Idaho National Laboratory Research & Development

Impacts

- Nuclear Leadership
- Collaborations
- Educational Contributions
- New Capabilities
- Science & Engineering

Idaho National Laboratory

FROM THE Director

John Grossenbacher
Director, Idaho National Laboratory

April 2012

The U.S. Department of Energy's national laboratories play a crucial role by conducting the type of research, innovation, testing and evaluation that is beyond the scope of regulators, academia or private industry alone.

Idaho National Laboratory's engineering expertise and applied science capabilities are particularly focused on deployment of technologies for nuclear energy, national security and new energy resources. A broad array of infrastructure, nuclear material inventory and vast expertise converge at INL, the nation's nuclear energy laboratory.

In these and other areas, INL uses these capabilities to innovate, evaluate and deploy new technologies that help protect the nation's resources and advance energy security. Productive partnerships with academia, industry and government agencies also help deliver high-impact outcomes.

This edition of INL's Impacts magazine highlights our newest leadership efforts, capabilities, collaborations and research accomplishments. Please take a few minutes to learn more about the critical resources and transformative innovations at one of the nation's premier applied-science laboratories.

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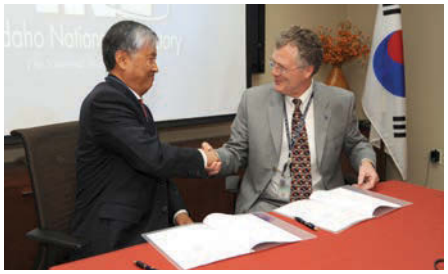

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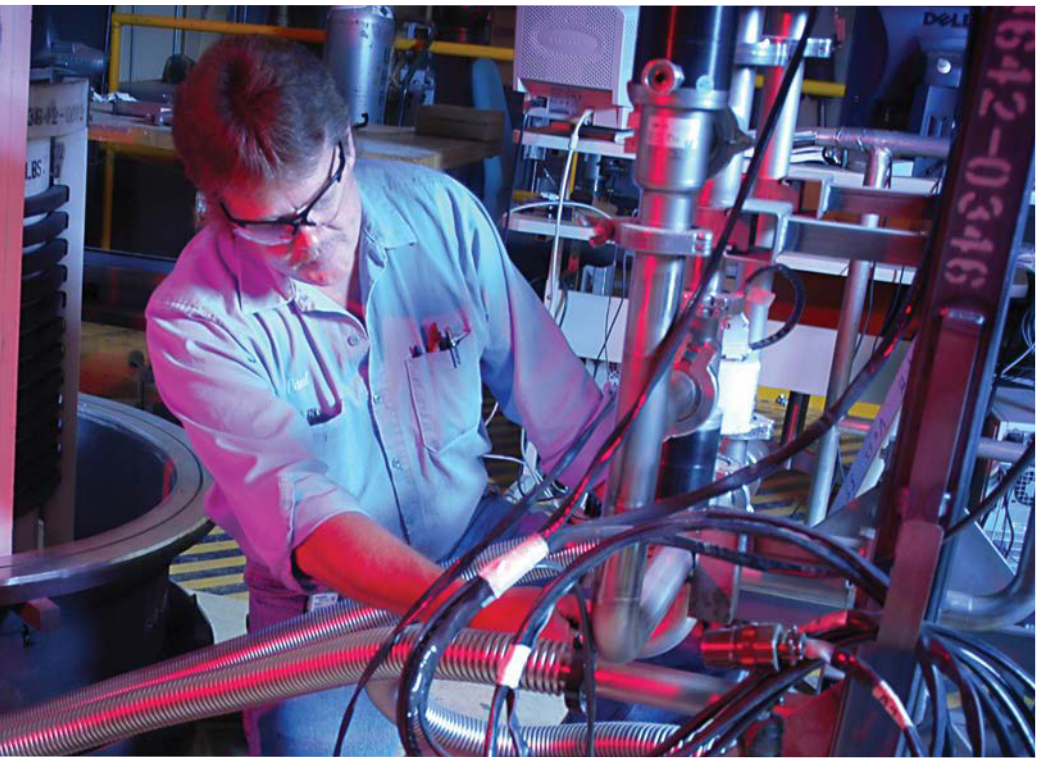
NUCLEAR Leadership

The Nation's Nuclear Energy Lab

INL is pioneering a model of leadership for the U.S. Department of Energy's Office of Nuclear Energy (DOE-NE). The model helps DOE-NE unite leading scientists and engineers with the world-class capabilities, unique facilities and the synergistic environment needed to conduct transformational nuclear research, development and demonstrations (RD&D). INL also is helping define how DOE-NE can work more closely with the nuclear energy industry by evaluating its RD&D needs and identifying where government capabilities may contribute.



A sophisticated furnace, which has since been installed in a hot cell at the Hot Fuel Examination Facility, is prepared and tested in the Fuel Conditioning Facility's mock-up area.

Complex-wide guidance
INL input and expertise continue to help DOE-NE develop a research strategy consistent with its Nuclear Energy Roadmap. INL is leading development of the roadmap implementation plans and guiding a research model that integrates broad technical expertise to match research endeavors with the right facilities and capabilities.

DOE-NE has selected INL to develop a new RD&D plan for used fuel storage and transportation. The plan will include specific science-based activities necessary to close knowledge gaps, and will identify facilities and resources needed to complete activities identified in the plan. INL also is leading a DOE-NE effort to devise a research plan for the development of accident-tolerant nuclear fuels.

Stewardship of research infrastructure is another important component of INL's contributions. INL led the development of DOE-NE's 20-year Facilities for the Future of RD&D report, which evaluates existing infrastructure capabilities, needs and options for closing gaps. As steward to the overwhelming majority of core nuclear energy RD&D capabilities, INL

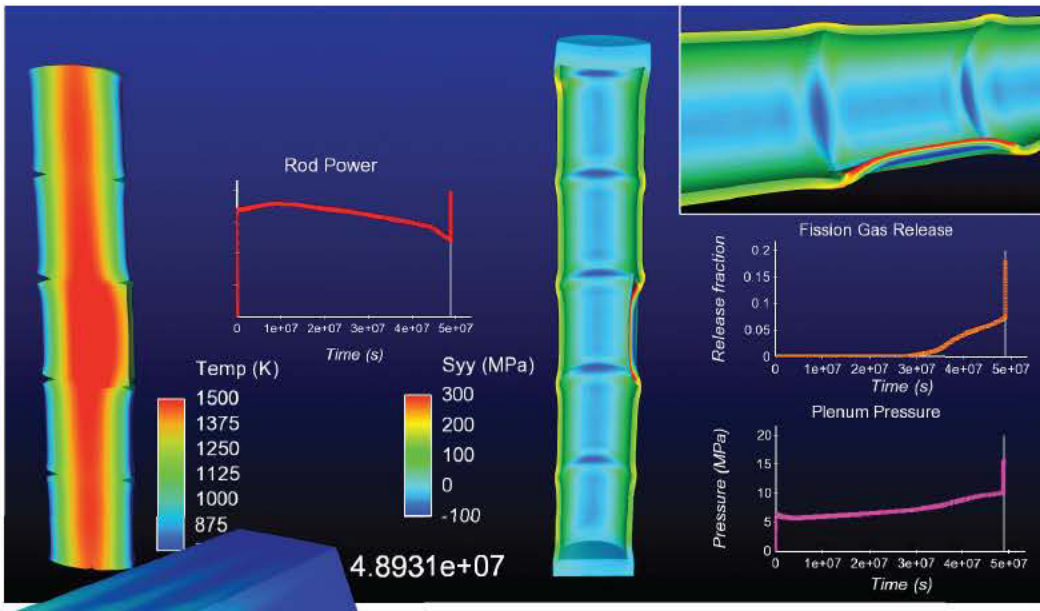
is helping to establish and optimize the use of a fully integrated set of multipurpose capabilities.

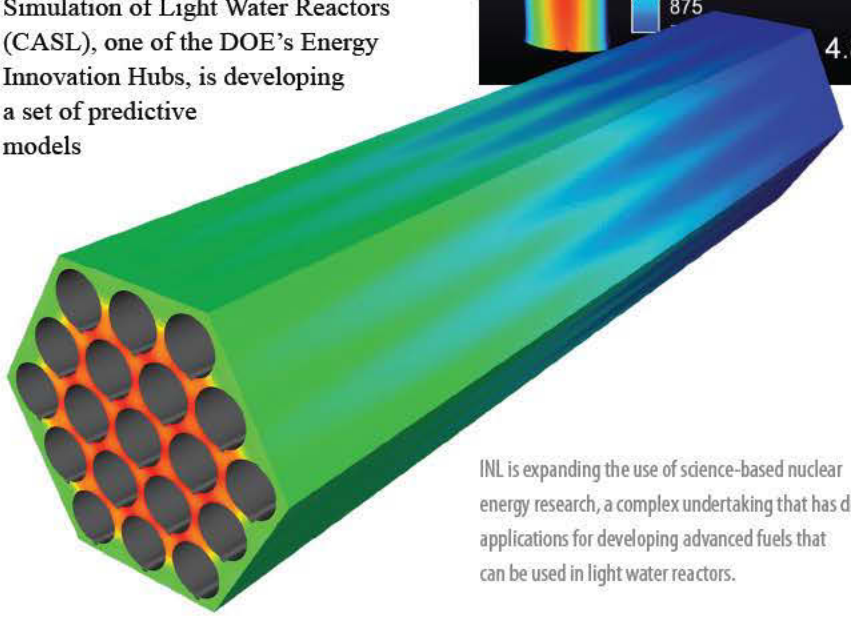
A science-based approach

INL has led a fundamental shift in how nuclear energy research and development is approached at universities, national labs and within regulatory and policy organizations. These efforts are transforming the way DOE-NE executes its nuclear research portfolio through the integration of fundamental research, modeling and simulation, small-scale experimentation, and larger scale demonstrations that are closely coordinated with industrial and international partners. This approach can make engineering-scale irradiation and testing far more focused and efficient. It may also eliminate some costly prototype demonstrations.

Light-water reactor modeling

The Consortium for Advanced Simulation of Light Water Reactors (CASL), one of the DOE's Energy Innovation Hubs, is developing a set of predictive models that simulate a light water reactor power plant. These simulations will help improve operating efficiencies, extend operating lifetimes, and reduce operating costs and waste volumes. The partnership — which includes several DOE laboratories, leading universities and industries — selected the INL-developed MOOSE/BISON/MARMOT modeling and simulation code suite as the basis for its fuels performance application (read more on page 21).





INL is expanding the use of science-based nuclear energy research, a complex undertaking that has direct applications for developing advanced fuels that can be used in light water reactors.

NUCLEAR Leadership (CONT.)

More than two dozen industry CEOs, labor and nongovernmental organization representatives, energy investors, and elected officials attended the Nuclear Energy Summit co-hosted by INL in Washington, D.C.

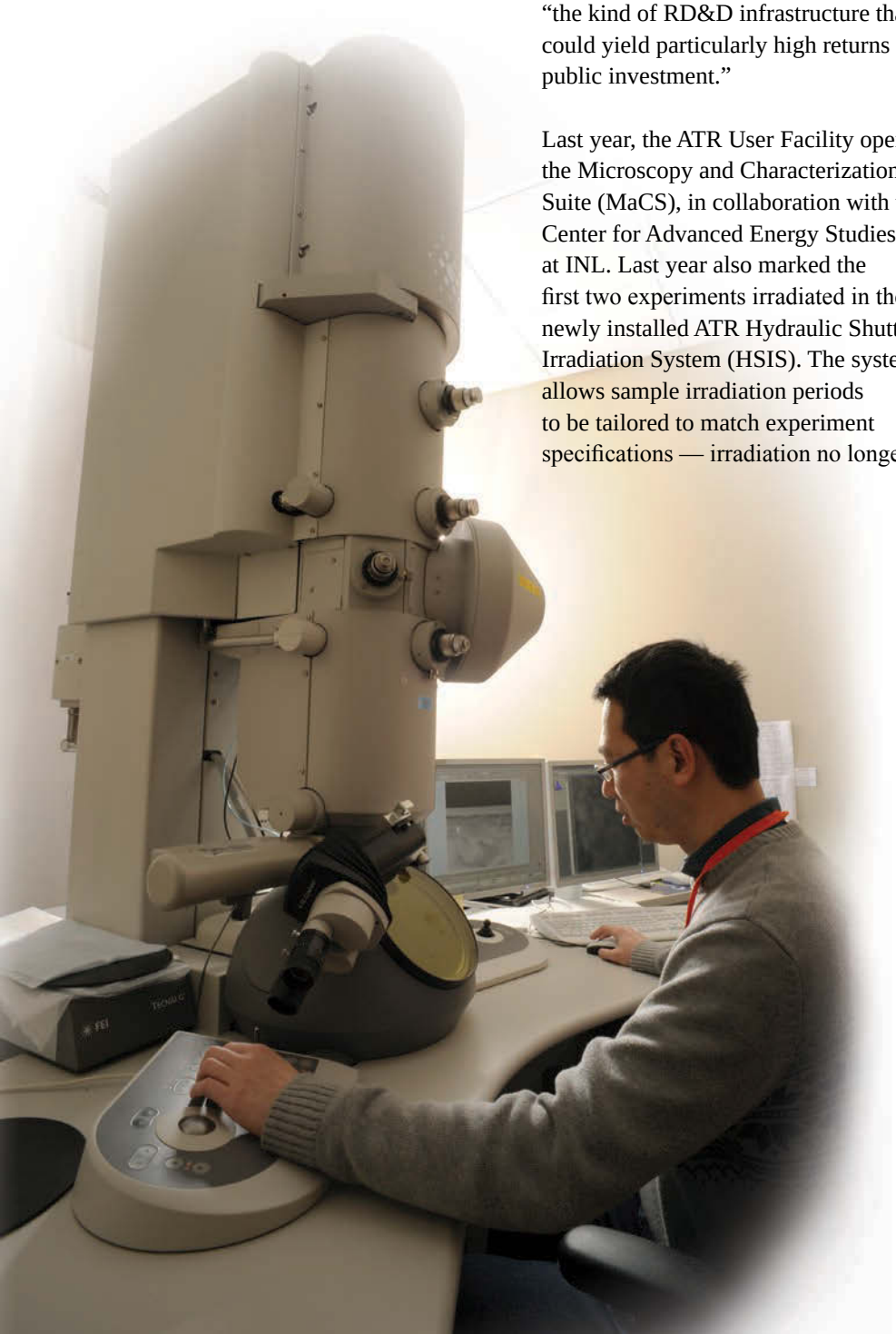
Nuclear Energy Summit
INL organized and co-hosted the "New Millennium Nuclear Energy Summit" in Washington, D.C., to initiate development of a long-term strategy and path forward for nuclear energy in the U.S. The summit attracted U.S. utility and energy company executives, the Nuclear Regulatory Commission chairman, energy policymakers from the Obama administration and other political figures. Discussions focused on U.S. nuclear energy challenges including financing, public-private partnerships, infrastructure, and new technology development. During the summit, Energy Secretary Steven Chu endorsed creation of a national clean energy standard requiring utilities to increase their use of low-carbon energy sources, including nuclear and clean-coal power.

National Scientific User Facility
The Advanced Test Reactor (ATR) National Scientific User Facility (NSUF) expanded beyond the simple idea of providing ATR irradiation space to external researchers. The facility is now defining a new 21st century model for stewardship of critical national capabilities. According to this model, unique national capabilities for reactor-based testing and analysis at universities and other laboratories are available to NSUF users, which enable the best scientific ideas to be paired with the nation's relevant experimental capabilities — ideas rather than institutions drive the research.

The Blue Ribbon Commission's final report to the Secretary of Energy noted that INL's ATR user facility exemplified "the kind of RD&D infrastructure that could yield particularly high returns on public investment."

Last year, the ATR User Facility opened the Microscopy and Characterization Suite (MaCS), in collaboration with the Center for Advanced Energy Studies at INL. Last year also marked the first two experiments irradiated in the newly installed ATR Hydraulic Shuttle Irradiation System (HSIS). The system allows sample irradiation periods to be tailored to match experiment specifications — irradiation no longer has to align with ATR operating and outage schedules. This flexibility allows for experiments as short as minutes and opens up new research opportunities at ATR for DOE research, university experiments and industry participants.

Light Water Reactor Sustainability
INL and the Electric Power Research Institute (EPRI) are leading implementation of DOE's Light Water Reactor Sustainability (LWRS) program. Last year, INL engaged utilities and vendors for advanced sensors and instrumentation work under the program. INL also is host and organizer of a workshop for the LWRS Advanced Instrumentation, Information & Control (II&C) Working Group. The workshop's objectives include updating the II&C vision document, reviewing results of pilot projects, previewing the planned FY 2012 research activities and touring INL simulation capabilities.



The MaCS lab enables national users to access high-end analytical equipment, including an atom probe, a transmission electron microscope, a focused ion beam system, a Raman spectrometer and an atomic force microscope.

International assistance

Following incidents at Japan's Fukushima Daiichi plant, DOE asked INL to organize its national laboratory response effort. Within two days of the earthquake, INL had identified points of contact at six national laboratories and had begun working with them to develop technical analyses covering a wide variety of emerging issues. INL scientists and engineers initiated studies that pinpointed issues associated with salt water cooling, analyzed worst case scenario accident progression, and identified remotely operated equipment capabilities that could be deployed at the Fukushima site. Senior INL managers also directly supported Energy Secretary Steven Chu during daily conference calls held to ensure that DOE was providing as much assistance as possible to the government of Japan.

Robotic assistance
INL deployed one of its robotics systems along with a suite of sensors to Japan. INL robotics experts outfitted a commercially available Talon robot with radiation-hardened cameras and sensors, which conferred the ability to take radiation readings, stamp them with a GPS location, and overlay the information on a Google Earth map.

INL employees Doug Few and Robert Kinoshita (left) prepare the Talon robot for service in Japan, and INL's Craig Conner, Cal Christensen, Victor Walker and Kinoshita pose with Japanese colleagues and the robot (above).

Accident recovery expertise
The events in Japan amplified interest in the recovery at the U.S. Three Mile Island Unit 2 (TMI-2) because parallels can be drawn between the two incidents. Japan's Central Research Institute of Electric Power Industry (CRIEPI) asked INL to perform research into the TMI-2 recovery effort and its applicability to the Fukushima Daiichi cleanup. INL researched these issues and summarized them in the "Three Mile Island Core Debris Packaging, Transportation, and Storage Summary," which also included research into the corrosion of spent nuclear fuel exposed to seawater.

"The professionalism and commitment of your staff contributed directly to the success of the Department's and the United States' ability to respond to the Fukushima incident . . . This was an outstanding example of how the Department and its employees can quickly come together . . . to address an issue of national and international importance."

–Peter Lyons,

Assistant Secretary for Nuclear Energy

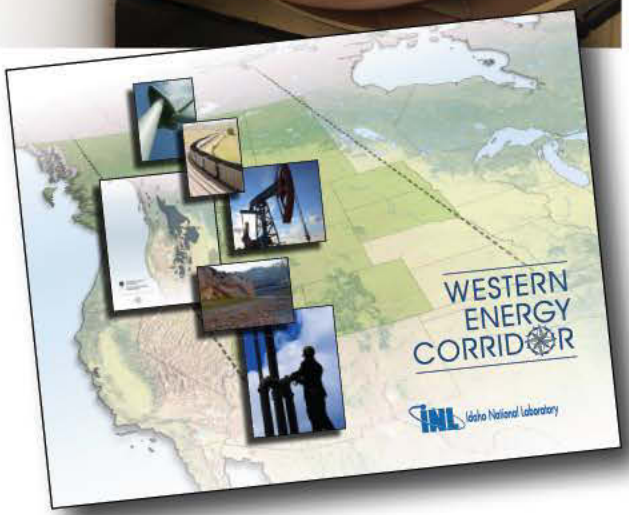
Commission support
INL supported the Blue Ribbon Commission on America's Nuclear Future by hosting a subcommittee visit (above) and providing comments on the 2011 draft report. The commissioners toured INL facilities in 2010 and consulted with experts to learn about expertise and research capabilities that might influence discussions about technology development opportunities and long-term nuclear fuel storage capabilities.

ADVANCING ENERGY **Security**

Improved energy security systems

INL is a multiprogram national lab that supports deployment of new energy solutions and critical infrastructure protection. INL's isolated site, test bed infrastructure and applied science focus are ideal for experimentation, demonstrations and assessments that help protect the nation's resources and security.

Unique INL capabilities enable its researchers and collaborators to generate large quantities of test materials for bioenergy producers.



The Western Energy Corridor report was produced at the request of Montana Governor Brian Schweitzer.

Advancing biofuels production
In 2011, the U.S. Department of Energy hosted a workshop at INL with government, university and industry partners to forge a path forward for improving the quality of biorefinery starting material. Roughly 100 workshop participants convened at INL to discuss technical challenges and tour the Feedstock Process Demonstration Unit (PDU), a powerful new research platform based at the lab (read more on pages 18 and 27).

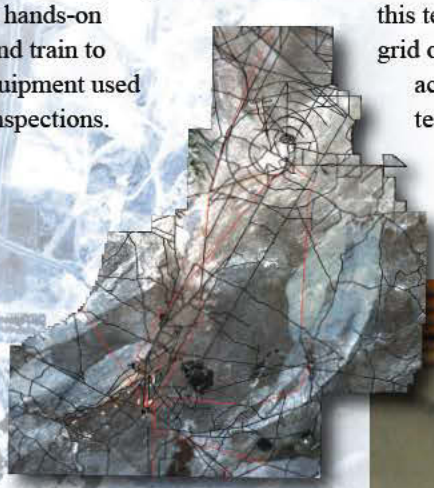
Assessing energy resources
Energy resources concentrated along the Rocky Mountains and northern plains in Canada and the U.S. are world class because of their diversity, magnitude and longevity. They also provide a foundation for regional economic development.

In 2011, INL conducted a comprehensive assessment of resources in this Western Energy Corridor to provide a stimulus for binational regional dialogue about their development. INL provided the Western Energy Corridor report to governors and premiers within the western region. The document provides an overview of the energy resources, associated infrastructure and influences within the region.

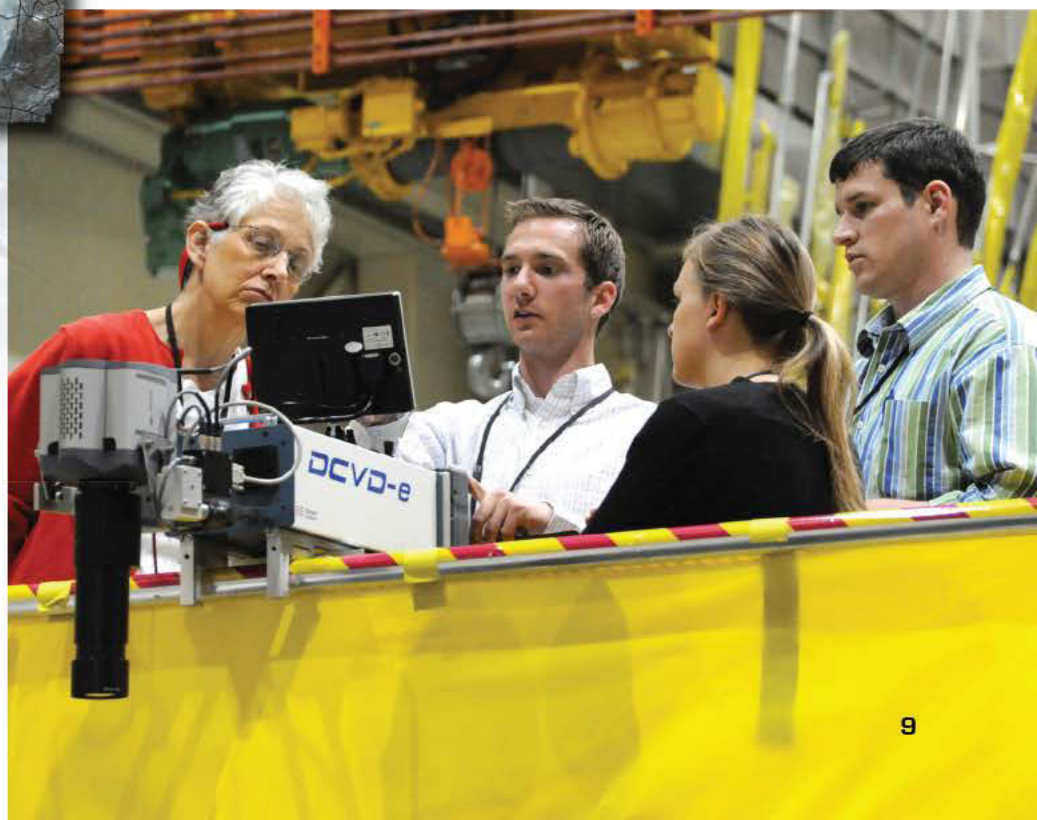
Supporting inspector training
INL teamed with the National Nuclear Security Administration (NNSA) to create a new course aimed at strengthening the training of U.S. nationals who want to apply for International Atomic Energy Agency (IAEA) inspector positions. The intensive two-week course, which was funded by NNSA and hosted by INL, gave prospective U.S. candidates in-depth, hands-on training with IAEA inspection equipment and procedures. Course participants complete more than two dozen hands-on modules and train to operate equipment used in IAEA inspections.

Geomagnetic storm testing
Last year, INL completed an Electromagnetic Pulse test to determine the effects of currents a geomagnetic storm may induce on large electrical grid transformers and downstream electrical components. The Defense Threat Reduction Agency (DTRA) sponsored the test, which included predictive modeling of the grid effects validated through test results. Dr. Mike Kuliasha, Director of DTRA's Nuclear Technology Directorate, visited the test site in July and affirmed the national significance of this testing to sustainable commercial grid operations and military mission accomplishment. Additional tests are planned in 2012 to take advantage of INL's electrical grid infrastructure.

Securing the grid
The Department of Energy's Office of Intelligence and Counterintelligence (DOE-IN) and INL hosted a two-day workshop in November 2011 on Protecting the Nation's Power and Distribution System from Emerging Threats. It brought together more than 100 leaders from the government, national laboratories and private sector to address threats to the nation's power grid.



INL's remote, secure site (left) is a proving ground for grid and wireless research. The nuclear safeguards inspection course at INL (below) is taught by former IAEA experts who now work at the lab.



Collaborations WITH...

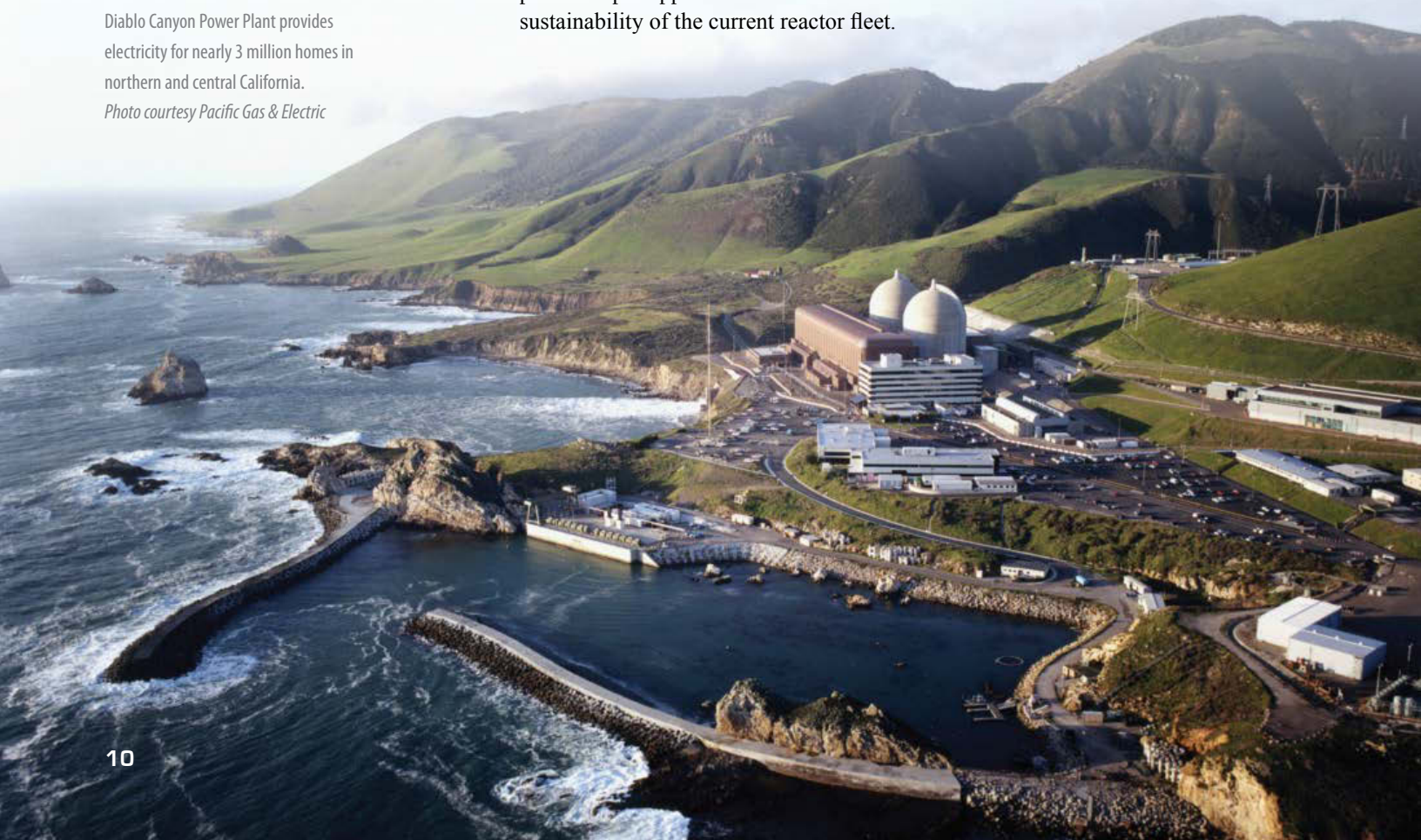
The nuclear energy industry

Engaging nuclear and other industries is a core INL objective. As the nation's lead laboratory for nuclear energy research and development, INL contributes analysis and information to inform industry progress. In FY 2011, INL held or supported 21 workshops with industry, government and international entities. INL's nuclear industry engagements crosscut laboratory, government and commercial sectors.

Sustaining the fleet

Half of the nation's current reactor fleet — 104 reactors that supply nearly 20 percent of U.S. electricity — are more than 30 years old. Sustaining and modernizing these plants is essential for their continued safe and efficient operation. Such efforts also can help bridge the implementation of new reactor designs. Several INL partnerships support modernization and sustainability of the current reactor fleet.

For example, INL is engaged with industry and participates in the Department of Energy Light Water Reactor Sustainability Utilities Working Group, whose members include 41 operating sites and 69 reactors. The group's goal is to identify and prioritize research aimed at fleet sustainability and modernization.



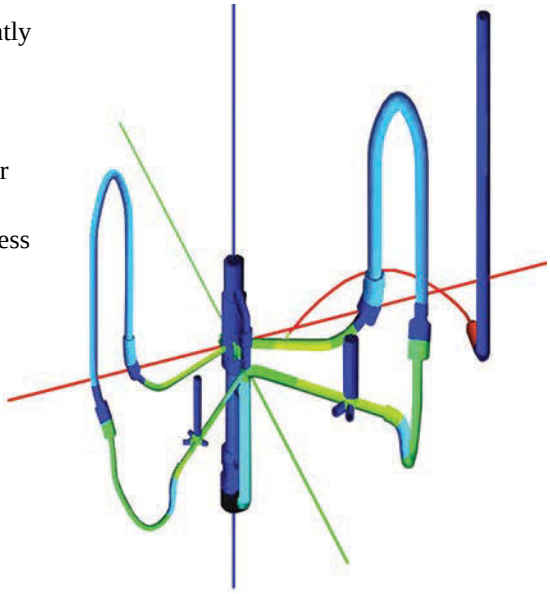
Diablo Canyon Power Plant provides electricity for nearly 3 million homes in northern and central California.
Photo courtesy Pacific Gas & Electric

The Electrical Power Research Institute is a partner on several INL research projects, including this project at the Center for Advanced Energy Studies investigating how different metallic alloys are damaged by the environment within nuclear power reactors.

Testing materials
The performance of materials is greatly affected by the high radiation fields inside a nuclear power reactor. INL and the Electric Power Research Institute (EPRI) are working together to understand stress cracking, crack growth rates and the fracture toughness of various material alloys while in high-radiation environments.

Updating control rooms
INL experts are providing technical collaboration to utilities to review aging analog instrumentation systems. INL suggestions for improving control technologies can improve human performance, bolster safety and reduce human error in power plants.

New reactor designs
INL has a long history of designing and building reactors, so it is only natural that a wide range of reactor designers seek to collaborate with INL to learn about INL advances in nuclear fuel design, human factors design principles and other areas. INL has agreements with many of these companies to share technical information and expertise. Such information can help support industry's development of both small modular reactors and larger advanced reactor designs.



Reactor safety analysis
INL has developed the industry's premier modeling tools for reactor and reactor fuel development and has licensed them for use to companies and universities around the world. This includes RELAP5-3D, which can be used for reactor safety analysis, reactor design, simulator training of operators, and as an educational tool by university nuclear engineering programs.

RELAP5-3D is a state-of-the-art simulation tool that allows users to model the coupled behavior of the reactor coolant system and the core for various operational transients and possible accidents that might occur in a nuclear reactor. RELAP5-3D has been licensed for numerous nuclear and non-nuclear applications, including modeling of jet aircraft engines and fossil power plant components. Renewed international interest in nuclear power, plus development of an improved RELAP5-3D licensing process, has enhanced INL's mission of advancing nuclear safety and research.

RELAP5-3D licenses in FY11

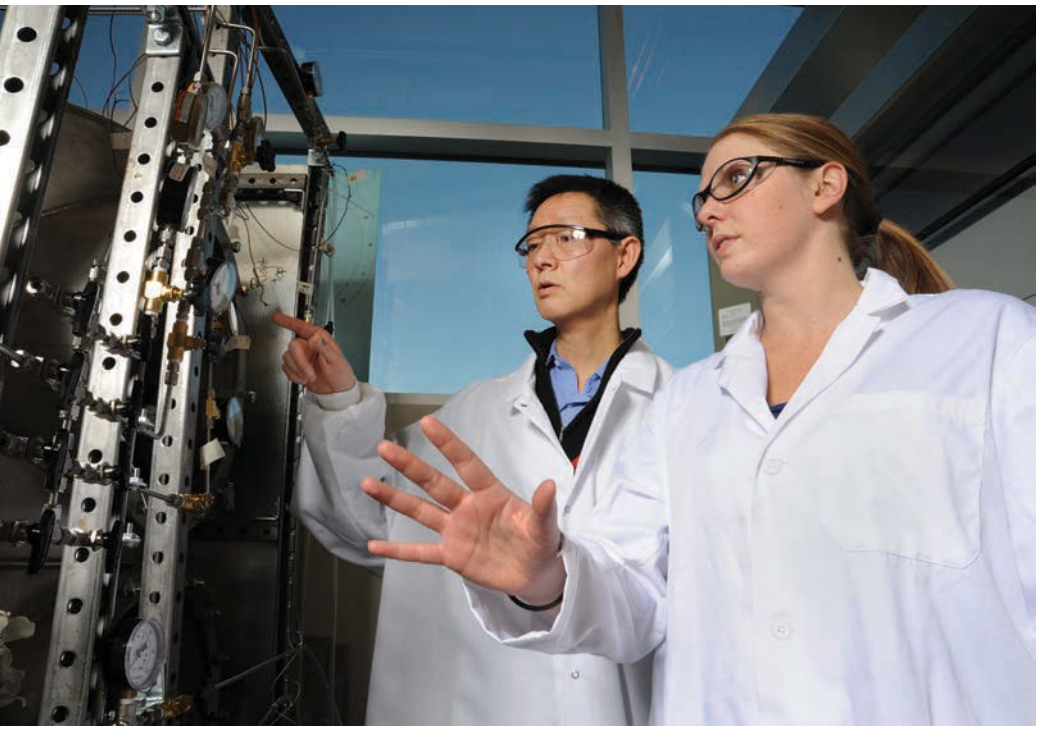
	Domestic	International	Total
Universities	9	7	16
Commercial Entities	12	14	26
Government Institutions	4	1	5
Total	25	22	47

During FY 2011, INL licensed RELAP5-3D to 47 diverse users.

Collaborations WITH...

Academic institutions

Partnerships with U.S. colleges and universities extend America's academic research capabilities and help develop the workforce of the future. Academic institutions and researchers across the nation are benefiting from access to the resources, capabilities and expertise at INL.



In FY2011, 47 students interned or conducted graduate-level research at CAES, which awarded $10,000 in college scholarships that year.

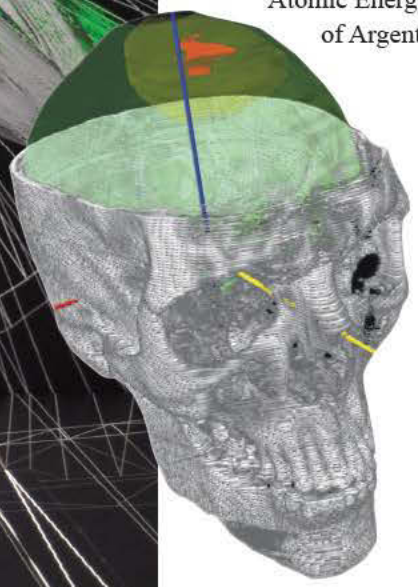
Idaho's research partnership
The Center for Advanced Energy Studies (CAES) at INL is a partnership between INL and Idaho's three public research universities. In FY 2011, more than 125 affiliated researchers from CAES partner institutions published more than 90 research findings and won $18.3 million in funding for research and infrastructure. CAES also continues to attract students to Idaho nuclear science and engineering university programs, with more than 550 students enrolling in such programs during the Spring 2011 semester.

Massachusetts Institute of Technology
INL provided technical support and leadership to the MIT study, "The Future of the Nuclear Fuel Cycle," and INL Director John Grossenbacher is an MIT Nuclear Fuel Cycle Study Advisory committee member. MIT professor Ju Li was appointed to the newly established Battelle Energy Alliance (BEA) professorship for Nuclear Science and Engineering. Dr. Li will apply his groundbreaking research into atomic-scale materials behavior to a broad range of challenges, including energy storage, waste management and reactor materials.

Wireless technology expert and MIT research scientist John Chapin visited INL as part of the lab's faculty exchange program. Chapin currently serves on several industry and government advisory boards including the Federal Communication Commission's Technical Advisory Council and the U.S. Army's Independent Review Team for Technology Readiness. During a symposium for INL employees, he noted how INL is positioned to support national needs related to spectrum sharing research and experimentation.

Space nuclear research
The Center for Space Nuclear Research is operated by the Universities Space Research Association (USRA) and INL. The center is a focus for engaging university research scientists in development of advanced space nuclear systems such as power and propulsion systems and radioisotope thermal generators. The center's Next Degree Program enables students with a B.S. or M.S. in an engineering or physical science field to work half time at the center while pursuing their next degree at the nearby Idaho State University/ University of Idaho extension campus.

Nuclear medicine research
Boron Neutron Capture Therapy is a promising experimental cancer treatment that could be the best option for certain aggressive types of tumors. INL is helping the University of Missouri design an experimental neutronic characterization of a new facility for Boron Neutron Capture Therapy research at the university's research reactor. The partnership is a continuation of INL's longstanding collaboration with the Division of Radiation Pathology of the National Atomic Energy Commission of Argentina.



A Mars Hopper designed through the Center for Space Nuclear Research and a dose estimate used for nuclear medicine research.

Collaborations WITH...

Other governments and agencies

State, regional, national and international policy makers rely upon objective data to inform their positions and decisions. So do government and industry agencies and associations. A diverse array of such partners is working with INL to research solutions to a variety of challenges.

Water resource management
In 2011, INL launched the Mountain West Water Institute (MWWI), a regional research institution dedicated to delivering solutions for sustainable water resource management in the Mountain West and the Western Energy Corridor. The Environmental Protection Agency (EPA) Office of Research and Development signed an agreement with INL to support the institute.

INL initiated the institute by hosting the MWWI Waters of the West Workshop in Salt Lake City, Utah. Attendees and speakers included representatives from water agencies and research institutions from the five MWWI states (Idaho, Utah, Montana, Oregon and Wyoming), the Western Governors' Association, Western States Water Council, U.S. EPA, U.S. Geological Survey, U.S. Bureau of Reclamation, and the National Oceanic and Atmospheric Administration.

INL has established a 10-year, three-party CRADA with Korea Atomic Energy Research Institute (KAERI) and University of Chicago Argonne to conduct electrochemical recycling research.

International Entities
INL continues to provide leadership to the Generation IV International Forum for development of advanced reactors; carries out research collaborations with major nuclear countries such as France, Japan and South Korea; and supports DOE in broad international nuclear energy engagement. Last year, INL worked with the Chinese Academy of Sciences to discuss opportunities associated with hybrid energy systems. INL experts also provided coordination and technical oversight for the transport of three shipments in support of the National Nuclear Security Administration's Russian Research Reactor Fuel Return Program.

U.S. defense agencies
The Defense Advanced Research Projects Agency (DARPA) signed a work-for-others agreement for the Deployable Reactor Program. DARPA is considering development of a small-scale nuclear reactor prototype for the on-site generation of electrical power in support of military operations in theatre. INL also supports a research fellowship program for the U.S. Air Force Research Institute. In 2011, two participants were selected to embark on research projects within INL's cybersecurity research and development department.

INL assisted various discussions with emerging nations seeking expertise in the safe use of nuclear energy. Mongolia (left), India and Chile were among nations exploring safe nuclear energy training and education requirements.

Private industry
INL works with private industry to help research, develop, demonstrate and deploy sustainable new energy resources and systems. For example, INL is working with Molycorp to improve recovery and processing of rare earth metals, which are crucial for hybrid cars, wind turbines and other green technologies. Cybersecurity analyses and training conducted by the Department of Homeland Security for private industry also were extensive in 2011 (more on page 30).

NEW Capabilities

Strategic Infrastructure

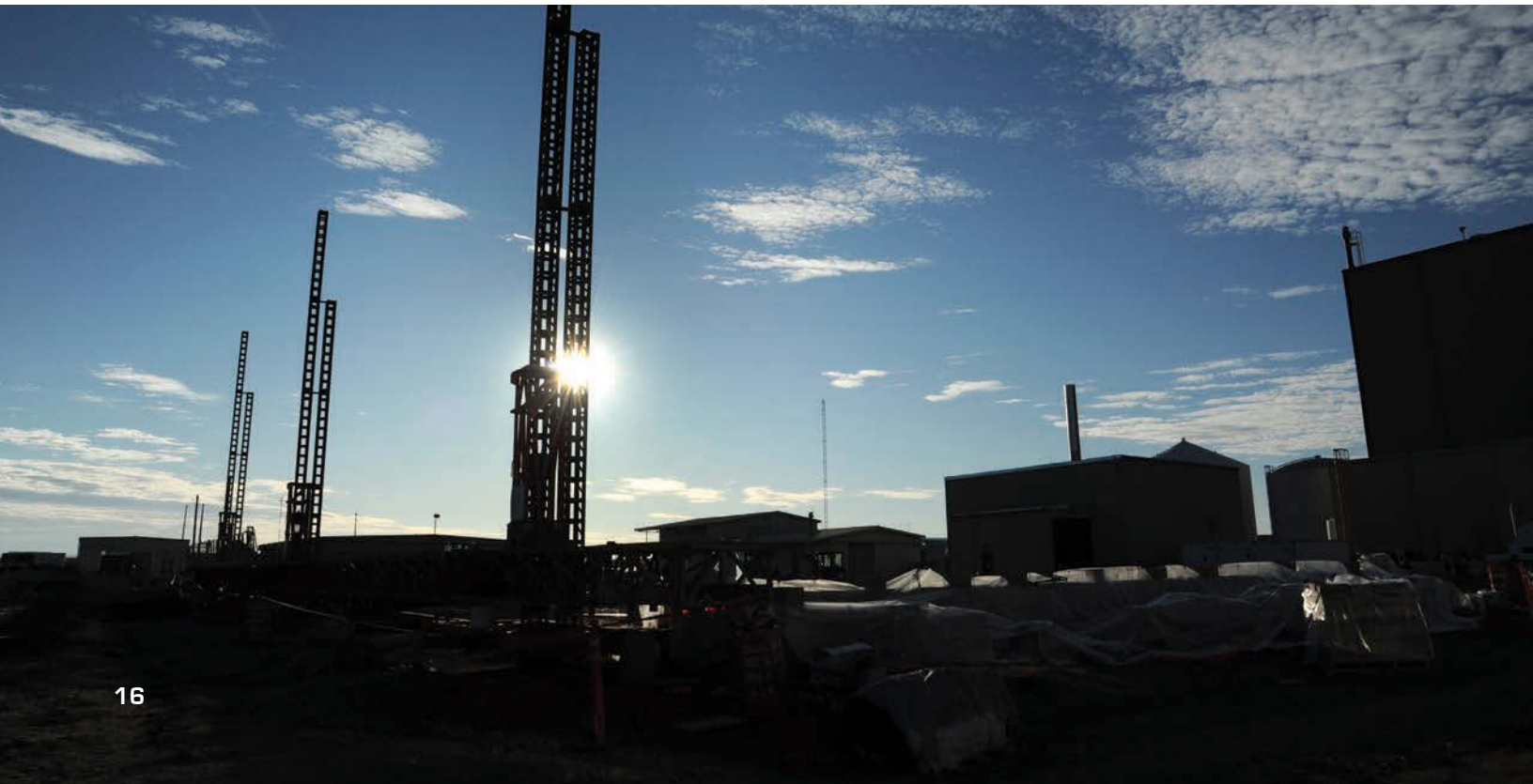
INL continues to build infrastructure and acquire advanced instrumentation and tools to develop, demonstrate and deploy state-of-the-art research capabilities. Capability needs outlined in the U.S. Department of Energy's Nuclear Energy Technology Roadmap help guide these efforts. INL initiated seven projects that work toward achieving the strategic infrastructure outlined in the INL Ten-Year Site Plan. Two of the projects were completed in FY 2011 and up to four additional projects will be initiated in FY 2012.

Irradiated Materials Characterization Lab

INL demonstrated considerable progress toward developing world-class post-irradiation examination capabilities in three main areas, including the Irradiated Materials Characterization Laboratory (IMCL). By year-end, the IMCL design was complete and construction was under way. The 8,500-square-foot test bed for developing advanced characterization techniques will be a Hazard Category 2 nuclear facility and will be operational by the end of calendar year 2012.

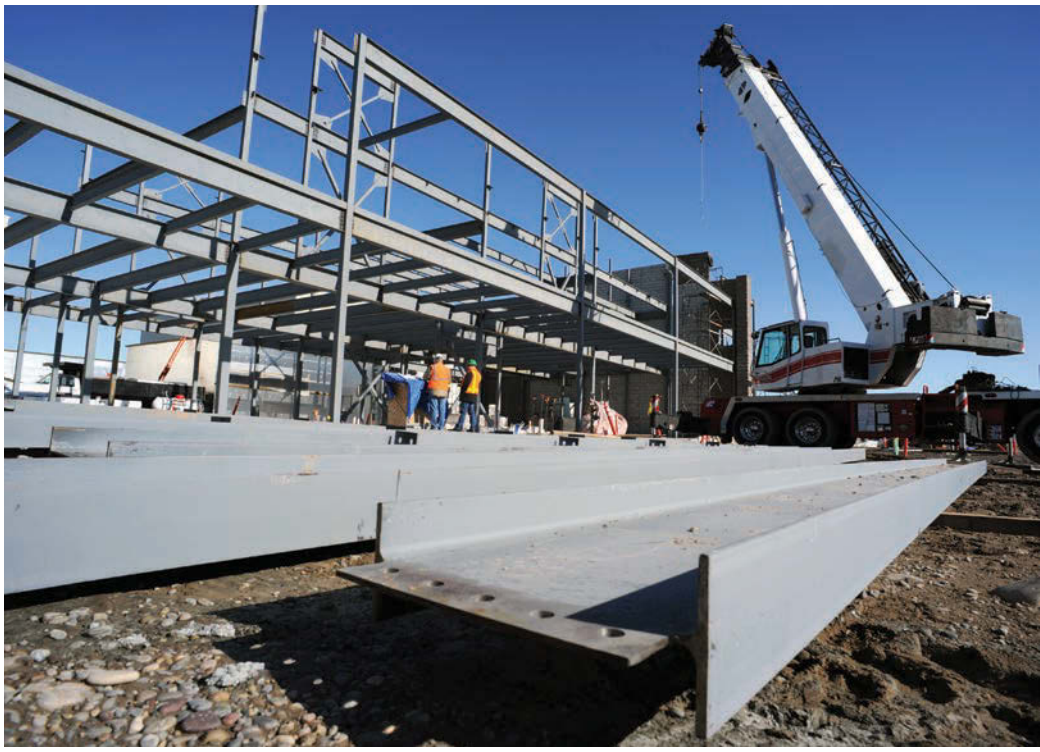
The abundance of work and employees at the Materials and Fuels Complex that hosts this facility drove the need for new office space. The INL Campus Development Office completed construction of a new office building, marking the first new office space at that facility in many years.

Construction of the IMCL will conclude in 2012.



Energy Systems Laboratory
In FY 2011, INL broke ground for the 91,000-square-foot Energy Systems Lab (ESL), which will house bio-energy feedstock engineering, advanced battery testing and integrated hybrid energy systems research. Hybrid Systems Testing Laboratories (HYTEST) will be completed after occupancy.

INL also delivered on-schedule and on-budget the DOE Radiological and Environmental Sciences Lab (RESL) and obtained private investment for construction of the Research and Education Lab (REL). Construction on the 149,000-square-foot REL will begin in Spring 2012.



"We have made an investment that will support the safety of thousands of workers across the DOE complex, protection of the environment, and consistency in radiological work. This facility houses a couple dozen of the best scientists in the DOE complex."

–Dennis Miotla, DOE Deputy Assistant Secretary for Nuclear Facility Operations/ Chief Operating Officer, on the new DOE Radiological and Environmental Sciences Lab at INL.

NEW Capabilities

The Advanced Test Reactor simulator's control room before (top) and after (bottom) replacement of its instrumentation and control systems.

Reactor control room upgrade
INL and the DOE invested more than $13 million to replace three of the Advanced Test Reactor's instrumentation and control systems. The three replacement systems — distributed control system (DCS), console display system (CDS) and the annunciator system — automate reactor process functions as well as monitor and display vital information to reactor staff in the control room. The replacement systems provide the same primary functionality as their predecessors while incorporating recent industry enhancements. The new systems offer leading-edge electronic and computing technology, including improved network communication speed, high-resolution LCD screens, and improved trending and reporting capabilities.

Biomass R&D platform
Last year, INL brought the new biomass Feedstock Process Demonstration Unit (PDU) online. The PDU is a pilot-scale research and development platform that is modular, deployable to other locations and accommodates large-scale testing of new processing approaches and equipment. Researchers can test ideas conceived in the lab by producing large quantities of feedstock so bioenergy producers can assess new recipes. The PDU provides a means to work with bioenergy producers to test laboratory-scale ideas. Biofuels PDUs also exist at other national labs, but INL's is the only one that focuses on the preliminary processing, formulation and densification of biomass feedstocks.

Radiological Response Training Range
INL completed the first full-scale exercise on its newly established Radiological Response Training Range (RRTR) in support of the National Technical Nuclear Forensics Center. The exercise involved close to 100 federal participants and observers and allowed the National Technical Nuclear Forensics multi-agency team to train in sample collection and analysis in a realistic environment.

The Radiological Response Training Range at INL enables the nation's emergency responders to effectively characterize and train in environments that safely simulate scenarios they might encounter while responding to major radiological incidents.

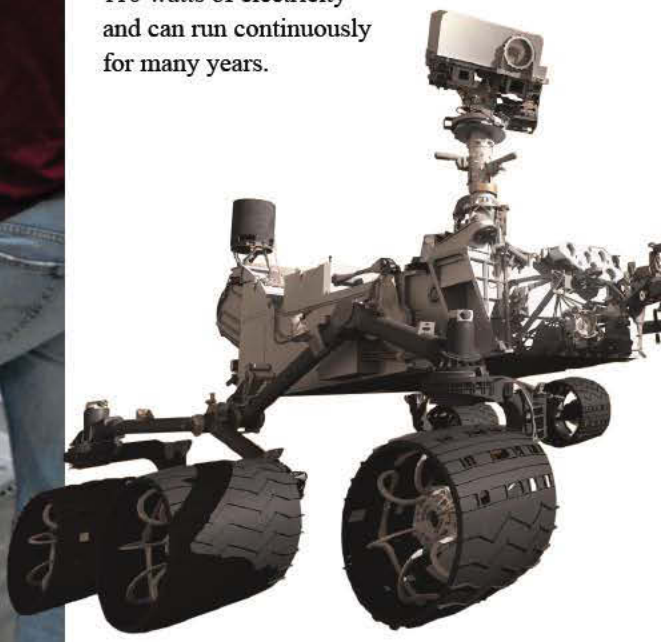
The biomass Feedstock Process Demonstration Unit at INL (top) is unique in the nation. INL's new supercomputer, Fission (bottom), is one of the 100 fastest computers in the world.

High Performance Computing
The data center supporting INL's High Performance Computing (HPC) capabilities was modified to support Fission, a high-speed supercomputer approximately six times larger than INL's existing supercomputer. The Center for Advanced Modeling and Simulation at INL (CAMS) will apply Fission's capabilities across a wide range of scientific disciplines to revitalize existing programs and fuel the vision for national programs.

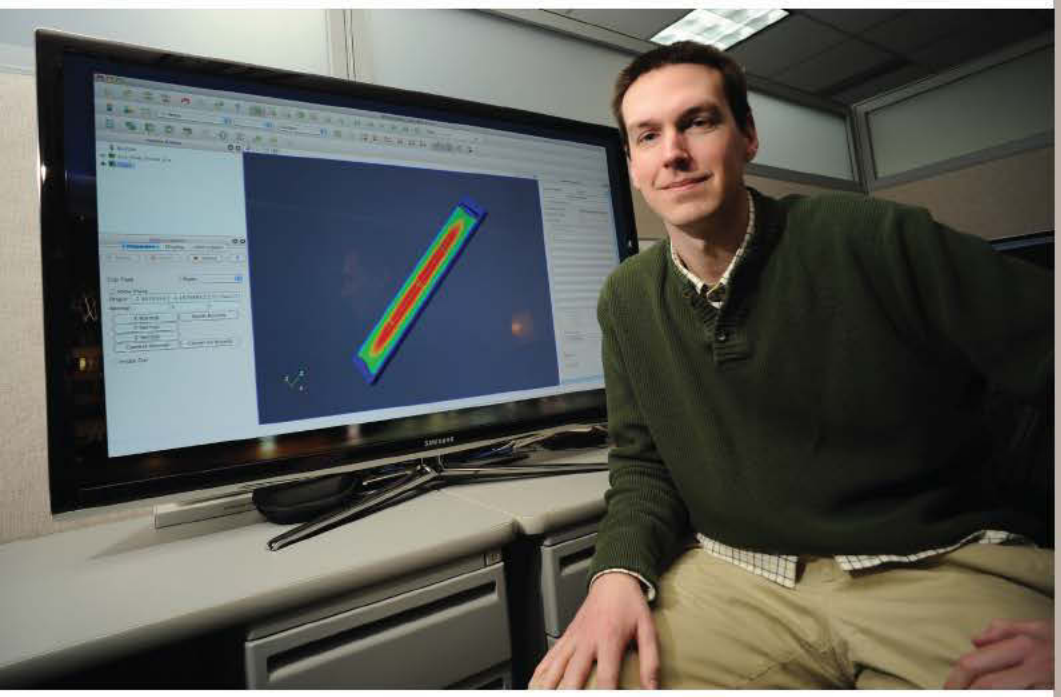
The National Nuclear Lab

Exceptional expertise, unique infrastructure, nuclear materials and strategic partnerships converge at INL, the nation's nuclear energy laboratory. INL's world-class capabilities and vertically integrated infrastructure support a science-based approach: experimentation, theory, modeling and simulation, and first-of-a-kind demonstration. This approach provides technically achievable, economically competitive and environmentally sustainable options for the entire nuclear enterprise.

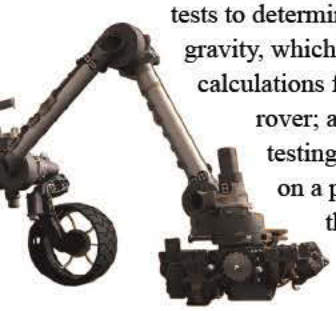
Powering Mars Science Lab
NASA's Mars Science Laboratory, which launched successfully in November, is carrying the most advanced payload of scientific gear ever used on Mars' surface (below). Those instruments are getting their lifeblood from a radioisotope power system assembled and tested at INL (left). The Multi-Mission Radioisotope Thermoelectric Generator provides a continuous source of heat and power for the rover Curiosity to complete its expedition in Mars' extreme temperatures and seasons. The power system provides about 110 watts of electricity and can run continuously for many years.



INL computational mathematician Derek Gaston led the INL Computational Frameworks Group that developed the revolutionary MOOSE simulation platform.



INL performs a series of tests to verify that the system will perform as designed during the mission. The tests include: vibrational testing to simulate rocket launch conditions; magnetic testing to ensure the system's electrical field won't affect the rover's sensitive scientific equipment; mass properties tests to determine the center of gravity, which impacts thruster calculations for moving the rover; and thermal vacuum testing to verify operation on a planet's surface or in the cold vacuum of space.



Modeling and simulation

An INL team has developed a computational framework that can accelerate nuclear fuels experiments by years. The Multiphysics Object-Oriented Simulation Environment, or MOOSE, is a computer simulation framework that advances the process for predicting the behavior of complex systems. MOOSE makes it easier to create simulations for complex mathematical models such as BISON or MARMOT, which enable study of fuel behavior at scales ranging from a grain to a full pin. This sort of work has illustrated, for example, how tiny defects in nuclear fuel pellets can amplify over time to impact safety or energy production. This work helps the nuclear energy industry refine its understanding of operating margins to maximize efficiency without impacting safety.

Radiation cleanup

INL researchers have developed a technology that can remove radioactive particles or toxic metals from contaminated building surfaces more quickly and cheaply than traditional methods. The approach uses a rigid foam alone or with a specialized clay to pull contamination off porous, horizontal or inverted surfaces. The new approach minimizes cost, waste volume and worker exposure. The R&D 100 Award-winning technology has been commercially licensed as Rad-Release Chemical Decontamination Technology, or simply Rad-Release.

ADVANCING Technology: NUCLEAR ENERGY

Pioneering nuclear research

INL has expanded the limits of nuclear research by pioneering techniques for microscopic examination of irradiated materials. Lab experts demonstrated a sample preparation technique that makes it easier for researchers to examine irradiated fuel at the nanoscale. They demonstrated successful use of a focused ion beam to prepare an irradiated fuel sample for nanoscale investigation using a transmission electron microscope. This accomplishment revealed material behavior that suggests increased stability of a new type of reactor fuel.

Lab researchers are also using a Local Electrode Atom Probe to study in atomic-level detail how materials respond to prolonged irradiation. This work can help researchers understand factors that may cause weaknesses in materials exposed to prolonged radiation inside a nuclear reactor. Such studies also can provide key information for computer models, which need data on a fine scale to accurately represent fuels and materials behavior.

Developing low-enrichment fuels
INL researchers are leading the development of new, low-enriched fuels to replace high-enriched fuels used in some reactors around the world. This latest effort in support of the Global Threat Reduction Initiative builds on years of success in converting research and test reactors to low-enrichment fuel by developing a uranium-molybdenum monolithic fuel for high-performance reactors. The fuel type has been successfully tested and shown to be stable under prototypical conditions in INL's Advanced Test Reactor.

Energy secretary awards
Seven INL employees received awards from Energy Secretary Steven Chu for their technical assistance in Japan and Kazakhstan. Employees Doug Burns, Cal Christensen, Betsy Connell, Harold McFarlane, Joy Rempe and Derek Wadsworth were recognized for contributions to the DOE's response following Japan's natural disaster that caused extensive damage to four nuclear reactors at the Fukushima Daiichi nuclear power plant. INL employee Eric Howden was honored for leading a 14-year initiative to secure 10 tons of highly enriched uranium and three tons of plutonium that originated in the former Soviet Union. Howden led the American portion of a joint U.S.-Kazakhstan effort to take inventory, secure and transport the spent fuel more than 1,500 miles to a more secure location.

Recognizing expertise
David Petti, INL Fellow and technical director of the Very High Temperature Reactor Technology Development Office, was selected as an American Nuclear Society Fellow. Petti was honored for leadership in development and demonstration of advanced fuels and materials. Specifically, he led the re-engineering and re-establishment of industrial fabrication capability, irradiation testing and demonstration of high burn-up particle fuels for High Temperature Gas-Cooled Reactors.

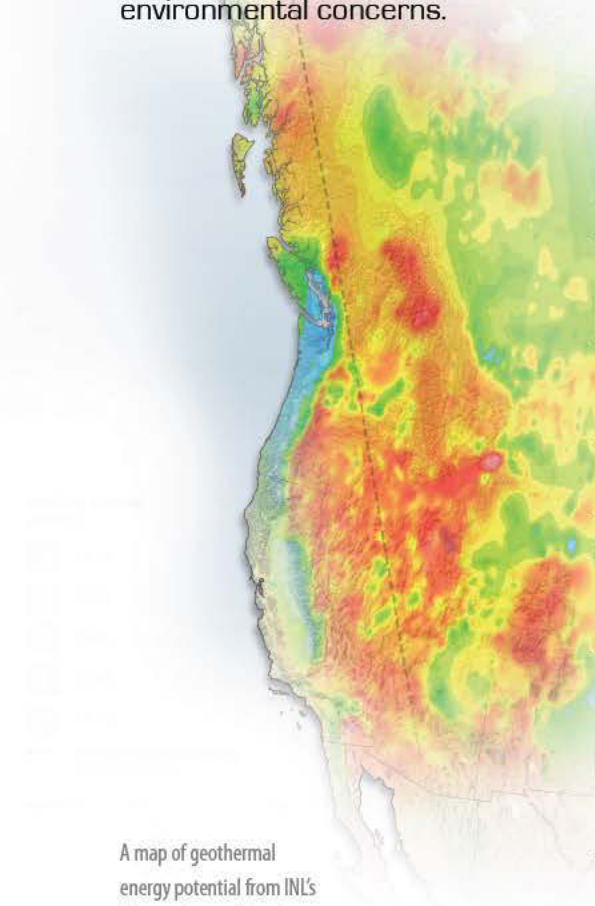
Joy Rempe, an INL Fellow and a nuclear engineer with nearly 30 years of experience in reactor safety and high-temperature testing, was appointed to a four-year term on the Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards. This committee is responsible for advising the NRC on technical health and safety impacts associated with reactor hazards.

Donald McEligot received an international award at the International Conference on Engineering Education in Belfast, Ireland. The International Network for Engineering Education and Research (iNEER) Leadership Award recognizes "visionary leadership in innovative research, consistent scholarship through international collaborations and pioneering contributions to engineering."

Terry Todd received the Robert E. Wilson Award from the Nuclear Engineering Division (NED) of the American Institute of Chemical Engineers. This is the NED's highest award and recognizes chemical engineering contributions to the nuclear industry, especially in the areas of nuclear fuel reprocessing and radioactive waste treatment technologies.

Clean energy challenge

INL is helping the energy industry and its regulators quickly, safely and securely expand energy supply, improve efficiency and address environmental concerns.



A map of geothermal energy potential from INL's Western Energy Corridor report.

Expanding energy supply

Researchers from INL and the Center for Advanced Energy Studies (CAES) formed a geothermal energy research team to explore turning the hot water flowing beneath Idaho into an economical source of power. In 2011, the team hosted a geothermal energy workshop that drew more than 70 people from industry, academia, government agencies and conservation groups. They worked to identify geothermal expertise at the CAES partner institutions, understand industry needs, identify research funding opportunities and discuss the possibility of a shared geothermal curriculum among the university partners

INL also conducted a comprehensive assessment of energy resources concentrated along the Rocky Mountains and northern plains in Canada and the U.S., known as the Western Energy Corridor. INL provided the Western Energy Corridor report to governors and premiers within the region to provide a stimulus for a binational regional dialogue about resource development.

Improving efficiency
Adding new transmission capacity is time-consuming and expensive. So INL wind power researchers are considering how to move more electricity through existing transmission lines. In areas where wind farms are being developed, there is potential to take advantage of wind cooling on transmission lines concurrent with wind power generation. An increase in wind speed of 5 mph blowing at a right angle to a high-voltage line can cool the line enough to increase the amount of current it can safely carry between 30 and 50 percent.

INL researchers are working with Idaho Power Company in a windy part of southern Idaho to translate detailed wind and temperature information into dynamic line ratings — real-time estimates of how much current each 500-meter segment of high-voltage line can safely carry when wind power is being generated. The research could help make electricity more affordable and accelerate renewable energy projects.

Transforming transportation systems
INL is helping reduce dependence on imported fuels with analysis and technology innovations related to advanced vehicles, alternative fuel development and improved energy storage technologies.

Advanced vehicle deployment
INL leads the Department of Energy's Advanced Vehicle Testing Activity by collecting data and performing independent analyses of advanced vehicle fleet demonstrations across the country. Cost-shared partnerships with vehicle manufacturers, charging infrastructure providers and universities encompass more than 100 industry, government and academic partners. INL is collecting and analyzing data from more than 9,000 electric drive vehicles and charging units.

INL has collected roughly 30 million miles worth of data from 26 states and two foreign countries related to advanced vehicle operation, maintenance, fuel use and life-cycle cost.

The Impedance Measurement Box (IMB) offers a quicker, cheaper battery monitor that leads to more accurate lifetime predictions and doesn't drain the battery during testing, as other methods may.

Energy storage improvements
INL collaborated with industry and academia to develop a smart battery monitoring system that can track the health of hybrid and plug-in hybrid electric car batteries just as a gas gauge lets you know when you're about to run out of fuel. The Impedance Measurement Box (IMB) offers a new tool that the electrical industry can use to better analyze energy storage systems and improve electrical operations. It has significant application in nearly all battery markets and won the R&D 100 Award as one of the most innovative inventions of 2011.

INL battery testing has contributed to increasing energy densities and extending battery calendar life from two years to 10. In addition, the lab is developing novel chemical solutions that improve abuse tolerance, lower cost, improve performance and show promise as advanced battery electrolyte materials.

Enhancing biofuel quality
Myriad activities demonstrated INL's leadership and numerous partnerships with industry, academia, government agencies and other national labs to improve the cost and quality of biomass feedstocks. INL organized a collaborative workshop and unveiled the Feedstock Process Demonstration Unit (PDU), a one-of-a-kind pilot-scale research and development platform (read more on page 18).

INL's biomass sample data system includes an extensive sample library (more than 2,000 samples and growing) and a data system that tracks samples and provides pedigree information about their handling.

In addition, INL developed the Biomass Research and Development Resource Library, which provides relevant, real-world information about research biomass samples. Biomass laboratory studies traditionally have been limited to pristine plant samples, which don't account for real-world variables such as industrial collection, drying or grinding methods. The new biomass sample data system allows simple logging of such information so research studies can control for these variables and learn how they impact sample integrity.

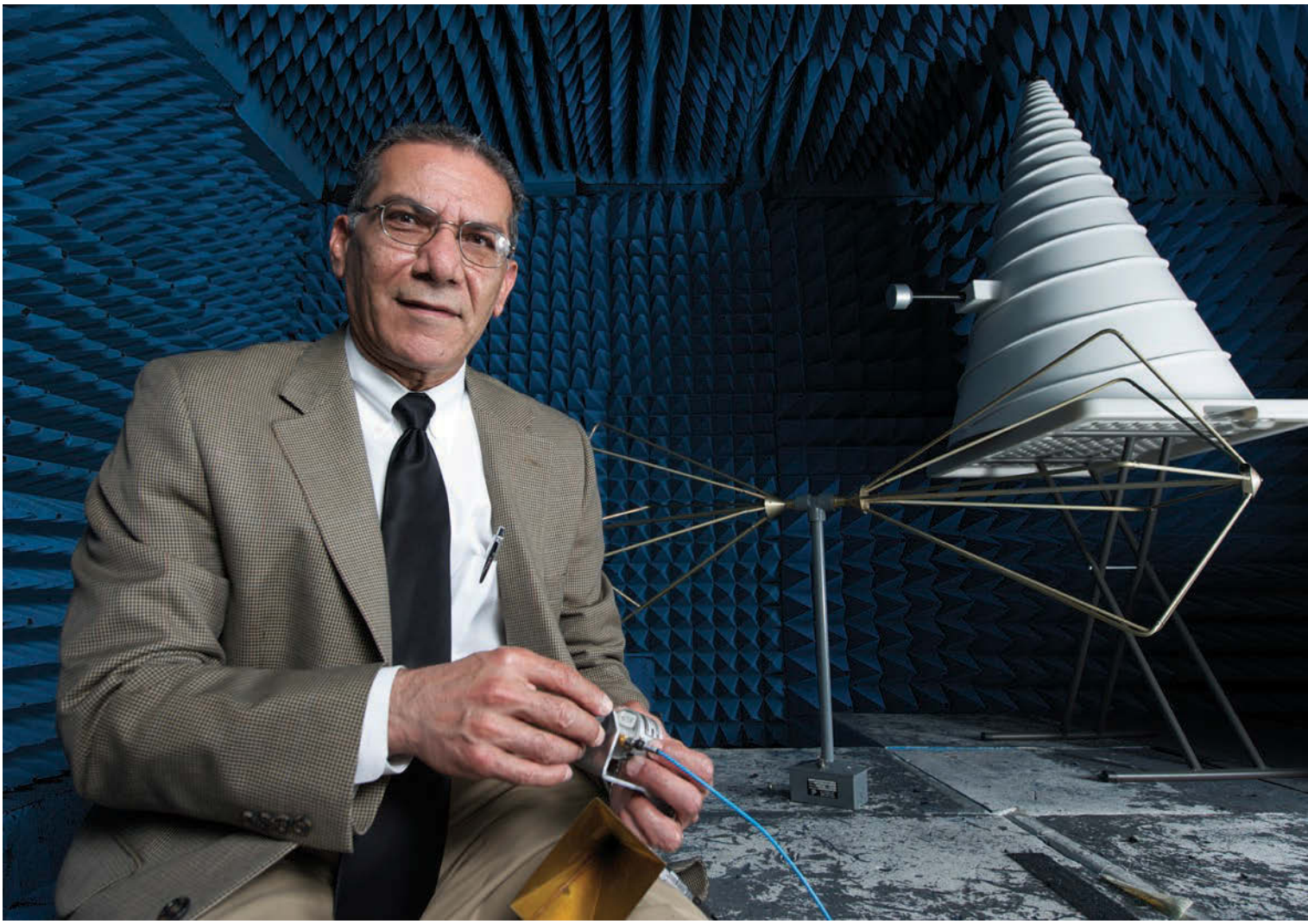
Finally, INL organized a symposium that was chosen for inclusion at the 2012 American Association for the Advancement of Science annual meeting. The panel included distinguished speakers from across the biofuels research community, including INL, DOE, the U.S. Department of Agriculture, and universities in the U.S. and Canada.

"The mobile Process Demonstration Unit to be housed here will have unique capabilities; not only in the nation but, we think, in the world. This is really the only one . . . and we're extremely proud that it's here in Idaho because this group has worked very hard."

— John Ferrell, Office of Biomass Program at DOE's Office of Energy Efficiency & Renewable Energy.

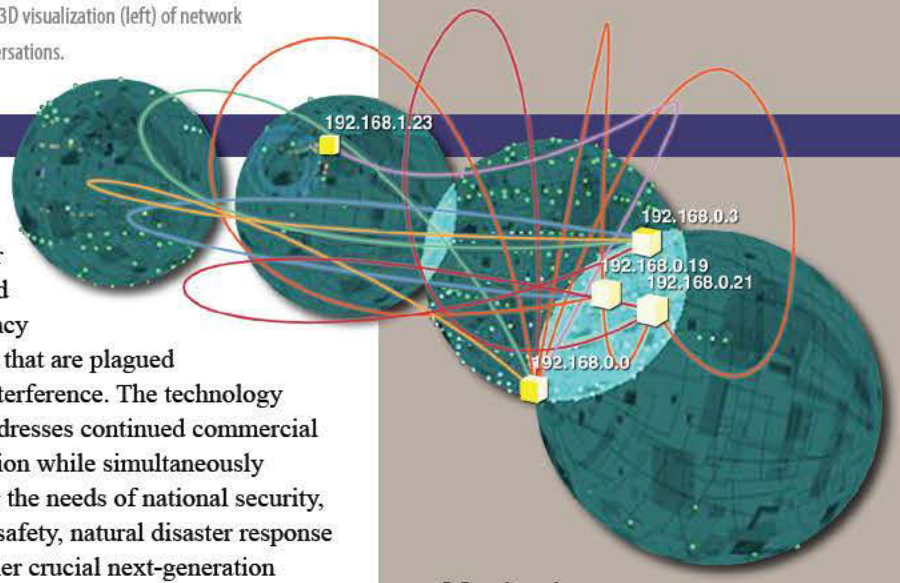
Enhancing national security

INL's multiprogram capabilities support critical infrastructure protection, cybersecurity and nuclear nonproliferation. Applied science and real-world assessments of improved energy systems and natural resource development help secure the country's future and protect the environment.



A team led by INL Chief Wireless Scientist Dr. Hussein Moradi has developed a wireless technology platform that identifies and utilizes available spaces in the radio frequency spectrum that are not occupied by other signals.

The Sophia tool developed at INL includes a navigable 3D visualization (left) of network data conversations.



Expanding spectrum usage
INL has developed a wireless technology platform that expands use of the available radio frequency spectrum while offering a secure, efficient, nearly undetectable communication channel that operates below the noise floor. The technology identifies and utilizes available spaces in the radio frequency spectrum that are not occupied by other signals. A novel method for spreading the transmission signal enables its receiver to avoid frequency spectra that are plagued with interference. The technology also addresses continued commercial expansion while simultaneously serving the needs of national security, public safety, natural disaster response and other crucial next-generation communication systems.

"As the nation looks to developing new and innovative technology to make the most efficient use of scarce spectrum resources, we feel that INL would be an ideal proving ground and could play an essential role in the development of a national-level spectrum-sharing wireless test bed."

—Andrew Clegg and Byron Barker, co-chairs of the Wireless Spectrum R&D Senior Steering Group, National Coordination Office for Networking and Information Technology R&D

Monitoring control systems
INL is developing software tools that can help utilities improve cybersecurity situational awareness of the industrial control systems that run industrial infrastructure. One of the tools being developed is the Sophia tool. It monitors network traffic and extracts the source, destination and conversations between control system components to alert users to suspect activity. The Sophia software is connected passively to minimize impact to the production control system operation, and it can be implemented on any control system installation. Energy sector utilities comprise most of the 13 entities currently participating in beta testing.

The ICS-CERT responds to and analyzes control systems-related incidents, conducts vulnerability and malware analysis, and provides situational awareness.

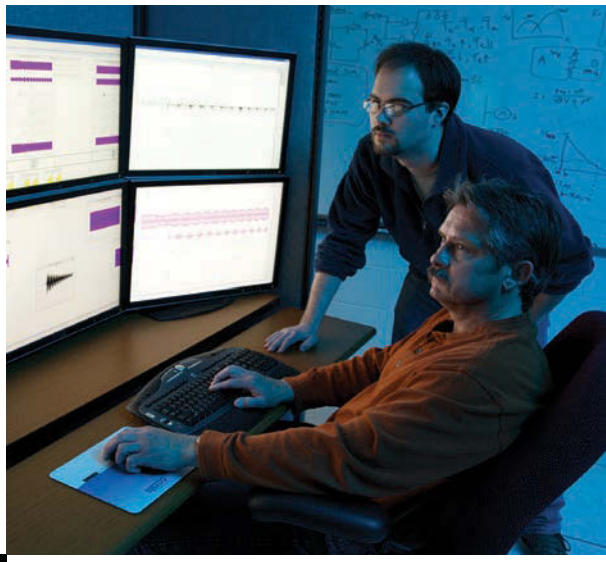
Boosting cybersecurity

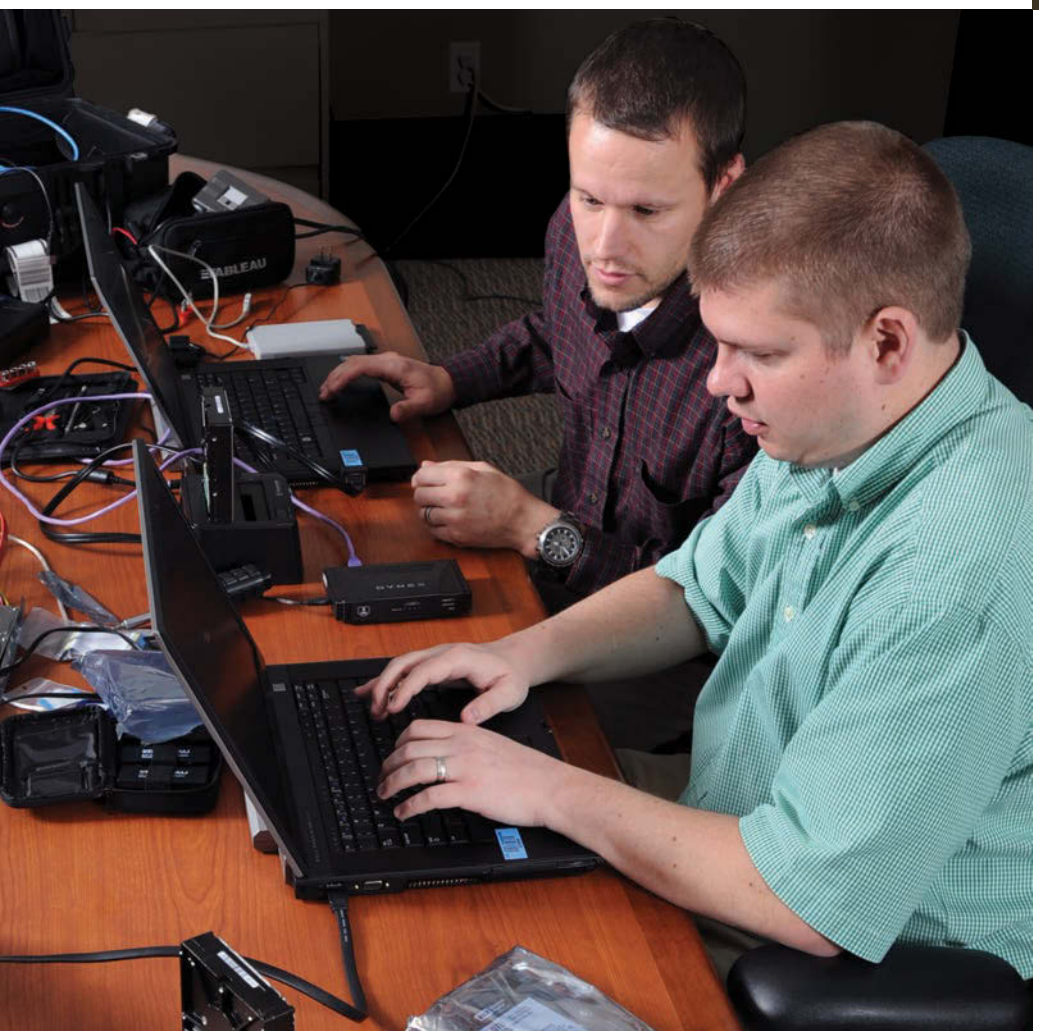
The Department of Homeland Security (DHS) Control Systems Security Program continues to provide increased support to owners, operators and vendors of critical infrastructure. In FY 2011, the DHS Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) continued to provide key support that addressed risk to the nation's critical infrastructure sectors. ICS-CERT fly-away teams (right) were deployed to seven organizations, and the ICS-CERT published more than 100 security alerts and advisories to the ICS community warning of various threats and vulnerabilities impacting control systems.

In FY 2011, the program also assisted the control systems community by conducting more than 40 cybersecurity training courses both domestically and internationally for public and private partnerships with more than 1,300 attendees. Additionally, more than 75 Cyber Security Evaluation Tool onsite assessments were completed and approximately 600 participants attended the Fall 2010 and Spring 2011 Industrial Control Systems Joint Working Group conferences.

Modeling the grid

INL continues to enhance grid modeling capabilities through testing and refinement of its Real Time Digital Simulation (RTDS) modeling approach. In collaboration with Dr. Santiago Grijalva from the Georgia Institute of Technology, INL has developed a technology roadmap defining gaps relative to Smart Grid design and implementation. Initial efforts involved development of a dynamic electric grid system model to define issues and parameters affecting power grid systems with high percentages of renewable generation capacity. INL successfully modeled and compared operational data at the F.E. Warren Air Force Base. Additional collaborations will allow validation and scalability, which utilities could use for renewable integration planning.





INL's RTDS helps power systems engineers (above) create a highly detailed power grid model.

INL Business CONTRIBUTIONS

INL by the numbers

INL's customers, collaborators and employees illustrate the lab's broad expertise and reach. A diverse public and private customer base utilizes INL research and testing capabilities. Last year, INL did nearly $1 billion worth of business, and nearly one-third of its customers were from outside the U.S. Department of Energy. INL technology partners hail from across the nation and the world.

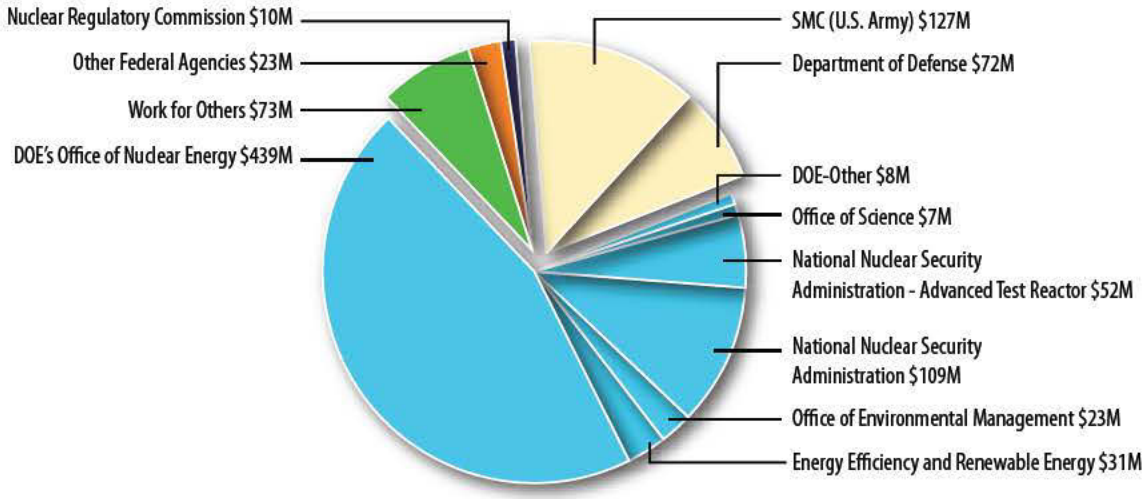
INL business volume

In FY 2011, INL did $974 million worth of business that included work for the Nuclear Regulatory Commission, the Department of Defense, several offices within the U.S. Department of Energy and other federal agencies. Nearly 10 percent of INL's business volume came from "work for others" that benefits state governments and private industry.

INL employees

INL employs more than 4,000 people, including 20 joint faculty and 11 post-doctoral researchers, and numerous graduate and undergraduate student interns. Roughly 65 percent of INL employees have post-secondary certificates or degrees. Approximately half of employees work in Idaho Falls, and the other half work at the lab's Industrial Research Complex at DOE's Idaho desert Site. When combined with all Site contractors, INL is the second largest employer in Idaho (second only to the state itself) and indirectly accounts for another 16,000 Idaho jobs.

INL's customer base in FY 2011



INL does research and testing on behalf of numerous offices within the U.S. Department of Energy and other federal agencies.

INL business partners
License agreements allow a business or other entities to reproduce, manufacture, sell or use INL-developed or -owned intellectual property. In FY 2011, INL signed 19 patent licenses and executed 57 copyright licenses, reaching 76 total license agreements last year. In FY 2011, INL signed 10 new Cooperative Research and Development Agreements worth more than $18.5 million. Last year INL added or re-negotiated 231 federal and 56 private sector Work for Others agreements worth a combined $66 million.

INL research collaborators and customers are based around the nation and the world, including Canada, France, South Korea, Australia, the United Kingdom, Argentina, Chile, Mongolia, China, India and some of the areas shown here.

LAB Sustainability CONTRIBUTIONS

Sustainability beyond buildings

INL is working toward lab-wide sustainability by seizing everyday opportunities ranging from adopting advanced technologies to simply turning lights off, recycling or purchasing environmentally friendly products. INL goals include energy efficiency, renewable energy use, recycling, sustainable buildings, electronics stewardship, greener fleets, greenhouse gas reductions and the full implementation of sustainable programs.

Reducing fleet fuel use

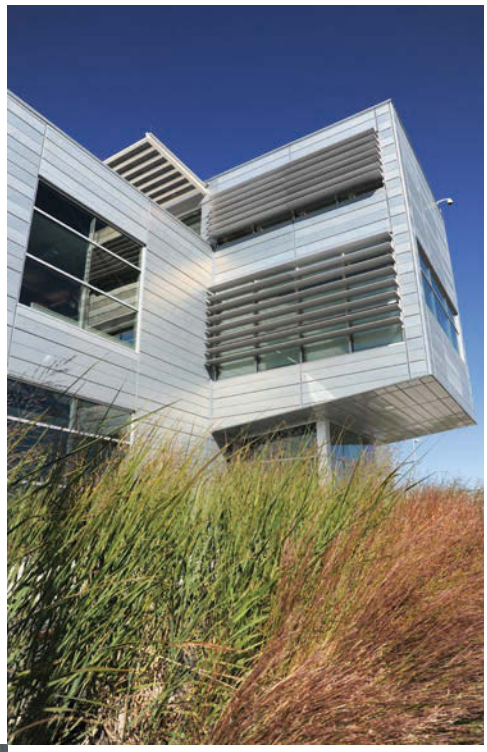
INL's mass transit system uses more than 80 buses to transport 3,250 employees to and from the Department of Energy's Idaho desert Site each day. Last year, INL reduced fleet petroleum fuel use nearly 3 percent while increasing alternative fuel use 11 percent compared to FY 2010. Since FY 2005, petroleum fuel use is down more than 25 percent and alternative fuel use is up nearly 80 percent.

Recognition of achievements

The U.S. Deputy Energy Secretary awarded a 2011 DOE Sustainability Performance Office Team Energy Management Award to an INL team for outstanding contributions to energy, water and vehicle fleet management and associated cost-savings at DOE facilities. The five-member team was honored for integrating sustainability into INL policies and operations. Their efforts have resulted in annual cost and energy savings of more than $1.6 million, more than 1 million kilowatt hours of electricity, nearly 600,000 gallons of fuel oil and about 190,000 gallons of diesel fuel.

Existing building improvements
The Common Support Building at INL's Advanced Test Reactor Complex earned LEED (Leadership in Energy and Environmental Design) certification in March 2011. INL also installed four cool roofs to reflect sunlight and lessen cooling costs. The new roofing meets the secretary of energy's requirements for "cool roofs" and eliminates more than $400,000 of deferred maintenance.

Energy Savings Performance
An Energy Savings Performance Contract brought $35-million worth of energy-saving infrastructure improvements to the lab's Materials & Fuels Complex. The complex transitioned from fuel oil to electricity for steam heating and replaced more than 6,000 outdated lighting fixtures. The project will reduce carbon dioxide emissions by 12 million pounds annually. Facility upgrades include energy-efficient lighting, heating systems and building controls.



New INL facilities are using xeriscaping to save water and associated landscape maintenance expenses.

U.S. Deputy Secretary Daniel Poneman (right) recognized INL's energy management efforts in November 2011.

Education CONTRIBUTIONS

Investing in the future

INL's contributions to improve Science, Technology, Engineering and Math (STEM) education across the state and nation are helping rebuild the nuclear energy workforce.

In FY 2011, INL supported approximately:

22	INL minigrants
2	Classroom makeover grants
3	i-STEM institutes
3	Regional scholastic tournaments
1	Statewide scholastic tournament
28+	STEM-based community activities
7	Technical school degree/ certificate programs
28	Dual credit scholarships
200	Interns
20	Native American high school scholarships
10+	College scholarships

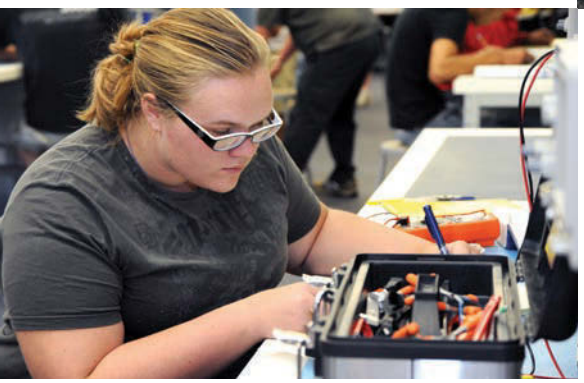
200,000+	Students
300+	K-12 schools
5+	Technical/community colleges
76	Percent of Idaho school districts

Statewide investment:
BEA invested $473,000 in K-20 education throughout Idaho in FY 2011. Through targeted initiatives that span kindergarten to college, INL reached dozens of communities, hundreds of educators and thousands of students in every region of the state.

DOE's Nuclear Energy University Programs funds nuclear energy research and equipment upgrades at U.S. colleges and universities. It also provides scholarships and fellowships to students studying nuclear science or engineering.

Workforce development
INL supported seven technical school degree/certification programs. The lab also helped dozens of Idaho high school students earn technical certificates or college credits by awarding 28 dual credit grants to help students pay the extra fees charged for dual credit courses.

INL awarded $10,000 each to Idaho State University's Energy Systems Technology and Education Center (ESTEC) and Eastern Idaho Technical College. The money funds scholarships for students in science, technology, engineering and math-related fields.



Two new programs were added at ESTEC, which INL helped establish. INL and industry input helped launch the new renewable energy technician program and nuclear operations technology program.

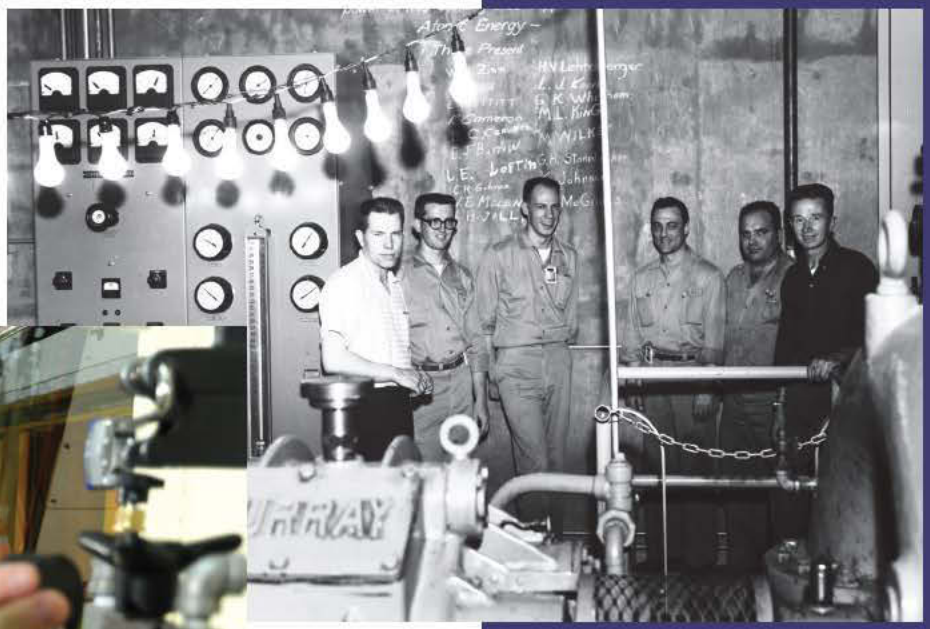
STEM education support
INL awarded 22 mini-grants (up to $2,000) to help teachers across Idaho improve STEM education through classroom equipment, materials and professional development. The lab also provided two $10,000 classroom-makeover grants and 24 informal STEM grants (worth between $2,000 and $4,000) to help pay for field trips, classroom supplies, science camps and other needs. INL also sponsored more than 28 community-based STEM events in FY 2011.

i-STEM
INL is a founding partner and primary sponsor of the Idaho STEM Initiative (i-STEM), a partnership of educators, government agencies and businesses working to improve STEM education. This year, approximately 400 Idaho educators attended i-STEM institutes held in three separate parts of the state. INL and partner schools received a $645,000 grant through the Idaho Department of Education to help cover the cost of these institutes for three years and to study their effectiveness.

Nuclear Energy University Programs
INL continued to administer DOE's Office of Nuclear Energy University Programs (NEUP) through the Center for Advanced Energy Studies. NEUP R&D contract awards announced this year included 51 recipients from 31 U.S. universities in 21 states. Partner institutions include 10 national laboratories, 15 industry partners, and seven others including foreign institutions. Ten minority-serving institutions were involved.

ABOUT INL

In operation since 1949, INL is a science-based, applied engineering national laboratory dedicated to supporting the U.S. Department of Energy's missions in nuclear and energy research, science, and national security.



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U.S. DEPARTMENT OF ENERGY