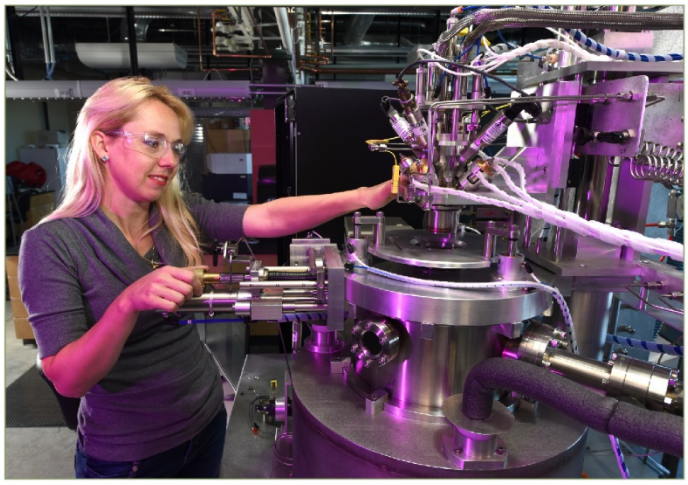
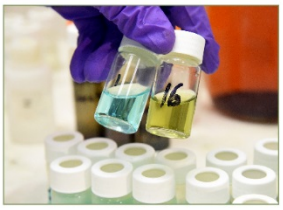
Battelle Energy Alliance, LLC (BEA) 2016

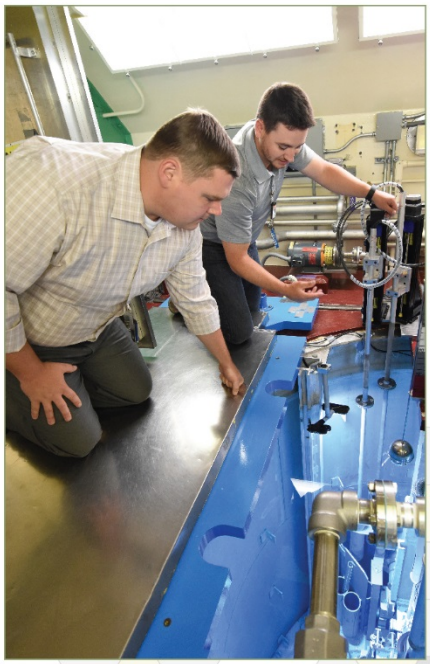
INL/EXT-16-39977

Self-Assessment Report

For Idaho National Laboratory (INL)







Idaho National Laboratory

Front Cover Graphics

1. E-RECOV developed by Dr. Tedd Lister to recover valuable rare earth elements from discarded electronics, which was named a National Innovation Awardee by TechConnect and won an FLC Far West Regional Award for "Outstanding Technology Development" in FY 2016.

2. Dr. Rebecca Fushimi operates the new Temporal Analysis of Products (TAP) reactor system at CAES. In FY 2016, DOE established the Transient Kinetics Industry Portal, a user facility-like program, to provide researchers from industry and academia access to INL's unique TAP expertise. INL is now home to two of the three TAP reactors in the U.S.

3. Aaron Craft, Research Scientist at MFC, and Mike Ruddell, Senior Reactor Operator of the NRAD reactor at the Hot Fuel Examination Facility. Aaron and Mike are in the reactor room looking down at the NRAD core 6 feet beneath them under water. NRAD recently doubled its production capacity for neutron radiographs from seven to fourteen radiographs per day. Another project recently produced the first fully digital neutron radiographs ever acquired at INL.

EXECUTIVE SUMMARY

In fiscal year (FY) 2016, Idaho National Laboratory's (INL) leadership in nuclear energy research development, demonstration, and deployment (RDD&D) resulted in a paradigm shift solidifying the role nuclear energy will play as a part of the nation's clean energy strategy. INL led the development of the plan for the Gateway for Accelerated Innovation in Nuclear (GAIN) and was named by the Department of Energy (DOE) Office of Nuclear Energy (NE) as the lead integration laboratory. As a result of the collaboration between INL, DOE-NE, NuScale™, and the Utah Associated Municipal Power Systems, a 35-acre area at the INL Site was selected for the construction of the nation's first full-scale Small Modular Reactor (SMR), which will result not only in regional clean energy, but also enable groundbreaking research in hybrid energy systems at INL. INL's continuing research for the National Nuclear Security Administration's Global Threat Reduction Initiative was highlighted in a 2016 manuscript[a] from The National Academies of Sciences, Engineering, and Medicine. The achievements on this program culminated this year in Japan's divestiture of weaponizable plutonium within their nuclear energy program, as well as enabling the advancement of nuclear energy through enhancement to nuclear security and safeguards through international nuclear-cybersecurity support for the International Atomic Energy Agency (IAEA) and Republic of Korea (ROK). INL Fellow Bruce Mincher's research with the University of North Carolina, featured in Science Magazine,[b] resulted in a new oxidation technique with the potential to help resolve spent fuel challenges. Lastly, nine out of 15 of INL's Technology Commercialization Fund proposals, which focused on making cutting edge nuclear, clean energy and national security research technology available to industry, were selected for investment in 2016.

In FY 2016, the management structure of the Laboratory was changed significantly with a new laboratory director in place with new strategic goals; the number of deputy laboratory directors was reduced from three to two, and the two associate laboratory directors (ALDs) established in FY 2015 to manage the Advanced Test Reactor (ATR) and Materials and Fuels Complex (MFC), respectively, completed their first full year with notable improvements in the facilities' contributions to research and operations safety. INL programs and projects continued to successfully address pressing issues and needs of DOE and the broader nuclear energy and national security community, even as the energy and security landscape in the United States (U.S.) experiences rapid changes. The breadth of INL research programs demonstrated the importance of INL in DOE's and in particular, DOE-NE's science and technology missions.

INL played a major role in the initiation of GAIN—now a major DOE-NE program led by the Laboratory. GAIN has begun to provide the nuclear community with access to technical, regulatory, and financial support necessary to move new or advanced nuclear reactor designs toward commercialization while ensuring the continued safe, reliable, and economic operation of the existing nuclear fleet. For example, under GAIN, INL helped design and implement a $2 million Nuclear Energy Voucher pilot program that assists new entrants into the nuclear field with access to nuclear research capabilities available at DOE national laboratories and Nuclear Science User Facilities (NSUF) partners. INL partnered with Third Way, Argonne National Laboratory, and Oak Ridge National Laboratory to host the first *Advanced Nuclear Summit and Showcase*. During the Summit, INL Laboratory Director Mark Peters

[a] National Academies of Sciences, Engineering, and Medicine, *Reducing the Use of Highly Enriched Uranium in Civilian Research Reactors*, Washington, DC: The National Academies Press, 2016.

[b] Dares, C. J., A. M. Lapides, B. J., Mincher, T. J. Meyer, "Low potential electrochemical oxidation of 243Am(III) in nitric acid by a derivatized, high surface area metal oxide electrode," *Science*, November 5, 2015, www.sciencemag.org.

played a notable role, moderating and participating in multiple panel discussions on the future of advanced nuclear energy, the role of private capital, and the federal government's role in nuclear innovation. The Summit established a vision of how national laboratories, the federal government, and industry can work together to foster growth in the advanced nuclear energy sector. Another success of GAIN includes INL's agreement with Southern Company Services to cooperatively address key Nuclear Regulatory Commission policy and licensing technical issues that are currently restraining advanced reactor development and deployment. This INL-supported Southern Company Services effort is drawing heavily on the expertise of the Southern Nuclear Company and other well-respected industry stakeholders to bring focus and committed industry action to these critical topics.

The INL-led Light Water Reactor Sustainability (LWRS) program received strong accolades and continues to be pursued in support of the domestic nuclear industry, but with most technical issues associated with the current fleet having been solved, the program emphasis has started to shift to license extensions beyond 60 years and economic improvements. INL completed irradiation of the Electric Power Research Institute (EPRI)-3 test train—the first project to utilize the reactivated ATR Loop 2A. The EPRI-3 irradiation consisted of two full ATR irradiation cycles with an approximate 2-year delay between cycles, during which a flow restriction issue in the experiment was resolved. With completion of all three test train irradiations, an NSUF project team can perform post-irradiation examination (PIE), including Irradiation Assisted Stress Corrosion Cracking (IASCC) tests, fracture toughness tests, tensile tests, and Transmission Electron Microscope (TEM) examination. The data obtained is expanding the very sparse data set available for IASCC of reactor structural materials and will help the EPRI Boiling Water Reactor-Vessel Internals Project determine inspection and replacement intervals for critical reactor components. This project represents a major step toward recognition of INL as a premier contributor to irradiated materials characterization in support of LWRS and safety. The project set a precedent for future NSUF-industry interactions by demonstrating viability of Loop 2A and the IASCC testing capability.

Atomic-scale imaging was demonstrated using the new Titan TEM installed in the Irradiated Materials Characterization Laboratory (IMCL). The imaging proves the fundamental stability of the IMCL platform with respect to vibration and electromagnetic interference. The state-of-the-art ultrafast chemical analysis capabilities allow the Titan TEM to perform nanoscale chemical analysis in a fraction of the time required by previous generation systems.

In FY 2016, INL took more significant steps to enable deployment of the first U.S. SMR by expanding its technical and siting support to NuScale™ and the Utah Associated Municipal Power Systems with the plan to site the first SMR at INL, which presents a positive development in the deployment of new nuclear in the U.S.

The Advanced Fuel Development program also continued to be pursued, with major emphasis continuing on the Accident-Tolerant Fuels program. The advanced modeling and simulation activities continued to grow from the MOOSE platform and several newer codes derived from MOOSE are being applied to a multitude of nuclear materials modeling challenges. The Nuclear-Renewable Hybrid Energy Systems initiative has expanded and is receiving increased emphasis in helping to meet Conference of Parties-21 (COP 21) goals. To demonstrate the viability of hybrid energy systems, INL collaborated with Enel Green Power and the National Renewable Energy Laboratory to assess the feasibility and reliability of the nation's first triple hybrid energy power plant. The project combined geothermal, concentrated solar, and solar voltaic panels at the Stillwater Plant in Fallon, Nevada. Both INL and National Renewable Energy Laboratory contributed to the project with studies predicting how the combined energy sources could increase plant production, and then comparing theoretical data with measured

results. Within a week of the project announcement, media coverage of the project included a dozen U.S. outlets reaching more than 426,000 people and nearly 20 international outlets reaching more than 2.8 million people.

The involvement of INL in most of the NE programs continues to be strong with INL researchers playing an important leadership role in technical coordination of activities among national laboratories, universities, industry, and international partners. The Laboratory continued to make progress to expand PIE capabilities, completing major installation of capabilities at the IMCL, which enables researchers to evaluate high-activity samples. Advanced PIE capabilities beyond IMCL remained a high priority with INL's submission of Critical Decision 1 (Conceptual Design Report) for the Sample Preparation Laboratory—a line item capital project to address PIE capability gaps found in IMCL, the Hot Fuels Examination Facility, Analytical Laboratory, and NSUF partner facilities. INL continued to make progress accelerating restart of the Transient Reactor Test Facility (TREAT), which will restore U.S. capability to perform transient irradiations in support of new fuel designs, such as accident-tolerant fuels.

In FY 2016, INL researchers had many firsts. INL completed installation and research to establish a nuclear mass separation system capable of improving the accuracy and precision of nuclear forensics analyses. This unique radioisotope mass separator improves the forensic investigations of nuclear/radiological sources and materials. INL completed TEM analysis of ultra-high burnup U-Mo monolithic fuel, revealing that the unusual fission gas bubble super lattice that forms during irradiation is retained to ultra-high burnup. The surprising stability of this fission gas structure attracted interest from DOE's Office of Basic Energy Sciences, who requested a proposal to further investigate the formation and stability of the structure. INL improved methods to prepare samples of U-MO dispersion fuel. The new technique reduced radiation by 1 million times, and is an important sample preparation technique for highly radioactive fuel. Early tests by INL researchers show that uranium silicide (U_3Si_2) has good corrosion resistance. This data is important as U_3Si_2 is a candidate fissile phase for use in accident-tolerant fuel systems with its higher fissile density, providing a benefit that offsets increased fuel cost. The resistance of U_3Si_2 to corrosion under light water reactor service conditions had been previously unknown. INL completed the first neutron-radiation performance tests of Ti_3SiC_2. The ceramic material Ti_3SiC_2 is a candidate material for nuclear application due to its high-radiation damage tolerance. Unlike conventional ceramics, Ti_3SiC_2 shows desired mechanical properties relevant to high-temperature, gas-cooled reactors. The radiation behavior of Ti_3SiC_2 in reactors had not been previously well understood. INL applied Atom Probe Tomography (APT) for the first time to analyze the fission product distribution in neutron irradiated metal fuel. The APT confirmed and quantitatively analyzed the fission product. This work contributed to enhancing the understanding of the gas bubble lattice formation and solid fission product distribution in irradiated fuel. INL performed its first use of IMCL's Focused Ion Beam (FIB) with a radioactive sample. This was an important step in resolving the backlog of FIB work at MFC. INL completed the largest single imaging campaign using the Neutron Radiography Reactor (NRAD), this campaign doubled the previous daily throughput, resulting in the largest single imaging campaign to pass through NRAD. The radiographs created a tomographic representation of a fuel specimen for the United States High Performance Research Reactor Program (AFIP-7) and are being digitized to reconstruct a three dimensional tomographic model to nondestructively study irradiation effects on the fuel assembly and its components.

INL commenced irradiation of the KiJang Research Reactor (KJRR) fuel experiment in the ATR. The Korean Atomic Energy Research Institute initiated the KJRR project in support of the construction of a new, dedicated radioisotope production facility in the KiJang province of South Korea. The primary purpose of the KJRR campaign is to provide data about the irradiation performance of the KJRR-fuel

assembly. The low-enriched uranium KJRR experiment contained approximately 618 grams of U-235. This was the highest U-235 content for any single experiment irradiated in the history of ATR. The KJRR experiment expanded ATR's capabilities to meet customer requirements while balancing core physics analysis for high-experiment fuel content against the maximum cycle operating durations. Irradiation is scheduled to complete in the spring of 2017 when it will be shipped to MFC for PIE. The KJRR experiment represents a significant research collaboration between ROK and the U.S.

INL's ATR was awarded the 2016 Meritorious Performance in Nuclear Operations Award by the Operations and Power Division of the American Nuclear Society. The honor was bestowed on the ATR staff for "*significant improvement in conduct of operations and human performance in support of the INL nuclear fuels and materials research mission*." INL took significant and unprecedented steps in FY 2016 to accelerate implementation of ATR/Advanced Test Reactor Critical investment strategies to improve facility reliability and maintain safe operations. INL completed or initiated repair and replacement of systems throughout the plant, including the M7 Primary Coolant Pump; Wide-Range Neutron Level Channel A; Log Count Rate Meter; Log-N/Period System; M-17, M-18, and M-19 Bypass Demineralizer Tanks; multiple electrical systems, breakers, panels, motor starters, and controllers; one of two evaporation pond liners; and procurement actions to replace the Advanced Test Reactor Critical control system. The investment in the plant is visually and more importantly, operationally noticeable. INL balanced maintenance and investment objectives with delivering customer irradiation objectives, including completion of a very demanding set of powered axial locator mechanism runs for the U.S. Navy, and resolved emergent operational challenges throughout the year in a safe and timely manner. The improved operations and plant reliability experienced in the first half of the year was impacted in the second half of the year with the emergent failure of a Chopped Dummy In-Pile Tube, difficulty meeting safety rod insertion and drop times during high primary cooling flow conditions prevalent during powered axial locator mechanism operations, and discovery of cracks in the beryllium reflector near the northwest region of core internals.

INL demonstrated national leadership in cybersecurity. INL leaders provided expert testimony to several Congressional Committees (Senate Energy and Natural Resources Committee, Subcommittee of the House Committee on Science, Space, and Technology, Senate Select Committee on Intelligence, etc.). INL's testimony led to legislative support for research and development programs and national policy changes affecting the protection of national critical infrastructure, including an emphasis on utilization of INL and other national laboratories in the protection of power grid and industrial control systems cybersecurity. INL also led the formation of the Cybercore Integration Center as an organizing construct to address national challenges in control systems cybersecurity. INL obtained support from DOE Secretary Moniz, multiple cyber components within Department of Defense services, universities, national laboratories, and industry to participate in the Cybercore Integration Center. INL grid security experts were key contributors to the successful development and completion of GridEx III, a national grid security exercise sponsored by the North American Electric Reliability Corporation and Electricity Sector Information Sharing and Analysis Center. GridEx III challenged participants to demonstrate the effectiveness of their response and recovery plans during severe cyber and physical security threat events. Over 4,200 utility and government staff from 360 organizations participated, including senior officials from the White House National Security Council representing Departments of Energy, Homeland Security, and Defense, the Federal Emergency Management Administration, National Security Agency, U.S. Cyber Command, U.S. Northern Command, North American Aerospace Defense Command, Federal Bureau of Investigation (FBI), and the National Guard.

DOE selected INL to lead four projects and collaborate on 8 other projects over the next 3 years as part of a $220 million Grid Modernization Initiative. The INL-led projects included "Smart Reconfiguration of Idaho Falls Power Distribution Network," "Systems Research Supporting Standards and Interoperability," "Diagnostic Security Modules for Electric Vehicles to Building Integration," and "Weather Data to Improve Capacity of Existing Power Lines," pointing to INL's relevance and impact in grid research.

DOE established an "industry portal" at INL to assist industry in retiring risk of game-changing technology. The Transient Kinetics Industry Portal, a user-facility-like program, provides researchers from industry and academia access to INL's expertise and unique Temporal Analysis of Product (TAP) reactor. The TAP reactor enables researchers to better understand—and improve—the catalytic reactions that are key to producing chemicals used to manufacture a range of consumer products, from diapers to diesel fuel. The Transient Kinetics Industry Portal is focused on developing advanced catalytic technologies that reduce the energy impact of ammonia synthesis and the conversion of natural gas in stranded and remote locations to ethylene, alcohols, and other high-value chemicals. Ammonia generation represents nearly 2% of the world's energy use, and the process has changed little since the beginning of the 20th century. INL installed its first TAP reactor in FY 2016 and acquired a second through a donation from an industrial partner. The Laboratory is now home to two of the three TAP reactors in the U.S.

INL researchers helped set national electric vehicle charging standards in support of revolutionizing transportation systems. INL partnered with government agencies, industry, and others to determine national and international standards for plug-in electric vehicles and charging infrastructure. INL tested eight wireless chargers from Nissan/Witricity, Toyota, and Qualcomm over 20 weeks as part of a Society of Automotive Engineers initiative (SAE J2954) to standardize these systems and ensure compatibility, safety, and performance levels. Researchers provided key technical expertise to the Environmental Protection Agency Energy Star program for certification of electric vehicle charging equipment. INL helped develop test methods for evaluating and certifying power losses. The White House Council on Environmental Quality appointed INL researchers to write standards for the electric circuit raceways needed to support installation of electric vehicle charging infrastructure in new commercial buildings and family housing greater than four stories—the American National Standards Institute (ANSI)/ASHRAE/Illuminating Engineering Society of North America/United States Green Building Council (USGBC) Standard 189.1-2014, "Standard for the Design of High-Performance Green Buildings."

INL continued to expand its clean energy deployment collaborations with industry. For example, researchers with INL's Biomass Feedstock National User Facility (BFNUF) recently demonstrated a new biomass processing option for an industrial customer. BFNUF researchers processed a load of pine wood chips for Advanced Torrefaction Systems, LLC. Their goal was to evaluate the performance of a catalyst the company believes will result in fewer gases being emitted during torrefaction—a process in which biomass feedstocks are converted into a viable coal substitute. Getting the torrefaction system up and running was a major milestone for BFNUF and provides the user facility with a unique, and timely, capability as concerns over pollutants, such as greenhouse gas emissions from coal-fired power plants, have prompted a renewed interest in torrefaction technology. The product known as "bio-coal" could potentially be used to generate electricity in existing coal-fired power plants, which are coming under fire for the amount of greenhouse gases they emit. BFNUF researchers demonstrated a new state-of-the-art biomass processing unit with an industrial collaborator. BFNUF researchers ran three batches of loblolly pine chips—all with different moisture levels—in the new Chemical Preconversion System (CPS) in collaboration with AdvanceBio, LLC, which manufactured the CPS. INL's CPS is the only one of its kind

in the country, greatly expanding the research capabilities of the BFNUF to remove problematic inorganic contaminants such as calcium or nitrogen from biomass feedstocks and improve feedstock quality. With the CPS, feedstocks that were once considered too contaminated to be useful are now viable. INL collaborated with the Center for Advanced Energy Studies (CAES) to host an intermountain west *Industry Water-Energy Workshop* to identify regional-relevant industry research and development needs and help establish regional collaborators for water-energy-related research. INL continued its success with DOE's Lab-Corps program, participating on three teams—the most of any national laboratory. The Lab-Corps program aims to strengthen entrepreneurial culture at national laboratories by focusing on private-sector needs and immersing national laboratory researchers in the commercialization process. Each team was tasked with finding an optimal path to bring clean energy technology to market by following a curriculum focused on customer interactions and market feedback.

An INL-developed water treatment technology was showcased at the *White House World Water Day Summit* in Washington D.C. A tabletop model of a portion of INL's patented Switchable Polarity Solvent-Forward Osmosis technology was one of nine demonstrations (and the only one from a national laboratory) selected by organizers to be highlighted during the *White House Summit*. The day-long event, which was held in conjunction with the United Nations World Water Day, was aimed at raising awareness of water issues and potential solutions in the U.S. and to catalyze ideas and actions to help build a sustainable and secure water future through innovative science and technology. Attendees included senior officials from various federal agencies, leaders from industry and nonprofit organizations, and media representatives.

INL provided state-wide leadership to advance economic and workforce development. INL assembled Idaho leaders from Idaho companies, such as Premier, Monsanto, Agrium, and Walsh Engineering, together with officials from Regional Economic Development East Idaho, Eastern Idaho legislators, and Idaho Department of Labor to discuss how to connect INL's and industry workforce needs with educational opportunities to drive growth in the talent pipeline for Idaho. INL's efforts to increase awareness in Idaho of Science, Technology, Engineering, and Mathematics (STEM) career needs informed new state investments: $1 million for the creation of a cyber lab at Boise State University in collaboration with INL, $2 million for STEM Action Center (up from $667,000 last year), and a one-time $10 million infusion of funding for the STEM Action Center to startup STEM programs, including computer engineering. An increase in the higher education budget by $25 million in a number of areas important to INL—a 9.6% increase in funding for community colleges and an 8.8% increase for 4-year institutions, which includes $5 million in startup funds to help any county willing to establish a community college district.

In FY 2016, INL demonstrated effective Integrated Safety Management/Safety Culture performance with notable external recognition of key staff and effective performance reflected across most strategic and cross-cutting areas. The National Registry of Radiation Protection Technologists awarded Chere Morgan, Radiological Control Division Director, the Charles Mc Knight Award for her enduring support for the advancement of radiological control technicians. John Irving, Ph.D, INL's senior NEPA/EMS staff member, received the National Assessment of Education Progress's lifetime fellowship award for his long-valued service to the association. Also, Carol Mascarenas, ESH&Q Director, was re-appointed by the governor to the Board of Department of Environmental Quality. Programmatically, INL strengthened the nuclear safety program with improved quality in submissions of Documented Safety Analysis changes with a key accomplishment this year being the upgrade of the TREAT Final Safety Analysis Report and Technical Specifications. Safety infrastructure improvements included fire alarm and protection systems targeted upgrades. The increase in the rate of occupational injuries and illnesses evident in prior years was

effectively halted, and performance in recent years has since plateaued. The severity of cases has substantially decreased, as indicated by reduction in the Days Away, Restricted or Transferred Case Rate, and lowering worker's compensation costs. Back and shoulder injury rates have notably decreased since union partnership with implementation of the "Back and Shoulder" school. The union senior leadership engagement in safety is also the best it has been in recent years. The number of radiological-related reportable events continued to decrease showing the effectiveness of improvement actions implemented in prior years. INL continued to invest in first line supervisor development with more than 100 supervisors and managers completing Battelle's Laboratory Operations Supervisor Academy (LOSA) and participating in follow-on activities, such as Facilities and Site Services Supervisor Forums and Radiological Dynamic Learning Activities. Indicators of "open reporting" improved as measured by the Annual Culture Survey; also, proactive reporting of issues and events to regulatory entities continued. INL continued to mature its application of contractor assurance with increased usefulness of the management review process and subsequent reports; Conduct of Operations and activity level work planning and control metrics drill down provided perspective into issues, enabled trending, and offered insight into overall health of programs. In FY 2016, there was visible engagement and leadership of senior managers in contractor assurance system (for example, ATR leadership's response to an ATR diesel fuel oil release, the emergency response organization response to a serious vehicle accident, and the continued effectiveness validations by Facilities and Site Services in response to the FY 2015 arc flash event). The year was not without its challenges. INL experienced two serious finger injuries, Technical Safety Requirement violations, findings in management and oversight of subcontractors, a Total Recordable Case Rate that is greater than the 5-year average goal, work control deficiencies that contributed to environmental protection issues, and an indication that some workers still perform work without formal controls, demonstrating continued attention is needed to ensure sustained improvement in both performance and culture.

Construction of the Remote-Handled Low-Level Waste disposal facility has achieved substantial progress in FY 2016. INL proactively managed project execution, including response to issues encountered under the design-build subcontract and experienced risk events while maintaining cost and schedule performance well within established departmental metrics. Notable in FY 2016 is the substantial completion of the Administration and Maintenance Buildings, and significant progress in vault installation. Late in the year, a nonconformance in lifting lugs fabrication/installation presented a significant risk (cost, schedule) to the project. As of the writing of this report, the project team was assessing the proposed recovery plan.

INL adopted the new Laboratory planning process and delivered a Laboratory Plan that was widely complimented for its quality. INL leaders positioned the Laboratory for the future with strategic hires, expansion of talent pipeline, and increased investments in R&D capabilities. INL hired a deputy ALD for National and Homeland Security, assuring a smooth transition of leadership when the incumbent ALD retires in FY 2017. INL brought in two exceptional leaders in nuclear energy to grow capability in support of GAIN: John Wagner (MFC Chief Scientist) and Rita Baranwal (GAIN Director). INL also hired a new Nuclear Nonproliferation Director, Dr. Mike Miller, and Technology Deployment Director, Jason Stolworthy, adding experienced and reputable leadership depth to the Laboratory. INL leaders continued efforts to reinvigorate and enhance the quality of the workforce by increasing strategic and critical hires, post-doctoral students, interns, joint appointments, and international researchers, enabling growth in research programs. This growth above planning levels has afforded the Laboratory the ability to address unfunded challenges, such as multifactor authentication implementation, transition of new environmental management contractors, additional research investments, and balance of plant infrastructure needs. The

Laboratory was also positioned to financially afford important future investment opportunities, including GAIN, Cybercore Integration Center, and new High Performance Computing Collaboration Center. The Laboratory built its pension reserve and reduced long-term liabilities by executing a lump sum buy out of terminated vested former employees and by continuing to invest in a DOE-approved alternate pension funding strategy.

The Laboratory successfully upgraded the Oracle e-Business Suite (eBS) application, a major milestone in addressing INL's aging business systems, reducing business and cyber risk, and optimizing a number of legacy customized processes and bolt-ons to utilize more standard functionality.

Finally, in FY 2016, INL was recognized for its Small Business Program leadership. DOE selected Stacey Francis as the 2015 Facility Management Contractor Small Business Program Manager of the Year for her commitment to partnering small businesses with INL. In FY 2015, INL exceeded all six socioeconomic goals for the second time since Francis has been at the helm. Notably, her efforts resulted in exceeding the small disadvantaged business goal by 40% and the woman-owned goal by over 200%. In FY 2016, INL is forecasted to also exceed all six goals.

CONTENTS

TABLES

ACRONYMS

ALD	associate laboratory director
ALSEP	actinide lanthanide separation process
ANSI	American National Standards Institute
APT	Atom Probe Tomography
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance, LLC
BFNUF	Biomass Feedstock National User Facility
CAES	Center for Advanced Energy Studies
CPS	Chemical Preconversion System
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
DOE-NE	Department of Energy Office of Nuclear Energy
ECCS	Emergency Core Cooling System
EPRI	Electric Power Research Institute
FBI	Federal Bureau of Investigation
FY	fiscal year
GAIN	Gateway for Accelerated Innovation in Nuclear
IASCC	Irradiation Assisted Stress Corrosion Cracking
IMCL	Irradiated Materials Characterization Laboratory
INL	Idaho National Laboratory
KJRR	KiJang Research Reactor
LOCA	loss of coolant accident
LOSA	Laboratory Operations Supervisor Academy
M^3	Material Management and Minimization
MFC	Materials and Fuels Complex
NSUF	Nuclear Science User Facilities
PEMP	Performance Evaluation and Measurement Plan
PIE	post-irradiation examination
RDD&D	research development, demonstration, and deployment
SAE	Society of Automotive Engineers

SMR	small modular reactor
STEM	Science, Technology, Engineering, and Mathematics
TAP	Temporal Analysis of Products
TEM	Transmission Electron Microscope
TREAT	Transient Reactor Test Facility
USGBC	United States Green Building Council

Introduction

This report provides Battelle Energy Alliance's (BEA) self-assessment of performance for the period of October 1, 2015, through September 30, 2016, as evaluated against the goals, performance objectives, and notable outcomes defined in the Fiscal Year (FY) 2016 Performance Evaluation and Measurement Plan (PEMP). BEA took into consideration and consolidated all input provided from internal and external sources (e.g., Contractor Assurance System [CAS], program and customer feedback, external and independent reviews, and Department of Energy [DOE] Idaho Operations Office [ID] quarterly PEMP reports and Quarterly Evaluation Reports).

After considering the information related to performance during the rating period, including feedback from the Office of Nuclear Energy (NE), Idaho Operations Office (ID), and other programmatic sponsors, BEA has self-assessed the Laboratory's performance at a grade of A, an adjectival rating of "Excellent." Table 1 documents BEA's assessment of performance to the goals and individual performance objectives. Table 2 documents completion of the notable outcomes. A more-detailed assessment of performance for each individual performance objective is documented in the closeout reports (see the PEMP reporting system). Table 3 includes an update to "Performance Challenges" as reported in the *FY 2015 Self-Assessment Report*.

Table 1. BEA Assessment of Performance Evaluation and Measurement Plan (PEMP) Performance.

Objective	Description	Final*
1.1	Nuclear Energy	A
1.2	National and Homeland Security	A
1.3	Science and Technology Addressing Broad DOE Missions	A
1.4	Collaborations	A
2.1	Provide Effective Facility Design(s) as Required to Support Laboratory Programs	A
2.2	Provide for the Effective and Efficient Construction of Facilities and/or Fabrication of Components	A-
2.3	Operation and Maintenance of Facilities	A-
2.4	Utilization of Facility(ies) to Provide Impactful S&T Results and Benefits to Internal and External User Communities	A-
3.1	Leadership and Stewardship of the Laboratory	A+
3.2	Management and Operation of the Laboratory	A-
3.3	Contractor Value-Added	A-
4.1	Provide an Efficient and Effective Worker Health and Safety Program	B+
4.2	Provide Efficient and Effective Environmental Management System	B+
5.1	Provide an Efficient, Effective, and Responsive Financial Management System	**A**
5.2	Provide an Efficient, Effective, and Responsive Acquisition Management System and Property Management System	**A**
5.3	Provide an Efficient, Effective, and Responsive Human Resources Management System and Diversity Program	**A**
5.4	Provide Efficient, Effective, and Responsive Contractor Assurance Systems, including Internal Audit and Quality	A-
5.5	Provide Efficient, Effective, and Responsive Information Management System	**A+**

Objective	Description	Final*
6.1	Manage Facilities and Infrastructure in an Efficient and Effective Manner that Optimizes Usage, Addresses Sustainability Goals, Minimizes Life Cycle Costs, and Ensures Site Capability to Meet Mission Needs	**A-**
6.2	Provide Planning for and Acquire the Facilities and Infrastructure Required to Support the Continuation and Growth of Laboratory Missions and Programs	A-
7.1	Provide an Efficient and Effective Emergency Management System	**A**
7.2	Provide an Efficient and Effective Cyber Security System for the Protection of Classified and Unclassified Information	**A**
7.3	Provide an Efficient and Effective Physical Security Program for the Protection of Special Nuclear Materials, Classified Matter, Classified Information, Sensitive Information, and Property	**A**

*Grades as submitted in PEMP close-out reporting system reports and Annual Self-Assessment Report.

Table 2. FY 2016 Performance Evaluation and Measurement Plan (PEMP) Stoplight Report by Notable Outcome.

Notable Outcome	***Description***	***Status/Risk***
1.1.A	Demonstrate high spatial resolution measurements at the micro-structural level on as-fabricated nuclear fuels and materials. Connect experimental measurements with advanced modeling and simulation allowing simulation and prediction of nuclear material property evolution under irradiation. This activity will be limited to demonstration of technique and methods on un-irradiated nuclear fuel and material samples.	✓
1.1.B	Develop a fundamental understanding of the solvent degradation mechanisms for advanced separation flowsheets such as actinide lanthanide separation process (ALSEP). Complete testing of ALSEP solvent extraction process in irradiation test loop. This Notable Outcome will provide needed information on solvent degradation in the extraction section of a flowsheet to separate minor actinides from used nuclear fuel.	✓
1.1.C	Based upon recent experiments, the NRC has proposed new peak-clad temperature and embrittlement oxidation limits that are more restrictive than the current operational limits which may impact current plant operational margin, increase plant fuel/analysis costs, limit the use of high burnup fuels, increase the complexity of analysis, decrease operational flexibility, and increase regulatory uncertainties. INL's Light Water Reactor Sustainability Program will help industry address this issue by using the Risk-Informed Safety Margin Characterization approach to demonstrate safety margins using coupled analysis tools for a loss-of-coolant-accident (LOCA) analysis including Emergency Core Cooling System (ECCS) performance under realistic plant conditions. This risk-informed analysis will include the effects of higher burnup on cladding performance as part of the LOCA/ECCS analysis in order to evaluate risk-informed margins management strategies for a representative pressurized water reactor. The integrated coupled analysis will include elements of core physics, cladding behavior, thermal-hydraulics, and scenario-based risk analysis in order to quantify safety margin for the new peak-clad temperature and embrittlement oxidation limits.	✓
1.1.D	Develop an execution plan for GAIN with input from appropriate stakeholders. Make a draft version available in summer 2016 to support the budget and work scope discussions for FY 2017 and out-years planning. Consistent with the planning discussions, deliver Rev. 0 to DOE-NE in August 2016. Complete Test/Demonstration Reactor Options Study and deliver it to DOE-NE.	✓

Notable Outcome	*Description*	*Status/Risk*
1.2.A	Within the National Nuclear Security Administration's "Prevent, Counter, and Respond - A Strategic Plan to Reduce Global Nuclear Threats (FY 2016 – FY 2020)," the Office of Defense Nuclear Nonproliferation highlights the nuclear fuel development capabilities at INL as critical to address a significant challenge in the success of the Material Management and Minimization (M^3) Program, converting high enriched uranium fueled research reactors to low enriched uranium fuel while retaining the original reactor's performance. To advance the objectives of the M^3 Program, INL will complete the installation of a new post-irradiation examination capability into the Hot Fuel Examination Facility by April 30, 2016. This equipment will assist researchers to better understand and evaluate fuel behavior and performance for eventual Nuclear Regulatory Commission fuel qualification, as well as advancing the science in fuel design and modeling and simulation.	✓
1.3.A	Advanced manufacturing is a major priority of the Federal Government. DOE has a goal to reduce, in 10 years, 50% of the life-cycle energy consumption of manufactured goods by targeting the production and use of advanced manufacturing technologies. INL will establish an industry centric collaboration that builds upon INL's catalyst, separations, and "materials by design" research capability focused on reducing life-cycle energy consumption of manufactured goods in the U.S. Specific actions include: • Establish an industrial advisory committee to help guide related research and hold the first technical review meeting, capturing and distributing written recommendations. • Form a consortium-based collaboration with industry and academia that actively seeks funding opportunities. • Conduct an industry-centric workshop on research challenges and publish the proceedings. • Bring the Temporal Analysis of Products (TAP) instrumentation to full operational status and begin generating data.	✓
2.2.A	Complete line-item project deliverables and critical decision milestones consistent with approved schedules and plans.	✓*
2.3.A	Develop a transient testing plan and schedule for reactor commissioning, sample vehicle and instrumentation commissioning, and projected reactor fuel experiments to support the first year of fuel transient testing. Complete final design review of the experiment vehicle and associated instrumentation required to execute the first transient test.	✓*

Notable Outcome	*Description*	*Status/Risk*
2.3.B	The Advanced Test Reactor (ATR) supports Office of Nuclear Energy (NE) research and development programs, Naval Reactors (NR) work in support of the U.S. Navy nuclear fleet, Office of Science (SC) research and isotope production programs, as well as a wide array of other users including the National Nuclear Security Administration (NNSA), and Nuclear Science User Facilities (NSUF). As such, safe and reliable operation of the ATR is critical to the DOE, NR and numerous other users and the INL will continue to improve the reliability and predictability of ATR operations by achieving and sustaining increased irradiation days per year. To improve operational reliability and increase annual irradiation days the ATR will execute the agreed upon funding strategy and develop appropriate planning documents to assure timely commencement when funding is provided. Reliability in ATR operations will be sustained through targeted plant health investments, high quality maintenance activities, and continuing to address on-going conduct of operations issues.	✓*
2.4.A	Develop and expand Biomass Feedstock National User Facility (BFNUF) capabilities and utilization. Specific actions include: • A User Facility industry advisory board will be established and convened for the purpose of providing technical recommendations, evaluation and suggestions for improvement. • User Facility utilization will be expanded by bringing a new advanced preprocessing capability online such as the pilot scale torrefaction system or Chemical Pre-Conversion System (CPS). The capability will be fully commissioned and an industry centric project will be executed utilizing the capability. • The Bioenergy Feedstock Library will be made accessible and utilized by external collaborators (industry and other institutions) and, using structured collaboration tools, the user interface will be customized to meet collaborator needs. User utilization will be documented.	✓

✓ Notable Outcome met.

* Notable Outcome has not been acknowledged as complete by DOE-ID as of October 7, 2016.

INL executes some of the nation's most complex and technologically advanced missions; focusing on RDD&D of reliable, affordable, clean energy technologies to sustain the economy and combat climate change; enhancing security of critical infrastructures; developing a science and engineering workforce and state-of-the-art facilities essential for advancing science and technology; developing innovative solutions; and enhancing collaboration in all stages of RDD&D in the 21st century. Delivering on INL's mission presents the Laboratory with unique risks and performance challenges. BEA has identified challenges to the INL's wide ranging operations as well as problems with specific management processes. The overall goal is to focus attention on key issues, with the objective of aiding in efforts to enhance the effectiveness and efficiency of Laboratory programs and operations. Table 3 represents the best opportunities to improve Laboratory performance strategically. Though there has been marked progress, many of these are enduring challenges from the prior year.

Table 3. Performance Challenges.

External Factors	
Integrated Waste Treatment Unit (IWTU) impact – INL's ability to acquire research quantities of commercial nuclear fuel for new work is impacted by the ability of an external contractor (i.e., Fluor) to meet regulatory-driven commitments to process waste.	*Idaho Settlement Agreement* – The reputation of INL has the potential to be negatively impacted by external contractor's ability to meet waste treatment milestones. INL must continue to actively engage with leadership at the community, state, and federal level to proactively educate and mitigate concerns.
Scientific and Technical Reputation	
Scientific and technical leadership reflected in publications – Increasing the leadership, impact, and reputation of INL will require continued visibility and communication through scientific literature. Tools and processes must support and encourage impactful publication, tracking, and assessing the quality of publications to better understand our leadership position.	*Scientific and technical leadership through internal and external collaboration* – The ability to support continued innovation requires continued access to and collaboration with broad scientific communities, industry, government, and thought leadership. Processes and resources must be designed to support this objective both internally and externally.
People – "Attract, Retain, Develop"	
Meeting the workforce needs of tomorrow – The ability to attract and retain talent through competitive salaries and other cash compensation, effective succession planning and professional development, and job classification system and benefits redesign to market will be essential to mission execution. Single point vulnerabilities remain a challenge. These were the result of past workforce reductions or are likely to be caused by the wave of retirements forecasted for the next 3–5 years. University collaboration, internships, postdoc program, joint appointments, etc., will need to be prioritized to address talent pipeline concerns.	*Improving scientific productivity and "thought" leadership"* – Increasing scientific leadership and impact will require effective development of early-mid career researchers through sustainable programs (e.g., formal mentoring, knowledge transfer, and peer reviews). In addition, processes and polices must support, rather than impede, scientific excellence and productivity. Processes must promote safety, address regulatory and contractual requirements, be easy to understand and implement, and encompass all interfaces and hand-offs. This must be done in a manner that limits administrative burden and the potential for error or non-compliance.

Strengthening first line supervisors and managers – The ability of supervisors and managers to establish a strong organizational culture that values the safe conduct of research, delivers frequent and meaningful performance feedback, and encourages and supports collaboration across INL will increase engagement, higher performance, and delivery of mission outcomes. This is a constant and ongoing challenge. Continued investment in leadership development forums (e.g., LOSA, LOLA) are essential to ensure work is performed safely every time.	*Diverse and inclusive work environment* – The ability to attract and retain a diverse workforce and create an inclusive work environment will establish a culture that values all employees' contributions and greater collaboration, and enables broader research outcomes.
Operations – Management Systems, Safety Performance, Governance	
Sustained high performance – INL must sustain a high level of operations performance. Although events cannot be completely eliminated, INL's ability to respond to events and identify and correct causal factors must be effective. In addition, INL's Contractor Assurance System must be transparent, self-critical, and effective at identifying and correcting performance deviations.	*Hazard identification* – Hazard identification is frequently the most challenging of the Integrated Safety Management System core functions. Assessments continue to identify hazards that are typically mitigated effectively; the greater challenge seems to rest on identifying hazards especially related to emerging conditions. Continued focus on understanding the hazards at all phases of research and operations is an important and continual challenge.
Governance - implementation of contract and oversight reforms – DOE and INL continue to implement a framework to improve Laboratory stewardship. This framework has the following objectives: (1) align governance to promote a mission-oriented and performance-based culture; (2) strengthen INL stewardship through effective communications, transparency, trust and clearly defined responsibilities; (3) collaboratively manage contract requirements to eliminate or reduce unnecessary burdens; and (4) enable system-level performance-based oversight and challenge that duplicate low-value oversight. These objectives are reflected in the Laboratory Agenda and Annual Laboratory Plan, and embedded in the Contractor Assurance System Management System approach to monitor and assess implementation and impacts. Continued attention to these objectives will assure long-term success of the Laboratory.	*Cyber security* – Protecting the Laboratory's networks, information, and services from unintended or unauthorized access, change, or destruction is an enduring and increasing risk. Direct and indirect requirements are growing to implement mandated cybersecurity improvements, defend against a rapidly evolving and increasing threat, maintain secure IT assets, and to provide leadership in developing secure IT and managed service solutions.

Infrastructure – Critical R&D Capability, IT, Roads/Grounds/Utilities, Legacies	
Sustained infrastructure investment – Significant multi-year fiscal challenges have resulted in an increase in deferred maintenance and/or needed upgrades: fire protection systems, Environment, Safety, and Health backlog (non-compliant ladders, USTs, etc.), roofs, roads and parking, fleet, rail, and other critical infrastructure (electric power grid, supervisory control and data acquisition, and information management capability). Funds are also limited to address decontamination and decommissioning of non enduring assets, and space optimization.	*Funding for ATR and MFC* – MFC's transition to a new cost model continues to present affordability and timing challenges with sponsors/funding sources. ATR is proceeding with a multi-year effort to improve plant and loop health with expected improvements in availability and irradiation days in support of research. Both face aging facility/equipment challenges requiring continued focus to ensure research commitments are met.
Business systems and decision support – A lack of a mature business systems environment, including a robust business intelligence capability limits the ability for INL to conduct performance monitoring, decision support, and predictive analytics. Business software applications are not well integrated, are approaching end of life, and are not user friendly. Many of the tools are in place, yet investment is still needed to coordinate disparate data sources.	*Information systems and technology applications* – INL has not effectively invested in technology, such as mobile applications and hardware, to increase connectivity and productivity. Information systems are aging and not broadly supported, increasing risk of cyber incidents, unplanned outages, new Congressional and Administration requirements to address cyber threats, and impacts to mission production/efficiency from outdated, unreliable systems. High Performance Computing is an essential capability. Although, INL acquired a new HPC computer (Falcon), it is expected that a replacement capability will be needed in 3–5 years.
Environmental legacy – Managing the disposition of environmental legacy waste and materials and establishing an enduring waste management capability create challenges to effectively address the long-term stewardship of the Laboratory. This includes managing impacts of new cleanup contracts, such as shared services (e.g., utilities, emergency services, bus service), disposition of spent nuclear fuel and other nuclear and legacy materials.	
Budget and Funding	
Indirect affordability insufficient to address infrastructures – Current management models require continued evaluation to ensure critical RDD&D capability investments are supported. The RDD&D Capability Management Model is a key example of a solution to address RDD&D capability investment and sustainment for long-term success.	*Work acceptance* – INL continued to make progress to define processes for proposing and accepting work; however, gaps remain in the Laboratory's ability to manage proposal submittals effectively, identify available resource capacity/capability and risks properly, and accept and plan work effectively to ensure full-cost recovery.