DISCOVERY IN ACTION

More than 30 years ago, Pacific Northwest National Laboratory worked with the Bonneville Power Administration to design and implement the largest effort to gather real energy-use data up to that time. These foundational data enabled the U.S. Department of Energy to begin setting design standards, including the Super Good Cents homes of the Northwest, which debuted in 1984. The data also provided the basis to develop energy efficiency measures to be included in building energy codes and led to the first efforts to set minimum efficiency standards for appliances. Improving energy efficiency in buildings and appliances significantly reduces the impacts of energy use by decreasing total energy consumption, peak energy demand and the nation's carbon footprint.

Keeping the lights on —and so much more

This is the third of a 12-part series that features some of the scientific challenges PNNL has tackled over its 50-year history and highlights its vision for the future. PNNL is one of 10 national laboratories overseen by the U.S. Department of Energy's Office of Science and has been managed by Battelle since its inception in 1965. Through this enduring partnership—and by working closely with sponsors and collaborators—PNNL builds upon its legacy to advance science and solutions that improve the lives of Tri-Citians and people around the world. This edition focuses on PNNL's work to increase energy efficiency and improve the reliability of the U.S. electrical grid.

Owned by the U.S. Department of Energy; operated by Battelle; and supported by academic, industrial and governmental collaborators, Pacific Northwest National Laboratory is celebrating 50 years of inspiring and enabling the world to live prosperously, safely and securely. Interdisciplinary teams at PNNL address many of America's most pressing issues in energy, the environment and national security through advances in basic and applied science. With an annual budget of about $1 billion and nearly 4,300 staff members, Battelle is the largest employer in the Tri-Cities.

Learn more about PNNL at **www.pnnl.gov** and through stories to commemorate 50 years of scientific discovery contributed by employees, retirees and the community at **www.celebrate.pnnl.gov**.

PACIFIC NORTHWEST NATIONAL LABORATORY

Imagine a volunteer force of clothes dryers and water heaters, marching in to save the region from a widespread power outage. While it might sound like science fiction, the DOE's Pacific Northwest National Laboratory developed a technology in the late 1990s that brings this concept to life.

The Grid Friendly™ Appliance Controller responds to distress signals on the grid and can instantly, inconspicuously and temporarily turn off certain functions of household appliances to relieve stress on the system. With even a few minutes' reprieve, grid operators could restore the balance between supply and demand—and prevent a problem from cascading out of control. A network of hundreds or thousands of appliances responding together could provide a fast, inexpensive safety net for the grid. This technology has been licensed to a company interested in developing it for commercial use.

"Our nation's energy needs have changed dramatically. Nobody was charging smart phones, running supercomputers or plugging in cars when the first power lines were strung," said Carl Imhoff, who leads PNNL's electricity infrastructure research. "Today, PNNL is looking at how to meet a growing demand with reliable, secure and affordable electricity, while integrating renewable resoures—like wind and solar—to bring the entire system into the information age."

Need for efficiency

Each year, the nation spends $300 billion and contributes 70 percent of its total electricity consumption to meet the energy demands of residential and commercial buildings. For more than two decades, PNNL researchers have supported DOE's Building Energy Codes and Appliance Standards programs by finding ways to decrease consumption, lower consumer energy bills and reduce the greenhouse gases emitted by electricity generation.

In the 1980s, PNNL worked with the Bonneville Power Administration on a multi-year program to gather real-time and comprehensive energy consumption data. The data collected informed early efficiency measures in the Northwest, becoming the foundation for DOE's building codes and appliance standards efforts, which are saving homeowners millions of dollars in annual energy costs.

Engineers and energy economists at PNNL draw upon applied building science, whole-building energy simulation and analysis to write and develop easy-to-implement, enhanced building energy efficiency codes, which can be adopted and enforced by state and local governments to make new buildings more comfortable and affordable.

Similarly, appliances are more efficient and affordable because of energy efficiency standards set by DOE. These standards are supported by technical and economic analyses performed by PNNL experts in Richland, Wash. and Portland, Ore.

Lighting the future

When highly efficient, sub-compact fluorescent lights were introduced in the 1970s, the bulbs didn't fit in existing fixtures and were significantly more expensive than conventional incandescent bulbs. PNNL helped manufacturers reduce the size, improve the performance and lower the cost of CFLs. Today, researchers support industry in delivering a new generation of even more efficient lights that use light emitting diodes, or LEDs.

In 2007, Seattle City Light worked with PNNL to explore using LED streetlights to reduce its carbon footprint, save money and improve customer service. The resulting $16.7 million invested by Seattle City Light to convert 41,000 residential street lights to LED fixtures between 2010 and 2014 is saving the city $2.5 million annually.

Mixing in renewables

Managing the energy system and ensuring reliability has become increasingly challenging as more electricity is produced by wind or solar energy instead of by more predictable, large-scale power production plants. Working with industry, researchers built a tool that accurately predicts whether an intermittent renewable resource will be available to meet demand and the impact of detected shortages.

Wind power efforts date back to 1980, when researchers wrote a national wind energy atlas used by industry, utilities and government agencies to assess the economic feasibility of installing turbines.

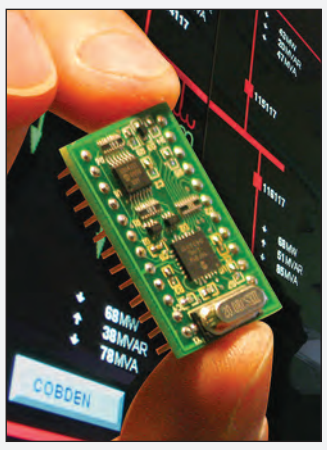
Today, PNNL scientists are developing energy storage technologies to help make renewable energy available when and where it's needed. Researchers also are determining the performance and cost requirements to make these technologies commercially viable.

Ushering in the modern grid

The power grid is a complex and interconnected network. It's possible for a minor disturbance to quickly escalate, like the major East Coast blackout in 2003. PNNL has developed a detection and visualization tool that allows grid operators to "see" growing problems. By combining real-time data with new analytic methods, these tools give operators the information they need to quickly take steps to prevent blackouts.

PNNL also developed VOLTTRON™, a software platform where appliances and devices such as lighting and electric vehicles are represented by "agents" that can communicate to more efficiently manage, prioritize and balance energy use. The source code for VOLTTRON™ is publically available so researchers and others can use it to develop applications.

"It's easy to take our electricity system for granted," said Imhoff, who also chairs DOE's Grid Modernization Laboratory Consortium. "The lights come on when we flip the switch. Our bills are among the lowest in the nation. But quietly, behind the scenes, PNNL is helping to keep the lights on and providing a more efficient and resilient energy infrastructure."



Concepts like this Grid Friendly™ Appliance Controller were tested in real homes by people who volunteered to participate in the 2006 Olympic Peninsula Smart Grid Demonstration Project that pioneered key smart grid concepts for DOE.

Researchers support a DOE program to evaluate commercially available light emitting diode products. PNNL also runs a facility that integrates robotics, sensors and software to test new lighting products before they go to market.

Building upon expertise in electricity transmission and distribution, PNNL created the Electricity Infrastructure Operations Center, a functioning control room that brings together industry software, real-time grid data and advanced computation. Shaped with input from utilities and researchers across the Northwest, technologies developed and tested here can be transferred to industry and address the national need to better manage and control the grid.

PNNL developed a Smart Charger Controller that tells the battery in a plug-in hybrid vehicle when to start and stop recharging based upon existing stress on the electric grid. A previous PNNL study showed that America's existing power grid could meet the needs of about 70 percent of all U.S. light-duty vehicles if battery charging was managed to avoid new peaks in electricity demand. The controller automatically recharges electric vehicles during times of least cost to the consumer and lower demand for power.