LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

SPRING 2014:
VOL. 12, NO. 4

The first experiment in FLEXLAB, the Facility for Low Energy eXperiments in Buildings, began in May. Read about what developer Webcor has planned and how its work there will help improve a building the company is designing and constructing for its client, Genentech.

CalCharge, the collaboration between the Berkeley Lab's Environmental Energy Technologies Division and the California Clean Energy Fund to accelerate the growth of energy storage in the state, announced its first corporate partners.

You'll also read about EETD's usual array of leading edge research in such areas as harnessing the power of vehicle-to-grid services to help increase the penetration of renewable energy, measurements of the cost of saved energy (program administrator) through utility-funded energy efficiency programs, and how the Superior Energy Performance Program helps industry save money and energy.

To learn more about EETD's work, please visit eetd.lbl.gov.

Don't forget to like us on Facebook, https://www.facebook.com/eet.div.lbnl, and visit our Vimeo channel, https://vimeo.com/eetd.

If you are new to the free quarterly *EETD News*, please subscribe [http://eetd.lbl.gov/newsletter/sub/newsletter_signup.php].

—Allan Chen




EETD News reports on research conducted at Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division, whose mission is to perform research and development leading to better energy technologies that reduce adverse energy-related environmental impacts. The Division's staff of nearly 400 conducts research on energy efficiency in buildings, indoor environmental quality, U.S. and international energy issues, and advanced energy technologies. The newsletter is published online once a quarter. For more information, contact Allan Chen, (510) 486-4210.

The *Center for Building Science News* was published between 1993 and 1998. It covered news of the Division's research in energy efficiency and buildings, the indoor environment, and energy analysis. You'll find all back issues, from Winter 1993 through Summer 1998, available here [http://eetd.lbl.gov/newsletter/cbs_nl/cbsnews.html].

Spring Newsletter: Vol. 12, No. 4 [http://eetd.lbl.gov/newsletter/nl47/]
Environmental Energy Technologies Division News [http://eetd.lbl.gov/newsletter/]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Berkeley Lab and Webcor Partner to Study Building Energy Performance in First FLEXLAB Experiment

FLEXLAB™ , the Facility for Low Energy eXperiments in Buildings, run by Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (EETD), has partnered with construction firm Webcor to test building energy performance. The testing will allow Webcor's engineers to predict and improve the energy performance for a new building being constructed for biotech company, Genentech, a member of the Roche Group. A building mockup will be studied at different building orientations specific to the actual construction site.

The research will take place in FLEXLAB's rotating testbed, a unit that rotates 270 degrees to allow researchers to study how building energy use and environmental parameters change in a variety of orientations relative to the sun. FLEXLAB's newly completed outdoor facility consists of four testbeds, consisting of two cells each, that can be outfitted in almost any combination of building envelope materials, windows and shade structures, lights, heating and cooling equipment, and controls to test new technology in real conditions. Two other testbeds, one for lighting and controls testing, and one for collaborative building design, have opened in an existing building at Berkeley Lab.

Berkeley Lab and Webcor will build a section of the building in the rotating testbed, collect data, and use these measurements to develop an accurate energy simulation model of the building. This practice allows the design team to better understand and predict the actual performance of the building, both for energy and comfort. The lab is the only facility in the U.S. that provides side-by-side, outdoor testing of fully integrated building systems (envelope, lighting, HVAC) in a fully reconfigurable space.

The U.S. Department of Energy's David Danielson, Assistant Secretary for Energy Efficiency and Renewable Energy, was on hand in Berkeley to tour the facility; meet with Webcor executives, Lab Director Paul Alivisatos, and Berkeley Lab researchers; and view the start of the installation.

DOE Assistant Secretary Danielson addresses Berkeley Lab staff at FLEXLAB

"The Energy Department's FLEXLAB is an exciting contribution that will help industry test comfortable, low-energy-use buildings technologies," says Danielson. "By advancing technologies that reduce our energy use in built environments, this project also brings us closer to meeting the ambitious goals of the President's Climate Action Plan and keeps America on the path to a clean energy future."

"We have to agree with other experts that this building, this facility, could be the most important building in the country. The DOE, Berkeley Lab, and its team have handed us a uniquely powerful tool, and now it is the architecture and engineering community's opportunity to put it to use," says Phil Williams, Webcor's Vice President for Building Systems and Sustainability.

Webcor CEO Jes Pedersen, EETD Division Director Ashok Gadgil, and DOE Assistant Secretary Danielson at FLEXLAB event

Webcor will ensure that the building operates according to specification when construction is finished. Operations and maintenance staff and occupants will provide input on the design from the outset, understanding how the integrated systems will work in operation. They will provide input on operations as well as functionality and comfort. This allows the team to identify potential performance and cost issues early on and address them, lowering the risk of delivered performance and the potential for costly change orders during the construction process.

"FLEXLAB will bring industry, DOE national lab scientists, manufacturers, and investors together, all working hand in hand on cutting-edge energy efficiency technologies and solutions," says Berkeley Lab Director Paul Alivisatos. "These partners can use the results from their FLEXLAB demonstrations to help encourage design, construction, and operation of high-performance buildings."

Mocking up and testing advanced designs will allow the buildings industry to build a case for new advanced technology, and scale up the opportunities for construction and operations cost reduction. Ultimately, this benefits consumers by leading to better-designed and operated, more-comfortable buildings with lower energy costs.

—Allan Chen

For more information:

Cynthia Regnier
(510) 486-7011
CMRegnier@lbl.gov

Mary Ann Piette
(510) 486-6286
MAPiette@lbl.gov

Additional information:

FLEXLAB website [http://flexlab.lbl.gov/]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Berkeley Lab Joins Its CalCharge Co-founders in Welcoming Its First Corporate Members

CalCharge, the organization that Lawrence Berkeley National Laboratory (Berkeley Lab) helped co-found to support and accelerate the growth of the California energy storage cluster, recently announced the enrollment of its first corporate members: Duracell, Hitachi, Volkswagen, LG, Eaton, Enovix, EnerVault, Farasis Energy, Halotechnics, Leyden Energy, and Primus Power.

These international giants and emerging startups join other founding members CalCEF, SLAC National Accelerator Laboratory, San Jose State University, the International Brotherhood of Electrical Workers, and the National Electrical Contractor's Association in this independent member-driven public-private partnership.

"Energy storage is the key to unlocking a clean energy economy," said Jeff Anderson, CalCharge President. "CalCharge is positioned to make California the center of gravity for energy storage technology development in the U.S. and globally."

"The Department of Energy's national laboratories and America's universities are science and engineering powerhouses at the forefront of clean energy innovation," said DOE Assistant Secretary for Energy Efficiency and Renewable Energy David Danielson. "These types of innovative public-private partnerships help leading businesses take full advantage of these world-class resources to accelerate innovation and create good paying jobs right here in America."

"Berkeley Lab is happy to be a founding Partner Member of CalCharge, given our several decades of battery technology leadership. That work has led to our partnership in the Department of Energy's Joint Center for Energy Storage Research, for example," says Berkeley Lab Deputy Director Horst Simon. "CalCharge is a great illustration of the ways that national labs, such as Berkeley Lab, can increase industry engagement and drive economic growth."

CalCharge has streamlined access to the national labs for its members.

"The DOE national labs, Berkeley Lab in particular, are national jewels," said Tom Stepien, Chief Executive Officer of Primus Power. "Through CalCharge, young companies like Primus Power can connect with world-class scientists and leading-edge equipment to more quickly achieve breakthroughs in their technology."

CalCharge offers its members access to programs in Technology Assessment and Acceleration, Professional Development, Pre-Commercialization Support, and Ecosystem Facilitation. This enables them to more easily collaborate, identify barriers to emerging technology success, and develop solutions that help clear the path to commercialization and adoption of energy storage technologies.

"California is home to one of the largest clusters of energy storage companies in the world," said House Democratic Leader Nancy Pelosi. "In the Bay Area alone there are more than 80 such companies and counting. CalCharge will connect California entrepreneurs, multi-national companies, and world-class scientists and provide them easier access to the resources and expertise they need. I am excited to see the progress CalCharge has announced, and we look forward to celebrating more achievements from this collaboration in the future."

"As a young, Silicon Valley-based company commissioning our first grid-scale storage system in California, EnerVault views CalCharge as a valuable resource for building the relationships to grow our market, our company, and our team," said Craig Horne, EnerVault Co-founder and Chief Strategy Officer. "CalCharge brings together all the stakeholders required to deliver on the promise of California's emerging long-duration energy storage market after the remarkable success of its renewable and solar programs."

Enovix, a local energy storage start-up, recently moved into its first production facility in Fremont, California. "Enovix is combining innovative 3-D cell architecture with an equally innovative business model to meet the increasing power needs of mobile devices," said Cameron Dales, Vice President of Operations at Enovix. "We see the CalCharge public-private partnership as an innovative model that fits well with ours. We recently moved into our first commercial-scale wafer fabrication facility in Fremont, and we are excited to be part of an organization dedicated to California leadership in energy storage innovation and commercialization."

"We're not a big firm yet, but we intend to have a big impact on enabling abundant clean energy," said Justin Raade, Founder and Chief Executive Officer of Halotechnics. "CalCharge is simplifying the process for us to access the facilities and expertise of the national labs to advance our technology development. They are saving us time and money, which will help us get to market more quickly."

"CalCharge is connecting innovators across the consumer, vehicle, and grid markets to accelerate the mass adoption of energy storage technologies," said Keith Kepler, Founder and Chief Technology Officer of Farasis Energy. "As a manufacturer of advanced lithium-ion cells and energy storage systems, Farasis sees participation in CalCharge as a way of facilitating collaboration with leading technology development teams in the energy storage space. This not only helps us grow our own company, but creates a thriving California energy storage sector that is a key driver of industry growth nationally and globally."

Additional information:

CalCharge [http://www.calcharge.org] website

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Berkeley Lab's RAPMOD Speeds Building Energy Modeling

A multi-billion dollar market exists for reducing the energy use of existing buildings, if scientists can only figure out a way to substantially reduce the cost and time required to assess building energy performance, recommend energy performance measures, and identify problems in building operations.

This is the goal of RAPMOD, the Rapid Building Energy Modeler, a collaborative project involving the University of California (UC), Berkeley; Lawrence Berkeley National Laboratory (Berkeley Lab); and engineers Baumann Consulting. RAPMOD, which was funded by an innovation grant from the Advanced Research Projects Agency-Energy (ARPA-E), is designed to tackle these problems head on.

The Rapid Building Energy Modeler (RAPMOD) Backpack

The technology, worn as a backpack, is designed to scan a building's interior, using several types of sensors, as its wearer walks through the building. RAPMOD generates a visual map of the building that can be input into energy simulation models and used to develop an understanding of the building's energy performance, leading to a list of recommendations for improving its efficiency.

RAPMOD is based on technology developed by Avideh Zakhor, Qualcomm Professor of Electrical Engineering at UC Berkeley's Department of Computer Science and Electrical Engineering, and her students. Zakhor has been developing technology to produce indoor three-dimensional models since 2007 under the sponsorship of the Army Research Office (ARO) and Air Force Office of Scientific Research (AFOSR). She developed the first fully automated fast outdoor mapping system in 2005, and it was licensed by Google in 2007 to help produce its 3-D Google Earth product.

Since then, Zakhor's research group has been advancing the technology for use in indoor 3-D mapping since 2007. In 2012, they teamed with a group of researchers led by Philip Haves, Leader of the Simulation Research Group in the Environmental Energy Technologies Division of Berkeley Lab, and with engineers Bauman Consulting, to adapt the technology to generate energy models of buildings quickly and inexpensively.

"It's possible to reduce the energy consumption of existing buildings significantly," says Haves, "through retrofitting — replacing old equipment with more energy-efficient technology — and through 'retro-commissioning,' the process of improving the routine operation of buildings by making equipment function properly."

Prior research suggests there is a potential to reduce whole-building consumption in the U.S. by 16 percent through retro-commissioning, which uses "low-cost or no-cost" measures. This maps to an energy-savings potential of $30 billion by the year 2030 and annual greenhouse gas emissions reductions of about 340 million tons of carbon dioxide (CO_2) per year. Retrofitting has a significant cost but can result in energy savings of 20 to 50 percent. Energy modeling is required for the detailed analysis needed to achieve deep savings cost-effectively and is also helpful in maximizing and verifying the savings from retro-commissioning.

"The problem," says Haves, "is that retrofits projects often 'cream-skim,' saving about 10 percent while ignoring the potential for deeper savings. We aim to reduce the cost, and improve the accuracy, of energy modeling to reduce the cost of identifying retrofit measures that will produce deep savings."

Creating building energy models is expensive and time consuming and requires a lot of skill. Many existing buildings have incomplete, outdated, or no design documentation, requiring specialists to go into the building and laboriously make measurements that they can import into the software required to create the model. The primary goal of the RAPMOD project is to reduce the cost of preparing an energy model for use in retrofit analysis and in model-based retro-commissioning. This same model can also be used in performance monitoring during routine operation to detect equipment faults and other operational problems.

There are also non-energy applications of the technology. It could be used to create maps of building interiors for emergency first responders, and Architecture Engineering Construction (AEC) companies could use the system to generate maps of the interior building structure and services (such as HVAC ducts and gas, power, and water lines) during construction. Such maps would help building managers keep their buildings in good repair and running well during the building's life. Game designers and real estate industry could also make use of interior mapping.

Realizing that Zakhor's 3-D modeling technology offered a faster way of gathering the data needed for these models, Haves invited Zakhor to explore a collaboration between her lab and Berkeley Lab's Simulation Research Group. Bauman Consulting was brought in to advise on industry practices and costs, and to conduct testing and demonstration. A prototype version of the RAPMOD system was shown at ARPA-E's Technology Innovation Conference in February 2014, and, a day later, demonstrated for member of Congress at a showing on Capitol Hill.

Secretary of Energy Ernest Moniz (left) views the RAPMOD technology at the ARPA-E Innovation Summit

How It Works

RAPMOD is fitted with several different sensors, including a LiDAR, which measures the distances to building surfaces using a laser, a visible light camera, and an infrared sensor. The camera and LiDAR generate a photorealistic three-dimensional model of the building's interior as the user walks through hallways, into rooms, and up and down staircases.

The infrared sensor measures the thermal properties of windows and detects thermal defects, e.g., in wall insulation or moisture leaks. It also measures the heat coming from lighting systems, other equipment, and building occupants, providing the model with information needed to calculate the energy required to heat and cool the buildings.

A major advantage of RAPMOD is that it does not need to be operated by high-cost energy experts. Technicians will be able do the building walkthrough and measured data will upload automatically for processing and importing into the energy modeling software. All this drives down the cost of producing the model substantially.

One major task in the research has been to integrate the infrared sensor into the equipment, and to determine how much it can tell users about the thermal characteristics of the building materials—the insulation in the walls, and the windows' U-values, a measure of how well they retain heat to the interior.

A first version of the RAPMOD system that maps building geometry is expected to be ready for field testing in the summer of 2014. A version that measures window properties and characterizes internal heat gains is expected to be ready for field testing and demonstration by the end of 2014.

The research team is now seeking partners among architect, engineering, and construction firms; consulting engineering firms; facility managers; energy service companies; and others to help test and demonstrate the technology in existing facilities.

—Allan Chen

For more information:

Philip Haves
(510) 486-6512
PHaves@lbl.gov

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

EETD's Vehicle-to-Grid Simulator Will Help Plug-In Electric Vehicles Become an Electric Grid Resource

Plug-in electric vehicles (PEVs) are here, and more are coming. By 2013, 100,000 PEVs were sold in the United States, and the number is growing. One study forecasts that more than a million plug-in hybrid electric vehicles (PHEVs) will be sold in California, New York, Washington, and Florida alone between 2013 and 2022. Electric vehicles (EVs) are also growing in range and sales. As the cost of battery packs comes down, the number of car shoppers willing to consider buying EVs will go up.

The growth of the PEV fleet means that an unplanned but potentially valuable energy storage resource is also growing—the battery packs of these vehicles. When PEVs are plugged in, they represent an opportunity to better manage the electricity grid. For instance, PEVs can be used to avoid potential shortages of electricity during peak times, provide extra storage capacity when the grid is generating more than it needs to satisfy demand, and encourage the growth of renewable energy by providing a buffer to balance out the intermittency of wind and solar generation.

Providing these vehicle-to-grid (V2G) services can also help the automotive market. The revenue from using a PEV to provide energy services to the grid could help offset some of the increased cost of purchasing the PEV. The increased incentive to buy PEVs replaces high-emissions vehicles with no- or low-emissions vehicles. This shifts air pollution away from population centers, helps meet increasingly stringent emissions regulations, and assists car manufacturers with meeting future CAFE (corporate average fuel economy) standards.

There is a need for proven technologies that can predict the grid availability of a collection of independently operated vehicles. Yet the electricity grid needs to precisely match the demand for power from second to second with supply, drawing on a variety of sources ranging from base and peaking power plants to intermittent sources such as wind and solar power.

How can electricity grid managers, government authorities, power markets, entrepreneurs, and other stakeholders harness the resource offered by the growing fleet of PEVs? A project at the Environmental Energy Technologies Division (EETD) of Lawrence Berkeley National Laboratory (Berkeley Lab) may help to answer that question.

"Many are saying that energy storage is important to the electricity grid, because it can be a buffer for the grid by providing power when it needs to smooth out sudden increases in demand or shortfalls in supply, or by storing power when an excess is available on the grid. Energy storage is high-value if it is able to respond quickly. The battery packs in electric vehicles are potentially very quick, compared to conventional sources today," says Samveg Saxena, a researcher in EETD's Grid Integration Group. When plugged into the grid, these vehicles could be a significant resource.

But there are many uncertainties that make using PEVs difficult: at any time, some PEVs are parked and charging up from different states of power depletion, and others are in use on the roads, so the capacity of the PEV fleet is always changing. Despite the opportunities, there are still many uncertainties, such as the effects upon battery degradation and battery lifetime from storing and sending power to and from the electricity grid, or whether enough PEVs can be tapped exactly when they are needed to meet grid demand.

Beyond this, says Saxena, "automotive and electricity utility stakeholders have not historically had to deal with these challenges together. Automotive battery manufacturers have to make sure that these grid services won't degrade the batteries. Electric grid operators have to make sure that PEVs can function effectively as a grid resource."

To study these issues, Saxena, EETD researcher Jason MacDonald, and UC Berkeley/EETD Professor Scott Moura have been developing a simulation platform called the Vehicle-to-Grid Simulator, or V2G-Sim.

"V2G-Sim's purpose is to be a simulation platform that couples sub-modules that address these concerns in a systematic way. It will help us understand the challenges of vehicle-to-grid services, as well as provide a platform for thinking through solutions, and simulating the effect of those solutions on the grid quantitatively," he explains.

The team's goal for V2G-Sim is to provide a platform for electric grid system operators, utilities, policy makers, battery and PEV manufacturers, researchers, and the business community. Each stakeholder may study and evaluate their perspectives on utilizing PEVs for energy services to the electric grid (one example is what the utility community calls *ancillary services*).

V2G-Sim models the usage of individual vehicles, including second-by-second energy use while driving or charging, and aggregates large numbers of simulated vehicles to produce grid-scale predictions of impacts and opportunities from vehicle-grid integration. The results are time-based models of vehicle behaviors as well as a spatial simulation of their location. Using the National Household Travel Survey, the development team has created profiles of vehicles approximating real-life situations. For example, it could emulate a car that charges overnight, leaves for work at 7:30 a.m., parks, runs an errand at lunchtime, and then drives home at 5:30 p.m. and plugs in to recharge. This is one of many scenarios modeled with statistical variations derived from real-world commuting data.

The preliminary version of V2G-Sim that the EETD team has created incorporates modules that address different aspects of the problem. Powertrain modules calculate the vehicles' states of charge and energy use second-by-second. Battery electrochemistry modules calculate the electricity inputs and outputs and changes to their internal chemistry. Battery degradation models integrated into V2G-Sim estimate the impact of battery use on its life-how many years it can last when being used for driving only versus driving plus grid services.

Figure 1 shows the results of a test case with V2G-Sim—how demand from the grid is using electricity from 1,000 PEVs second-by-second over 24 hours starting at midnight. Figure 2, from the same test, shows the activity profiles of 12 individual vehicles—their states of charge as a function of time. Sometimes they are plugged in and charging; other times, they are unavailable. Figure 3 shows an example of the spatial resolution from V2G-Sim. In this example, spatial charging is resolved for 659 PEVs at home and work locations in the San Francisco Bay Area, but V2G-Sim enables much finer spatial resolution of vehicle charging; for example, by neighborhood.

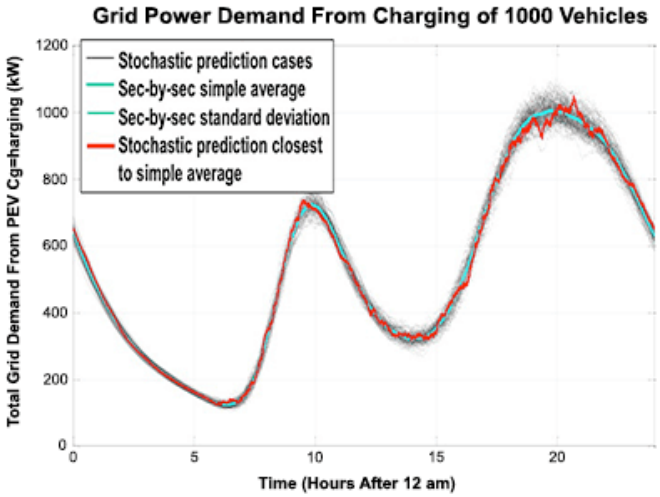


Figure 1. V2G-Sim test case results—grid demand for electricity from 1,000 PEVs over 24 hours.

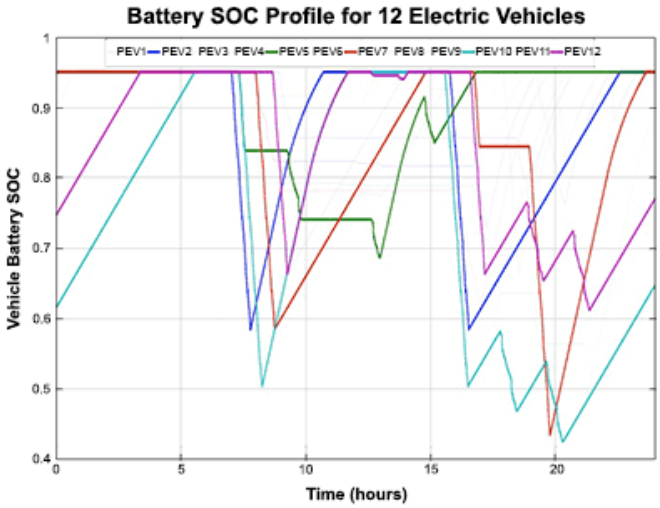


Figure 2. V2G-Sim activity profile for 12 vehicles.

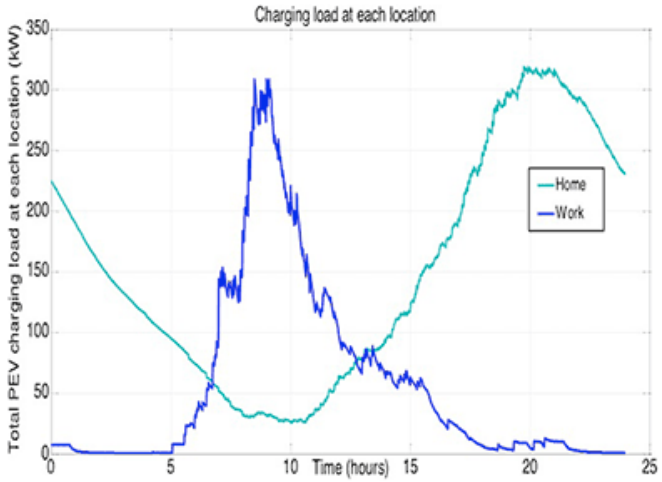


Figure 3. Spatial charging for 659 PEVs at home and work locations in the San Francisco Bay Area.

The version of the tool that is in development now,V2G-SIM Analysis, is intended as an analytical tool for research. "In the near term," says Saxena, "our vision is to release 'V2G-Sim Analysis' as a research tool to improve the cross-disciplinary understanding of how V2G services could perform, the impact that vehicle-grid integration will have on individual vehicles and on the grid, and how grid infrastructure can be planned for more PEVs." V2G-Sim Analysis will be a valuable research tool for many parties to quantitatively understand the challenges from vehicle-grid integration, including grid operators, utilities, policy makers, battery manufacturers, and the business community. The development team plans to follow up with another version of the platform, 'V2G-Sim Operations,' to enable real-time operations of a grid, which uses many PEVs as a resource. "The approach we're taking," he says, "is to develop a tool that will have a broad impact, and to ramp up the real-time use of PEVs to provide rapid energy response services to the grid."

In this vision, battery manufacturers might use V2G-Sim Analysis to link to their electrochemical models of battery technologies to quantify battery degradation and devise ways of making long life-cycle batteries that effectively provide both vehicle propulsion and electric grid services. Advanced battery technology researchers at Berkeley Lab and elsewhere are already interested in using V2G-Sim in their studies of the electrochemistry of battery degradation. Plug-in electric vehicle manufacturers could link the platform to their own vehicle design platforms to adapt powertrain design for electric grid integration.

Grid managers could eventually use the Operations version of the platform to coordinate PEV resources in real-time for grid services such as smoothing the electricity supply curve from the intermittence of renewables such as wind and solar power. This, in turn, might help encourage greater use and integration of renewable power sources on the grid, because its managers have a greater ability to compensate for power fluctuations from these sources.

Utilities and business entrepreneurs could use V2G-Sim Analysis to develop and understand the impact of managed charging control algorithms for PEVs, so that they can provide optimal service both as a vehicle and as an energy service to the grid.

Entrepreneurs interested in creating a business by harnessing the fleet of PEVs of a region with a large PEV stock could use V2G-Sim to make informed decisions about how much regulation capacity to bid into the grid's markets. Information such as the composition of the PEV fleet, the state of charge and availability of energy at any time of the day or night, the locational availability of power throughout the region—where PEVs are connected to the grid—all influence these decisions.

The electricity regulatory community can use the same type of information to integrate the regulation of V2G services into the current regulatory framework of the grid.

"Our short-term goal," says Saxena, "is to release V2G-Sim Analysis to the research community, automotive and battery manufacturers, and grid stakeholders. In the long term, we want to further validate the model so that system operators and the regulatory community can begin to use PEVs in real time, as part of the dynamic electricity system."

—Allan Chen

For more information:

Samveg Saxena
(510) 269-7260
SSaxena@lbl.gov

Additional information:

This research was funded by Berkeley Lab's Laboratory Directed Research and Development program.

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Berkeley Lab Report Identifies the Program Administrator Cost of Saving Energy Through U.S. Utility Customer-Funded Energy Efficiency Programs

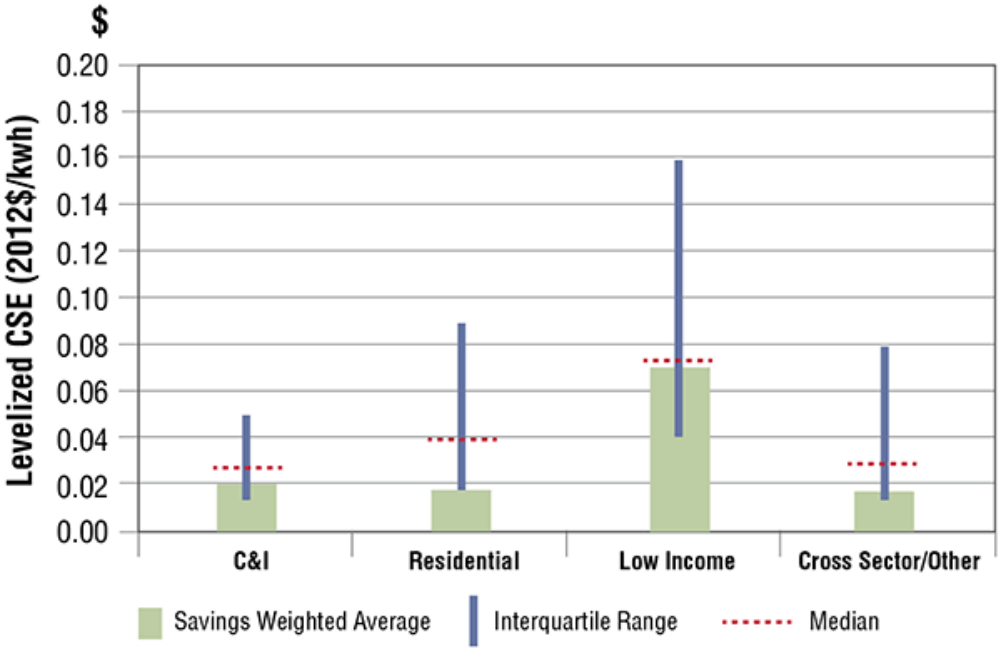
As more states and utilities turn to energy efficiency programs to manage demand for electricity and natural gas, it is important to understand how much it costs to save energy. By examining regulatory reports on efficiency programs in 31 states, Lawrence Berkeley National Laboratory (Berkeley Lab) researchers determined the cost of saving energy through efficiency programs funded by utility customers in the period 2009–2011. The resulting report presents those costs at the national and regional level for all sectors and for the most prevalent program types.

The report, *The Program Administrator Cost of Saved Energy for Utility Customer-Funded Energy Efficiency Programs,* was written by Berkeley Lab's Environmental Energy Technologies Division (EETD) researchers Megan A. Billingsley, Ian M. Hoffman, Elizabeth Stuart, Steven R. Schiller, Charles A. Goldman, and Kristina LaCommare. They gathered a total of more than 4,000 program-years' worth of costs and energy savings data, as reported by 107 program administrators on 1,700 individual efficiency programs. Administrators of those programs typically use different names for their programs, and practices vary among states for reporting program cost and savings information. To address these differences, the EETD researchers developed a standard approach to handling the data and classifying the programs. The result is the most comprehensive and detailed program database reported to date, offering a rich portrait of national and regional efficiency program investments and covering more than 60 different types of efficiency programs.

In the report, calculations of the cost of saved energy (CSE) are based upon gross energy savings and the costs borne by the program administrator. Cost contributions by program participants are infrequently reported by program administrators, and thus the reported results are not the "all-in" cost, known in the industry as the *total resource cost*. The report provides a levelized CSE by targeted sector (residential, commercial, industrial, and low-income customers) and program type, as defined by technology, action, or delivery approach. For each market sector and program type, the report identifies a range of costs as reported by energy efficiency program administrators, including the median CSE value and a savings-weighted average CSE.

Among the key national and regional findings:

- The U.S. weighted-average electricity CSE was slightly more than two cents per kilowatt-hour (kWh). While this levelized CSE is somewhat lower than values reported by other studies, it should be noted that this study contains the largest sample of program administrators to date. Furthermore, nearly 40% of the electric program administrators in the LBNL database have offered programs for less than four years, and so may be early in accessing energy savings in their respective state economies or may be targeting the least costly savings opportunities first.
- Residential electricity efficiency programs had the lowest average levelized CSE, at $0.018/kWh. Lighting rebate programs accounted for at least 44% of total residential lifetime savings, with a savings-weighted average levelized CSE of $0.007/kWh.
- Commercial, industrial and agricultural efficiency programs had an average levelized CSE of $0.021/kWh.
- Efficiency programs in the Midwest had the lowest average levelized CSE ($0.014/kWh), while programs in Northeast states had a higher average CSE value ($0.033/kWh). The average CSE for programs in the West and South were $0.023/kWh and $0.028/kWh, respectively. Note that only four states in the South are included in this report.
- Natural gas efficiency programs had a savings-weighted average levelized CSE of $0.38 per therm, with significant differences between the commercial/industrial and residential sectors (average values of $0.17 vs. $0.56 per therm, respectively).
- Annual regulatory reporting on the costs and savings of efficiency programs is inconsistent in quality and thoroughness. Not surprisingly, program administrators in different states often use varying definitions of savings and program costs. Market sectors and program types are not characterized in a standard fashion. Many program administrators do not provide the basic data needed to calculate a levelized cost of saved energy at the program level.



Residential programs have the lowest savings weighted cost of saved energy ($0.018/kWh) followed by commercial and industrial (C&I) programs ($0.021/kWh).

The report asserts that there is a direct connection between the maturation of energy efficiency as a resource and the need for consistent, high-quality data and periodic reporting of efficiency program costs and impacts. The report urges state regulators and program administrators to consider annually reporting certain essential data at a portfolio level and more comprehensive reporting of program-level data (e.g., lifetime energy savings, participant costs). Policymakers and system planners have shown increasing interest in integrating energy efficiency as a resource, and the value of transparent and complete reporting of program metrics is a foundation for increasing their confidence in this resource.

For more information:

Ian Hoffman
(510) 495-2990
IHoffman@lbl.gov

Additional information:

Download the report and summary presentation [http://emp.lbl.gov/publications/program-administrator-cost-saved-energy-utility-customer-funded-energy-efficiency-progr?utm_source=BenchmarkEmail&utm_campaign=CSE%20Report&utm_medium=email]

Electricity Markets and Policy Group Publications [http://emp.lbl.gov/reports?utm_source=BenchmarkEmail&utm_campaign=CSE%20Report&utm_medium=email]

This research was funded by the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability.

LAWRENCE BERKELEY NATIONAL LABORATORY

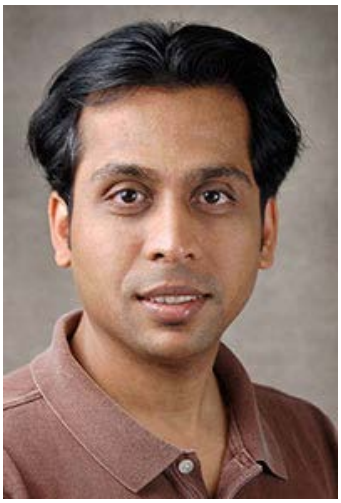
Environmental Energy Technologies Division

NEWS

OpenADR Standard Published as an International Publicly Available Specification

In February, Open Automated Demand Response (OpenADR) achieved another milestone toward becoming an international standard when the International Electrotechnical Commission (IEC), a renowned standards development organization, released a profile of OpenADR 2.0 as a Publicly Available Specification (PAS). This action recognizes OpenADR as a standard that will enable our electricity systems to be more responsive and smarter about operating under numerous economic, environmental, and security restraints. OpenADR 2.0 is already a national standard in the United States, as the result of Smart Grid standards interoperability activities coordinated by the National Institute of Standards and Technology (NIST) and Smart Grid Interoperability Panel (SGIP).

Demand Response Research Center (DRRC) researchers at Lawrence Berkeley National Laboratory (Berkeley Lab) originally conceived of and developed the OpenADR specification in 2002, to support automated demand response and dynamic pricing electricity programs. Since then it has been further developed by the Organization of Structured Information Standards (OASIS) and has become a national standard that is widely supported by Smart Grid stakeholders and vendors. It is an integral element of Smart Grid activities worldwide. The OpenADR Alliance, a nonprofit organization with more than 100 members, is now responsible for its adoption and is testing a certification authority for an OpenADR 2.0 standard.



Girish Ghatikar

"We're very pleased by this action," said Girish Ghatikar, Deputy Leader of Berkeley Lab's Grid Integration group and Vice-Chairman of the OpenADR Alliance. "Its acceptance by the IEC demonstrates that vendors, standards organizations, and users alike recognize OpenADR's broad usefulness in enabling electricity service providers and customers to participate in demand response transactions."

A primary OpenADR focus has always been on empowering customers with choices to manage their energy use and save money. For scaled adoption of standards such as OpenADR across national and global Smart Grid deployments, regulatory and policy mechanisms are recognizing the importance of standards to overcome any market adoption barriers swiftly and effectively. Through appliance standards, buildings codes, and design specifications, OpenADR can enable a fleet of buildings, equipment, and appliances to participate in demand-side management programs that will deliver energy-cost savings, grid transactions, and environmental benefits. Such developments are fundamental to help national and international market actors

realize the benefits associated with the Smart Grid more swiftly and in a manner that ensures greater security, interoperability, and reduced cost to society. For example, California's Title 24 building code now requires that standards-based messaging protocols such as OpenADR be included as a part of building energy controls. As more states and countries adopt the OpenADR standard, its use in the Smart Grid will expand, offering customers additional choices in how they use energy.

Development of OpenADR is supported by the California Energy Commission's Public Interest Energy Research Program. The OpenADR Publicly Available Specification is IEC PAS 62746-10-1.

—Mark Wilson

For more information:

Rish Ghatikar
(510) 486-6768
GGhatikar@lbl.gov

Additional information:

OpenADR's specification page [http://www.openadr.org/specification]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Superior Energy Performance Program Demonstrates 1.7-Year Payback

For years, industrial facilities have saved energy by investing in more-efficient equipment or operational methods as old equipment ages and new strategies emerge. However, studies show that to achieve deep, persistent energy savings, companies must implement a facility-wide process that continuously monitors those changes and allows for improvements that ensure optimal performance.

With that in mind, the U.S. Department of Energy (DOE) and the U.S. Council for Energy-Efficient Manufacturing (U.S. CEEM) developed and are implementing the Superior Energy Performance™ (SEP) Program. The program is designed to increase the energy efficiency of industrial facilities through implementation of an energy management system (EnMS) based on the ISO 50001 energy management system standard and by obtaining third-party verification of the resulting energy performance improvements. The SEP program was opened to widespread participation in December 2013 and has more than 40 facilities participating in a national demonstration program. Seventeen of those facilities have already received SEP certification, and with the recent announcement of the program many more are expected to benefit.


Peter Therkelson


Aimee McKane

To spur that participation, Lawrence Berkeley National Laboratory (Berkeley Lab) researchers Peter Therkelsen and Aimee McKane collaborated with Ridah Sabouni and Tracy Evans of Energetics Incorporated and DOE's Paul Scheihing to assess the costs and benefits of industrial facilities being certified to the SEP program, and to examine the business value of SEP and ISO 50001. Their paper, "Assessing the Costs and Benefits of the Superior Energy Performance Program," shows that implementation of ISO 50001 coupled with SEP energy performance targets results in quantifiable and significant energy savings and energy cost savings for the facilities examined. They found that the payback period for SEP participation, taking into account energy cost savings attributable to SEP and all SEP associated costs (including internal facility staff time), to be equal to an average of 1.7 years.

Pairing ISO 50001 with SEP

McKane, Deputy Group Leader at Berkeley Lab, first proposed the development of an international energy management system standard in 2007. She was instrumental in establishing U.S. leadership for the development of the standard and continues to be involved as the Chair of the U.S. Technical Advisory Committee to ISO TC 242, the committee responsible for developing the ISO 50001 portfolio of standards.

"ISO 50001 and SEP provide an approach to energy performance improvement that provides significant energy saving and cost benefits," says McKane. "At the same time, it prepares organizations to bring their energy efficiency programs to the next level, one of continual improvement based on effective use of available data."

Benefits of ISO 50001 and SEP

The ISO 50001 standard provides a structure for engaging every level of an organization in management of its energy use and consumption, through a range of actions from robust operational control to the application of new technologies. An EnMS integrates energy management into a business culture of continual improvement, so that it is less reliant on the efforts of individual champions. These energy management business processes also result in greater and more sophisticated use of available data, which improves decisions about which projects to implement and leads to more persistent energy savings from implemented projects. The SEP program combines the energy management business processes of ISO 50001 with transparent, third-party verification of energy performance improvement. This external verification of results is proving valuable to the industrial facilities that have completed their certifications. The program is accredited by the American National Standards Institute (ANSI) and the ASQ National Accreditation Board (ANAB).

Facilities that participate in the SEP program are provided with DOE's Energy Performance Indicator (EnPI) software to help staff calculate energy performance improvement results. The DOE provides support by guiding facilities to external technical assistance and third-party certification audits. This study focused on nine facilities that were certified during the demonstration phase of SEP, and who agreed to share detailed data on their energy uses, consumption, and costs.

Quantifying the Costs and Benefits

The research team sent out a questionnaire, conducted interviews, and analyzed energy data that the facilities had collected to determine the costs and benefits of implementing ISO 50001 and being certified in the SEP program. These costs and benefits were utilized to calculate the marginal payback of participating in the SEP program.

Results showed that after implementing an ISO 50001-conformant EnMS, all of the facilities achieved greater energy savings from operational improvements than from capital projects. **Nearly three-quarters of energy and cost savings were from operational improvements—in fact, three facilities achieved SEP certification through these improvements alone**.

A representative of Cooper Tire, in Texarkana, Arkansas, explained one of the key benefits. "SEP has helped justify expenditures to management. The measurement and verification requirement helps to identify real cost savings, allowing us to reinvest those savings into additional energy projects."

Not surprisingly, the longer that a facility had the EnMS in place, the more energy it saved. As the EnMS and training became more ingrained in daily operations, savings rose. This study also showed that even though SEP program achievement targets are focused on energy savings (not energy cost savings), facilities can realize significant energy cost savings. Overall, savings beyond the business-as-usual operating costs began two quarters after beginning implementation of an EnMS.

Benefits of Participation

Implementation of the ISO 50001 standard and SEP program resulted in annual energy savings (0.174 TBtu, on average) and energy cost savings ($503,000, on average) for the nine facilities. These savings only include operational energy savings associated with EnMS implementation. **Capital project implementation results in additional savings that are not considered in the calculation of SEP payback**, since SEP implementation has no specific requirements for capital projects. Other productivity gains, though known to result from EnMS and energy performance improvement actions, are also not considered in this SEP payback calculation.

The facilities that participated in this study stated that the SEP program helped them to identify no-cost or low-cost operational programs and quantify the impact of those efforts on energy performance. All nine facilities showed greater energy savings during SEP participation than they did before the program. Facilities with annual energy consumption greater than 0.27 trillion Btu (approximately $1.9 million per year based upon national energy price averages) can expect to cover their implementation costs in less than two years.

Costs of Participation

All facility costs associated with SEP program implementation were collected from each facility studied. These costs include external technical assistance, EnMS metering and monitoring equipment, ISO 50001/SEP third-party certification audits, and internal facility staff time spent developing the EnMS and preparing for the third-party audit. This very conservative cost-accounting approach includes the full market value of facility staff time associated with developing the EnMS and meeting SEP requirements. It also assumes that there were no existing staff costs associated with energy-efficiency initiatives.

Including internal staff time, the average cost per facility was $319,000. The quantified internal facility staff time was the greatest component of these costs, representing 67 percent of costs. External technical assistance represented 18 percent of costs, metering equipment represented 9 percent of costs, and third-party audits represented 6 percent of costs. As both the facilities and DOE gain more experience with implementation, these costs are expected to decline.

The facilities reported that expert assistance was crucial, since the concepts of an integrated EnMS were new to staff, as was the software used to assist facilities in determining their level of energy performance improvement. Because the facilities in the study participated during the demonstration phase of the SEP program, DOE provided targeted technical assistance, the full cost of which was included in the overall cost of implementation per facility. Facilities also reported that costs associated with external technical assistance will be greatly reduced as ISO 50001 and the SEP program is implemented in other facilities within the same parent company.

The facilities all approached the metering and monitoring required for the SEP certification differently, demonstrating that this program element need not be complicated or expensive. Facilities are required to meter, monitor, and record energy consumption both for the whole facility and individually for "significant energy uses." Significant energy uses (SEUs) are those identified by the facility as having substantial energy consumption and offering considerable potential for energy performance improvement. Common examples included process dryers, boilers, and paint booths. One facility installed more metering than was required to receive the certification, but most simply used existing utility revenue meters combined with existing or new submeters. Four facilities installed no new metering equipment at all. Facilities view the additional costs for metering as money well spent, since they provide the data to both show the program's energy benefits and better identify areas that need further attention.

The facilities welcomed the third-party verification of their energy savings as an unbiased proof of the value of their programs, both internally and to external stakeholders, and saw the average $19,000 cost for auditing and certification (in a range between $16,000 and $20,000) as reasonable.

Implementing a robust EnMS to meet the requirements of SEP certification requires an industrial facility to invest staff resources, and may also require outside support. However, once a facility has established an EnMS, maintaining the EnMS requires considerably less effort, while the benefits of deeper and more sustained energy savings are ongoing. In addition, once the EnMS and methods for monitoring SEUs have been established, capital expenditures for metering equipment and operational costs of consultants are expected to be considerably less.

Building on the Program's Successes

The study's methodology, analysis, and results are being used to develop a framework for a planned Global Superior Energy Performance Partnership (GSEP) Energy Performance Database. However, because conducting the phone interviews and individually processing facility data is not scalable, future studies will need to devise a streamlined data collection approach. The U.S. Department of Energy is considering the integration of a cost/benefit methodology into EnPI, to standardize data collection and analysis and enable facilities to obtain results immediately.

As a measure of success, all of the facilities stated that they would pursue recertification, three years after their initial certification, and several indicated that they would seek SEP certification for other facilities within their parent company.

—Mark Wilson

For more information:

Peter Therkelsen
(510) 486-5645
PTherkelsen@lbl.gov

Aimee McKane
(518) 782-7002
ATMcKane@lbl.gov

Additional information:

Paul Therkelsen and Aimee McKane (Lawrence Berkeley National Laboratory), Ridah Sabouni and Tracy Evans (Energetics Incorporated), and Paul Scheihing (United States Department of Energy). 2013. "Assessing the Costs and Benefits of the Superior Energy Performance Program." [http://eetd.lbl.gov/publications/assessing-the-costs-and-benefits-of-t] LBNL-6349E.

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

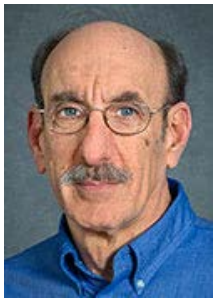
Research Highlights

Berkeley Lab and PPG Team to Produce Dark Coatings With Unprecedented Solar Reflectance

Lawrence Berkeley National Laboratory (Berkeley Lab) and PPG Industries have teamed to develop dark-colored pigments for cool metal roof and façade coatings that incorporate near-infrared (NIR) fluorescence and reflectance to improve energy performance. The program's goal is to develop a more advanced class of dark-colored pigments that can convert a portion of the absorbed visible light energy into NIR energy that is radiated away from buildings.

The new pigment technology under investigation would be a significant advance over current cool-coating pigments. The team estimates that cool coatings based on the new pigment technology could achieve effective solar reflectance (ESR) values of 0.5 to 0.7, compared to ESR values of 0.1 to 0.3 for standard pigments. An ESR improvement of 0.4 and widespread deployment of coatings with these pigments for residential applications in warm and hot areas of the United States could save up to $1.3 billion annually in related energy costs.

The work is funded by the U.S. Department of Energy.



Stephen Selkowitz

EETD's Stephen Selkowitz Receives *Engineering News-Record* 2014 Award of Excellence

The editors of *Engineering News-Record* have given Stephen Selkowitz the magazine's 2014 Award of Excellence. Selkowitz received the award "for relentlessly working to reduce the carbon footprint of buildings and for moving the nation toward better building performance, as well as for being the master of commercializing energy-efficient building technologies and the mastermind of FLEXLAB," the Facility for Low-Energy eXperiments in Buildings located at Berkeley Lab.

For more information:

Stephen Selkowitz

(510) 486-5064

SESelkowitz@lbl.gov

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division NEWS

Sources and Credits

Sources

Energy Efficiency & Renewable Energy's Energy Savers

These web pages [http://energy.gov/energysaver/energy-saver] provide information about energy efficiency and renewable energy for your home or workplace.

DOE's Energy Information Administration (EIA)

EIA [http://www.eia.gov/] offers official energy statistics from the U.S. Government in formats of your choice, by geography, by fuel, by sector, or by price; or by specific subject areas like process, environment, forecasts, or analysis.

DOE's Fuel Economy Guide

This website [http://www.fueleconomy.gov/] is an aid to consumers considering the purchase of a new vehicle.

DOE's Office of Energy Efficiency & Renewable Energy (EERE)

EERE's [http://www.eere.energy.gov/] mission is to pursue a better energy future where energy is clean, abundant, reliable, and affordable; strengthening energy security and enhancing energy choices for all Americans while protecting the environment.

U.S. DOE, Office of Science [http://science.energy.gov/]

U.S. EPA, ENERGY STAR Program [http://www.energystar.gov/]

California Energy Commission [http://energy.ca.gov/]

Credits

Editor
Allan Chen

Contributing Editor
Mark Wilson

Art Director
Anthony Ma

Web Design
Sondra Jarvis

Circulation
Joanne Lambert

Division Director
Ashok Gadgil

Building Technology and Urban Systems
Mary Ann Piette

Communications Office
Allan Chen

Energy Analysis and Environmental Impacts
Charles Goldman

Energy Storage and Distributed Resources
Venkat Srinivasan

Environmental Energy Technologies Division

The mission of the Environmental Energy Technologies Division is to perform research and development leading to better energy technologies and the reduction of adverse energy-related environmental impacts.

Ordering Information

EETD News
Lawrence Berkeley National Laboratory
University of California

Tel: (510) 486-4835
Fax: (510) 486-5394
Email: JMLambert@lbl.gov

LBNL/PUB-821 Vol. 12, No. 4 [http://eetd.lbl.gov/newsletter/nl47/], Spring 2014

The current and all past issues of *EETD News* [http://eetd.lbl.gov/newsletter/] are available on the World Wide Web.

Sign up for an "e-mail" subscription and get on our Electronic Notification list [http://eetd.lbl.gov/newsletter/sub/newsletter_signup.php]. You will receive an e-mail when a new issue is available.

This work was supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Ernest Orlando Lawrence Berkeley National Laboratory is a multiprogram national laboratory managed by the University of California for the U.S. Department of Energy. The oldest of the nine national laboratories, Berkeley Lab is located in the hills above the campus of the University of California, Berkeley.

With more than 4,000 employees, Berkeley Lab's total annual budget of nearly $600 million supports a wide range of unclassified research activities in the biological, physical, computational, materials, chemical, energy, and environmental sciences. The Laboratory's role is to serve the nation and its scientific, educational, and business communities through research performed in its unique facilities, to train future scientists and engineers, and to create productive ties to industry. As a testimony to its success, Berkeley Lab has had 11 Nobel laureates. EETD is one of 14 scientific divisions at Berkeley Lab, with a staff of 400 and a budget of $40 million.
