Introducing Hyper-Efficient Technologies into the U.S.

Clark W. Gellings & Marek Samotyj, Electric Power Research Institute, Palo Alto, CA

ABSTRACT

There is a unique opportunity to accelerate the introduction of several "hyper-efficient" electricity utilization technologies into the U.S. that have been developed and deployed in other countries. Demonstrations and assessments are needed to lay the groundwork for commercialization of these technologies leading to a substantial impact in electricity consumption for several major end uses of electricity.

As a result of several factors, manufacturers of electrical apparatus in Japan, Korea and Europe have outpaced U.S. firms in the development of electric end-use technologies whose overall efficiency is substantially above that of the best available in the U.S.

This paper outlines the need for demonstrations to determine the best commercialization path to verify performance and validate applicability in U.S. buildings and other locations. Issues that need to be resolved include adopting service voltages, frequency, electromagnetic compatibility, verifying power quality, and meeting U.S. codes and standards as well as UL labeling. This paper describes a family of "hyper-efficient" cutting-edge technologies. The portfolios of technologies which will be discussed are:

- Variable refrigerant flow air conditioning and heating systems
- Ductless residential heat pumps and air conditioners
- Heat pump water heating
- Hyper-efficient residential appliances
- Data center energy efficiency
- Light-emitting diode (LED) street and area lighting

Background

The single easiest and overall most cost-effective way to meet future consumer demand for electricity is to invest in mitigating some portion of that demand rather than to invest in new power production technology. Investments in enhancing end-use energy efficiency either by codes and standards, regulatory policy, encouraging consumer adoption of the best available energy-efficient technologies can offer substantial return to consumers, society and electricity industry stakeholders. While the adoption of the best available energy-efficient technologies by all consumers in 100% of applications is far from complete, retail service providers, states and other organizations interested in promoting increased efficiency are beginning to question the availability of the "next generation" of energy-efficient technologies. After several years of unsuccessfully trying to encourage the electricity sector to fill in the gaps of R&D in advanced utilization appliances and devices – EPRI has turned instead to the goal of transferring proven technologies from overseas.

As a result of several factors, manufacturers of electrical apparatus in Japan, Korea and Europe have outpaced U.S. firms in the development of high-efficiency electric end-use technologies. This project creates a unique opportunity to demonstrate those "hyper-efficient" electricity utilization technologies. These demonstrations could lay the groundwork for commercialization of these technologies leading to a substantial reduction in electricity consumption for several major end uses of electricity. This demonstration focuses on the foundation of end-use electricity utilization – the end-use energy-consuming technology that converts electricity in buildings into space conditioning and lighting, and data computation.

If fully deployed, these technologies could reduce the demand for electric energy by over 10%. In addition, collectively these technologies have the potential reduced electric energy consumption in residential and commercial applications by up to 40% for each application. They represent the single greatest opportunity to meet consumer demand for electricity known to be available today.

What Are the Elements of This Demonstration Project?

Demonstrations are needed to verify performance and validate applicability in U.S. buildings and other locations. Issues that need to be resolved include adopting service voltages, frequency, electromagnetic compatibility, verifying power quality, and meeting U.S. codes and standards as well as UL labeling.

The technologies will be demonstrated with several utilities in different climate regions to assess their performance when deployed in diverse environments. This will ensure a thorough evaluation. EPRI will establish a collaboration with numerous utilities and demonstrate these hyper-efficient technologies with six to eight utilities.

The following technologies would be included in this demonstration:

- Variable Refrigerant Flow Air Conditioning and Heating Systems
- Ductless Residential Heat Pumps and Air Conditioners
- Heat Pump Water Heating
- Hyper-Efficient Residential Appliances
- Data Center Energy Efficiency
- Light-Emitting Diode (LED) Street and Area Lighting

Technical Description

This project will demonstrate and evaluate the performance of hyper-efficient technologies at multiple utility sites. Within the scope of the project, EPRI will identify and qualify the technologies for demonstration, work with manufacturers to secure their availability, create the demonstration protocol, run and execute tests and evaluate the data. With support of participants and engagement with manufacturers and industry groups, EPRI will help identify the best means toward broader market penetration. For selected technologies, EPRI will also identify acceptable levels for the outcomes that lead to attaining ideal behavior or level of comfort, i.e., ambient unit noise or spectrum of perceivable light.

In addition, EPRI will assess the opportunity to integrate smart controls into the devices to evaluate the feasibility of including them in load control strategies as a dispatchable resource.

Various incentive mechanisms, including innovative rates sent directly to the premises controller, will be applied. The consumer's response to these mechanisms will be assessed. The overall business case for each demonstration project will be assessed from the utility, consumer and societal point of view.

Table 1 summarizes the preliminary plans to test 845 devices at 45 sites.

Table 1. EPRI Energy Efficiency Demonstration Sites and Devices

Residential	# Sites	Devices/Sites	Total Devices
Heat Pump Water Heater	7	50	350
Ductless Heat Pump	6	25	150
Hyper-Efficient Appliances	7	25	175
Commercial			
Variable Flow Refrigerant	7	2	14
LED Area Lighting	12	12	144
Data Centers	6	2	12
TOTAL	**45**		**845**

Variable Refrigerant Flow Air Conditionings

Ducted air conditioning systems with fixed-speed motors have been the most popular system for climate control in multi-zone commercial building applications in North America. These systems require significant electricity to operate and offer limited opportunities to manage peak demand.

Multi-split heat pumps have evolved from a technology suitable for residential and light commercial buildings to variable refrigerant flow (VRF) systems that can provide efficient space conditioning for large commercial buildings. VRF systems are enhanced versions of ductless multi-split systems, permitting more indoor units to be connected to each outdoor unit and providing additional features such as simultaneous heating and cooling and heat recovery. VRF systems are very popular in Asia and Europe and, with an increasing support available from major U.S. and Asian manufacturers, are worth considering for multi-zone commercial building applications in the U.S.

VRF technology uses smart integrated controls, variable speed drives, refrigerant piping, and heat recovery to provide products with attributes that include high energy efficiency, flexible operation, ease of installation, low noise, zone control and comfort using all-electricity technology.

Ductless space conditioning products, the forerunner of multi-split and VRF systems, were first introduced in Japan and elsewhere in the 1950s as split systems with single indoor units and outdoor units. These ductless products were designed as quieter, more efficient alternatives to window units.1

Products have evolved from a few indoor units operating off each outdoor unit, to multi-split products with 4 units to 8 units in the late 1980s, to 16 units in the early 1990s, to 32 units by 1999. Today's advanced systems permit as many as 60 or more indoor units to operate off one outdoor unit, enabling application in large commercial buildings. Electronically commutated motors, inverter-driven/capacity modulated scroll compressors, multiple compressors, versatile configurations and complex refrigerant and oil circuitry, returns, and controls have enabled this technology to be applied to virtually any commercial building.

Ductless and multi-split products are often considered factory-built systems, competing with traditional unitary products, whereas some manufacturers position their VRF systems as engineered systems that are alternatives to traditional field-applied systems such as chillers. U.S. sales of all ductless, multi-spit and VRG products will be around 250,000 units in 2007. Less than 10,000 of these are VRF units.

---

1 Lee Smith, "History Lesson: Ductless Has Come a Long Way," ACHR News, April 30, 2007.

In Japan, VRF systems are used in approximately 50% of medium-sized commercial buildings (up to 70,000 ft2) and close to 33% of large commercial buildings (greater than 70,000 ft^2).

Sales in Japan, where the VRF concept was developed, and other parts of Asia have been strong. In Europe, where many existing buildings did not have air conditioning, retrofit opportunities have also created strong demand.3

Ductless products entered the United States market in the early 1980s, but market penetration was minimal. Lack of Japanese manufacturer support infrastructure, and market unfamiliarity with the technology held back sales. Moreover, ozone depletion issues became a concern at that time, and the issue of a high refrigerant charge of multi-split systems was likely a strong negative for the system. Since that time, refrigerant developments, advances in charge management, controls and inverter technology have transformed the technology. And Asian manufacturers have re-entered the U.S. market individually or in partnership with U.S.-based manufacturers to help promote the technology.

Evidence of the applicability of this technology in the U.S. is the inclusion of a multi-split variable refrigerant flow system with zoned inverter-driven heat pump and heat recovery in the renovation of the headquarters building of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) in Atlanta, Georgia.4

Mitsubishi Electric Company and Daikin are the leaders in VRF system shipments in the U.S., sharing about 90% or more of the market. Other manufacturers combine for the remaining 10% of less. (In Japan, Daikin is the leading manufacturer with more than 50% of the market and Mitsubishi Electric is second.) Manufacturers of VRF products that are currently sold in the U.S. are listed in Table 1 along with contact information and selected product characteristics.

Other manufacturers that produce and sell multi-split system air conditioners and heat pumps in Europe and Asia (and in some cases in the U.S.) include Aircon, Blue Star, Chigo, Daewoo, Gree, Haier, Hitachi Products, LG Electronics, Ninbo Silva, Panasonic, Robaire, Tadiran, Toshiba and Zenithair. More of these manufacturers are likely to enter the U.S. market as success is achieved by current suppliers. Bondaire, ECR, Klimaire, and York (Johnson Controls) are manufacturers of mini-split and multi-split systems with bases of operation in the United States, but they do not currently manufacture VRF systems. Most major U.S. manufacturers have been selling ductless mini-split systems (one indoor unit and one outdoor unit) for some time.

Some U.S. companies manufacture their own ductless systems while others purchase and brand systems from Asian manufacturers.

Customers desire products that enhance comfort and productivity at a reasonable capital cost and energy cost. The low noise, individual controllability and effective temperature control of multi-split system air conditioners and heat pumps can enhance workplace productivity. The energy saving features of the product, such as capacity modulation, zone control, heat recovery and low duct losses contribute to ownership cost savings. However, the cost effectiveness of the technology is highly application dependent. Cost and energy use data should be obtained from detailed analysis and corresponding rigorous laboratory and field testing of multi-split systems. The need for this information currently exists for applications in the United States.

Manufacturer and case study information from outside the U.S. show systems that are cost-effective, but results, again, depend on specific application features. Typically, energy savings are

---

2 Mark Dyer, "Approaching 20 years of VRF in the UK," Modern Building Services, June 2006. http://www.modern-building –services.co.jk/news/fullstory.php/aid/2127/Approaching_20_years_of_VRF_in_the_UK.html

3 William Goetzler, "Variable Refrigerant Flow Systems," ASHRAE Journal, April 2007, http://bookstore.ashrae.biz/journal/journal_s_article.php?articleID=16

4 Spellman Johnson, "ASHRAE Headquarters Building Renovation, Mechanical Systems Narrative," June 26, 2007.

achieved, ranging from 10% to 60%, depending on climate and the type of system displaced, among other factors. Initial costs are also typically higher, with payback periods dependent on energy savings.

Figure 1 shows a single outdoor unit and a general schematic of multiple indoor units in a VRF heat pump system. The indoor units include wall-mounted, floor-mounted, ceiling cassette and concealed ducted configurations.

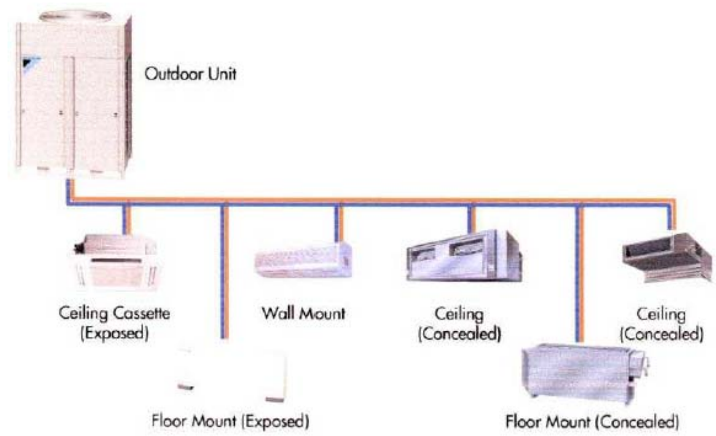

Figure 1. Major components of a VRF system including the range of possible indoor unit configurations and a typical outdoor unit. (Courtesy of Daikin)

Ductless Residential Heat Pumps and Air Conditioners

A variation of VRF systems described above are VRF systems applied to residential applications. These are called ductless residential heat pumps and air conditioners. Approximately 28% of residential electric energy use can be attributed to space conditioning. Use of variable frequency drive air conditioning systems can offer a substantial improvement when compared to conventional systems.

In many climate zones, the industry has long recognized that the application of electric-driven heat pump technology would offer far greater energy effectiveness than fossil fuel applications. However, except in warmer climates, the cost and performance of today's technology is insufficient to realize that promise. These ductless systems have the potential to substantially change the cost and performance profile of heat pumps in the U.S.

Heat Pump Water Heating

Heat pump water heaters (HPWHs) based on current Japanese technology are three times more efficient than electric resistance water heaters and have the potential to deliver nearly five times the amount of hot water, even compared to a resistance water heater.

HPWH are significantly more energy efficient than electric resistance water heaters, and can result in lower annual water heating bills for the consumer, as well as reductions in greenhouse gas emissions. But the high first costs of heat pump water heaters and past application and servicing problems have limited their use in the United States.

Water heating constitutes a substantial portion of residential energy consumption. In 1999, 120,682 GWh of electricity and 1,456 trillion Btu of natural gas were consumed to heat water in residences, amounting to 10% of residential electricity consumption and 30% of residential natural gas consumption.5 While both natural gas and electricity are used to heat water, the favorable economics of natural gas water heaters have historically made them more popular than electric water heaters.

Heat pump water heaters, which use electricity to power a vapor-compression cycle to draw heat from the surrounding environment, can heat water more efficiently for the end user than conventional water heaters (both natural gas and resistant element electric). Such devices offer consumers a more cost-effective and energy-efficient method of electrically heating water. The potential savings in terms of carbon emissions at the power plant are also significant. Replacing 1.5 million electric resistance heaters with heat pump water heaters would reduce carbon emissions by an amount roughly equivalent to the annual carbon emissions produced by a 250 MW coal power plant.

Heat pump water heaters have been commercially available since the early 1980s and have made some inroads in some places in the world, particularly in Europe and Japan.

There seem to be several reasons, both technical and economic, for the relatively shallow market penetration of HPWH in the U.S. Early models suffered from reliability problems, which have given the technology a bad reputation in the past. Units tend to be noisier than conventional water heaters, although more recent units are better in this respect than older units. Heat pump water heaters heat water at a slower rate, and to a lower temperature, than conventional units, though these issues can be addressed – at the cost of efficiency – through the addition of a supplemental electric resistance heater. The high initial cost, long payback times, and lack of consumer awareness are also significant factors.6

Operation of heat pump water heaters are based on the same thermodynamic cycle found in the common household refrigerator or air conditioner, the vapor-compression cycle. A fluid refrigerant is circulated through a loop, in which it successively undergoes expansion, evaporation, compression and condensation, as shown in Figure 2.

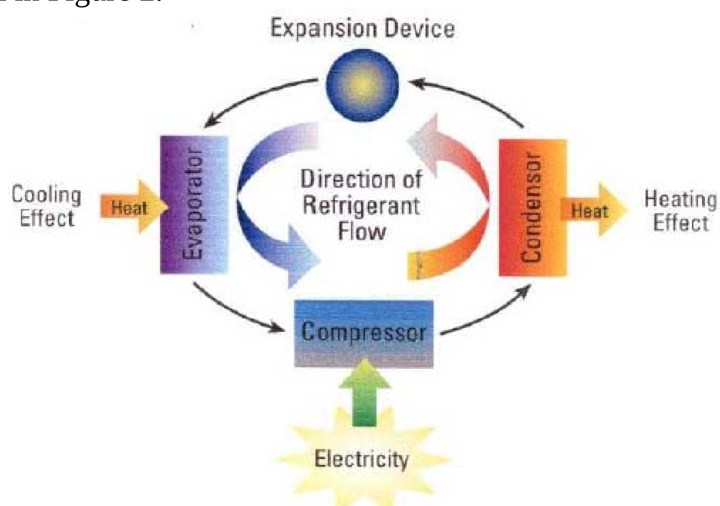

Figure 2. Operation of a Heat Pump.[9] Liquid refrigerant at high pressure is forced through an expansion valve into a low-pressure evaporator. The liquid evaporates, absorbing heat from the surrounding area. The gaseous refrigerant is then compressed by an electric compressor. At high pressure, the refrigerant condenses back into a liquid, rejecting heat into its surroundings.

5 Energy Market Profiles – Volume 1: 1999 Commercial Buildings, Equipment, and Energy Use and Volume 2¨ 1999 Residential Buildings, Appliances, and Energy Use, EPRI, Palo Alto, CA: 2001.
6 Heat Pump Water Heater Technology: Experiences of Residential Consumers and Utilities, Oak Ridge National Laboratories, Oak Ridge, TN: June 2004. ORNL/TM-2004/81.

In most residential heat pump water heaters, the evaporator is placed in contact with the surrounding air, allowing the construction of water heaters that fit the same footprint as conventional water heaters. Such water heaters are commonly called "drop-in" designs. There are two predominant types of drop-in heat pump water heaters: Integral heat pump water heaters, which replace existing water heaters, and remote heat pump water heaters, which add a heat pump unit to the tank of an existing water heater.

A relatively recent heat pump water heater technology, developed in Japan and called Eco Cute by its developers, uses CO_2 (carbon dioxide) as the refrigerant and boasts of remarkably high COP. Eco Cute products, an example of which is show in Figure 3, are compelling because the refrigerant is cheap and readily available, and has much less global warming potential than most haloalkane refrigerants.

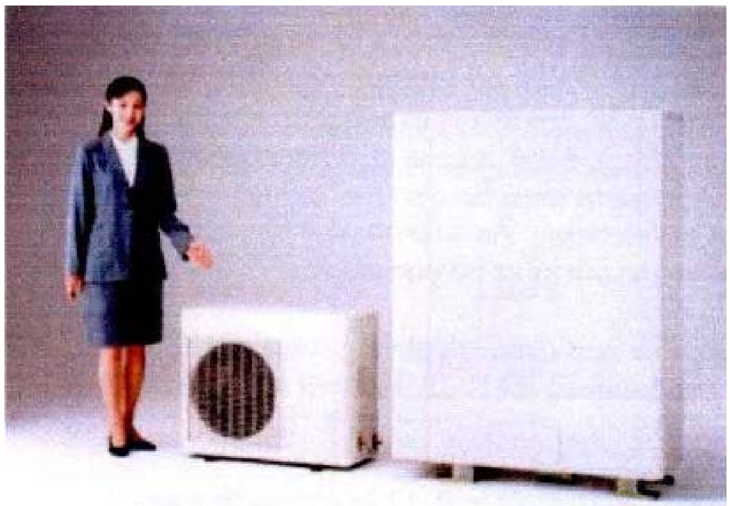

Figure 3. Eco Cute Heat Pump Water Heater System

The Eco Cute technology was originally developed as a collaborative effort between Tokyo Electric Power Company (TEPCO), the Central Research Institute of Electric Power Industry (CRIEPI), and DENSO Corporation. The team developed the high-efficiency compressor technology, the compact heat exchanger, and the system control logic that takes advantage of time-of-use electric power rates. The development started in 1999, and the first commercial Eco Cute system was introduced in Japan in 2001. With water heating representing nearly 30% of residential energy consumption in Japan, a national government subsidy was instituted and has helped expand the market for Eco Cute heat pump water heaters.7

Eco Cute units are not sold in the U.S., but the market has grown substantially in Japan, with 225,000 units sold in 2005, as shown in Figure 5.8 According to the data obtained by TEPCO, about 350,000 Eco Cute systems were shipped in fiscal year 2006.9 Currently, there are 18 manufacturers of Eco Cute water heaters for residential application in Japan.

7 W. Ishida, "Japanese Heat Pump Water Heater Market Growing, "Appliance Magazine (September 2005). Available at www.appliancemagazine.com/.

8 Hashimoto9, K. "Technology and Market Development of Heat Pump Water Heaters in Japan," presented at IEA HPP Workshop – Japan, May 17, 2006. Available at http://www.heatpumpcentre.org/Workshops/Workshop_Tokyo_May_2006/Sum_HP_Water_Heaters_Hashimoto.pdf.

9 Presentation by Hirofumi Ida of TEPCO to EPRI, August 10, 2007.

Hyper-Efficient Residential Appliances

Driven in part by high electricity prices and government encouragement, Japanese, Korean, Vietnamese and European markets have witnessed the introduction and widespread adoption of "hyper-efficient" residential appliances including electric heat pump clothes washers and dryers, inverter-driven clothes washers, multi-stage inverter-driven refrigerators, and advanced-induction ranges and cook tops.

Depending on the application, these appliances can use 30% less electricity than conventional U.S. appliances as claimed by inverter-driven refrigerator manufacturers or 50% less as claimed by heat pump clothes dryers. However, there are issues with regard to their acceptance with U.S. consumers and their actual performance. EPRI is going to include these two types of appliances in its energy efficiency demonstration effort. We are in touch with manufacturers in the USA, Europe and Asia in our search for the most hyper-efficient technologies.

Data Center Energy Efficiency

Data centers consume 30 terawatt hours of electricity per year. The technologies that are employed in those buildings today only allow 100 watts of every 245 watts of electricity delivered to actually be used to provide computational ability. The steps in between delivery to the building and actual use include the following conversions:

- Uninterruptable Power Supplies 88-92% Efficient
- Power Distribution 98-99% Efficient
- Power Supplies (AC to DC) 68-75% Efficient
- DC to DC Conversion 78-85% Efficient

In addition, all the lost energy has to be cooled. That is typically done with air conditioning requiring 1,000 watts for each tone of cooling, typically at an efficiency of 76%.

In this demonstration, EPRI will apply the same technical expertise to efficiency efforts for data centers as it successfully contributed to the "80 PLUS" Program. 80 PLUS is a manufacturer buy-down program for efficient power supplies in desktop PCs and desktop-derived servers – designed as a multi-year, utility-funded project. 80 PLUS power supply qualifications were established with efficiencies of 80% efficiency at 20%, 50% and 100% load, and true power factor (PF) greater than 0.9 at 100% load.

Power supplies are used in multiple applications in residential, commercial and industrial applications ranging from consumer electronics to industrial programmable logic controllers. The advent of new higher-efficiency power supply technologies is upon us, and the opportunity now presents itself to transform the commercial and light industrial marketplace, while simultaneously creating opportunities for increased power distribution system utilization capacity. The objective of this research effort is to understand how new state-of-the-art energy-efficient power supply technologies may fit into the long-range solutions to electric service provider objectives for energy-saving opportunities through an actual field implementation and measurement program.

Successful project results will allow funders to make more informed recommendations to their customers when the requests for accurate information about energy-saving products and technologies come in from those customers. This in turn – also becomes the benefit for the project funders and their customers.

To accomplish the broad yet measurable goals of the research, the electric utility sponsors, EPRI and supporting team members will partner together and complete a series of targeted efforts that will achieve the goals of understanding the requirements for a market transformation involving:

- Technology implementation of "higher-efficiency" power supply technology.

- Quantification of system losses in the power supply before and after implementation.
- Benefits assessment due to penetration of "higher-efficiency" power supplies.
- Technology transfer to participating funders and to the energy-efficiency community.

This work will be implemented via a series of very focused and measurable tasks that will ultimately bring to fruition a clear understanding of how the new state-of-the-art energy-efficient power supply technologies fit into the long-range solutions to electric service provider objectives for energy savings. To this end, a number of sites located around the U.S. will be selected.

Selection will be based upon reviewing a number of applications and load types for characterization and definition of the target opportunity. This could include one or more – but is not limited to – data centers, commercial facilities, residential or multi-tenant buildings. The objectives of this task are to define the parameters (i.e., voltage, current, power, power factor) that will be useful in characterizing the select power supplies in an accurate and methodical way.

Subsequently, a comprehensive test plan will be developed. The objective of this is to create a comprehensive test plan that clearly defines and documents the:

- Procedure to deploy/install/retrieve data from monitoring devices if field sites are chosen.
- Procedure to confirm field data with lab testing.
- Procedure to introduce and characterize the higher-efficient power supplies.

Thereafter, testing will proceed which implements the plan – with the primary goal of ensuring that the research does result in a clear direction and understanding of the energy-improvement benefits moving forward with a full-scale implementation. This task will manage the logistics of actual installation of the monitoring equipment, collecting both the energy-efficiency data and the power-usage profile data. This will be accomplished for both the existing power supplies and for the new higher-efficiency power supplies.

Data analysis will then proceed which will accurately define the full potential for energy savings due to the improvement in power supply efficiency and to provide a clear understanding of:

- The base-line power consumption and energy usage of existing loads versus the energy-savings benefit achieved through the implementation of the higher-efficiency power supplies.
- The extrapolation to city-wide, area-wide and other market segments.
- Potential impacts of improved power supply efficiency on CO2 emissions, given certain penetration levels.
- Peripheral benefits of the new power supplies from a harmonic current reduction perspective.
- How the data may be used to support state-wide market transformation and policy development.

EPRI research in this area can provide credible and unbiased assessments of the performance and of the economic benefits from using new more energy-efficient power supply technologies. The collaboration of multiple utility sponsors in this research area provides a unique opportunity to significantly increase the knowledge base and amount of information analyzed through this project. In this demonstration, EPRI will apply this methodology toward improving data center efficiencies and power supplies. Improving server power supplies will yield savings for the data center operator and allow for more computing space through increased computational density. This project will also seek to improve the "balance of plant" through lower HVAC costs – 1 to 1.5 kWh saved at the plug. These demonstrations will also typically reduce lighting energy use by 30%. In addition, reducing losses and improving power factor will likely reduce cable loading due to harmonic elimination. Other non-energy benefits to power factor correction (PFC) will be to alleviate many of the problems caused by harmonics in power distribution systems. Solutions to those problems can be costly. PFC will avoid the use of these solutions, thus enabling better use of the existing system. This project will allow:

- Testing in the field to verify real-world energy savings resulting from power supply efficiency improvement.
- Demonstration of the holistic savings from energy efficiency in data centers.
- Development of market transformation plans, guidelines and analysis criteria.

Light-Emitting Diode (LED) Street and Area Lighting

Street lighting is an important lifestyle enhancement feature in communities all over the world. There is a move across the United States to replace existing street and area lights – normally mercury vapor, high-pressure sodium (HPS) or metal halide (MH) lamps – with new technology that costs less to operate, and LEDs are at the forefront of this trend. Since LED street and area lighting (LEDSAL) technology is still relatively new to the market, utilities, municipalities, energy service providers, and lighting designers have expressed a keen interest in what the tradeoffs are between conventional lighting and LEDSAL. Cost is probably first among them, with the disadvantage of higher initial cost, but the advantage of lower operating costs.

Several important tradeoffs to consider when adopting LED street lighting and area light (LEDSAL) are presented in this white paper, organized according to their advantages and disadvantages. The advantages include energy efficiency, lower operating costs, durability, flexibility, and improved illumination that can lead to increased safety. On the disadvantages side are higher first costs, lower immunity to electrical disturbances, lower LED efficacy, varying fixture designs, three-wire installation, and unsuitability for retrofits into conventional fixtures.

LEDSALs offer a number of advantages related to power and energy use, light quality, safety and operating costs. The key advantages include:

- Lower Maintenance Costs – LED street and area lighting fixtures will offer reduced maintenance cost.
- Longer Lamp Life and Operating Temperature – The longer life of the LED light source and the level of illumination it provides over its lifetime are a primary advantage of LEDSAL.
- Light Dimming and Light Load Control – With the advent of electronics that convert 60- or 50-hertz AC energy to the DC energy required to drive LEDs, integrating intelligent control of the LEDs is relatively simple.
- Less Wasted Light – LEDSALs utilize LEDs that are “smaller-point sources” than the HID lamps used in conventional street lights.
- Improved Color Performance – LEDs can put out more light in the blue part of the spectrum, especially compared to high-pressure sodium (HPS) lamps, improving vision.
- Scalability – With LED systems, increasing light output in an existing installation is easily accommodated.
- Low Effective Projected Area (LED) – Luminaries (complete lighting units) can withstand reasonably high wind loads caused by storms and other weather events.
- Cross-Application Versatility – Compared to conventional street lights, LEDSALs offer greater ability to be reconfigured for different applications.
- More Environmentally Friendly – LEDs contain no environmentally hazardous materials.
- Durability – LEDSALs are more durable, reducing the risk of damage from vibration caused by shipping, installation, maintenance and weather-related events.
- Less Susceptibility to Moisture – Nearly all LED lighting engines are sealed against moisture, and most LED drivers are also sealed against moisture.

These Demonstrations

EPRI will design the overall scope and manage the demonstration project. EPRI will also identify and qualify the technologies for demonstration, work with manufacturers to secure their availability, create the demonstration protocol, run and execute tests, and evaluate the data.

With supporting participants and engagement with manufacturers and industry groups, EPRI will help identify the best means towards achieving broader market penetration in U.S. markets.

For each demonstration, EPRI will assist the host utilities in selecting and evaluating sites.

The host utility will secure customer commitments and aid with the coordination and schedule of access to the customer locations. Host utilities will be responsible for the installation of the equipment, customer support, and removal of the equipment if necessary. Utilities will also aid in the installation of monitoring equipment and, in some cases, downloading data and returning monitors to EPRI. In street and area demonstrations, utilities will install luminaries provided by EPRI.

Conclusions

There are numerous motivations to embrace this national demonstration on energy efficiency. These include:

- There is increasing consumer interest and motivation to adopt more efficient, sustainable technologies.
- There is increasing regulatory support and encouragement including a movement to make accelerated engagement in energy efficiency more profitable.
- For a number of energy service providers, energy efficiency is now and will increasingly be one of the key technologies which will enable them to meet consumer demand.
- These demonstrations comprise a bundle of technologies, some of which have been successful in overseas markets and others which are under development in the U.S.

RD&D values of bringing foreign technologies to the U.S. and testing them are substantial. While EPRI is taking several near-commercial technologies to the next step as part of this demonstration, EPRI is principally providing value through the development of credible data, information, measurement and verification (M&V) substantiation, and support and applications guidelines that can create a step-function change in the use of electricity in buildings. While some of these technologies have been used overseas, they have not been applied in U.S. buildings.

Performance of the air conditioning, heating and water heating technologies has been documented in some Japanese installations (less so in Korea and Europe). But not with the rigor which will be required to satisfy what are typically U.S. measurement and verification (M&V) criteria. In addition, U.S. buildings, climactic zones and patterns, and therefore, thermal load profiles and ambient conditions for equipment installed outdoors or in partially conditioned spaces, differs substantially from Japan, Korea and Europe. Rigorously determined verifiable data is needed for these U.S. installations.

Reliability of the air conditioning, heating, water heating and appliance technologies is a key issue as well. For example, many U.S. utility executives were disheartened over the performance and reliability of heat pump water heaters in the 1980s when they were first aggressively demonstrated. Utilities, craft groups, distributors and manufacturers need “proof” that these technologies are reliable.

In addition, EPRI believes that some of these technologies, as presently configured, will have difficulty competing due to their potentially higher initial cost. Research will be conducted to determine how these devises can be reconfigured or reengineered so as to reduce their cost.

In the case of LED lighting and data center energy efficiency, there is considerable development needed to determine the optimal technical solutions, in addition to addressing the questions detailed above.

These demonstrations will provide a step-function change in how electricity is used in U.S. buildings. By literally acting as a “technology accelerator” through a combination of the application of the traditional RD&D role for some of the elements of technology in these demonstrations and the development of credible, verifiable information. In addition, in order to witness the widespread adoption of these technologies, some U.S. standards may need to be modified.