# Revolutionary Discoveries for a Better World

Argonne NATIONAL LABORATORY

# at ARGONNE, our Life's Work Makes a Difference

The world's best and brightest minds come to Argonne National Laboratory to make scientific discoveries and technological innovations that improve the quality of life throughout the nation and the world. Argonne's scientists and engineers are dedicated to solving society's most pressing problems in sustainable energy, a clean environment, economic competitiveness and national security.

Argonne Scholar Vilas Pol found an inexpensive way to turn an environmental nuisance into a potential energy solution. His discovery turns plastic grocery bags into carbon nanotubes, a component of lithium-ion batteries used in many applications, including cars.

# CONTENTS


Meeting 21st Century Challenges ..... 4

Solving Problems, Fueling Innovation ..... 6

Powerful Tools for Discovery and Innovation ..... 10

Our National Scientific User Facilities ..... 12

Collaboration is the Key to Success ..... 16

Argonne — A Great Place to Work and Live ..... 18

About Argonne ..... 22

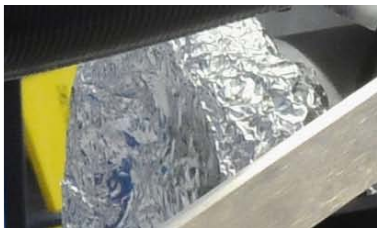
# Meeting 21st Century Challenges

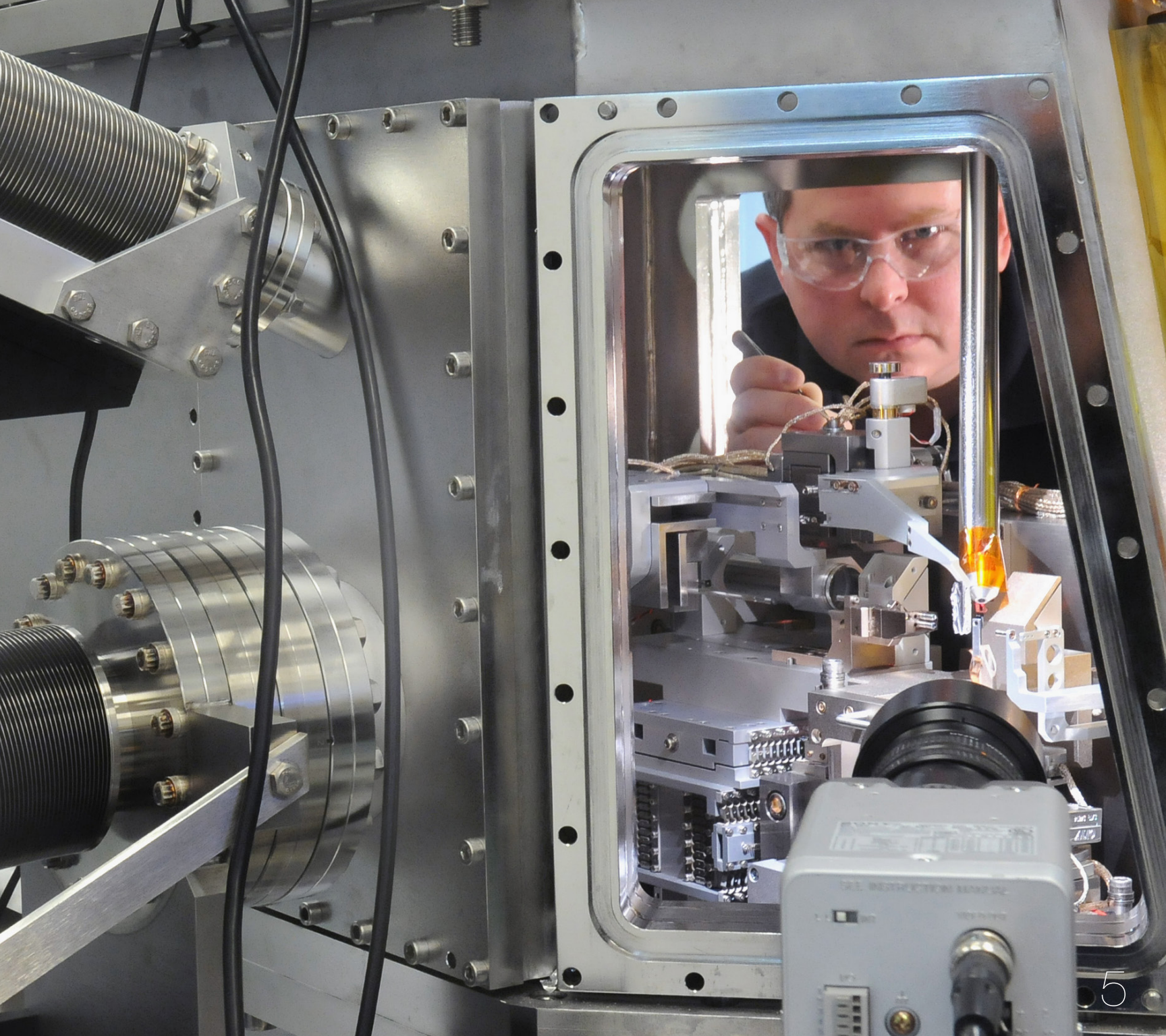
Chartered in 1946 as the nation's first national laboratory, Argonne enters the 21st century focused on solving the major scientific and engineering challenges of our time: sustainable energy, a clean environment, economic competitiveness and national security.

Argonne is pursuing eight major research initiatives that support the U.S. Department of Energy's goals to create innovative and game-changing solutions to national problems.

Argonne's path to achieving these goals cuts across traditional research boundaries between basic and applied science and engineering to create a fertile environment for bold and visionary efforts. Our research teams translate fundamental breakthroughs into the revolutionary discoveries and technological innovations required by the nation and the scientific community at large.

Physicist Robert Winarski uses the Hard X-ray Nanoprobe at the Advanced Photon Source to examine the extremely detailed inner workings of cells and materials at the nanoscale. Researchers are exploring these tiny worlds with the hope of developing beneficial innovations, such as new solar technologies, alternative fuels and drugs to fight disease.





# Solving Problems, Fueling Innovation

## ENERGY, ENVIRONMENT AND NATIONAL SECURITY

Five of our major research initiatives address practical energy, environment and security challenges.

### Biological and Environmental Systems

Changes in climate can affect biodiversity, the cost of food, our health and even whole economies. Argonne is developing computational models and tools designed to provide new insights into complex biological processes and their economic, social and health effects. Research spans from the molecular level to whole organisms and their interaction with climate, the ecosystem and human activities. This effort will improve our understanding of the world around us while increasing the accuracy of regional climate models to better inform public policy.

Scientist Ken Kemner and a team of Argonne microbiologists, chemists, physicists and geochemists are working to better understand exactly how some bacteria could be used to chemically change the radioactive and toxic form of uranium into a form that is less harmful. This could help reduce the danger posed by the more than 1,000 uranium-contaminated sites across the nation.

## Alternative Energy and Efficiency

Reducing our dependence on petroleum is a national priority. Argonne is addressing the major materials, chemical and infrastructure challenges of developing and deploying advanced transportation fuels and engines on a national scale. We are developing both chemical fuels and biofuels optimized for combustion in current engine designs, as well as improved combustion schemes for future engine technologies. Researchers in Argonne's solar energy program are devising solar-fuel and solar-electric devices and systems that are efficient, scalable and economically competitive with fossil energy sources in use today.

Mechanical engineer Steve Ciatti has developed a combustion system that operates with high efficiency and practical levels of power density while drastically reducing tailpipe emissions. If the advanced system can be made robust enough for real-world use, it would greatly revolutionize the vehicles we drive.

Analytical chemist Sabeen Ahmad tests the acidity of samples produced in the pilot-scale Separative Bioreactor. As part of the laboratory's efforts toward a viable, sustainable biomass industry, the Argonne-developed technology allows both the continuous production and recovery of biobased chemicals and fuels.

Argonne's **internationally recognized** transportation research program is at the forefront of **advanced vehicle technology** development, helping to accelerate the transition to alternative energy sources.

Biologist Dan Schabacker loads a biochip onto a reader for analysis. Developed initially to determine the “signatures” of biological agents that can be used for bioterrorism, Argonne’s biochip technology could also become a standard diagnostic tool for human and veterinary medicine.

## Nuclear Energy

Nuclear power is one of the few commercially available carbon-free sources of energy. Argonne is capitalizing on its role as a national center of high-performance computing to implement a science- and simulation-based approach to developing advanced nuclear energy. Much of this effort focuses on advanced fuel-cycle technologies that maximize the efficient use of nuclear fuel, reduce proliferation concerns and make waste disposal safer and more economical.

## National Security

Argonne provides the nation with critical security and defense technologies that prevent and mitigate events having the potential for mass disruption or destruction. Our work focuses on threat decision science, sensors and materials, infrastructure assurance, emergency response, cyber security and the nonproliferation and forensics of radiological and nuclear materials and equipment.

## Energy Storage

Argonne is pursuing major scientific and engineering advances in high-performance batteries for all-electric vehicles, storage for the national electric grid and manufacturing processes for these materials-intensive devices.

Chemist and materials scientist Ilias Belhorouak monitors the fabrication of electrode materials for use in a plug-in hybrid vehicle's energy storage system. Argonne is the Department of Energy's lead laboratory for advanced battery technology research.

# POWERFUL TOOLS FOR DISCOVERY AND INNOVATION

Three of our major research initiatives aim to develop the next-generation tools needed to keep America's scientific enterprise strong.

## Hard X-ray Sciences

Argonne develops leading-edge high-energy X-ray techniques to study materials and chemical processes under real conditions in real time. This understanding is critical to developing game-changing new technologies in such fields as transportation, energy storage, environmental protection, health and medicine, and national security.

## Leadership Computing

High-performance computing is becoming increasingly important as more scientists and engineers use modeling and simulation to study complex chemical processes, exotic new materials, advanced energy networks, natural ecosystems and sophisticated energy technologies. One of the world's fastest computers for open science, Argonne's IBM Blue Gene/P, is capable of more than 500 trillion calculations per second. By 2012, Argonne will be home to an IBM Blue Gene/Q supercomputer capable of running programs at 10 quadrillion calculations per second. It will be able to do in one second what it would take every man, woman and child in the world to do if they performed a calculation every second for more than two weeks.

## Materials and Molecular Design and Discovery

Argonne is making revolutionary advancements in the science of materials discovery and synthesis — predicting, understanding and controlling where and how to place individual atoms and molecules to achieve desired material properties. The ultimate goal, which lies many years in the future, is to design new materials with useful new properties and build them one new atom at a time.

Argonne Leadership Computing Facility (ALCF) Director Pete Beckman (left), Director of Science Paul Messina (center) and Manager of User Support and Outreach David Martin celebrated the ALCF's surpassing two billion processor-hours of computations at a mind-boggling speed of more than 500 trillion calculations per second. The ALCF enables scientists and engineers to conduct cutting-edge research in just weeks or months rather than years.

Led by Distinguished Fellow Andrzej Joachimiak, researchers at Argonne's Midwest Center for Structural Genomics are using X-ray crystallography at the Advanced Photon Source to crack the genetic code of important proteins. This will provide the basis for advances in alternative energy sources, bioremediation strategies and new therapeutics and diagnostics to improve human health.

# National Scientific User Facilities Enable Great Discoveries and Use-inspired Research

Argonne designs, builds and operates world-class national scientific user facilities that annually host more than 4,400 scientists and engineers from leading academic, industrial and government laboratories worldwide. These facilities enable researchers to conduct experiments they cannot perform anywhere else in the world and provide access to Argonne staff expertise and support in a wide array of technical fields.

Argonne's Advanced Photon Source and Center for Nanoscale Materials

## Advanced Photon Source

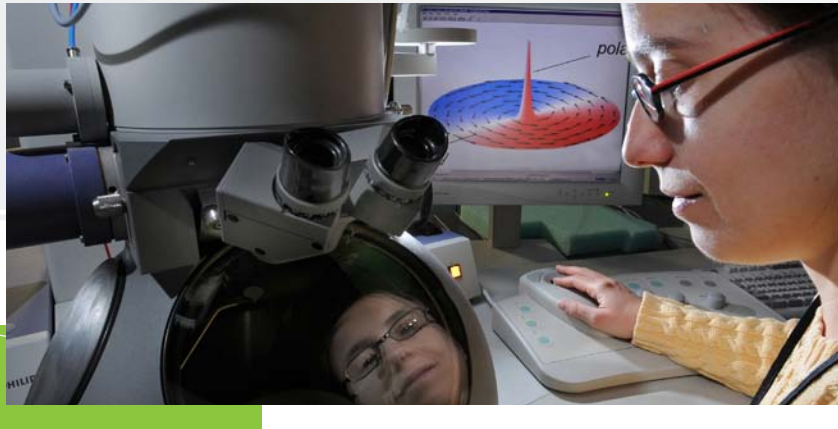
The most brilliant X-ray beams for research in the Western Hemisphere at the Advanced Photon Source (APS) are used for forefront basic and applied research. Users of the APS conduct research that extends from the center of the Earth to outer space, from new information on combustion engines and microcircuits to new drugs and nanotechnologies whose scale is measured in billionths of a meter. The APS enhances America's competitiveness in such areas as superconductors, semiconductors, pharmaceuticals, polymers and catalysts, and promises to have far-reaching impact on our technology, economy, health and fundamental knowledge of the materials that make up our world.

## Argonne Leadership Computing Facility

One of the fastest and most energy-efficient supercomputers in the world for open science, the IBM Blue Gene/P Intrepid is available to the international computational science community to accelerate major scientific discoveries and engineering breakthroughs for humanity. No longer mere tools in the search for technical knowledge, supercomputers have become increasingly essential to almost every aspect of science and engineering. For example, researchers are using Argonne's supercomputer for the analysis and design of advanced nuclear reactors, to develop new medical treatments for incurable diseases, assess the impacts of climate change and design new materials required for advanced energy storage technologies.

## Argonne Tandem Linear Accelerator System

The Argonne Tandem Linear Accelerator System (ATLAS) is the premier DOE National User Facility for low-energy nuclear research — the energy domain best suited to study the properties of atomic nuclei, the core of matter and the fuel of stars. Scientists from all over the world use the facility and the associated experimental equipment to understand the nuclear force that binds protons and neutrons into nuclei, to determine the rates of the nuclear reactions that make the stars shine and to measure with exquisite precision the fundamental symmetries of nature. In addition, the facility is a fertile ground for applications in fields as varied as material science, geology and medicine. Furthermore, continuous improvements and upgrades of the facility keep it at the forefront of nuclear research.



In research conducted at the Center for Nanoscale Materials and the Electron Microscopy Center, materials scientist Mihaela Tanase discovered a new method to control the way atoms in a magnetic disk orient themselves to form "nanoscale vortices." This could change the way we store data electronically, eventually enabling the writing and reading of digital information with greater sensitivity, reliability and efficiency.

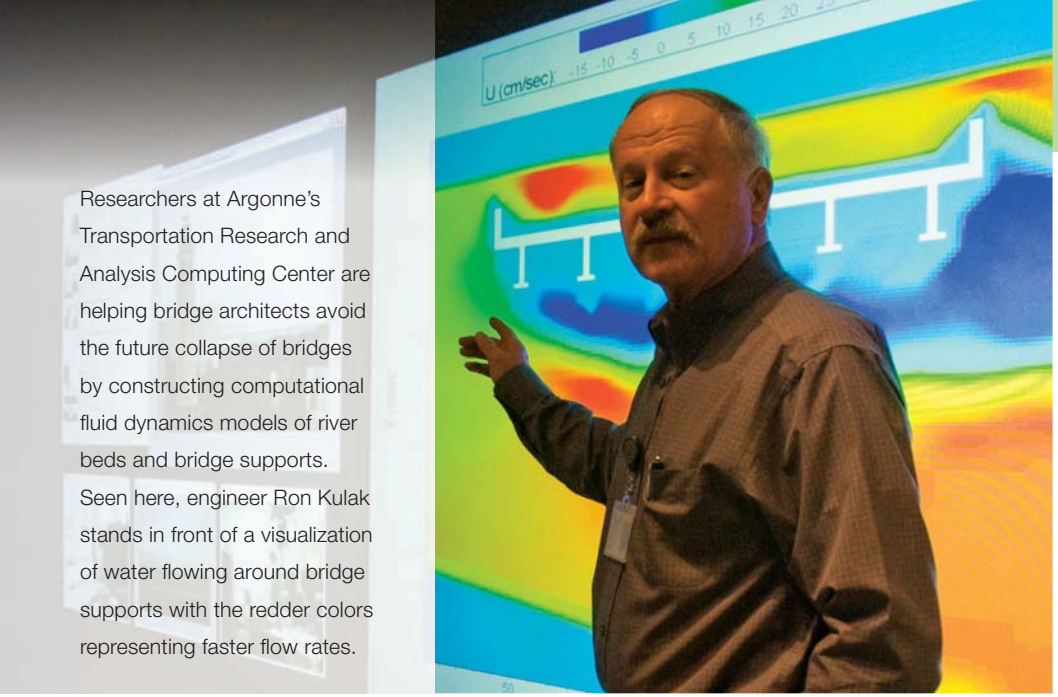
## Atmospheric Radiation Measurement Climate Research Facility

Led by Argonne, nine U.S. Department of Energy national laboratories comprise the Atmospheric Radiation Measurement (ARM) Climate Research Facility, which provides the world's most comprehensive observational and data gathering capabilities for climate change research. ARM serves nearly 5,000 registered users from 15 federal and state agencies, 375 universities and 67 countries. Data collected gives scientists a way to identify important atmospheric processes and verify climatological computer models that give us the clearest picture of how the Earth's climate is changing.

## Center for Nanoscale Materials

Working at the nanoscale (just billionths of a meter), users of Argonne's Center for Nanoscale Materials (CNM) are creating new materials, methods and technologies to address some of the world's greatest challenges in energy security, lightweight but durable materials, high-efficiency lighting, information storage, environmental stewardship and advanced medical devices, to name just a few. As one of the world's foremost nanotechnology research institutions, CNM provides its users with the premier instrumentation and staff expertise necessary to fabricate extraordinarily tiny devices from the "top-down" by writing with electron beams; to self-assemble nanoparticles and atomically-thin films into highly-ordered nanostructures from the "bottom-up;" and to probe structure and performance at the nanoscale with microscopes based on atomic force, spin-polarization and in three dimensions with the world's highest-resolution X-ray microscope.

Two ARM researchers install a precipitation sensor on the tundra outside of Barrow, Alaska.




Researchers at Argonne's Transportation Research and Analysis Computing Center are helping bridge architects avoid the future collapse of bridges by constructing computational fluid dynamics models of river beds and bridge supports. Seen here, engineer Ron Kulak stands in front of a visualization of water flowing around bridge supports with the redder colors representing faster flow rates.

## Electron Microscopy Center

Argonne's Electron Microscopy Center (EMC) develops and operates a suite of instrumentation that includes several of the world's unique electron microscopes. These instruments provide EMC users a broad range of capabilities for imaging, diffraction and spectroscopy that are essential for world-class materials characterization; such information is necessary to the development of advanced energy technologies. Research activities include defect and transformation processes, microstructure and properties of complex oxides, physical behavior of nanoscale and magnetic materials, the structure of amorphous materials through fluctuation electron microscopy and more recently, programs in magnetic structures and domain dynamics. EMC users have created strong, hard carbon nanotubes, discovered longer-lasting metal alloys and controlled tiny magnetic "tornadoes" at the nano level that could improve data storage.

## Transportation Research and Analysis Computing Center

Funded by the U.S. Department of Transportation, the Transportation Research and Analysis Computing Center (TRACC) provides federal, regional and state transportation program researchers, and those from private industry, with a state-of-the-art massively parallel computer system, advanced scientific visualization capability, high-speed network connectivity and modern engineering analysis software to enable improvements in the efficiency, economics and safety of transportation systems. Large-scale, detailed models of the systems and underlying phenomena are used in areas such as crashworthiness, aerodynamics, evacuation planning, combustion, thermal management, weather modeling and traffic simulation.

# Collaboration is the Key to

Because no single organization has the reso… cientific… technological challenges, Argonne actively … national laboratories.

Argonne collaborate… industry in…

- Licensing its technology, …
- Transforming its technology into … ,
- Creating new start-up compa… blog… market, and
- Conducting research … to … solve … ologic… ems.

The i… nne's daily activities is reflected in the …

For more information on working with Argonne, visit

www.anl.gov

# Success

Senior scientist Michael Wang (seated foreground) led the development of Argonne's Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) model, which is widely recognized as the "gold standard" for evaluating and comparing the environmental impacts of transportation fuels and advanced vehicles. The free software has more than 10,000 users worldwide, including government agencies, the auto and energy industries, research institutions, universities and public interest groups. Other members of the GREET team include (from left) analysts Andy Burnham, Jeongwoo Han and Amgad Elgowainy.

Argonne works proactively with industry to identify commercialization opportunities, license new applications and introduce technologies to the private sector.

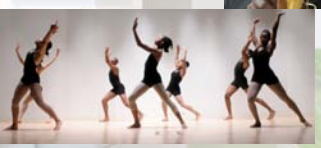
# Argonne

## A Great Place to Work…

Argonne is dedicated to hiring, developing and retaining top-quality staff. The laboratory offers job stability, advancement, outstanding benefits and the opportunity to contribute to research that addresses the nation's major R&D challenges and advances the frontiers of science and technology.

The laboratory is committed to nurturing and developing talent. Argonne encourages and values lifelong learning with tuition assistance for doctoral and post-doctoral studies. More than 1,500 college graduate students and post-doctoral researchers from some 190 U.S. universities gain valuable experience every year as part of our daily R&D activities. The Strategic Laboratory Leadership Program, one of many educational opportunities available to employees, develops future research leaders who are well versed in strategic thinking.

Argonne strongly encourages its employees to balance work, home and community activities. The laboratory's lengthy list of benefits includes an on-site child care center, a credit union, flexible work schedules and generous leave and vacation programs. A wide variety of social clubs such as the Hispanic Latino Club, the Arts and Crafts Club, Engineering Golf League, Running Club, Chinese Association, Choral Group and Chess Club promote fellowship and diversity at Argonne.



Argonne employees support local and national nonprofit health and welfare agencies and have contributed more than $4.5 million in the past five years through the Argonne Combined Appeal.

The laboratory's pollution prevention programs have saved Argonne and taxpayers millions of dollars since 1996 by diverting waste from landfills, conserving energy, improving indoor air quality and reducing operating costs. Argonne's land management program protects its natural habitats of tall grass prairie, oak savanna, oak forest and wetland areas, which clean the air and water, reduce flooding and enhance the site's aesthetics.

Located 25 miles southwest of Chicago in DuPage County, Illinois, Argonne occupies 1,500 wooded acres surrounded by the Waterfall Glen Forest Preserve. Numerous biking and hiking trails are available throughout the laboratory and the forest preserve.

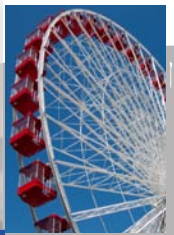
Agronomist and soil scientist Cristina Negri is investigating the effectiveness of phytoremediation — the use of plants and trees to clean and restore the environment.

# …and a Great Place to Live

Argonne's surrounding communities offer diverse, attractive housing choices. The Chicago area boasts top-rated schools and universities and a superior transportation network of interstate highways, rail and bus lines. The laboratory's campus is about half an hour by freeway from two major international airports, O'Hare and Midway.

Argonne's proximity to Chicago offers employees world-class museums, a diverse theater scene, major music and dance companies, the fabulous lakefront, boating and fishing, premier shopping and fashion, distinct and culturally diverse neighborhoods, more than 7,300 places to eat and drink, and sports teams in all major professional leagues and more than 100 college teams.

# ARGONNE



# about Argonne

The nation's first national laboratory, Argonne is the Midwest's largest federally funded R&D center. With more than 1,200 scientists and engineers in dozens of fields and a unique suite of leading-edge scientific user facilities, Argonne conducts basic and applied research focused on solving the nation's challenges in sustainable energy, a clean environment, economic competitiveness and national security.

## For more information

Communications & Public Affairs
9700 S. Cass Avenue, Bldg. 201
Argonne, IL 60439
630.252.2200
www.anl.gov
media@anl.gov

## Location

Argonne is located in DuPage County, Illinois, about 25 miles southwest of Chicago, just off Interstate 55.

## Management

Argonne is managed by UChicago Argonne, LLC for the U.S. Department of Energy's Office of Science.

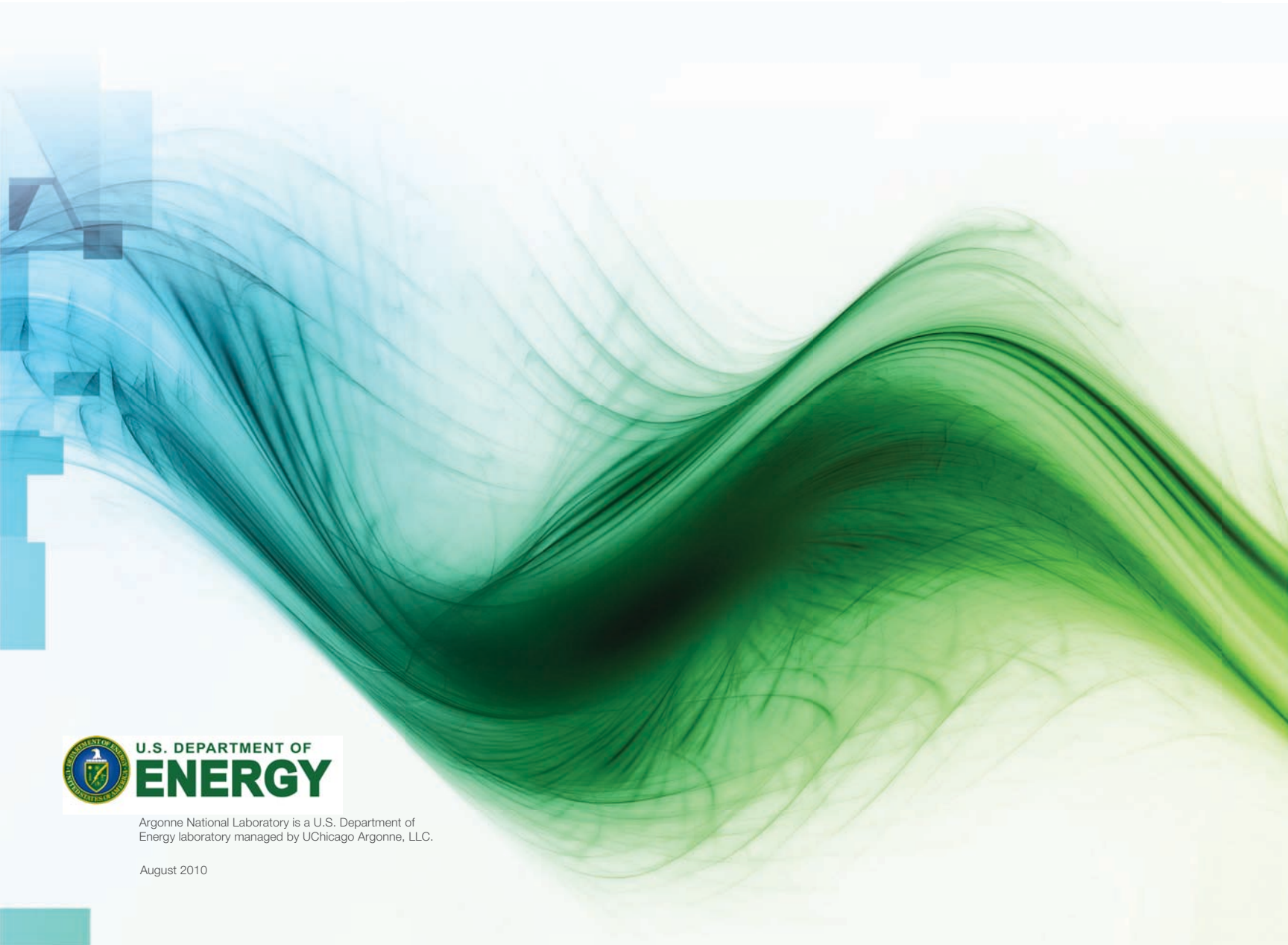
## Funding

The laboratory's annual operating budget of about $650 million supports more than 200 research projects.

## Staff

About 3,200 employees work at Argonne, including more than 1,200 scientists and engineers, three-quarters of whom hold doctoral degrees. Additionally, Argonne's user facilities host more than 4,400 researchers from around the world on an annual basis.

## www.anl.gov



U.S. DEPARTMENT OF ENERGY

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