LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Winter 2011 Editor's Letter

The Department of Energy's Commercial Building Partnerships initiative is establishing collaborations to increase energy efficiency in new and existing commercial buildings. It teams National Laboratory researchers and private technical experts with commercial building owners and operators, to assist in the design, construction, and validation of low-energy buildings. Read more about it in this issue. You'll also find out about Berkeley Lab's role in the U.S.-China Clean Energy Research Center; the current status of OpenADR, the demand response communications protocol for the Smart Grid; Berkeley Lab's own energy-efficient data center project, and more.

Please invite your friends to subscribe [http://eetd.lbl.gov/newsletter/sub/newsletter_signup.php] to the EETD News.

—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].

Winter Newsletter: Vol. 9, No. 3 [http://eetd.lbl.gov/newsletter/nl34/]
Environmental Energy Technologies Division News [http://eetd.lbl.gov/newsletter/]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Commercial Building Partnerships Come Together

The LOOP, in Isla Vista, CA, is a building project receiving technical assistance from DOE's Commercial Buildings Partnerships initiative to increase the energy efficiency of its design.

Earlier this year, the U. S. Department of Energy (DOE) announced the second phase of its Commercial Building Partnerships (CBP) initiative, designed to establish collaborations to increase energy efficiency in new and existing commercial buildings.

Managed by Lawrence Berkeley National Laboratory (Berkeley Lab), the National Renewable Energy Laboratory (NREL), and the Pacific Northwest National Laboratory (PNNL), the effort teams laboratory researchers and private technical experts with commercial building owners and operators, to assist in the design, construction, and validation of low-energy buildings.

More than two dozen projects were selected in 2008 for the first phase of CBP, and those projects are currently under way. Then, last spring, NREL sent out a call soliciting new commercial partners to propose low-energy building projects. At the same time, Berkeley Lab sent out a request to identify private technical teams that would be qualified to assist the CBP commercial partners in this second round of projects. The second round will be financed by $21 million of American Recovery and Reinvestment Act funding. Ever since the application deadline closed in May, the labs have been evaluating the submissions and matching the technical teams with selected projects.

Commercial Building Partnerships, Phase 2	
Company/Facility	**Location**
Cascadia Center for Sustainable Design and Construction; The Bullitt Foundation	Seattle, WA
Center for Alternative, Renewable Energy, Technology and Training; Clark Atlanta University	Atlanta, GA
The College of Architecture + Planning at the University of UT	Salt Lake City, UT
The Defense Commissary Agency; Lackland Air Force Base	San Antonio, TX
Grand Valley State University	Allendale, MI
Hines	Somerset, NJ
The Home Depot	Rocklin, CA
Living City Block	Denver, CO
The LOOP at the University of CA; Mesa Lane Partners	Santa Barbara, CA
Long Beach Gas and Oil	Long Beach, CA
MA Institute of Technology	Cambridge, MA
OR Built Environment & Sustainable Technologies Center	Portland, OR
Shy Brothers Farm	Westport, MA
Sierra NV Job Corps	Reno, NV
Smart Grid Development	North Kingstown, RI
Twentieth Century Fox Film Corporation	Los Angeles, CA
University of CA Merced	Merced, CA
University of SC	Columbia, SC
U.S. Army	Fort Bragg, NC
U.S. General Services Administration	Portsmouth, NH
U.S. General Services Administration	Region 9 locations
U.S. General Services Administration	San Francisco
Walmart	Two locations to be determined

The two- to four-year CBP projects are managed in six stages: predesign and planning, preliminary design, final design, construction and commissioning, performance verification and reporting, and deployment planning. At the end of each stage, the project is evaluated to ensure that it is progressing as expected and that it meets its predetermined criteria. The technical and business case studies prepared at the final reporting stage will be publicly available, so that other businesses can also benefit from the lessons learned during each project's implementation.

MIT's Stata Building is receiving technical assistance for an energy-efficient lighting retrofit project.

The CBP program is part of DOE's Commercial Building Energy Alliances (CBEA), which has the broad goal of transforming commercial building energy efficiency. Each of the winners, which were announced in late November, will receive between $200,000 and $1.2 million of technical assistance; funding does not go directly to the participants, but instead funds the technical experts from the national laboratory or private industry that work with the commercial partners and their design teams. The 23 newly selected partners (see sidebar) are located throughout the country and range from well-known retailers such as The Home Depot and Walmart to universities and military bases.

It is expected that the new buildings that CBP commercial participants will construct based on this program will achieve a minimum of 50 percent energy savings relative to ASHRAE/IESNA Standard 90.1-2007, that retrofits of existing buildings will achieve a minimum of 30 percent energy savings, and that portfolio building retrofits will achieve substantial energy savings for more than one building system.

DOE/EERE's Commercial Building Partnerships [http://www1.eere.energy.gov/buildings/commercial_initiative/building_partnerships.html]

DOE News Announcement [http://www.energy.gov/news/9838.htm]

NREL CBP Program Announcement [http://www.nrel.gov/news/press/2010/836.html]

EETD article, "New Opportunities to Improve Commercial Building Energy Efficiency" [http://eetd.lbl.gov/news-archives/news-cbp.html]

This work is funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

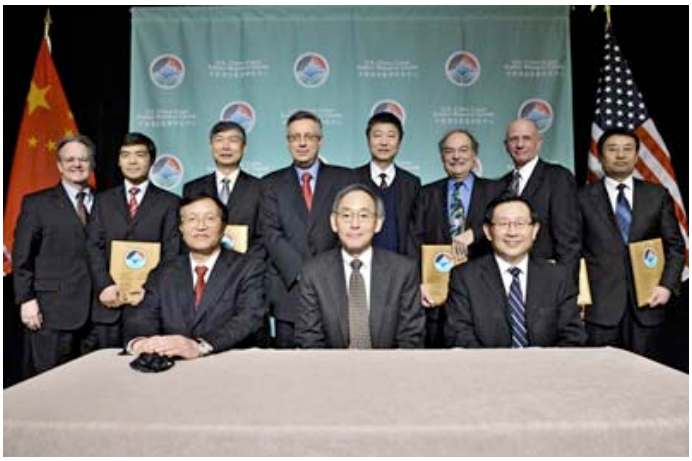
LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

World's Two Energy Giants Establish Joint Clean Energy Research Center

The two largest greenhouse gas-emitting nations, the United States and China, have formed a partnership to research and develop clean energy technology. Agreements formalizing the research plans of the U.S.-China Clean Energy Research Center (CERC), announced jointly by President Barack Obama and President Hu Jintao more than a year ago, were signed in January 2011 during a state visit of the Chinese President and other officials to Washington D.C.



U.S.-China Clean Energy Research Center signing ceremony, January 18, 2011, Washington, D.C.

Back: Robert C. Marlay, U.S. Department of Energy; Minggao Ouyang, Tsinghua University, China Clean Vehicles Consortium; Li Peigen, Huazhong University of Science and Technology, China Advanced Coal Technology Consortium; Dennis Assanis, University of Michigan, U.S. Clean Vehicles Consortium; Jiang Yi, Vice Dean, School of Architecture, Tsinghua University, China Clean Building Consortium; Mark Levine, Lawrence Berkeley National Laboratory, U.S. Clean Buildings Consortium; Jerald J. Fletcher, West Virginia University, U.S. Advanced Coal Technology Consortium; Xu Shisen, China Huaneng Group, China Advanced Coal Technology Consortium.

Front: Zhang Guobao, Administrator, China National Energy Administration; Stephen Chu, Secretary, U.S. Department of Energy; Wang Gong, Minister, China Ministry of Science and Technology.

Focusing on three areas—building energy efficiency, clean vehicles, and advanced coal technology—the Center will serve as the coordinating agency for the work of Chinese and U.S. teams in each area, with equal funding contributed by the two nations. Lawrence Berkeley National Laboratory's (Berkeley Lab's) Mark Levine will lead the buildings energy efficiency area (CERC-BEE) for the United States.

Berkeley Lab's counterpart in China is the Building Energy Research Center at Tsinghua University. Oversight of the project in China will be carried out by the Ministry of Housing and Urban-Rural Development (the former Ministry of Construction).

Levine leads the China Energy Group, a research team that works collaboratively with Chinese colleagues to improve energy efficiency in China, primarily through joint policy studies and presentations to senior leaders in China. He was Director of Berkeley Lab's Environmental Energy Technologies Division (EETD) from 1996 to 2006.

"For a year since the announcement in 2009," said Levine, "U.S. and Chinese officials have worked together to develop a research plan and draft the agreements that were signed by Energy Secretary Chu and the Chinese Ministers of Science and Technology (Wan Gang) and Energy (Zhang Buobau). We're now putting the research into motion, starting up projects that will lead to new advanced technology and significantly lower carbon emissions."

Levine presented the research plan for the U.S.-China collaboration on buildings at a meeting attended by the scientific leaders and industry partners of the research effort from both countries. He thanked EETD staff member Anthony Ma for his hard work in creating the presentation and its many visual elements.

"Our goal," said Levine "is to build the knowledge, technologies, tools, and human relationships that position the U.S. and China for a future with very low energy buildings with very low carbon dioxide emissions." To that end, CERC- BEE (Buildings Energy Efficiency) plans to conduct research in four areas: monitoring and simulation, the building envelope, building equipment, and whole building efficiency. The plan includes a strong component to support commercialization of research products.

In addition to managing the overall effort, Berkeley Lab is contributing research expertise in policy analysis, energy-efficient building design, windows and daylighting technology, and cool roofing materials. Six other U.S. institutions are participating in the effort: the Department of Energy's Oak Ridge National Laboratory; the California Lighting Technology Center at the University of California, Davis; Massachusetts Institute of Technology; the Natural Resources Defense Council; the National Association of State Energy Officials; and private-sector energy consulting firm ICF International.

The research plan sets out five-year goals that include developing new technology and implementing field demonstrations of energy-efficient lighting systems, energy control systems and real-time monitoring networks, cool roofs, and integrated window systems.

In the first year of operation, CERC-BEE plans to bring a Chinese-designed real- time energy monitoring system to the U.S. for installation and testing in buildings. Researchers, along with two of the U.S. industry partners will share and analyze the large databases produced by the real-time monitoring in Chinese and U.S. buildings.

They also plan to identify and study the energy use of buildings of similar designs, areas, and climate conditions in both countries. Researchers will analyze what elements of the buildings make them high- or low-energy consumers. Finally, the research teams will produce a compilation of emerging energy-efficient building technologies.

The U.S. and Chinese teams will collaborate on all of these efforts and on most of the other research as well.

"We place a high priority on building long-term partnerships between U.S. and Chinese researchers in the buildings energy efficiency area—this will be a significant outcome of our work," Levine said.

A final detailed work plan will be completed by March. Various research projects are in start-up mode now.

CERC-BEE's industrial partners are Dow Chemical, Schneider Electric, Honeywell, the Energy Foundation, St. Gobain, Bentley, Climate Master, GE Global Research, and Pegasus Capital Advisors. "We hope over the coming year to demonstrate the unique strength of the Chinese-U.S. collaboration on energy efficiency in buildings, so that new industrial partners will be willing to contribute additional resources to strengthen the CERC research effort" said Levine.

The Chinese research consortium is led by the China Academy of Building Research; Tshinghua, Chongqing, Tongji, and Tianjin Universities; and the Center for Building Energy Efficiency Research of the Ministry of Housing and Urban-Rural Development. These leading institutions will oversee other research groups.

In addition to Levine, Berkeley Lab-EETD participants include Nan Zhou (one of two deputies, with Michaela Martin of ORNL); Tianzhen Hong, building simulation lead; Eleanor Lee, windows and daylighting lead; and Ronnen Levinson, cool roofing/urban heat islands lead.

—Allan Chen

View the U.S.-China Clean Energy Research Center [http://www.us-chinacerc.org/] website.

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Environmental Energy Technologies Division

NEWS

OpenADR Alliance Begins to Advance OpenADR as Smart Grid Standard

The OpenADR Alliance, a nonprofit corporation created to foster the development, adoption, and compliance of a Smart Grid standard known as Open Automated Demand Response (OpenADR) held its first members' meeting at Lawrence Berkeley National Laboratory (Berkeley Lab), on January 20 and 21, 2011.

Automated demand response is a set of pre-programmed steps in a building or industrial facility that automatically triggers to reduce peak power use when the electricity grid is in danger of falling out of supply-demand balance or when real-time electricity prices are high. OpenADR is a communications specification that makes it possible for facilities managers to implement automated demand response (AutoDR) by providing a standard set of Internet signals for describing the state of the grid and actuating a demand response.

OpenADR was developed by Berkeley Lab researchers and industrial partners through the Demand Response Research Center (DRRC), which is funded by the California Energy Commission's Public Interest Energy Research (PIER) Program.

In May 2010, following eight years of development, OpenADR became one of 16 Smart Grid standards supported by the U.S. Department of Energy and the National Institute of Standards and Technology's Smart Grid Interoperability Standards effort. Open standards are supported by market stakeholders because they lower costs, both for consumers and the utilities adopting these technological innovations.

Berkeley Lab, a founding member of the OpenADR Alliance, hosted more than 50 people from 32 companies, government agencies, utilities, and research institutions. Pacific Gas and Electric Company, Southern California Edison, and Honeywell are the other founding members.

Michael Gravely, manager of energy systems research at the California Energy Commission, delivered the keynote address. He noted that meeting the 33 percent renewable energy target in California by 2020 will require the state to use technologies like OpenADR and energy storage to balance the cyclical nature of solar and wind generation and integrate renewable power on the grid.

"I was very impressed with the level of industry support shown by those attending the first OpenADR Alliance meeting," said Mary Anne Piette, chair of the OpenADR Alliance and deputy head of the Building Technologies Department at Berkeley Lab. "Our members made significant progress identifying key goals and priorities for the Alliance, along with the formation of technical and marketing committees."

Technical committees were established to help move forward OpenADR's pathway to a Smart Grid standard and toward wider industry adoption. The group also began the process of setting up a conformance and testing program, so that members will eventually be able to submit products for testing and certification of compliance with OpenADR. "The OpenADR Alliance is an important milestone in bringing the OpenADR-compliant products to marketplace and in its wide-scale adoption," said Girish Ghatikar, the interim technical director of the OpenADR Alliance, and program manager at Berkeley Lab.

A newly formed technical committee is facilitating the development and transition to OpenADR 2.0. Feature sets and test cases for this new version of OpenADR will help establish a framework for the testing and certification program. The committee has discussed cooperation with various standards-setting organizations now working to establish Smart Grid standards, to allow technology and system suppliers, energy customers, and utilities and their regulators to maximize its benefits.

Although the definition of the Smart Grid varies, most in the field agree that a smart electrical grid incorporates sensors, physical control systems, and software in the buildings connected to the electricity grid, as well as on the grid itself, to maintain the grid's continuous operation. It does this by preventing or correcting problems in real time, as well as by reducing peak power use during high-congestion periods and by helping to maximize consumers' energy efficiency over a longer time horizon.

The Smart Grid allows its managers and users to understand its state of health from moment to moment, maximize efficient use of energy, participate effectively in utility load-shifting programs (in which the customer can delay energy use to periods when the price is lower in return for price breaks), and minimize energy bills.

—Allan Chen

For more information, contact:

Girish Ghatikar
(510) 486-6768
gghatikar@lbl.gov

OpenADR Alliance [http://www.openadr.org/]

Demand Response Research Center [http://drrc.lbl.gov/]

OpenADR Activities [http://openadr.lbl.gov/] within LBNL

"OpenADR Specification to Ease Building Power Reductions [http://eetd.lbl.gov/newsletter/nl28/eetd-nl28-2-openadr.html]" *EETD News*.

"Berkeley Lab Researchers Announce OpenADR Specification to Ease Saving Power in Buildings Through Demand Response" [http://newscenter.lbl.gov/press-releases/2009/04/27/openadr-specification/] Berkeley Lab News Center.

OpenADR research is funded by the California Energy Commission's Public Interest Energy Research (PIER) Program.

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Energy Efficient Data Center Retrofit — Wireless Sensor Network

Passive rear door heat exchanger devices help optimize energy efficiency in a data center at Lawrence Berkeley National Laboratory.

Over the decades, the energy efficiency technologies and processes researched and developed at Lawrence Berkeley National Laboratory (Berkeley Lab) have supported energy-efficient technologies throughout the world. From time to time, however, Berkeley Lab has the opportunity to apply its solutions right on its own grounds.

In 2007, Berkeley Lab's 40-year-old data center had HVAC problems and was running out of cooling capacity. In response, it instigated a project to address those challenges while showcasing energy-saving data center technologies. The project was a partnership of the Lab's IT Division and Environmental Energy Technologies Division (EETD). Berkeley Lab engineers worked with Taylor Engineering, ANCIS Corporation, and SynapSense to reconfigure the data center's HVAC system and install a wireless sensor network (WSN) to collect real-time data and enable operators to visualize system performance. The WSN provides real-time feedback so that they can adjust temperature and humidity optimally, to minimize energy use.

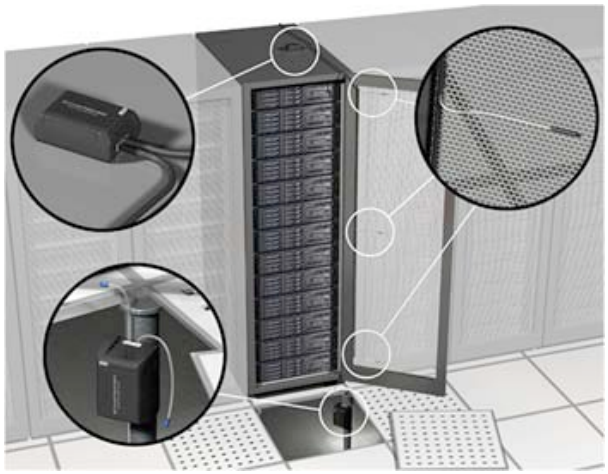
In its initial facility review, Taylor Engineering found inefficiencies with airflow and cooling. Although the center had more than enough cooling capacity to meet server cooling needs (a 20-ton cooling system and water-cooled computer room air conditioner [CRAC] units for underfloor cooling), the cooling was unbalanced, and there were a number of hot spots throughout the facility. To get the most out of the existing cooling systems, and to help rebalance the airflow, ANCIS Corporation and SynapSense were brought in.

The opened back of a server rack with rear door heat exchanger devices installed.

ANCIS conducted computational fluid dynamics (CFD) modeling to better understand the airflow patterns and to evaluate efficient airflow before reconfiguring the conditioning systems. Wireless sensors provided by SynapSense were used to help tune the existing system. The CFD modeling and wireless sensors helped engineers design and reconfigure the system more quickly and at less cost, as well as help ensure that the resulting system configurations would perform more effectively and

more efficiently than its predecessor. As a result of these efforts, the center was able to increase its IT load, greatly reduce the number of hot spots, and do so with fewer CRAC units than when the project started.

In 2009, to help mitigate the heat from an increasing load, data center rack cooling was improved with rear-door heat exchangers (RDHx). These units were added to cool the hot air coming from the servers before it was released into the data center. By fall of that year, it was clear that all of the changes at the center had really paid off. The modifications enabled the total IT load to reach 500 kilowatts (kW)—more than 30 percent higher than it had been when Taylor Engineering, ANCIS Corporation, and SynapSense had first assessed the facility.



Wireless sensors provide the data to help operators maximize data center energy efficiency.

However, because Berkeley Lab's need for research computers is constantly growing, it once again asked Taylor Engineering to see if it could determine a way to modify the cooling system so that it could accommodate an additional 207kW server load.

The end result is a data center that can now support the increased server load at a higher efficiency, with better temperature control and no increase in installed cooling equipment. The WSN data collection and data visualization systems continue to be used to optimize the facility's operation. Payback for the WSN modifications is estimated to be 1.5 years.

This overall retrofit process also identified some key strategies that can be used by other data centers interested in making their facilities more efficient:

- Gather air temperatures and develop trend information with an energy monitoring and control system (EMCS), building automation system (BAS), or other monitoring system before installing additional cooling.
- Meter and monitor equipment to provide energy use data to support design and optimize performance.
- Optimize airflow management before installing additional cooling.

—Mark Wilson

For more information, contact:

Dale Sartor
(510) 486-5988
DASartor@lbl.gov

Geoffrey Bell
(510) 486-4626
GCBell@lbl.gov

Data Center Rack Cooling with Rear-door Heat Exchanger
(Technology Case-Study Bulletin, June 2010) [PDF [http://hightech.lbl.gov/documents/DATA_CENTERS/rdhx-doe-femp.pdf]]

Wireless Sensors Improve Data Center Energy Efficiency
(Technology Case-Study Bulletin, September 2010) [PDF [http://hightech.lbl.gov/documents/data_centers/wireless-sensor-doe-femp.pdf]]

Data Center Airflow Management Retrofit
(Technology Case-Study Bulletin, September 2010) [PDF [http://hightech.lbl.gov/documents/data_centers/airflow-doe-femp.pdf]]

This research is funded by the California Energy Commission's Public Interest Energy Research program.

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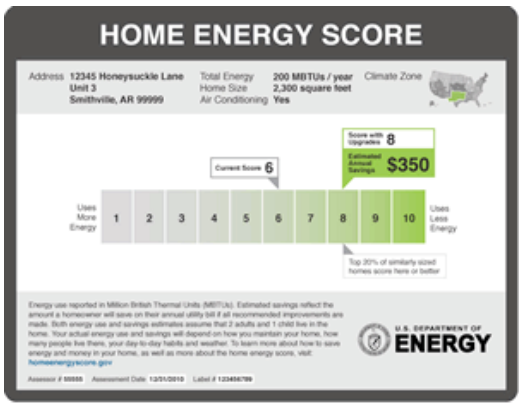
Environmental Energy Technologies Division

NEWS

Home Energy Score Pilot Program

In November 2010, Vice-President Biden and Energy Secretary Steven Chu announced the launch of the Home Energy Scoring Program, based on the Home Energy Scoring Tool created by Lawrence Berkeley National Laboratory's (Berkeley Lab's) Home Energy Saver development team. The team was led by Environmental Energy Technologies Division (EETD) researchers Evan Mills and Rich Brown, and the tool was based on Berkeley Lab's calculating engine for the Home Energy Saver—the DOE-2 building energy simulation program.



[http://www1.eere.energy.gov/buildings/homeenergyscore/]

In fall 2009, Vice-President Biden and the White House Council on Environmental Quality sent out the call to establish a program that would enable homeowners to quantify their home's energy efficiency and identify recommendations for improving it. To support that program, Berkeley Lab's Home Energy Saver team developed the Home Energy Scoring Tool, which enables users to quantify a home's energy performance, compare it on a scale of 1 to 10 to other homes in the area and to others in the same climate zone, and identify recommendations for improving the home's energy efficiency. Each recommended activity also includes information on the estimated utility bill savings, its payback period, and the quantity of greenhouse gas emission reductions.

The tool is used by a trained, certified home energy assessor, who can gather about 40 data inputs and provide a score in less than an hour. To ensure a balanced comparison, the tool divides the United States into 19 climate zones, so that it can provide an "apples- to-apples" energy use comparison among houses in the same climate.

The program is being piloted in 10 U.S. communities until late spring 2011, and it will be launched nationally late in 2011.

—Mark Wilson

US DOE Press Release: "Vice President Biden Launches Home Energy Scoring Program [http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=433]" *EERE News*. November 9, 2010.

The U.S. Department of Energy's Home Energy Score [http://www1.eere.energy.gov/buildings/homeenergyscore/] website.

This work is funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

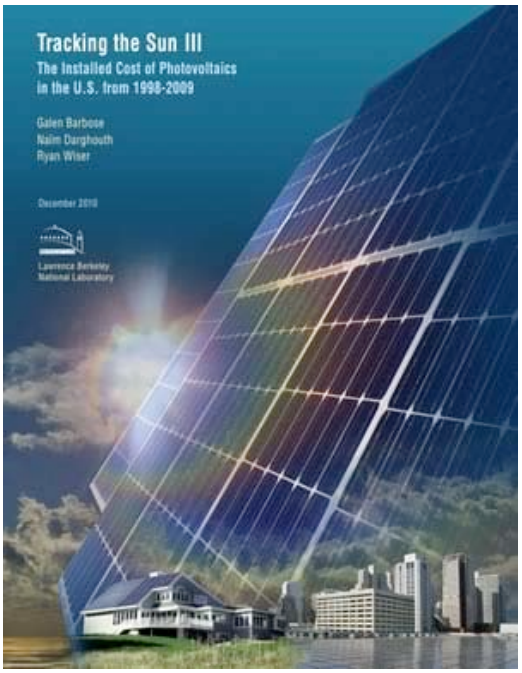
LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Berkeley Lab Report Shows Steep Decline in Installed Cost of U.S. Photovoltaics

Environmental Energy Technologies Division (EETD) researchers at Lawrence Berkeley National Laboratory (Berkeley Lab) have released a study on the installed costs of solar photovoltaic (PV) power systems in the U.S., showing that the average cost of these systems remained largely unchanged from 2008 to 2009, before beginning a steep decline in 2010.



The number of solar PV systems in the U.S. has been growing rapidly in recent years, as governments at the national, state, and local levels have offered incentives to expand the market. With this growth comes a greater need to track and understand trends in the installed cost of PV.

"A goal of government incentive programs and other policy support mechanisms is to stimulate demand for PV, and thereby drive down the cost of PV systems. One purpose of this study is to provide reliable information about the historical costs of installed systems in the United States," says report co-author Ryan Wiser of Berkeley Lab's EETD.

According to the report, the decline in PV installed costs seen by customer-owners of such systems in 2010 follows a significant drop in the wholesale cost for PV modules in 2009. As report co-author Galen Barbose explains, "Based on our data, average installed costs held steady at $7.50 per watt from 2008 to 2009, even though wholesale module prices dropped substantially over this period. However, that drop in module prices appears to have made its way to customers in 2010." Modules typically represent about half the installed cost of a PV system.

The report presents partial-year data for systems installed in 2010 from the country's largest PV incentive programs. In the California Solar Initiative Program, average installed costs dropped by $1.00/watt (W) between 2009 and the first ten months of 2010, and in New Jersey, costs dropped by $1.20/W between 2009 and the first six months of 2010.

"This reduction in installed costs marks an important departure from the trend of the preceding four years, during which costs seen by customer-owners of PV systems remained relatively flat as rapidly expanding U.S. and global PV markets put upward pressure on both module prices and non-module costs. This dynamic has now shifted, as expanded manufacturing capacity in the solar industry, in combination with the global financial crisis, led to a decline in wholesale module prices," says Naïm Darghouth, another report co-author.

Although the recent decline in PV installed costs appears to be primarily associated with reductions in module prices, the longer term trend toward lower installed costs is also the result of a decline in non-module costs, such as the cost of labor, marketing, overhead, inverters, and the balance of systems. According to the report, average non-module costs in the U.S. declined by $1.40/W from 1998 to 2009, while module costs declined by $2.50/W over the period from 1998 to 2007.

The study—the third in an ongoing series that tracks the installed cost of PV in the U.S.—examined 78,000 grid-connected PV systems installed between 1998 and 2009 in 16 states. It found that average installed costs, in 2009 dollars, declined by 30% from $10.80/W in 1998 to $7.50/W in 2009—equivalent to an average annual reduction of $0.30/W, or 3.2 percent per year in real dollars. Focusing on two of the largest solar markets, California and New Jersey, costs in the first six to ten months of 2010 dropped an additional 14 percent and 16 percent respectively, relative to 2009.

Costs Differ by Region and Type of System

Differences in average costs by region and by installation type also emerged from the study. Additionally, installed costs show significant economies of scale—small PV systems completed in 2009 that were less than 2 kilowatts (kW) in size averaged $9.90/ W, while large systems greater than 1,000 kW averaged $7.00/W.

Installed costs were also found to vary widely among states. Among those PV systems completed in 2009 and less than 10 kW in size, average costs ranged from a low of $7.10/W in Texas to a high of $9.60/W in Minnesota. Based on these data, and on installed cost data from the sizable German and Japanese PV markets, the authors suggest that PV costs can be driven lower through large-scale deployment programs, but that other issues are also important determinants to achieving cost reductions.

The study found that the new construction market offers cost advantages for residential PV systems. Among small residential PV systems in California completed in 2009, those systems installed on new homes cost $1.60/W less than comparably-sized systems installed in rooftop retrofit applications.

Cash Incentives Declined

The study also found that the average size of direct cash incentives provided by state and local PV incentive programs declined over the 1998–2009 study period. Other sources of incentives, however, such as federal investment tax credits (ITCs) and the Treasury Grant Program, have become more significant. For commercial PV systems, the average combined after-tax value of federal and state ITCs, plus direct cash incentives provided by state and local incentive programs, was $3.90/W in 2009, down slightly from its peak in 2006 but still a near-record high. Total after-tax incentives for residential systems rose by more than a third to $3.90/W in 2009 due to the elimination of the $2,000 cap on the Federal ITC for residential systems that had previously been in place.

The increase in total after-tax incentives for residential PV from 2008 to 2009 resulted in a significant decrease in the net installed cost—that is, the installed cost facing a customer after receipt of financial incentives. On average, the net installed cost for residential PV was $4.10/W in 2009, down by roughly 24 percent from 2008 levels. In contrast, average net installed costs for commercial PV remained virtually unchanged from 2008 to 2009, at approximately $4.00/W.

For more information, contact:

Galen Barbose
(510) 495-2593
GLBarbose@lbl.gov

Ryan Wiser
(510) 486-5474
RHWiser@lbl.gov

Tracking the Sun III: The Installed Cost of Photovoltaics in the U.S. from 1998–2009, [http://eetd.lbl.gov/ea/emp/re-pubs.html] by Galen Barbose, Naïm Darghouth, and Ryan Wiser.

The research was supported by funding from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Program) and by the Clean Energy States Alliance, a national nonprofit coalition of leading state clean energy programs that work together to advance renewable energy project deployment in their states and across the country.

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Research Highlights

Carla Peterman Appointed to California Energy Commission by Governor Jerry Brown

Governor Jerry Brown has appointed Carla Peterman to the California Energy Commission.

Peterman is a doctoral candidate in the Energy and Resources Group, University of California, Berkeley, and a graduate student researcher with the Environmental Energy Technologies Division of Lawrence Berkeley National Laboratory. Her primary research interests are renewable energy, technology innovation, and climate change mitigation policy. Her dissertation examines the effect of market transformation activities, such as subsidies, on the U.S. solar photovoltaic market. At Berkeley Lab, Peterman researches solar photovoltaic markets and the impact of renewable subsidy programs on PV deployment and cost.

Her Berkeley Lab research publications are available by searching the publications page [http://eetd.lbl.gov/EA/emp/emp-pubs.html] of the website of the Electricity Markets and Policy Group of the Environmental Energy Technologies Division.

Peterman holds an Msc. in Environmental Change and Management and an M.B.A. from Oxford University, where she studied as a Rhodes Scholar. She also has a B.A. in History from Howard University.

For more information, see:

- Energy Markets and Policy Group staff page [http://eetd.lbl.gov/EA/emp/staff/peterman.html]
- Energy and Resources Group [http://erg.berkeley.edu/news/2011news/EnergyCommision.shtml]
- UC Energy Institute [http://ei.haas.berkeley.edu/]
- Energy and Resources Group profile of Peterman [http://erg.berkeley.edu/people/Student_Spotlight/Student_Spotlight_Carla_Peterman.shtml]
- Governor Brown's press release [http://gov.ca.gov/news.php?id=16886]

EETD Scientists Recognized by the American Council for an Energy-Efficient Economy

Charles Goldman, a scientist in the Environmental Energy Technologies Division, has been given a special award by the American Council for an Energy-Efficient Economy in recognition of the "Electricity Markets and Policy Group's critical achievements and leadership in the energy efficiency field." Goldman is the leader of this research group.

The award was presented at a reception during the ACEEE's "Energy Efficiency–Advancing Our Economy, Environment, and Security" conference in Washington D.C., which celebrated the organization's 30 years of work in energy efficiency. DOE's

Cathy Zoi, Acting Under Secretary and Assistant Secretary, Energy Efficiency and Renewable Energy, was the featured speaker at the reception.

Art Rosenfeld, who has returned to the Environmental Energy Technologies Division with the title Distinguished Scientist Emeritus, was also recognized as a visionary in energy efficiency. The ACEEE said of Art and Amory Lovins:

"Arthur H. Rosenfeld and Amory Lovins have been visionaries in the field of energy efficiency. What we know as energy efficiency today is in significant part because of their imagination, dedication, and hard work. Art Rosenfeld, one of ACEEE's founders, recently retired as head of the California Energy Commission. Amory Lovins is Chairman and Chief Scientist of the Rocky Mountain Institute."

Ashok Gadgil's Students Help Design Sustainable House

Students from "Design for Sustainable Communities," a class taught by Lawrence Berkeley National Laboratory's Ashok Gadgil at the University of California, Berkeley, developed the business model for a an innovative cottage now on the market. The economical 420-square-foot cottage uses sustainable materials and features a concrete slab foundation to absorb solar heat that warms the house at night.

The house was designed by Kevin Casey, an MBA graduate from UC Berkeley's Haas School of Business, along with students from City and Regional Planning, Civil Engineering, the Haas School of Business, and Gadgil's class. Casey is now the CEO of New Avenue Homes, which helps interested home buyers finance and build the structures. They range from $60,000 to $125,000, and are designed for infill development and for those looking for a very low-cost residence.

For more information, see:

- Design for Sustainable Communities [http://enviro.berkeley.edu/node/3668]
- New Avenue Homes [http://www.newavenuehomes.com/]

Energy Efficiency Retrofits for Healthier Interiors

Many U.S. residents living in multifamily buildings may be exposed to high levels of potentially harmful indoor contaminants, and often their ability to remedy that problem is limited because they do not own the property or have the money fix the problems.

The United States is looking for ways to improve indoor environmental quality (IEQ) as part of its aggressive energy retrofits in subsidized multifamily housing. Lawrence Berkeley National Laboratory researchers Federico Noris, William Fisk, Brett Singer, and Iain Walker are teaming with a variety of consultants to develop protocols that identify packages of beneficial retrofits capable of reducing energy use and improving IEQ. The team will conduct energy and IEQ retrofits in 15 apartments (in three different buildings) for different California climates. Energy use and IEQ conditions will be monitored before and after the retrofit implementation. Those data will be compared to data from unretrofitted apartments and analyzed to determine the retrofit's effects on energy use and IEQ. The research program will cover the cost of retrofitting the apartments.

The three-year project, which began in May 2010, is currently recruiting buildings and apartments for the retrofits. To meet the needs of the project, buildings must be low-rise, subsidized housing more than 20 years old, be metered at the individual apartments, and have at least 15 apartments. Further criteria [http://apartmentenergy-ieqretrofits.lbl.gov/more-information] are listed at the project website.

Apartment Retrofits for Energy and Indoor Environmental Quality [http://apartmentenergy-ieqretrofits.lbl.gov/]

This work is funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, and the California Energy Commission's Public Interest Energy Research (PIER) Program.

For more information, contact:

Federico Noris

Post Doctoral Fellow, LBNL

(510) 289-4324

FNoris@lbl.gov

The Healthy Zero Energy Buildings Website

The Healthy Zero Energy Buildings [http://hzeb.lbl.gov/] (HZEB) website has made its debut.

The HZEB research program's goal is to develop the information needed for scientifically-sound commercial building ventilation standards that balance energy efficiency objectives with the need to maintain acceptable indoor air quality.

Zero (net) energy buildings have a net energy consumption of zero over a typical year. The California Public Utility Commission and the California Energy Commission have adopted the goal of all new commercial buildings constructed to zero net energy levels by 2030.

HZEB research is funded by the California Energy Commission's Public Interest Energy Research (PIER) program. Stakeholders who will help guide the research include California Energy Commission, California Department of Health Services, California Air Resources Board, California Division of Occupational Safety and Health, U.S. Environmental Protection Agency, the National Institute of Standards and Technology, and the private sector HVAC and building industries.

Healthy Zero-Energy Buildings [http://hzeb.lbl.gov/]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division NEWS

Sources and Credits

Sources

DOE's Energy Savers

This website [http://www.energysavers.gov/] provides information about energy efficiency and renewable energy for your home or workplace.

DOE's Energy Information Administration (EIA)

EIA [http://www.eia.doe.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://www.er.doe.gov/]

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

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

Credits

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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

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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.
