

Overcoming Market Barriers to Energy Efficiency

Many technologies that can make a significant difference in building energy use already exist or are close to commercialization, but are underutilized. PNNL's technology and market experts interact extensively with stakeholders – including building owners, technology purchasing agents, equipment manufacturers, utilities, energy-efficiency organizations, and government agencies – to develop collaborative projects that foster the introduction and deployment of advanced technologies. PNNL uses several innovative techniques including:

- Forming groups of buyers and approaching manufacturers willing to develop advanced technologies with the assurance of an adequate market
- Helping organize design competitions such as Lighting for Tomorrow, a competition that increases the market presence of attractive, energy-efficient lighting fixtures
- Developing pre-packaged combinations of technologies that are easily implemented in the field, such as the innovative, high-efficiency lighting solutions developed under the DOE Commercial Lighting Initiative
- Working with utility programs to qualify technology solutions for energy efficiency incentive and rebate programs
- Conducting technology demonstrations and field performance evaluations for new technology, such as PNNL's support to the Technology Validation Program for the U.S. Navy
- Supporting the development of voluntary product guidelines, such as DOE's ENERGY STAR® specifications for solid state lighting products
- Testing products to ensure they meet manufacturers' claims and conducting independent assessments of technology cost and performance
- Documenting best practices – for example, results of DOE's Building America program – a residential energy efficiency demonstration effort.

PNNL SUCCESS STORY:

For the first time in 2007, the Lighting for Tomorrow competition included solid-state lighting fixtures. The winner was a recessed down light, which fits in standard recessed housings. It exceeds the efficacy of even the most efficient fluorescent systems. See: <http://www.lightingfortomorrow.com/>.



Understanding the Impacts: Analysis and Planning

PNNL's staff of engineers, economists and business analysts work together to perform technology market assessments, economic impact analyses, and a wide range of analyses on building energy topics. Researchers analyze building trends, project future building energy consumption, assess the costs and benefits of new technologies, develop buildings-related data sets, and build tools to support analysis of building issues. For example,

- A PNNL-developed software tool – BEAMS (Building Energy Analysis and Modeling System) – provides estimates of future energy, cost and emissions savings resulting from energy efficiency programs.
- PNNL's MiniCAM (Mini Climate Assessment Model), an integrated assessment model, makes global 100-year projections of energy supply/demand and greenhouse gas emissions. Recently, we added detail to MiniCAM for the U.S. buildings sector and advanced building technologies.
- PNNL's ImSET (Impact of Sector Energy Technologies) tool is an input-output model of the U.S. economy used to estimate the impacts of energy supply and efficiency programs on employment.

Many of PNNL's technical analyses are funded by DOE and tailored toward evaluating the energy and environmental benefits of advanced building technologies in support of program planning activities. These include development of technically robust multi-year program plans for DOE's Building Technologies Program and assistance in application of performance management principles to research and development programs.

About PNNL

PNNL's buildings energy efficiency work is an important element in a wider portfolio of research and development work funded by DOE, other federal agencies and the private sector. PNNL is a DOE Office of Science laboratory that solves complex problems in energy, national security, the environment and life sciences by advancing the understanding of physics, chemistry, biology and computation. PNNL employs 4,000 staff, has a \$700 million annual budget, and has been managed by Ohio-based Battelle since the lab's inception in 1965.

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Buildings Sciences Capabilities at Pacific Northwest National Laboratory

From Concept to Commercialization and Beyond

Buildings account for about 40 percent of our nation's energy use. That's 72 percent of U.S. electricity and 55 percent of natural gas, resulting in 39 percent of U.S. carbon dioxide emissions and a range of other negative environmental impacts.¹ The buildings sciences team at Pacific Northwest National Laboratory (PNNL) is committed to dramatically improving the energy efficiency of buildings and reducing their environmental footprint. With three decades of experience in the buildings energy field and a multi-disciplinary staff of scientists, engineers, economists and market experts, PNNL is a leader in all stages of buildings-related research, technology development and deployment. The PNNL buildings portfolio includes:

- Materials science research supporting advancements in buildings technologies and systems
- Development of tools, approaches and technologies for improving the efficiency of building operation and maintenance
- Technical assistance to design, build and evaluate high-performance, sustainable buildings
- Support for improved building energy codes and equipment standards



- Design and implementation of market transformation programs aimed at bridging the gap between product development and full-scale market adoption
- Analysis of building energy trends and economics as well as energy-efficiency program design, planning and deployment.

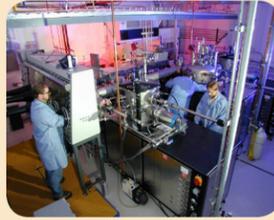
Providing the Science Foundation

Some of the key challenges in improving building energy efficiency involve advances in materials science. PNNL's applied science research serves as the foundation for breakthroughs in lighting, distributed energy production and other important building systems.

Working at the molecular level to improve efficiency and reduce costs, PNNL scientists are paving the way for the introduction of organic light-emitting diodes for solid-state lighting and other applications.

PNNL TECHNOLOGY: Solid-State Lighting

Solid-state lighting using organic light-emitting diodes (OLEDs) involves direct light emission from an organic semiconductor material applied as a thin film. Compared to an incandescent lamp, which turns most of the input power into heat, an OLED could potentially generate equivalent light using 90 percent less energy. PNNL is designing molecular structures that will lead to stable OLEDs at reduced costs. In related work, PNNL developed Barix™ barrier film technology, an ultrathin hermetic coating that can protect OLEDs, as well as displays and solar cells, from damage caused by atmospheric exposure. See: <http://eere.pnl.gov/buildingtechnologies/ssl.stm>.



PNNL's extensive knowledge base in materials synthesis, testing, design optimization, fuel processing and catalysis is supporting the development of solid oxide fuel cells, which can be used in distributed energy applications.

Leading the development of Micro Chemical and Thermal Systems (MICRO-CATS™) for a variety of applications, PNNL's microsystems offer efficiency advantages in heating, cooling and power-generation applications.

The Laboratory's materials science capabilities have been applied to developing lightweight materials, bio-products, optical materials and coatings that can be used to create a wide range of innovative building technologies and components, including new construction materials and systems, fenestration and other building envelope technologies.

Improving Energy Efficiency and Demand Response

Poor operation and maintenance (O&M) of buildings can result in 10 to 30 percent excess energy use. PNNL works with building owners and operators to develop and implement strategies for retrofitting building equipment and improving O&M practices, resulting in increased energy efficiency, lower energy costs, longer equipment life, reduced equipment downtime, and enhanced occupant satisfaction.

Understanding current building operating conditions is the first step in reducing energy consumption. PNNL uses state-of-the-art metering technologies to measure parameters such as temperature, pressure

flow, illumination and power to determine operational issues and quantify energy savings potential in buildings. PNNL engineers have developed wireless devices for electricity end-use metering that enable near real-time measurement, tracking and reporting without installing expensive wiring.

Tools such as PNNL's Facility Energy Decision System (FEDS) software can be used to identify retrofits, determine life-cycle costs and paybacks and prioritize options. FEDS has been used to identify tens of millions of dollars of cost-effective retrofits, particularly for the U.S. Army.

PNNL also develops sophisticated tools, such as the Whole-Building Diagnostician and the Rooftop Diagnostician, to help building operators diagnose and address equipment malfunctions.

PNNL TECHNOLOGY: Whole-Building Energy Module

PNNL's Whole-Building Energy (WBE) module, a component of the Whole Building Diagnostician, tracks electric energy use at the whole-building level. An enhanced version, called Energy Expert, was commercialized by NorthWrite Inc., and recently won a 2008 Excellence in Technology Transfer Award. Energy Expert uses trend data to automatically detect, and provide alerts for, anomalies in energy consumption. It creates a model that predicts future energy use and alerts building operators to variances between actual and expected consumption. See: <http://availabletechnologies.pnl.gov/technology.asp?id=60>.



Similarly, Decision Support for Operations and Maintenance (DSOM), a diagnostic software program developed by PNNL, significantly increases productivity and efficiency of central plant systems by monitoring performance of system components.

Training is key to PNNL's approach to improving O&M. PNNL is training businesses that install and service HVAC equipment in the state of Washington to offer a new service: retuning ineffective energy management and control systems in large commercial buildings. This service reduces HVAC energy use by up to 20 percent. The retuning of more than 50 buildings and the continued efforts of these HVAC businesses will result in significant long-term savings.

Through the U.S. Department of Energy (DOE) Federal Energy Management Program, PNNL wrote best practices guides for both O&M and metering. These guides, and the related training provided by PNNL, are helping reduce energy use throughout the federal government.

PNNL TECHNOLOGY: Grid Friendly™ Appliance Controller

This patented device won a Federal Laboratory Consortium award in 2007. A recent demonstration in 150 homes for clothes dryers and water heaters showed that Grid Friendly™ appliances are a technically feasible way to manage grid contingencies and prevent power outages. See: <http://gridwise.pnl.gov/>.



To support the implementation of peak demand reduction strategies and improve reliability of the electric grid, PNNL researchers developed the Grid Friendly™ Appliance controller, which senses the conditions of the grid by monitoring the frequency and voltage of the system and then provides automatic demand response by very briefly shutting down the appliance during disturbances.

Striving for Sustainable Design

Sustainable design integrates environmental, societal and economic goals into the design, construction and operation of a building. This approach includes minimizing energy use and ecological impacts and maximizing occupant satisfaction and community benefits, while adhering to sound life-cycle cost principles.

PNNL staff accredited under the Leadership in Energy and Environmental Design (LEED®) rating system use an integrated systems approach to support sustainable design in individual building projects and multi-building sites. Researchers study the benefits and costs of sustainable design and develop software tools, such as the Environmental Design Guide for Engineers, or EDGE, which provides information about more than 250 opportunities to incorporate sustainable design into projects.

PNNL SUCCESS STORY:

PNNL, together with the American Society of Heating, Refrigerating and Air-Conditioning Engineers and other collaborators, recently completed a series of Advanced Energy Design Guides to provide recommended approaches for dramatically decreasing energy consumption in commonly built commercial buildings, such as small offices, retail buildings and warehouses.



Energy efficiency is a primary focus within PNNL's approach to sustainable design. Our engineers use building simulation models, such as EnergyPlus, BLAST, DOE-2 and TRACE, as well as more specialized component models to study building energy loads. They develop strategies for decreasing energy use through improved use of high-efficiency equipment, lighting, the building envelope and architectural elements. PNNL's building energy simulation capability is the foundation for many of our building analysis projects.

Reshaping the Market through Codes and Standards

Improved building energy codes and equipment standards are proven mechanisms for increasing energy efficiency in buildings. Under PNNL's Building Energy Codes Program (BECP), supported by DOE, PNNL staff work collaboratively with the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the International Code Council, the states and other stakeholders to improve energy efficiency in building energy codes, make the codes easier to understand and implement, and assess code barriers to new energy-efficient technologies and practices. PNNL has the expertise to help building owners interpret and understand the codes and to provide technical assistance and training in the United States and abroad. PNNL estimates the annual impact of these activities to be over 100 trillion Btu of primary energy savings and almost \$780 million in energy cost savings.

PNNL TECHNOLOGY: Code Compliance Tools

PNNL developed REScheck™ for residences, and COMcheck™ for commercial buildings, to help builders and code officials determine code compliance. REScheck™ simplifies and clarifies code compliance with the Model Energy Code, the International Energy Conservation Code and a number of state codes. COMcheck™ includes software as well as manual code compliance and reference guides to simplify and clarify commercial and high-rise residential energy code compliance. REScheck™ and COMcheck™ were downloaded more than 130,000 times in 2007. See: <http://www.energycodes.gov/>.



In addition to working on model codes, PNNL plays a key role in helping DOE develop and update appliance and equipment standards as well as equipment test procedures. These standards serve as a mechanism to "raise the bar" – in a cost-effective way – for energy-using equipment in U.S. buildings.