in nuclear facilities are focused on improving the availability and predictability of facility capabilities, address differed maintenance, and ensure the safe and efficient operations of these unique facilities. Reduction in risk drives mission enablement and enterprise portfolio investments of discretionary investment in INL's support elements. Key risks that drive investment priorities for INL's support elements include (1) improving reliability of base infrastructure that support INL mission including facilities, utilities, fleet, roads, roofs, and general purpose equipment, (2) improving reliability and security of information technology and digital information assets in support of mission, including effectiveness of cyber defenses against intrusion, data loss, and damage; (3) given the staff retirement profile in the coming years, staffing shortfalls that impact mission delivery, operational effectiveness, efficiency, and compliance; (4) establishing effective, graded approach to project and work scope management; (5) ensuring performance meets expectation and compliance meets statutory, regulatory, and contract requirements; (6) enabling ability to provide effective and efficient services; (7) ensuring management reserve is adequate to address unknowns. INL sets aside about 10–20% of its available discretionary funds to address these needs.

The LDRD program benefits INL and DOE by providing the Laboratory with resources for developing new R&D capabilities to better meet the Department's needs, seeding innovative staff-initiated research, and attracting and retaining research staff to maintain the vitality of the Laboratory. A principal benefit of the LDRD program is that it allows the

Laboratory to develop new R&D capabilities and build capacity in anticipation of future DOE and national needs. LDRD investment at INL may be grouped into the following categories of investment trying to achieve different objectives:

- Strategically driven investment (cross-cutting and directorate led investment). Most of LDRD budget supports strategic initiatives. The intent is to position the Laboratory to effectively support DOE in carrying out its overarching mission in energy and security.
- Investment in staff-initiated innovative ideas (Transformational Program) allows the research staff to pursue novel research ideas that may have a high risk for failure, but also have high potential for making significant advances if the novel concepts are proven. Such R&D investments are expected to lead to new sources of support from DOE or other federal agencies, thus strengthening the core science and technology capabilities of the Laboratory. Through its support of staff-initiated R&D, the LDRD program promotes high morale among the Laboratory staff by giving them the opportunity to pursue and investigate their most innovative ideas while they are still fresh and enthusiasm is high. Consequently, the program is a major contributor to achieving and maintaining staff excellence at the Laboratory, as well as an important tool in recruiting new staff to help develop key R&D capabilities.
- Strategic hire investment allows INL to add senior individuals with critical skills to the INL staff. Strategic hires can build and lead new research programs and areas and for long-term contribution and leadership.
- Named postdoc investment allows INL to attract, recruit, develop, and inspire early career researchers who have the potential to develop into INL's future scientific and technical leaders. This appointment is highly competitive and is intended to recognize and provide these individuals with a competitive award, research experience, mentorship, and training to develop their capabilities. The engagement of early career research talent is critical to building and developing critical capacity and capability at INL to deliver INL's mission.



More information:

Dr. Todd Allen

Deputy Laboratory Director
for Science and Technology

todd.allen@inl.gov
(208) 526-8096