Demonstrations Encourage Wider Use of Efficient Technologies
THE STORY IN BRIEF

Several hyper-efficient electric end-use technologies are now being considered for use in the United States, where for a variety of reasons they are not yet widely used. EPRI and several U.S. utilities are collaborating on a demonstration project to expand understanding of these promising technologies and of the barriers to their deployment in the United States. The ultimate aim is to overcome those barriers to help substantially reduce overall power consumption and carbon emissions.

Of all the ways proposed to reduce the growth of carbon emissions, one of the most cost-effective is to reduce consumer demand for electricity through greater end-use efficiency. It’s also one of the potentially quickest solutions—especially considering that a variety of highly efficient new end-use technologies are available and ready for deployment. The problem is that each of these technologies faces specific barriers to broader use in the United States, even though several have already been widely adopted in Europe and Asia.

To help overcome these barriers, EPRI is launching a demonstration project—hosted by multiple utilities—aimed at providing critical information and operating experience related to six promising technologies. These technologies were chosen because of their ability to reduce electricity consumption significantly in some of the largest demand categories—up to 40% in specific applications. Overall, full deployment of the six technologies could reduce U.S. electricity consumption by as much as 7% and reduce carbon emissions by more than 160 million tons per year—the equivalent of taking 30 million cars off the road.

The six technologies that will be included in the energy efficiency demonstration are air conditioning that uses variable refrigerant flow; heat pump water heating; ductless residential heat pumps and air conditioners; hyper-efficient residential appliances; data center energy efficiency; and light-emitting diode (LED) street and area lighting.

Commercial Cooling and Heating
Space cooling and heating accounts for 17% of total electricity use in the commercial sector. Currently, the most commonly used technology in commercial buildings relies on air conditioning systems with air ducts and fixed-speed fans. Such systems are relatively inflexible and inefficient because of the need to move large volumes of air throughout a building.

The demonstration will include air conditioning and heating technologies that achieve greater efficiency by circulating a refrigerant through pipes to space-conditioning units in each climate zone. Such variable refrigerant flow (VRF) systems reduce operating costs by controlling the amount of refrigerant that flows from a central heat pump compressor to individual evaporators in various parts of a building. VRF systems provide more-precise temperature control in a given zone, enhancing comfort and allowing some rooms to be heated at the same time others are cooled.

Ductless VRF systems are widely used in Japan, in about half of medium-sized commercial buildings and a third of large buildings. High energy costs and retrofit opportunities have created a strong demand in Europe. In such installations, energy savings of 10–40% have been reported.

Barriers to Address
VRF systems face a variety of barriers in the United States, including a relatively long payback period, consumer concerns about reliability and availability of service, lack of an established supply chain, insufficient verification of performance, and concerns about integration with the utility power system. EPRI’s demonstration of VRF systems at several sites in different climate zones will focus on providing empirical data on which to base a business case for their purchase and installation.

Residential Ductless Heat Pumps
A conceptually similar ductless heat pump (DHP) system for residential applications employs a highly efficient ac/dc inverter to drive fans and compressors that can ramp up and down to quickly match the cooling and heating load of a residence. This heat pump system features an outdoor compressor, reducing the noise level inside. Cooled or heated refrigerant circulates through insulated lines to fan-coil units located in various living spaces. Individual thermostats can be set to the temperature desired for each indoor fan-coil unit.

Compared with the use of conventional electric space heaters or air conditioners, DHP systems offer improved comfort, less noise, and energy savings of 10–30%. DHP technology is widely used in Europe and Asia, commanding a market share of more than 50% in Japan as well as limited use in Hawaii.
**Barriers to Address**

Codes and standards in overseas markets are more favorable toward DHP systems than are codes in the United States, where most residences use central ducted systems to deliver cooling and heating. Another major barrier is the initial cost of DHP: $3,000 to $5,000 per ton of capacity (the amount of energy required to melt a ton of ice in a day, or about 12,000 Btu)—several times the cost of a conventional, forced-air system. In addition, most consumers are unaware of the advantages of DHP, and many contractors are not yet qualified to install these systems.

The EPRI demonstration will provide empirical data on DHP performance, on actual efficiency in the field, and on life-cycle costs. The findings will be shared with the U.S. Department of Energy (DOE) and various standards-influencing organizations for their consideration during the process of developing new standards and codes. If DHP measures up, this demonstration could prompt the more widespread substitution of electric heat pumps for gas- or oil-fueled residential heating and cooling systems. Until now, the cost and performance constraints of heat pumps have largely limited their use to warmer climates, but the deployment of DHP systems could substantially increase penetration and enhance the efficient use of energy.

**Heat Pump Water Heating**

Water heating accounts for 9% of U.S. residential electricity consumption. The application of heat pump technology to residential water heating could provide a reduction of up to 50% in energy consumption, compared with conventional alternatives. Heat pump water heaters (HPWHs) could also provide the additional benefits of limited space cooling and dehumidification at no additional cost.

HPWH systems are now manufactured by a limited number of relatively small companies in the United States, and DOE has given the technology its ENERGY STAR® efficiency label. Major U.S. manufacturers are expected to introduce their own lines of HPWH systems next year. Market penetration is much more advanced overseas, however, and Japanese manufacturers have gone a step further by introducing a line of “Eco-Cute” HPWHs that use carbon dioxide as a natural refrigerant, eliminating the threat of ozone depletion.

By 2015, HPWHs are expected to significantly grow with the proliferation of data centers. But the energy inefficiency of most data centers not only wastes energy—for every 100 watts (W) of computing power, about 145 W is lost to power supplies and ac-to-dc conversion or is dissipated as waste heat—but also limits how much computation can be performed on-site.

EPRI’s project will demonstrate a variety of strategies for improving the energy efficiency of data centers, including development of efficient power supplies, optimization of cooling and ventilation technologies and physical configurations, minimization of power distribution and conversion losses, and development of server virtualization software.

More than 3.1 billion power supplies are used with servers and personal computers, consuming about 3–4% of all electricity used in the United States. Improving the efficiency of computer and server power supplies could lower overall U.S. electricity use by 1–2%, for savings of $3.4 billion to $6.8 billion per year. Prior EPRI work in testing and specifying efficient desktop computer power supplies has helped pave the way for an ENERGY STAR® designation for power supplies. The same work has been the technical foundation for the 80 PLUS program, which provides incentives for PC power supply manufacturers to produce more-efficient units.

This project will evaluate the power supply efficiencies of data center rack equipment, such as servers. It will also assess opportunities to reduce thermal losses and, as a result, lower cooling loads. For every kilowatt-hour (kWh) saved at the server plug, another 1 to 1.5 kWh can be saved through reduced air conditioning requirements in large commercial data centers. In addition, eliminating a number of power supply conversions will increase the overall efficiency by avoiding the loss inherent in each conversion. Also, the continuing development of new software technology will cut down on the number of servers...
Barriers to Address
A major component of the demonstration will be to collect product-specific performance data on various manufacturers’ power supplies as they are deployed on utility systems. Implementing energy efficiency measures may result in disruption to data center operations. Any retrofit upgrades would need to be scheduled with major overhauls of the complete data center.

“Hyper-efficient” Appliances
EPRI has identified a set of residential appliances that may use as little as half the electricity required by conventional U.S. models.

In some Asian countries, market penetration of hyper-efficient appliances approaches 80%, but none of these units are commercially available now in the United States. Research conducted by EPRI indicates that two of the most promising technologies in the demonstration program are an inverter-driven refrigerator and a heat pump clothes dryer. The refrigerator has the potential to reduce energy consumption by about 30%, compared with conventional models, because the inverter drive provides variable-speed operation. The clothes dryer delivers potential energy savings of up to 30% because the heat pump technology reclaims the heat and dehumidifies the recycled air. This is much more efficient than conventional resistance or gas heating, which vents the hot, saturated air through an exhaust after a single use.

Barriers to Address
High electricity prices in Europe and Asia, coupled with government policies, have provided the early impetus for these technologies. Adapting them for the U.S. market is expected to be a lengthy and costly process, after which extensive testing and demonstration will be required before they are accepted by consumers and trade organizations. A key task of the demonstration project is to identify barriers to deploying them in the United States. Understanding consumer reaction to the unfamiliar designs or to the results achieved will be a goal. Nationwide tests will benchmark appliance performance, and the results will be used to build an informational database on the technologies.

LED Street and Area Lighting
Conventional street and area lighting systems today rely mainly on high-intensity discharge (HID) lamps. Whereas HID lighting is approximately 75% efficient, LED efficiency is about 90%. The new technology may require less maintenance as well. It will be necessary to better understand the impact of the different color rendition of LEDs, particularly in comparison with the yellowish light of high-pressure sodium HIDs or the bluish hue of mercury vapor HIDs.

Barriers to Address
The EPRI demonstration will focus on understanding performance, energy consumption, maintenance costs, and the lifetime cost of ownership, and it will investigate susceptibility to voltage sags, swells, and transients. The study will also examine the human perception of LED street and area lighting as it relates to security and safety.

EPRI as a Deployment Facilitator
EPRI’s Industry Technology Demonstration on Energy Efficiency is now enrolling participants and selecting 45 host utility sites to field-test the six technologies. An expected nine-month preparation phase, including equipment installation and test design, will be followed by roughly two years of data collection. EPRI will establish the program’s scope and manage each demonstration project. After testing is complete, program participants will work with manufacturers and industry groups to identify the best ways to achieve broader market penetration of the most promising new technologies.

“These demonstrations are intended to lay the groundwork for understanding the impact of several highly efficient electrical end-use technologies in the United States,” said Tom Reddoch, EPRI’s director of energy utilization. “Although most of these technologies are already being used abroad, considerable work will be needed to adapt them for use in this country and to reach utility and consumer acceptance. EPRI’s demonstration program can play a critical role in accelerating this process.”

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WINTER 2008 17