

# ADVANCING FRONTIERS IN ENERGY AND ENVIRONMENT



**Pacific Northwest**  
NATIONAL LABORATORY





## OUR MISSION IS TO . . .

Increase U.S. energy capacity and reduce dependence on imported oil through contributions in:

- clean fossil energy
- nuclear energy
- electricity infrastructure
- energy efficiency and renewable energy.

Reduce environmental effects of human activity and create sustainable systems through contributions in:

- environmental health and remediation
- sustainable environmental systems
- nuclear regulatory support.



Front cover: Researchers at PNNL are delivering new knowledge about the processing and use of glass for hazardous waste stabilization and storage.

Above: PNNL's work in vehicle emissions is helping to make fuel-efficient diesel engines a more environmentally friendly option for transportation applications.

## IT IS A TRANSFORMATIONAL TIME IN AMERICA AND THE WORLD.

Change is unprecedented and rapid. Nations fiercely compete for limited natural resources. Carbon emissions threaten environmental quality worldwide. Growing cities wonder where they'll acquire new supplies of clean water and electricity. Ultimately, these and other energy and environment challenges test national and global economies—and possess the potential to diminish our quality of life.

At the U.S. Department of Energy's (DOE's) Pacific Northwest National Laboratory, we believe the best way to address change is to create change—through visionary discovery and innovation. There is no single solution to our energy and environment challenges. Instead, we must closely examine the outcomes we need to achieve the energy security, environmental footprint, and economic performance we need as a nation.

By framing the issue this way, future investments in research, development, and deployment will help America be a leader in meeting its growing needs with secure, sustainable, and affordable energy.

PNNL stands ready to deliver outcomes for America. Our expertise was forged through decades of successful research and development and provides us with the foundation for understanding the complex interrelationships between energy and environment issues. Our interdisciplinary research teams bring objective, balanced approaches to their work. We offer unique facilities and a demonstrated ability to move science and technology from discovery to deployment. We readily collaborate with other national laboratories, private industry, and universities to deliver the most effective solutions.

PNNL is a national laboratory making national impacts in the energy and environment fields.

PNNL's Electricity Infrastructure Operations Center helps researchers develop and test new knowledge and tools for improved management and control of the nation's power grid.



# DELIVERING ENERGY SOLUTIONS

There are many energy challenges in the world today. Global consumption continues to increase, regional tensions threaten to interrupt supplies, and carbon emissions grow. At PNNL, we're building a bridge to a better energy future. Our scientists and engineers are helping transport the nation from today's energy economy to renewable, nuclear, and near-zero-emission hydrocarbon energy systems.

We're also anticipating key energy issues of the future—including the likelihood that nations will adopt restrictive carbon management policies to reduce emissions. We are prepared to deliver the new ideas and solutions that will facilitate these policies and mitigate the resulting energy and economic impacts.

Our energy research emphasis includes clean fossil energy, nuclear energy, improvements to the electricity infrastructure, and energy efficiency and renewable energy. From basic research to applied, our work ranges from delivering new understanding and new discoveries to driving down the costs of technologies to make them economically viable and ready for deployment.

**Clean fossil energy.** PNNL seeks to enable economically and environmentally sustainable conversion of America's hydrocarbons—including coal, oil, gas, and biomass—to gases, liquid fuels, electricity, and chemicals. We apply to this objective our expertise in chemical and materials science, catalysis, process engineering, sub-surface science and engineering, and other disciplines. As part of the effort, PNNL is

## ENERGY FACTS

- World consumption of liquid fuels and other petroleum is projected to grow by almost 900,000 barrels per day in 2008 and an additional 1.4 million barrels per day in 2009.
- The United States imports nearly 60 percent of its petroleum.
- Tensions in the Middle East and other regions continue to raise concerns about oil supplies.
- Increasing fuel costs for energy generation could boost U.S. residential electricity prices by an annual average of nearly 10 percent in 2009.
- The United States has 25 percent of the world's coal supply.
- Coal is used to generate about half of the electricity in the United States and is the fastest growing energy resource in the world.



Coal gasification offers a clean, versatile process for turning coal into electricity and capturing carbon dioxide. Researchers are using PNNL's research-scale gasifier to advance gasification technology.



partnering with industry in the development of near-zero-emission power generation and processing technologies, and pursuing innovative approaches for carbon sequestration. Advances in clean fossil energy will help meet America's energy demand, improve the nation's ability to tap its own abundant hydrocarbon resources for energy, and allow the continued use of fossil fuels, even as the United States and other nations begin restricting carbon emissions.

**Nuclear energy.** Expansion of nuclear energy diversifies and strengthens America's energy mix. PNNL combines its prominent nuclear science capabilities with nonproliferation and nuclear safety

expertise to accelerate safe and economic expansion of nuclear power. We provide solutions in four areas that enable nuclear energy growth: safety, spent fuel disposition, nonproliferation, and life extension. As we help extend the life of existing reactors, we will also support next-generation reactors and fuel-cycle technologies. PNNL's Radiochemical Processing Laboratory, with its specialized instrumentation, is home to our chemical separations and fuel recycling research. As part of our strategy, we are working toward the creation of a research, development, and demonstration center at PNNL to advance technologies for spent fuel and radioisotope processing.

**Electricity infrastructure.** As the home of the Electricity Infrastructure Operations Center (EIOC), PNNL is at the forefront of power systems research and development in America. We marshal our significant electricity infrastructure and power system engineering capabilities to make the nation's power grid more efficient and productive. As national demand for electricity increases, PNNL will continue to deliver new tools and methods that more effectively manage supply and demand, and enhance grid security. We'll also help ensure the grid is ready to bring new sources of generation, such as wind and solar power, on line. The EIOC provides a real-time test bed for the technologies we develop and serves as a platform for collaborative research and development.

**Energy efficiency and renewable energy.** PNNL applies its long-standing expertise in chemistry, catalysis, materials, computational science, biotechnology, and other disciplines to the task of advancing energy efficiency and renewable energy. Our technological breakthroughs and innovation will help:

- promote energy efficiency in transportation and enable the transition to electric- and hydrogen-powered vehicles
- expand energy efficiency in commercial buildings
- enable sustainable use of biomass-derived fuels and chemicals that can be delivered to the marketplace via existing infrastructures
- increase domestic supplies of water, wind, geothermal, and solar energy resources.



Thin films—or microscopic layers of material with unique, useful properties—offer enormous potential for energy applications. PNNL research in this discipline is yielding innovative approaches in areas that include solid-state lighting and displays, batteries, and photovoltaics.



# PROTECTING THE ENVIRONMENT

We are at an environmental crossroads, nationally and internationally. In America, the nation must address day-to-day impacts of human activity, solve the problem of legacy waste at former U.S. weapons production sites, and lend expertise to emerging global issues, such as carbon emissions. PNNL applies its capabilities to develop solutions that protect air, water, and land, and to address numerous interrelated energy issues. Our research agenda focuses on environmental health and remediation, sustainable environmental systems, and nuclear regulatory support.

**Environmental health and remediation.** Our goal is to reduce environmental effects from nuclear waste and accelerate cost-effective cleanup of contaminated sites. With PNNL signature capabilities in predictive process and subsurface science, we already are helping to address nuclear waste issues at the DOE's Hanford Site in southeastern Washington State. Our efforts are leading to new research concepts for enabling the processing and disposal of radioactive waste and the mitigation of environmental effects of contaminants in the subsurface.

## ENVIRONMENT FACTS

- The amount of radioactive waste from U.S. weapons production would fill the Louisiana Superdome.
- 98 percent of carbon dioxide emissions result from combustion of fossil fuels; U.S. carbon dioxide emissions are increasing and China's carbon dioxide emissions are outpacing predictions.
- More than 100 nuclear reactors are in the planning stages or are being built worldwide. In the next few years, the U.S. Nuclear Regulatory Commission anticipates receiving applications for more than 30 new reactors in the United States.



PNNL researchers conduct water sampling in support of studies into groundwater and river interactions and the effects on river ecology.





**Sustainable environmental systems.**

Our expertise is delivering technology and management solutions to predict and mitigate the environmental impact of energy development and climate change. For example, we are applying our capabilities—in subsurface, surface, and atmospheric sciences, sensors, and regional-scale modeling—to understand, predict, and mitigate effects of global climate change and promote healthy, sustainable ecosystems. We are also developing approaches to predict the impact that emerging energy technologies will have on water resources and deliver mitigation solutions.

**Nuclear regulatory support.** Our safety and environmental leadership will help enable the responsible use of nuclear power in America and globally. In the United States, more than 30 new reactors are on the drawing board. We will partner with the U.S. Nuclear Regulatory Commission and apply our expertise in environmental analysis and nuclear safety to improve reactor designs, licensing processes, and safe operations for proposed reactors. We'll further contribute our knowledge and experience in areas including nondestructive examination and materials performance to enable safe, extended operation of existing reactors.

PNNL knowledge, augmented by the testing capabilities of the Pretreatment Engineering Platform, is helping to shed light on hazardous waste-processing characteristics and inform environmental cleanup approaches on DOE's Hanford Site.



# OUR PEOPLE DELIVER OUTSTANDING RESULTS

More than 1,000 staff at PNNL—including 550 scientists and 250 engineers—directly support energy and environment research. Our expertise is concentrated in disciplines that include chemistry, environmental science, geology, health physics, life sciences, and materials science. We also possess significant acumen in chemical, electrical, environmental, mechanical, and nuclear engineering. We readily assemble interdisciplinary teams to tackle tough problems and deliver results.

## We're at the forefront of thought leadership and collaboration

PNNL's energy and environment experts serve as resources to policymakers, lead national forums, and participate in prestigious professional societies and academies. We understand the importance of research collaborations, and we frequently partner with other national laboratories, industry, and universities. We recently reached landmark agreements with China to work together in energy, science, and security.



PNNL's Radiochemical Processing Laboratory is a Hazard Category 2 non-reactor nuclear lab that facilitates work with highly radioactive materials. Researchers in the RPL are advancing solutions in radioactive and hazardous waste cleanup, nuclear fuel processing and disposal, and medical isotope production.

Outstanding computing resources are a hallmark of EMSL, the Environmental Molecular Sciences Laboratory, at PNNL. These capabilities advance molecular science in areas such as aerosol formation, bioremediation, catalysis, climate change, hydrogen storage, and subsurface science.



# WORLD-CLASS FACILITIES

Outstanding facilities provide a solid foundation for PNNL's energy and environment research.

## Applied Process Engineering Laboratory (APEL)

APEL is a unique business startup center. It provides laboratory, engineering, and manufacturing space to PNNL and other tenants. APEL holds permits for air and water discharge and flammable storage.

## Bioproducts, Sciences, and Engineering Laboratory (BSEL)

BSEL provides a highly collaborative environment and contemporary tools for bio-based products and biofuels research. Washington State University Tri-Cities and PNNL jointly operate the 57,000-square-foot laboratory, which opened in 2008.

## Electricity Infrastructure Operations Center (EIOC)

The EIOC at PNNL combines industry-leading software, real-time power grid data, and advanced computation into a fully capable control room setting. The ideas and technologies developed here address the national need to better manage the grid. The EIOC also is available to utilities, vendors, government agencies, and universities interested in research, development, or training.

## Environmental Molecular Sciences Laboratory (EMSL)

EMSL is a DOE national scientific user facility located at PNNL. This modern laboratory provides integrated experimental and computational resources and supports research in the environmental molecular sciences.

## Marine Sciences Laboratory (MSL)

The MSL, located at Sequim, Wash., is DOE's only marine laboratory. The facility provides analytical and general purpose laboratories, as well as wet or support laboratories supplied with heated and cooled freshwater and seawater. MSL also operates a 28-foot research vessel.

## Pretreatment Engineering Platform (PEP)

Researchers will use this novel platform to test and analyze simulated hazardous waste and predict waste processing characteristics. The resulting knowledge helps inform waste treatment decisions on the nearby Hanford Site.

## Radiochemical Processing Laboratory (RPL)

The RPL serves as a cornerstone of PNNL research in environmental cleanup and the beneficial use of radioactive materials. The 144,000-square-foot Hazard Category 2 non-reactor nuclear laboratory contains specialized facilities and instrumentation for work with highly radioactive materials.

## Research Aircraft Facility (RAF)

PNNL operates DOE's Research Aircraft Facility, serving atmospheric scientists at DOE and other government and industry laboratories. RAF's airborne research capabilities help build understanding of atmospheric processes.

## Subsurface Visualization Laboratory

The Subsurface Visualization Laboratory is being developed at PNNL. The laboratory will serve as a platform for PNNL's carbon sequestration work, helping demonstrate and integrate PNNL capabilities in subsurface science as they relate to clean fossil energy and environmental health and remediation.



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