



Environmental Energy Technologies Division

NEWS

FALL 2013:
VOL. 12, NO. 2

[FLEXLAB Q&A](#)

[CalCharge Summary](#)

[ESCO Industry Report](#)

[Energy-Efficient High
Performance Computer
Working Group](#)

[Tracking the Sun VI Report](#)

[Wind Turbines/
Residential
Property Values](#)

[Low-Carbon Data Centers](#)

[Award-winning Conducting
Polymer Binder Gets Better](#)

[3M Window Film](#)

[VOC True Read](#)

[Max Tech Winners](#)

[Potential CHP Penetration in
California](#)

[Research Highlights](#)

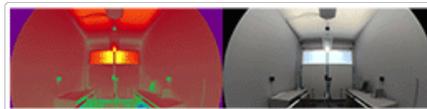
[Sources and Credits](#)

In this packed issue of *EETD News*, you can learn about a wide variety of recent research results, technology developments and works in progress here at Berkeley Lab's Environmental Energy Technologies Division. We lead with a Q&A with the leader of the Facility for Low-Energy eXperiments in Buildings (FLEXLAB) and follow up with a brief update on CalCharge, another significant new activity aimed at bringing advanced batteries to the marketplace more quickly. You'll find much more on energy service companies, wind turbines and property values, solar PV, energy-efficient computing and data centers, and battery and indoor air quality technologies.

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

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

Fall Newsletter: Vol. 12, No. 2 [\[http://eetd.lbl.gov/newsletter/n145/\]](http://eetd.lbl.gov/newsletter/n145/)

Environmental Energy Technologies Division News [\[http://eetd.lbl.gov/newsletter/\]](http://eetd.lbl.gov/newsletter/)

©2013 Environmental Energy Technologies Division [\[http://eetd.lbl.gov/\]](http://eetd.lbl.gov/)

E.O. Lawrence Berkeley National Laboratory [\[http://www.lbl.gov/\]](http://www.lbl.gov/)

Disclaimer [\[http://www.lbl.gov/Disclaimers.html\]](http://www.lbl.gov/Disclaimers.html)



Environmental Energy Technologies Division

NEWS

A Q&A with Cindy Regnier, Manager of the Facility for Low-Energy eXperiments in Buildings (FLEXLAB)

The Facility for Low-Energy eXperiments in Buildings (FLEXLAB) is designed to be a national focal point for developing, simulating, and testing energy-efficient technologies and strategies for buildings. FLEXLAB users will conduct research and develop technologies at FLEXLAB on single components as well as whole-building integrated design and operation. This research is aimed at substantially lowering the energy use, and improving the comfort and performance, of both new and existing buildings. FLEXLAB is a facility of Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (EETD).



Artist's conception of a portion of the FLEXLAB facility

In the following Q&A, Cindy Regnier, FLEXLAB's manager, discusses the facility's capabilities and how the facility will be used when it opens.

How is the construction of FLEXLAB going? When will it be ready for users?

Construction is going well. At this point, FLEXLAB is on time and on budget, and construction should be complete in early 2014, including the commissioning process. Following that, we will put the facility through a calibration process to determine testbed accuracies, begin testing the data acquisition system, and gathering baseline data from its many sensors.

Who do you expect will be the primary users of FLEXLAB when it is completed? And what needs does FLEXLAB address for these users?

The diversity of users is broad—maybe broader than you think. FLEXLAB can address the energy-efficiency needs of utilities, federal and state research programs, manufacturers, building owners, and the AECO [architecture, engineering, construction and owner-operated] community.

Product manufacturers of almost any type of building product or service are natural user groups for FLEXLAB. It can help extend the impact and market potential of products by developing integrated design solutions—such as automated shading coupled with dimmable lighting systems—that validate performance (for example, visual comfort), as well as energy savings.

FLEXLAB can also help where they've developed an emerging technology whose performance isn't yet recognized in industry—for example, code, or simulation tools. They need verified performance data and a means to extend results to the rest of industry.

We expect to work with the AECO community, too. The developer and AECO community is increasingly being asked to deliver guaranteed performance of building designs, whether for energy performance disclosure laws or for other energy efficiency-related purposes. The community currently only develops mockups for constructability, not verification of energy or

comfort performance. Verification of a design's energy and overall performance in FLEXLAB lowers risk for construction of the facility, especially where there are unique combinations of low-energy systems or high-risk elements that might affect comfort and performance, such as full-height glazing.

AECO users will be able to specify and test innovative systems for their designs in one or more of FLEXLAB's testbeds, and use feedback data from their operation to improve their designs. Building new energy-efficient buildings or improving the energy performance of existing buildings in an investment portfolio enhances value. AECO users will develop higher confidence in new innovative design strategies with high energy-efficiency targets—reducing financial risk of these projects. This confidence, backed by data, can differentiate the truly innovative AECO firms in the marketplace.

Utilities need verified performance of emerging technologies to increase certainty of their impact on energy use. They also need R&D in emerging areas of energy-reduction strategies to meet their energy efficiency programmatic goals, such as whole-building integrated system performance.

How about the public sector?

For federal and state energy-efficiency programs, R&D in FLEXLAB can help them determine the best technologies to reach aggressive energy savings goals, such as California's goal of net-zero energy buildings by 2030. To get there, it's necessary to develop whole-building integrated solutions that optimize performance and are cost-effective.

FLEXLAB is uniquely suited for integrated system development because its infrastructure enables users to measure the interactions between multiple systems. In addition, FLEXLAB's relationship with industry throughout our partnership program will allow for greater connections to demonstration and deployment opportunities, significantly increasing the impact and outreach of their R&D portfolio.

Policymakers and building code officials will find that they can utilize testing results from FLEXLAB to help guide the improvement of energy-efficiency codes and standards for buildings. And of course, the buildings research community is interested in working with us to develop new building technologies, as well as building simulation tools.



FLEXLAB Manager, Cindy Regnier

What are some of the energy efficiency problems that FLEXLAB was designed to address?

One problem that is occupying many minds right now is how to successfully integrate HVAC, facades, shading, lighting systems, and controls in a way that's cost effective and generates aggressive energy savings. FLEXLAB provides unique capabilities for testing in this area. The interior spaces are reconfigurable, so the user can create multiple zonal conditions, such as core and perimeter, for testing whole-building or zone energy savings.

Reconfigurable lighting systems allow you to test different lighting technologies and controls, assess their impact on thermal loads and HVAC energy use, and measure energy use and impact on visual comfort of the lighting itself. Through reconfigurable glazing and shading systems, the user can measure the impact of different glazing technologies on convection, thermal loads, energy use, and comfort.

The HVAC systems are also fully reconfigurable—we can provide full airside or hydronic-side heating and cooling. Each testbed also has radiant in-slab tubing with topping slabs of varying thicknesses to test different thermal mass and control strategies. Overall, we can provide everything from an older 1970s-era HVAC system to displacement ventilation, radiant panels, and other efficient alternatives.

The ability to mock up older systems and facades is important to allow us to study cost-effective energy-saving retrofit strategies.

Give some examples of integrating controls with operation.

Integrating building load control with the grid is an area that's ripe for new technological solutions. For example, what are the

optimal electric vehicle charging strategies when coupled with building loads that can reduce peak demand on the grid? FLEXLAB will have networked charging stations nearby, for testing performance under real conditions.

Automated facades coupled with daylight dimming are a major challenge for designers, because their controls strategies vary and performance can be uncertain (such as motorized blinds, shades, or electrochromic glass). The designer needs to optimize incoming sunlight for work surfaces, but minimize incoming solar heat gain, heat loss during the winter, and glare. FLEXLAB can provide quantified strategies for these controls scenarios.

At FLEXLAB, the user can control and measure the performance of every design element and operational strategy—room configuration and occupancy, type of shading system, and automated (or manual) control strategy. One- and two-story testbeds will be available, along with a rotating testbed that be used to position the testbed in different orientations with respect to the sun. The two-story testbed will allow users to conduct skylight and clerestory studies, as well as tests that evaluate stacked floor conditions.

A FLEXLAB user can try different design and control strategies, test the performance of each, determine which system meets performance requirements the best, and improve on that system with further redesign and testing, which can be done with the testbed occupied or unoccupied.

EETD researchers have had a lot of prior experience researching these issues, correct?

Yes. Scientists here [in the Environmental Energy Technologies Division of Berkeley Lab] have conducted years of research addressing daylighting and automated control solutions. We worked with the New York Times Company to help them develop an automated shading and daylight dimming system for their new headquarters building, testing potential technologies in a testbed we helped them develop in New York.

We'll apply our years of experience in daylighting, demand response, automated controls and sensors, lighting systems, and other areas of building science to help FLEXLAB users design and execute tests that will help them solve their unique problems.

What makes FLEXLAB unique among building test facilities?

FLEXLAB is unique in having the ability to address the performance and optimization of integrated systems and technologies in buildings. No other facility can do this. Other existing testing facilities tend to focus on R&D around a specific technology. This limits their ability to address deeper energy saving opportunities that arise from integrating building systems to work together for maximum energy efficiency.

Savings from integrated design and operation will ultimately push buildings to net-zero energy territory. The additive savings from individual energy-efficient technologies just won't achieve this level of performance.

Also, at FLEXLAB, we can look at other aspects of high-performance systems beyond energy efficiency, including thermal and visual comfort, and indoor environmental quality.

How can interested potential users learn more about FLEXLAB?

They can look at our website, FLEXLAB.lbl.gov , and they can email flexlab.info@lbl.gov to be put in touch with someone from the FLEXLAB team.



Environmental Energy Technologies Division

NEWS

CalCharge Provides Energy Storage Companies with Access to Streamlined, Cost-Effective Research

For nearly two years, Lawrence Berkeley National Laboratory (Berkeley Lab) has worked with CalCEF and other key partners to launch CalCharge—a public-private partnership designed to accelerate the development, commercialization, and adoption of new energy storage technologies for the consumer, transportation, and grid markets. Through the use of an innovative, streamlined Cooperative Research and Development Agreement (CRADA), emerging and established companies, academic and research institutions, government agencies, and other key stakeholders will be able to conduct research with Berkeley Lab much more easily. This streamlined approach is designed to increase the sector's growth and spur the creation of advanced manufacturing capacity and processes.



CalCharge

With nearly 100 battery and electrochemical storage companies in the state, California boasts one of the largest, most dynamic clusters of energy storage companies in the United States. Berkeley Lab and CalCEF conducted extensive research from 2011 to 2013 to identify and develop solutions to research gaps that impair product development in this sector. This work consisted of both general market analysis and direct engagement with and feedback from a broad cross-section of stakeholders. Based on that research and input, Berkeley Lab and CalCEF developed CalCharge to help California's energy storage companies benefit from cost-effective access to the state's world-class research and testing facilities.

To generate a thriving California energy storage cluster that drives industry and market growth globally, CalCharge is offering four programs:

- Technology Assessment and Acceleration
- Professional Development
- Pre-Commercialization Support
- Ecosystem Facilitation

These programs will help companies forge strategic relationships that will better leverage existing resources and dramatically expand access to California's array of world-class research and testing facilities found in the national labs, universities, and other organizations.

Through the CRADA, member companies will be able to access services, facilities and personnel at Berkeley Lab significantly faster, and at a lower expected cost, than they could through traditional bilaterally negotiated contracts. The CRADA is expected to become a national model for industry engagement with national laboratories. It will enable CalCharge members to:

- Develop and commence a collaborative research project in a fraction of the time required to negotiate an individual company CRADA.
- Design smaller-scale projects than would be cost effective through an individual company CRADA.
- Divide larger projects into tiered stages that can be conducted in rapid sequence.
- Designate intellectual property generated during the project as Protected CRADA information and prevent its public disclosure and publication.
- Obtain an exclusive license and/or title to any subject inventions developed during the cooperative research project.

The core group of institutional and major corporate members and the first emerging company members will soon be announced.

To learn more about CalCharge and to request membership information when it becomes available, please email membership@calcharge.org .

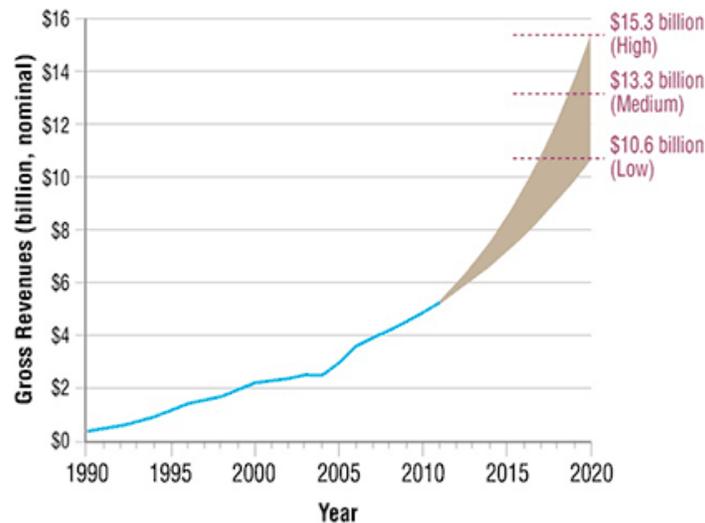


Environmental Energy Technologies Division

NEWS

Berkeley Lab Finds Steady Growth Among U.S. ESCOs, Despite Recession

Aggregate revenue growth rates for U.S. energy service companies (ESCOs) significantly outpaced U.S. gross domestic product growth from 2009 to 2011 and could more than double in size by 2020 according to a new report by Lawrence Berkeley National Laboratory (Berkeley Lab) researchers.



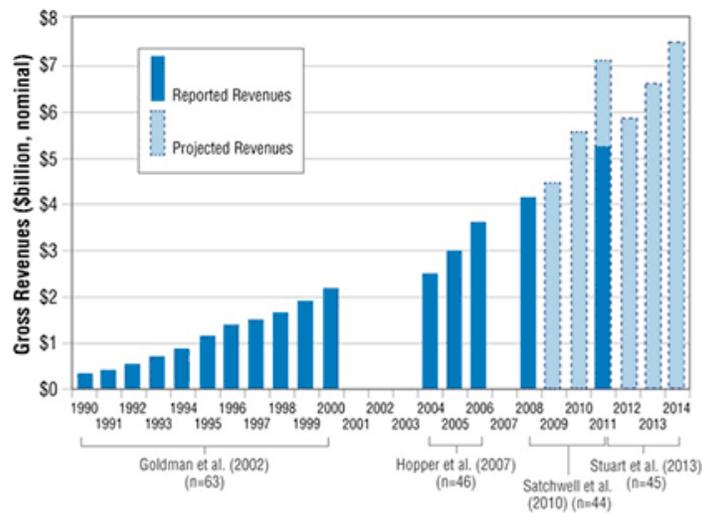
Aggregate industry revenues with long-term projections: 1990–2020

Energy service companies primarily use performance-based contracts to provide energy efficiency, renewable, and other energy-related services while guaranteeing that installed equipment, controls, and other measures will deliver a specified amount of cost and resource savings to the customer. For decades, private- and public-sector ESCO customers have relied on performance-based projects to reduce their operating costs and reap significant energy, water, and other savings, using little or no up-front cash. Each year this industry typically saves customers: (1) the amount of energy consumed by nearly 2 million households, (2) more than 20 million tons of greenhouse gas emissions, and (3) more than \$4 billion in utility bills.

According to *The President's 2013 Climate Action Plan*, performance-based contracts "drive economic development, utilize private sector innovation, and increase efficiency at minimum costs to the taxpayer, while also providing long-term savings in energy costs." Performance contracting allows customers to pay back the capital and financing costs of efficiency improvements over time, out of the stream of dollar savings generated by performance-based projects. This approach reduces the need to use tax dollars or other appropriated funds to generate these savings. Federal, state, and local policies that remove existing barriers and encourage the future use of performance-based contracts will continue to be vital for industry growth into the future.

The research team analyzed the size of the U.S. ESCO industry by market segment and through growth projections and trends. Researchers collected information from 35 ESCOs, publicly available data on ESCO financial performance, and industry experts.

"The ESCO industry has experienced fairly steady growth since the 1990s, and despite the recession, continued to grow about 9 percent per year from 2009 to 2011," said Elizabeth Stuart, a researcher in Berkeley Lab's Electricity Markets and Policy (EMP) Group in the Environmental Energy Technologies Division (EETD) and lead author of the report.



Berkeley Lab estimates of reported and projected ESCO industry revenues: 1990–2020

"We anticipate that U.S. ESCO industry revenues could double in size between today and 2020," said co-author Peter Larsen, an economist at Berkeley Lab. "Based on historical trends, it is possible that the industry could grow 8 to 12 percent annually depending on a number of scenarios—potentially achieving revenues of more than \$15 billion in 2020. There are a number of factors that could impact the industry's ability to achieve this expected growth, including clean energy and infrastructure modernization policies, as well as expansion of ESCO services that take advantage of emerging opportunities."

Energy service companies provided estimates of the total building floor area in each customer segment that had received performance-based energy efficiency retrofits since 2003. Market penetration was highest in the K-12 schools market (42 percent penetration) and lowest in the private commercial buildings sector, where about 9 percent of eligible building space was estimated to have received retrofits since 2003.

The research team also estimated the remaining market potential for ESCOs. "If ESCOs were able to retrofit the remaining floor space, the investment potential in facilities typically addressed by the ESCO industry ranges from about \$71 to \$133 billion," said co-author Charles Goldman, Department Head at Berkeley Lab. "The private commercial sector, K-12 schools, and healthcare facilities are the markets with the largest remaining investment potential."

"There is still a significant market for ESCOs working in the government and universities market segments," said report co-author Donald Gilligan, President of the National Association of Energy Service Companies. "ESCOs have a strong track record working in these markets—federal, state and local—and we expect clean energy policies to continue to drive demand for the services that ESCOs offer these customers."

The study revealed a number of key findings:

- About 45 companies operating in the U.S. met the research team's strict definition of an ESCO.
- Performance-based contracts made up about 70 percent of ESCOs' business in 2011, while 15 percent came from non-performance-based projects, 7 percent from administering energy-efficiency programs for utilities, and just under 4 percent for consulting and renewable power purchase agreements.
- Public and institutional markets (federal, state, and local governments; K-12 schools; healthcare/hospital facilities; and colleges and universities) continue to be ESCOs' primary customers, accounting for about 84 percent of the industry's revenue in 2011. About 8 percent of 2011 revenues came from private commercial customers.
- Energy service companies reported a significant decline in revenue from renewable generation projects since 2008, both in terms of percent of total revenues (from about 15 percent in 2008 to 6 percent in 2011) and absolute dollar amounts (from about \$560 million in 2008 to \$250 million in 2011).
- The U.S. ESCO industry is similar in size to ESCO industries in Germany and France (about \$4 to \$5 billion) and China (about \$4 to \$7 billion in 2012), though definitions of ESCOs and revenue reporting practices vary across countries.
- Small ESCOs reported that about 15 percent of their projects relied on funds from some type of federal program since 2009. Medium and large ESCOs reported that about 30 percent of their projects relied on federal programs.

For more information:

Charles Goldman
(510) 486-4637
CAGoldman@lbl.gov

Additional information:

The full report, *Current Size and Remaining Market Potential of the U.S. Energy Service Company Industry*, is available for download [<http://emp.lbl.gov/publications/current-size-and-remaining-market-potential-us-energy-service-company-industry>].

Information on Berkeley Lab's ESCO industry research may be found here [<http://emp.lbl.gov/projects/energy-services-company-esco-industry-and-market-trends>].

The work was funded by the U.S. Department of Energy's Office of Weatherization and Intergovernmental Programs (OWIP) within the Office of Energy Efficiency and Renewable Energy (EERE).



Environmental Energy Technologies Division

NEWS

Bringing Energy Efficiency to High Performance Computing

The ability of high performance computers (HPCs) to solve complex applications very quickly has risen exponentially since their introduction in the 1960s; unfortunately, so has their electricity use. Many supercomputers require more than a megawatt of electricity to operate, and annual electricity costs can easily run into millions of dollars. As the use of HPCs became more widespread, researchers at Lawrence Berkeley National Laboratory (Berkeley Lab) saw the need to improve the energy efficiency of supercomputers and the infrastructures that support them.

Berkeley Lab researchers organized the Energy Efficient High Performance Computing Working Group (EE HPC WG) in 2008 to promote energy-efficient computing best practices and to drive improvements in the energy performance of HPC systems. At the time, the concept of energy-efficient computing was often a distant afterthought in the race to improve supercomputer computational performance as quickly as possible.



William Tschudi

"We were convinced that bringing U.S. Department of Energy (DOE) national laboratories together to demand more-efficient supercomputers would bring the issue to the forefront for supercomputer developers and vendors," says Bill Tschudi, leader of the High Tech and Industrial Systems Group at Berkeley Lab. "As a significant segment of the HPC market, the national labs were interested not only in spurring more efficient designs and equipment, but also in reducing their own energy bills—costs that were siphoning money from their mission."

The DOE's Federal Energy Management Program (FEMP) provided funding for Berkeley Lab to start the group, which hoped to serve both as a united front to promote energy efficient computing and as a forum for sharing best practices. The strategy worked. Awareness of the need for energy efficient HPC grew, which sparked competition among vendors to improve HPC energy efficiency even before end users asked for it. Today, realizing the benefits of energy-efficient HPCs, end users are putting requirements in proposal requests, and vendors are not only responding to those requests, but are also participating in many of the EE HPC working group's activities.

Berkeley Lab continues to provide ideas and lead the working group, which is now supported by the DOE Sustainability Performance Office. The group's members—over 380 of them from 20 countries—participate voluntarily and self-select topics of interest to the group. Members include representatives from other federal agencies, universities, private industry, and vendors of HPC and data center equipment, including prominent companies such as Intel, Emerson, IBM, Cray, and others.

Grassroots Collaboration

The EE HPC WG consists of three subgroups: one focused on infrastructure, another on systems, and a third on outreach and conferences.

- Dale Sartor, from Berkeley Lab, and Natalie Bates, a Berkeley Lab subcontractor, co-lead the Working Group and oversee the working group's general activities.
- Bill Tschudi, of Berkeley Lab, and David Martinez of Sandia National Laboratory, co-lead the Infrastructure Subgroup.
- Berkeley Lab's John Shalf and Erich Strohmaier co-lead the Computing Systems Subgroup.
- Lawrence Livermore National Laboratory's Anna Maria Bailey and Marriann Silveira co-lead the Conferences Subgroup.

Within each of those subgroups, small teams are formed to address specific issues. Examples are the HPL Power/Energy Measurement Methodology team, Liquid Cooling Commissioning team, and HPC Demand Response team, which all meet (virtually) multiple times each month.

"Working group members participate in whichever sub-group project interests them and can benefit from their expertise," explains Tschudi. "Once the subgroup members have made progress on their issue, they present it to the larger group for feedback and further development." Once completed, the groups disband and typically select other topics of interest.

Members drive the working group's agenda, which ensures that the projects meet the membership's most pressing needs. A March 2013 member survey showed that members identified 12 out of the 14 activities currently being conducted by the group as high-value activities. In that same survey, more than half of the members identified "improving software to tune for energy efficiency" as an activity to pursue in the future.

The working group as a whole meets (virtually) bi-monthly, but occasionally meets in person at supercomputer conferences such as the SC Conference, International Supercomputing Conference (ISC), and others. Members of the group also present papers at SC and ISC and arrange annual "Birds of Feather" sessions (informal meetings) to discuss recent developments in the field.

Moving Toward Common Approaches

In its nearly five years of existence, some of the working group's most important achievements have been in developing common metrics, measurement protocols, and guidelines for the supercomputer industry: for liquid cooling of supercomputers, for determining power usage effectiveness, and for measuring power during computational output.

Development of Guidelines for Liquid Cooling of Supercomputers

When vendors began producing liquid cooling systems, no standard thermal guidelines existed. By evaluating systems from the processor to the atmosphere, the EE HPC WG identified temperatures that could be supported, and developed a set of recommended temperatures that vendors could use to design equipment. The working group's recommendations first appeared in an ASHRAE white paper and are now in ASHRAE's guidelines of recommended temperatures. Supercomputer vendors participated in this process throughout.

Development of New Metrics for Determining Power Usage Effectiveness

The Power Usage Effectiveness (PUE) metric has been used for years to determine how much of the power in a data center is consumed by the IT equipment (as opposed to other facility loads such as cooling and power distribution). However, this metric is not effective in determining the efficiency of computer equipment when the system's cooling fans or power conversions are located outside of the computer itself. The working group developed two new metrics to help evaluate these situations: (1) ITUE (IT-power usage effectiveness), which is similar to PUE but focuses on energy use inside the computer equipment, and (2) TUE (total-power usage effectiveness), which combines PUE and ITUE to provide a ratio of total energy (that of both internal and external support equipment) as well as the specific energy used in the HPC. The TUE can be used to compare one HPC system to another. The metrics were demonstrated on Oak Ridge National Laboratory's (ORNL's) Jaguar supercomputer system, and the working group plans to seek acceptance of the TUE metric through industry groups such as the Green Grid industry association.

Development of a Standard Method to Measure Computational Output

Every year, a list known as the *Green 500* ranks the 500 most efficient supercomputers. The list helps supercomputer users and vendors identify the most efficient systems; however, because the methods used to determine efficiency have not been uniformly performed, the current comparisons are not as accurate as they could be. The EE HPC working group is developing a standard method that all users can use to measure power uniformly.

Commissioning Liquid-Cooled Supercomputer Systems

Commissioning of liquid-cooled supercomputers is a relatively new requirement. The working group decided to share best practices and develop a liquid cooling commissioning guideline to inform those that have not dealt with liquid-cooled systems. The subgroup working on this task includes vendors that provide liquid-cooled supercomputers and infrastructure cooling equipment.

Sharing Knowledge and Expertise

Because the working group's member base is so dispersed and varied, its website is a key tool for keeping members informed. Webinars inform members of the subgroups' progress, and the presentations from these webinars are archived on the site, along

with the working group's published papers. To expand the reach of the working group's expertise, a member from Lawrence Livermore National Laboratory tracks conferences and other meetings where members could speak about new developments and receive feedback on various topics.

An Award-Winning Accomplishment

In 2013, members of the EE HPC WG won the Gauss Award, sponsored by the German Gauss Center for Supercomputing, for their paper, "TUE, a New Energy-Efficiency Metric Applied at ORNL's Jaguar." The award is presented for the most outstanding paper in the field of scalable supercomputing at the ISC conference held annually in Germany. Intel's Mike Patterson, the primary author, presented the paper at the conference. Bill Tschudi and Henry Coles of Berkeley Lab's Environmental Energy Technologies Division (EETD) were contributing authors. The paper described the TUE energy metric, including a description of its trial use at ORNL's scientific computing center.



Oak Ridge National Laboratory's Jaguar Supercomputer
Courtesy of Oak Ridge National Laboratory, U.S. Dept. of Energy

SC13 Workshop

The workgroup also shares its expertise through workshops. It will present the "Building" Energy Efficient High Performance Computing Fourth Annual EE HPC WG Workshop at SC13 in Denver, Colorado, in November. This popular annual workshop will feature high-profile researchers discussing new developments in energy-efficient HPC from both the facilities and system perspectives; from architecture through design and implementation.

Helping to Meet EISA Goals

By sharing information and developing common approaches, the workgroup is helping to reduce HPC energy use. For example, the Energy Independence and Security Act of 2007 (EISA) requires the U.S. federal government to reduce energy intensity in all its facilities, including laboratories and industrial buildings, by 30 percent by 2015. The work done by Berkeley Lab and EE HPC WG volunteers is helping federal facilities measure and quantify energy savings, as well as helping vendors design energy-efficient supercomputer equipment. The growth in computing energy use makes this goal a challenge; however, the EE HPC WG is dramatically improving energy performance from its business-as-usual trajectory.

"Interest in the EE HPC working group, continues to grow," says Tschudi. "The original vision of what the group could accomplish continues to be fulfilled through collaboration with the best minds engaged in supercomputing. DOE's leadership in encouraging and supporting this activity is providing energy savings and other benefits throughout DOE labs, as well as the industry at large."

—Mark Wilson

For more information:

Bill Tschudi
(510) 495-2417
WFTschudi@lbl.gov

Additional information:

Energy Efficient High Performance Computing Working Group website [<http://eehpcwg.lbl.gov/home>]

'Building' Energy Efficient High Performance Computing Fourth Annual EE HPC WG Workshop [<http://eehpcwg.lbl.gov/conferences>]

Patterson, Michael K., Stephen W Poole, Chung-Hsing Hsu, Don Maxwell, William Tschudi, Henry Coles, David J Martinez, and Natalie Bates. 2013. "TUE, a New Energy-Efficiency Metric Applied at ORNL's Jaguar." [PDF [http://eetd.lbl.gov/sites/all/files/isc13_tuepaper.pdf]]



Environmental Energy Technologies Division

NEWS

U.S. Installed Price of Solar Photovoltaic Systems Continues Rapid Decline

The installed price of solar photovoltaic (PV) power systems in the United States fell substantially in 2012 and through the first half of 2013, according to the latest edition of *Tracking the Sun*, an annual PV cost-tracking report produced by Lawrence Berkeley National Laboratory (Berkeley Lab).



Tracking the Sun VI report

Installed prices for PV systems in 2012 fell by a range of roughly \$0.30/watt (W) to \$0.90/W, or 6 to 14 percent, from the prior year, depending on the size of the system. "This marks the third year in a row of significant price reductions for PV systems in the U.S.," explains Galen Barbose of Berkeley Lab's Environmental Energy Technologies Division, one of the report's co-authors. Within the first six months of 2013, PV system prices in California fell by an additional 10 to 15 percent, and the report suggests that PV system price reductions in 2013 are on pace to match or exceed those seen in recent years.

The report indicates that the median installed price of PV systems completed in 2012 was \$5.30/W for residential and small commercial systems smaller than 10 kilowatts (kW) in size and was \$4.60/W for commercial systems of 100 kW or more in size. Utility-scale systems installed in 2012 registered even lower prices, with prices for systems larger than 10,000 kW generally ranging from \$2.50/W to \$4.00/W. The report also highlights the wide variability in PV system pricing, detailing the installed price differences that exist across states and across various types of PV applications and system configurations.

The market for solar PV systems in the United States has grown rapidly over the past decade. The sixth edition of Berkeley Lab's *Tracking the Sun* report series describes historical trends in the installed price of PV in the United States. It is based on data from more than 200,000 residential, commercial, and utility-scale PV systems installed between 1998 and 2012 across 29 states; representing roughly 72 percent of all grid-connected PV capacity installed in the United States. The study is intended to provide policymakers and industry observers with a reliable and detailed set of historical benchmarks for tracking and understanding past trends in the installed price of PV.

Recent PV System Price Reductions Driven by Falling Hardware Costs, While "Soft" Costs Persist

According to the report, recent installed price reductions for PV systems are primarily attributable to steep reductions in the price of PV modules. From 2008 to 2012, annual average module prices on the global market fell by \$2.60/W, representing about 80 percent of the total decline in PV system prices over that period.

Non-module costs—such as inverters, mounting hardware, and the various non-hardware or "soft" costs—have also fallen over the long-term, but have remained relatively flat in recent years. As a result, they now represent a sizable fraction of the total installed price of PV systems. This shift in the cost structure of PV systems has heightened the emphasis within the industry and among policymakers on reducing non-module costs.

The report specifically highlights soft costs—which include such things as marketing and customer acquisition, system design, installation labor, and the various costs associated with permitting and inspections—as the most promising target for further PV system price reductions. "Soft costs are especially important from the perspective of public policy efforts," Barbose notes. "Unlike module prices, which are established based on global supply and demand, soft costs can be influenced more directly by local, state, and national policies aimed at accelerating deployment and removing market barriers."

Adds co-author Ryan Wiser, also of Berkeley Lab, "There simply are limits to how much further module prices can fall, and so it stands to reason that continued reductions in PV system prices will need to come primarily from the soft cost side."

PV System Prices in the United States Higher than in Other Major Markets

The report also compares PV system pricing in the United States to a number of other major international markets and finds that U.S. prices are generally higher. The differences are particularly stark in comparison to Germany, Italy, and Australia, where the price of small residential PV systems installed in 2012 was roughly 40 percent lower than it was in the United States.

The report attributes much of the difference in PV system pricing to soft costs, citing the fact that the cost of PV modules and other hardware is typically similar across countries. "These international experiences suggest that deep near-term reductions in soft costs are attainable in the United States," says report co-author, Naïm Darghouth, also with Berkeley Lab. He adds further that, "Reductions in soft costs may naturally accompany growth in market size, as we've seen in some of the largest markets such as Germany and Italy, though other factors are also clearly important."

Price Declines for PV System Owners in 2012 Offset by Falling Incentives

Rebates and other forms of cash incentives for residential and commercial PV systems are offered by state agencies and utilities in many U.S. regions. These incentives have declined significantly over time, falling by roughly 85 percent over the past decade. Within the span of just 2011 to 2012, median cash incentives from state and utility programs fell by \$0.40/W to \$0.60/W, depending on PV system size.

States and utilities have reduced incentives both in response to, and to encourage further, installed price declines. Cash incentives provided through state and utility programs have also fallen over time as other sources of financial support for PV projects—most notably, increases in federal tax incentives and the emergence of solar renewable energy certificate (or SREC) markets in a number of states—have become more widely available or lucrative.

Wide Variability in PV System Pricing Observed

The study also highlights the significant variability in PV system pricing. For example, among PV systems less than 10 kW in size and completed in 2012, 20 percent of systems had an installed price less than \$4.50/W, while another 20 percent were priced above \$6.50/W.

This variability is partly associated with differences in pricing across states, where the median installed price of PV systems less than 10 kW ranged from \$3.90/W to \$5.90/W in 2012. The report points to an array of potential underlying drivers for these cross-state pricing differences, including market size, the size of incentives available, and level of competition among installers, labor costs, customer characteristics, administrative and regulatory compliance costs, and sales tax exemptions for PV.

The report also examines the variation in PV system pricing across various types of applications and technologies, including: systems with microinverters versus central inverters, systems with Chinese versus non-Chinese modules, systems with varying module efficiencies, residential new construction versus residential retrofit, building-integrated versus rack-mounted systems, rooftop versus ground-mounted systems, and tracking versus fixed-tilt systems.

For more information:

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

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

Additional information:

The report, *Tracking the Sun VI: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2012*, by Galen Barbose, Naïm Darghouth, Samantha Weaver, and Ryan Wiser, may be downloaded here [<http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf>].

The research was supported by funding from the U.S. Department of Energy's Solar Energy Technologies Office of the Office of Energy Efficiency and Renewable Energy.



Environmental Energy Technologies Division

NEWS

Berkeley Lab Study Finds No Evidence of Residential Property Value Impacts Near U.S. Wind Turbines

Lawrence Berkeley National Laboratory (Berkeley Lab) analyzed more than 50,000 home sales near 67 wind facilities in 27 counties across nine U.S. states, yet was unable to uncover any impacts to nearby home property values.

"This is the second of two major studies we have conducted on this topic [the first was published in 2009—see below], and in both studies [using two different datasets] we find no statistical evidence that operating wind turbines have had any measureable impact on home sales prices," says Ben Hoen, the lead author of the new report.

Hoen is a researcher in the Environmental Energy Technologies Division of Berkeley Lab.

The new study used a number of sophisticated techniques to control for other potential impacts on home prices, including collecting data that spanned well before the wind facilities' development was announced to after they were constructed and operating. This allowed the researchers to control for any pre-existing differences in home sales prices across their sample and any changes that occurred due to the housing bubble.



Berkeley Lab research confirms no measureable impacts of declining property values near wind turbines.

This study, the most comprehensive to date, builds on both the previous Berkeley Lab study and a number of other academic and published U.S. studies that also generally find no measureable impacts near operating turbines.

"Although there have been claims of significant property value impacts near operating wind turbines that regularly surface in the press or in local communities, strong evidence to support those claims has failed to materialize in all of the major U.S. studies conducted thus far," says Hoen. "Moreover, our findings comport with the large set of studies that have investigated other potentially similar disamenities, such as high-voltage transmission lines, landfills, and noisy roads, which suggest that widespread impacts from wind turbines would be either relatively small or non-existent."

The report was authored by Ben Hoen (Berkeley Lab), Jason P. Brown (formerly USDA; now Federal Reserve Bank of Kansas City), Thomas Jackson (Texas A&M and Real Property Analytics), Ryan Wisner (Berkeley Lab), Mark Thayer (San Diego State University), and Peter Cappers (Berkeley Lab).

For more information:

Ben Hoen
(845) 758-1896
BHoen@lbl.gov

Ryan Wisner
(510) 486-5474
RHWisner@lbl.gov

Additional information:

Download the new 2013 report [<http://emp.lbl.gov/sites/all/files/lbnl-6362e.pdf>]: *A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States*

Download the 2009 LBNL Report [<http://emp.lbl.gov/sites/all/files/REPORT%20lbnl-2829e.pdf>]: *The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis*

More information about DOE's Wind Program [<http://www1.eere.energy.gov/wind/index.html>].

The research was supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.



Environmental Energy Technologies Division

NEWS

Berkeley Lab Research Highlights Best Strategies to Achieve Low-Carbon Data Centers

Because data centers are responsible for one to two percent of the world's electricity use, they are the target of considerable research into how to reduce their carbon emissions. However, assessing the true carbon intensity of data centers has not been easy. There are numerous metrics in circulation, as well as claims about their energy and carbon emissions performance. Climate policies with financial incentives for reducing carbon intensity can help push data centers toward greater energy efficiency, but policymakers do not have a clear way to discern which metrics are useful for defining a low-carbon data center.

In a recent Perspective in the journal *Nature Climate Change*, Eric Masanet, Arman Shehabi, and Jonathan Koomey propose that energy models of data centers provide "actionable guidance" to policymakers. They present the results of one such model that offers a typical U.S. data center carbon footprint and how much its footprint is reduced through different carbon management strategies.



Arman Shehabi

Masanet is with Northwestern University, McCormick School of Engineering; Shehabi, the Environmental Energy Technologies Division of Lawrence Berkeley National Laboratory; and Koomey, Stanford University's Steyer-Taylor Center for Energy Policy and Finance.

Their research suggests that the carbon footprint reduction resulting from managing the lifecycle of IT devices (through lifetime extension and recycling initiatives) is dwarfed by that of best-practice energy efficiency in the data center. "Efficient IT device operation is the most important feature to reinforce through policy incentives," says Shehabi.

Best-practice efficiency reduces the emissions from data centers during their operation. It includes such strategies as using the most energy-efficient equipment available and server virtualization and application consolidation, which together lead to higher utilization of each server's computing capacity.

Low-carbon electricity (for example, from renewable power sources) also contributes substantially to reducing carbon footprint. Therefore where possible, they should be located close to accessible grids that provide low-carbon electricity.

However, this research suggests that while using renewable electricity helps reduce data center carbon emissions, the strategy must be coupled with best-practice efficiency. "Existing data centers should maximize IT-device efficiency, especially as these devices can turn over quickly and thereby deliver rapid improvements," the authors write.

"Data centers that are inefficient would use far more low-carbon electricity than technically required and end up squandering scarce renewable power that could otherwise be reducing the emissions of more energy-efficient customers elsewhere," says Shehabi."

Data centers should also be located in areas with cool outside air. The "free cooling" of appropriate climate zones reduces the need for mechanical cooling and electricity use.

For more of their recommendations, see:

Masanet, Eric, Arman Shehabi, and Jonathan Koomey. 2013. "Characteristics of Low-Carbon Data Centers. [<http://dx.doi.org/10.1038/nclimate1786>]" *Nature Climate Change* 3(7). July. 627-630. [Supplementary Information [<http://www.nature.com/nclimate/journal/v3/n7/abs/nclimate1786.html#supplementary-information>]]

See also Koomey's blog post [<http://www.koomey.com/post/54013825367>] about the article.



Environmental Energy Technologies Division

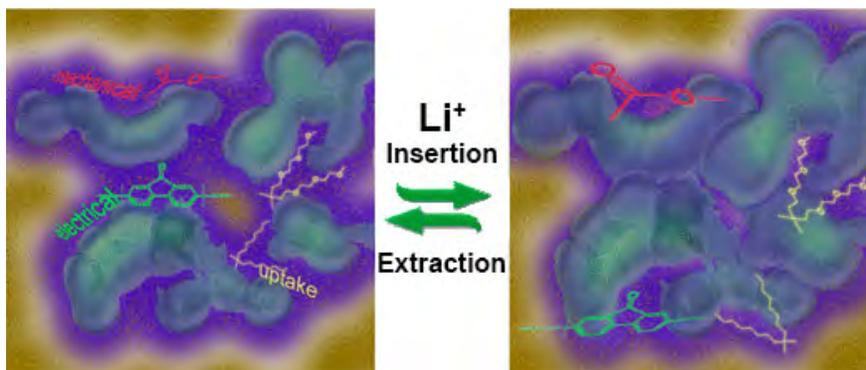
NEWS

Conductive Adhesive Improves Lithium-ion Battery Storage by 30 Percent

An award-winning technology that can boost the capacity of rechargeable lithium-ion batteries has just gotten even better.

Lawrence Berkeley National Laboratory (Berkeley Lab) battery researcher Gao Liu and his team earned a coveted R&D 100 Award [<http://newscenter.lbl.gov/news-releases/2013/07/08/2013-rd-100-awards/>] this year for their invention of an electrically conductive rubbery adhesive that can be mixed with particles of silicon to form a battery's negative electrode, or anode. Lithium-ion batteries whose anodes are built with this "conducting polymer binder" can store 30 percent more power than those with conventional anodes made with aggregated carbon particles. Now, by literally tinkering at the edges of this new polymer material, researchers have raised its performance another notch.

That was the promise of the technology, says Liu: "In addition to developing this binder, we developed a method to engineer and test ways to improve it. We are continuing to use those tools, and now we are approaching an ideal design."



Schematic of an ideal binder system for high-capacity battery electrodes. The binder developed in this work features optimized electric conductivity in lithium environment, strong mechanical adhesion, ductility, and high electrolyte uptake. All these optimized functionalities were integrated into one conductive polymer.

In a paper published in July in the online edition of the *Journal of the American Chemical Society* [<http://pubs.acs.org/doi/abs/10.1021/ja4054465>], Wanli Yang, a beamline physicist at Berkeley Lab, and Gao Liu, both lead authors, and their colleagues describe how they modified the original binder, which was already an excellent conductor of electrons, to boost its capacity to transport positively charged lithium ions. Because the flow of positive and negative charges in a battery is always balanced, the performance limits of the original polymer binder were determined by its less-than-ideal transport of lithium ions.

During a charging cycle, lithium ions are transported within the binder to the embedded silicon particles through the uptake of an electrolyte, which consists primarily of organic solvents filled with lithium ions in solution. By modifying the chemical structure of their original binder—adding "side chains" of ether molecules—they tripled its uptake of electrolyte solution. As a result of the improved ion flow, the specific capacity of the silicon anode made with the new binder rose to 3,750 milliampere-hours per gram (mAh/g) from the 2,100 mAh/g achieved by the original version. That 80 percent improvement meets the theoretical limit of a silicon anode's storage capacity. "It means we are using 100 percent of the silicon particles embedded in the conducting polymer binder," says Liu. "That makes it pretty close to the 'ideal' binder."

Liu's original polymer binder, which he calls *PFM* or *PFFOMB*, was notable for its combined traits of adhesion, elasticity, and electrical conductivity. The adhesion made the polymer stick to particles of silicon, which is preferable to graphite as an anode material because it can store ten times as much charge as carbon. Conductivity was essential, because without it the binder would simply insulate the silicon. The elasticity was crucial, because silicon literally swells to four times its size when it draws in lithium ions during battery charging, and then shrinks back to its original volume upon discharge. After just a few charge/discharge cycles, this breath-like movement would break conventional binders, ruining the battery. *PFM*'s ability to accommodate this motion solved that problem, making higher-capacity silicon anodes for lithium-ion batteries a practical alternative.

The improved binder, which the team calls *PEFM*, not only enhances lithium-ion flow, it also maintains the elasticity and electron conductivity of the original; and as a bonus, the electrical traits of the added side chains actually improve the binder's adhesion to the silicon particles. "An ideal binder system should provide inherent electronic conductivity, mechanical adhesion and flexibility, and sufficient electrolyte uptake to warrant high ionic conductivity," says Liu. "The polymer we developed meets these challenges of an ideal binder system."

Liu says his team will continue to fine-tune its conducting polymer binders. The next goal is to find materials that offer comparable performance at lower cost. Significant testing will be required to determine that batteries made with the new silicon composite anodes can last as long as those made with graphite. To fully meet the needs of the next generation of electric vehicles and plug-in hybrids, the improved anodes must be coupled to improved cathodes, separators, electrolytes, and other components to make the truly "ideal" lithium-ion batteries of the future.

—Sabin Russell

For more information:

Gao Liu
(510) 486-7207
GLiu@lbl.gov

Additional information:

The work was funded by the Office of Vehicle Technologies of the U.S. Department of Energy, under the Batteries for Advanced Transportation Technologies (BATT) program and by a University of California Discovery Grant.



Environmental Energy Technologies Division

NEWS

Berkeley Lab/3M Team Demonstrate Potential to Significantly Reduce Building Lighting Energy Use

Daylighting is the strategy of admitting light from the sun and sky to reduce the use of electric lighting in buildings. Since lighting energy use represents 13 percent of the total primary energy used by buildings in the United States (5.42 quadrillion Btu in 2010), these technologies can play a significant role towards meeting U.S. and state energy-efficiency and greenhouse gas emission-reduction goals. Conventional windows cannot provide useful daylight beyond about one to one-and-a-half times the head height of a window because interior shades, when lowered to control direct sun and glare, diminish daylight penetration. Daylight technologies counter this problem, increasing illuminance deeper in the room from vertical clerestory windows by redirecting sunlight (and diffuse light) towards the ceiling plane. Lack of performance data has severely limited the uptake of these technologies into the marketplace and slowed innovation. Architects, engineers, and building owners are typically unwilling to take the risk of adopting emerging technologies without clear evidence that they perform well.

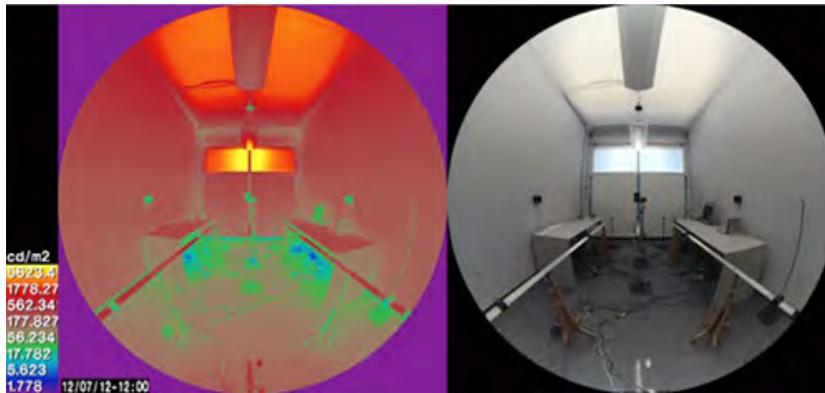


Outdoor view of the windows testbed facility.

Lawrence Berkeley National Laboratory (Berkeley Lab) has been collaborating with the window industry to develop and evaluate innovative daylighting technologies that can reduce lighting energy use by as much as 50 percent up to 40 feet from windows. Since lighting is often the single largest energy use in commercial buildings, these technologies could make a significant contribution to reducing the nation's energy use. Researchers in Berkeley Lab's Environmental Energy Technologies Division (EETD) are using simulation tools (Radiance, Window, EnergyPlus, COMFEN) and new measurement facilities to accurately assess where and how much solar radiation and daylight flux can be effectively controlled by innovative new optical materials and systems as they are redirected into the building's interior. Using these tools, calculations of energy use and visual discomfort can be performed more accurately and in a fraction of the time needed in the past. As a result, industry partners can now determine how well new optical designs will work long before they invest a lot of time and resources into prototype fabrication and testing in the field.

"There's a large potential to speed up the time to market and reduce the development cost of new energy-efficient technologies through the use of these simulation tools," says Andrew McNeil, Senior Scientific Engineering Associate at the EETD.

An example of the benefits of this approach is a collaboration Berkeley Lab has developed with the 3M Corporation. 3M developed a microstructured prismatic film consisting of linear multi-sided prisms 50 to 250 micrometers high. Results from simulation analysis indicate that a small clerestory window with the 3M dual-film system and a lower window with conventional shades can daylight a 40-foot-deep perimeter zone facing south, east, or west in virtually all U.S. climates and save up to 40 percent of annual lighting energy, compared to the same zone with no daylighting controls. Environmental Energy Technologies Division researchers corroborated these findings with measured data in Berkeley Lab's Advanced Windows Testbed facility. 3M has initiated partnerships with window manufacturers to incorporate their new film in new and retrofit applications in commercial and residential buildings.



Indoor view showing how sunlight is redirected to the ceiling on a sunny day in December at noon. The daylighting film is installed in the upper clerestory window.

"We are very excited to have been able to collaborate with Berkeley Lab over these past three years. When we launch our product in fall 2013, we hope to see accelerated adoption of our products, since we will be able to explain the energy-efficiency and comfort impacts of this innovation with confidence to potential customers," said Raghunath Padiyath, Lead Product Development Specialist of the 3M Renewable Energy Division.

Because calculation speed was vastly increased with the new software, McNeil was able to derive a more optimized single-film design using the power of Berkeley Lab's cluster computing farm of 128 parallel processors, genetic algorithms, and some pretty fancy coding. This design is expected to produce the same level of performance at lower cost, pending outcomes from field studies that are now in progress. 3M is evaluating this design for production.

The U.S. Department of Energy and the California Energy Commission through its Public Interest Energy Research (PIER) Program provided funding for both the development of the simulation tools and field tests conducted on behalf of industry. The simulation tools are available to the public at no cost and have been used to assist other U.S. and California-based manufacturers with new product developments. These clean technology investments are designed to create jobs and make businesses in U.S. and California more competitive worldwide and help achieve aggressive federal and state energy and greenhouse gas reduction goals, which benefit consumers and businesses through lower utility bills.

This study was conducted by: Andrew McNeil, Jacob Jonsson, Anothai Thanachareonkit, and Principal Investigator, Eleanor Lee (Berkeley Lab) in collaboration with Raghunath Padiyath and Doug Huntley (3M Renewable Energy Division), and Bing Hao (3M Corporate Research Materials Laboratory).

This research was supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy and the California Energy Commission through its Public Interest Energy Research (PIER) Program.

Additional information:

3M Performance

- A. Thanachareonkit, E. S. Lee, and A. McNeil. "Empirical assessment of a prismatic daylight-redirecting window film in a full-scale office testbed." Accepted for presentation to the Illuminating Engineering Society of North America (IESNA) 2013 Annual Conference, Huntington Beach, California, October 26-29, 2013 and for publication in *Leukos*, the journal of the IESNA. [PDF <http://eetd.lbl.gov/daylight/daylight-field-test.pdf>]
- A. McNeil, E. S. Lee, and J. C. Jonsson. "Daylight performance of a microstructured prismatic window film in deep plan open plan offices." To be submitted to *Solar Energy*. Summary. [PDF <http://eetd.lbl.gov/daylight/daylight-summary.pdf>]

Simulation Tools

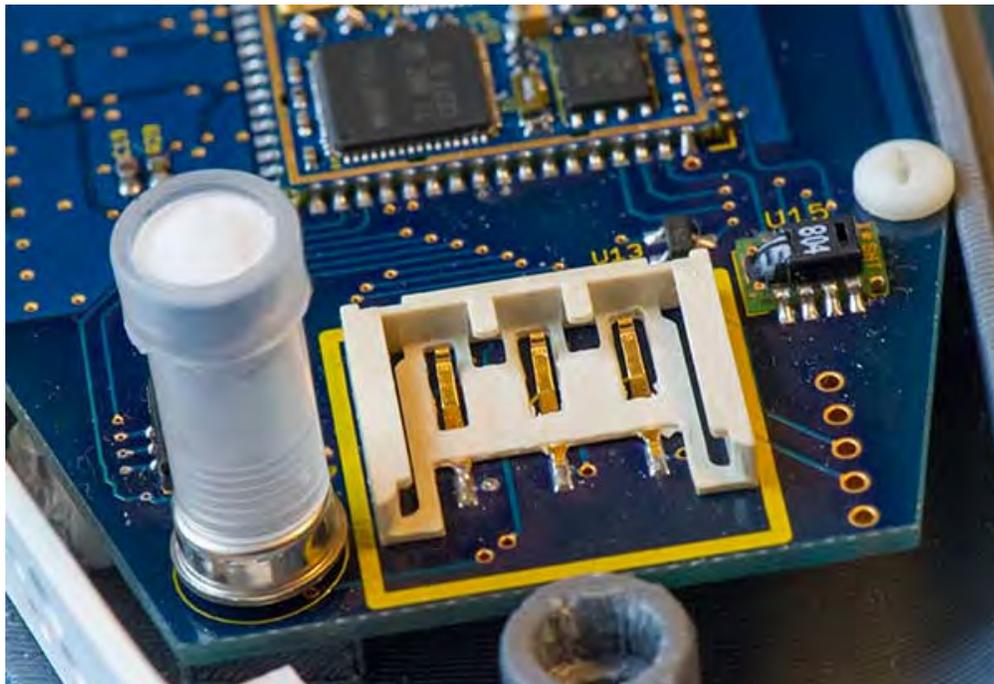
- McNeil, A., and E. S. Lee. "A validation of the Radiance three-phase simulation method for modeling annual daylight performance of optically complex fenestration systems." *Journal of Building Performance Simulation* 2012: 1-14. LBNL-5606E.
- Ward, G., R. Mistrick, E. S. Lee, A. McNeil, and J. C. Jonsson. "Simulating the daylight performance of complex fenestration systems using bidirectional scattering distribution functions within Radiance." *Leukos, Journal of the Illuminating Engineering Society of North America* 7(4) 2010. LBNL-4414E. [PDF <http://eetd.lbl.gov/sites/all/files/publications/lbnl-4414e.pdf>]
- Radiance software <http://radiance-online.org/>

- WINDOW software [<http://windows.lbl.gov/software/window/window.html>]
 - EnergyPlus software [<http://apps1.eere.energy.gov/buildings/energyplus/>]
 - COMFEN software [<http://windows.lbl.gov/software/comfen/comfen.html>]
-

Berkeley Lab's VOC True Read Improves Monitoring Precision

With a move toward smarter building ventilation systems that respond to specific inside-air conditions as they arise—resulting in healthier air at a lower cost—comes a need for more precise monitoring of indoor conditions such as temperature, humidity, carbon dioxide levels, and pollutants such as formaldehyde gas. Lawrence Berkeley National Laboratory's (Berkeley Lab) new VOC True Read device enables the long-sought accurate detection of formaldehyde gas in indoor air. This affordable device screens out interfering compounds that lead to false readings of indoor formaldehyde gas, allowing building systems operators to more quickly respond to precise readings of indoor formaldehyde gas, and use that information to bring in fresh air to maintain healthy standards.

The VOC True Read device, developed by Berkeley Lab researchers Meera Sidheswaran and Lara Gundel, uses an innovative honeycomb filter design that strips water vapor, alcohols, and other volatile organic compounds (VOCs) from a sample, allowing formaldehyde—or other target gases—to pass through to a detector. The filter presents an economical solution to the need for accurate formaldehyde measurement in that it can be attached to, and retrofit to, in-place sensors to increase their detection accuracy. The filter's internal structure can be arrayed in various ways to adsorb other interferents, as needed. The device provides accurate, long-term, inexpensive, real-time monitoring of building air using proton transfer-reaction mass spectrometry (PTR-MS) to assist with exposure assessment and demand-controlled ventilation.



The VOC True Read device's innovative trap design strips water vapor, alcohols, and other VOCs from the sample, allowing formaldehyde—or other target gases—to pass through to a detector.

Health Hazards of Formaldehyde

Formaldehyde, labeled a known carcinogen by the National Toxicology Program of the Department of Health and Human Services, is ubiquitous in the indoor environment of buildings in the form of gas. While higher levels of formaldehyde exposure can cause cancer, lower-level exposure can trigger nasal and eye irritation, nausea, difficult breathing, or allergic reactions and asthma attacks. Workers in office buildings are commonly exposed to varying levels of formaldehyde gas given off by products made with pressed wood containing glues made with urea-formaldehyde resin.

To mitigate pollutants such as formaldehyde from inside air, conventional building ventilation practices simply bring in a set amount of outside air, which must be conditioned before being circulated within the space. This can result in over-ventilation, wasting both energy and money. Demand-control ventilation (DCV) systems use sensors to monitor and measure the air and provide feedback to a central controller, resulting in an increase or decrease in ventilation as needed. Compared with conventional ventilation strategies, DCV results in significant energy savings of up to 40 percent. To make DCV more reliable, a growing market for accurate formaldehyde sensing and real-time monitoring technology has emerged.

Currently available real-time formaldehyde sensors work well in environments contaminated *only* with formaldehyde, but have long been plagued by a lack of accuracy and drift-prone readings in environments with interfering elements such as water vapor and polar VOCs such as methanol and ethanol—typical conditions in most indoor work environments.

How the Device Works

As air flows freely through the inlet of the VOC True Read device, it passes through an elongated chamber (or chambers) containing tubes covered in a commercially available polymeric or carbon-based adsorbent. Low-molecular-weight oxygenated compounds (such as ethanol) bind easily to the adsorbent, while formaldehyde, unaffected, passes through the device's outlet and on to a detection device. The surface area of the coated channels is sufficient to adsorb interfering gases. The filter is compatible with sensors and instruments ranging from microelectronic metal-oxide semiconductors to PTR-MS.

The internal design's channels can be arrayed in various ways—as a honeycomb, open-cell foams, or multiple co-linear cylinders—depending on need. A similar inlet can be added with a stripper designed to remove water vapor from the sampled air. A plurality of denuders can be used in one device, each targeting specific compounds. The VOC True Read's architecture can be tailored to remove other gases, including aromatic compounds such as toluene, benzene, o-xylene, or limonene; as well as alcohols and alkanes. The air sample, after passing through the filtration device, can flow on to a variety of detection devices.

Multiple Applications and Benefits

This versatility of the VOC True Read device also makes it useful in industrial air-pollution monitoring in facilities where formaldehyde use is heavy (e.g., in the manufacture of paper, paint, and textiles); medical research (monitoring a patient's breath for biomarkers of disease); in mortuaries and hospitals, where formaldehyde gas levels can soar; and on microelectronic sensors.

Using this retrofit, manufacturers can market their ventilation systems as smart, accurate means for keeping air safe to breathe at a much lower cost. The technology will help advance existing test sensors from a research to a marketable phase by increasing their accuracy, and some smaller, currently available formaldehyde sensors can be fitted with the device. It could also be used for real-time outdoor air pollution monitoring.

This technology is available for licensing.

Additional information:

"Channelized Filter Inlets or Strippers for Improved Real-Time Formaldehyde Measurement" (Available Technologies). Berkeley Lab Technology Transfer and Intellectual Property website. [<http://www.lbl.gov/Tech-Transfer/techs/lbnl3035.html>]



Environmental Energy Technologies Division

NEWS

Ultra-Efficient Heat Pump Clothes Dryer Wins Max Tech and Beyond Design Competition

An ultra-efficient two-stage heat pump clothes dryer (HPCD) prototype brought home the gold for the University of Maryland (UMD) design team who developed it during a spirited, year-long competition. The Max Tech and Beyond [\[http://maxtechandbeyond.lbl.gov/\]](http://maxtechandbeyond.lbl.gov/) Design Competition is a project of the Energy Efficiency Standards group at Lawrence Berkeley National Laboratory, funded by the Emerging Technologies Program of the U.S. Department of Energy (DOE). The competition promotes the rapid development of energy-efficient appliances that outperform currently available models and supports the education of the next generation of U.S. clean energy engineers. The UMD team was one of eight college teams that participated.



From left to right: Dr. Yunho Hwang (lead PI), Tao Cao (lead student), Anto Sheryl Peter, Amer Abdul Razak Charbaji, Laeun Kwon, Xiaojie Lin, Dr. Jiazhen Ling (faculty support), and Cong Peng

At the end of the 2012/2013 academic year, expert judges presented the award to the UMD team for its outstanding technological engineering achievement in the advancement of energy-saving appliances. A close runner-up, Ohio State University, won an honorary mention for educational impact and business plan development for their hybrid air/water conditioner (HAWC).

The UMD team showcased their winning prototype in October at the DOE-sponsored 2013 Solar Decathlon XPO [\[http://www.the-xpo.org/\]](http://www.the-xpo.org/), held in Irvine, California. The Solar Decathlon challenges collegiate teams to design, build, and operate solar-powered houses that are cost-effective, energy-efficient, and attractive.

In addition, both of the Max Tech winning teams had the opportunity to participate in the Entrepreneurship Academy at UC Davis [\[http://entrepreneurship.ucdavis.edu/bizdev.php\]](http://entrepreneurship.ucdavis.edu/bizdev.php) in September. The Entrepreneurship Academy helps to bring new technologies to market by connecting student entrepreneurs with leaders in the business and investment communities.

The support provided by the Max Tech and Beyond Design Competition was critical for the development of these prototype technologies and, for some teams, paved the way to other prizes. The HAWC team won first place in a college-wide engineering capstone design showcase and took the top clean energy prize in a local business plan competition.

"Our success in these activities can be traced back to the resources, advice, and structure provided by the Max Tech organizers," says Professor Mark Walter, the team's faculty advisor. "In addition to our technical achievements in building a prototype that met our coefficient of performance (COP) improvement goals, our project has exceeded our expectations for a design-build educational experience."

The student leader of the UMD team, Tao Cao, similarly praised the competition's educational experience. "Working on the UMD dryer team for the Max Tech and Beyond Design Competition was quite a rewarding experience for me," says Cao, "and

it has definitely strengthened my interest in working in the eco-engineering area." The competition has sparked a growing interest in the fields of sustainability and energy-efficiency enhancement at UMD, as evidenced by the now popular Ultra-Low Energy Use Appliance Design course, according to the team's faculty advisor, Dr. Yunho Hwang.



The winning University of Maryland team's ultra-efficient two-stage heat pump clothes dryer (HPCD) prototype.

The award-winning two-stage HPCD from the UMD team takes dryer efficiency a major leap beyond what is currently available. In the United States, an energy-efficient clothes dryer is not a readily available option; most electric clothes dryer models consume similar amounts of energy. In Europe and Japan, such a search would be more successful, as more efficient heat pump clothes dryers can be found there. Heat pump dryers typically consume about one-third less energy than conventional electric dryers.

The two-stage HPCD goes further, combining compact heat exchangers, a brushless direct-current (DC) motor, and a vapor injection cycle to deliver energy savings of 59 percent compared to an existing state-of-the-art U.S. electric clothes dryer. Experimental testing of each dryer's energy use followed DOE's published clothes dryer test procedures. With an estimated 67 million U.S. households that use electric clothes dryers, nationwide energy savings could amount to 21 gigawatt-hours, if all these households switched to the prototype HPCD. Hwang is seeking industrial partners to bring the prototype to market.

Dr. Hwang attributes the team's success to the students' enthusiasm and perseverance. "They were really interested in improving energy efficiency, more than just taking a class," says Hwang. "Students on the team spent extra lab hours and weekends working on constructing the dryer prototype and testing."

The team at Ohio State University was also enthusiastic about reducing household energy use. According to the U.S. Energy Information Administration, in 2009, more than 65 percent of all energy use in U.S. homes was dedicated to space/air conditioning and water heating. Targeting both of these end-uses could achieve significant energy savings. That was the original thinking that resulted in an earlier HAWC prototype.

The 2012/2013 team built upon this work to develop the HAWC 2.0 prototype. Recognizing that newer buildings tend to be better insulated and more airtight, the team aimed to develop an air and water conditioning system that is well suited to meeting smaller loads, better controls humidity, and does all this more efficiently. In conjunction with the technical development, the team created a business plan that informed many of the decisions made regarding the features of HAWC 2.0, the physical layout, and pricing.

The HAWC 2.0 system employs an appropriately sized desiccant wheel, a sensible heat exchanger, and a variable-speed compressor. The desiccant wheel is used to control humidity while improving efficiency by approximately 49 percent. Hybridization of air conditioning and water heating, which takes full advantage of the heat produced during the vapor compression cycle, results in a 30 percent improvement in the appliance's COP. According to the team's testing, the HAWC 2.0 provides a 73 percent yearly energy cost savings over a conventional central air conditioning, dehumidification, and ventilation system, with a payback period of just over 3.4 years.

Max Tech and Beyond is sponsoring another competition during the academic 2013/2014 year to further encourage and support the next generation of energy engineers, with additional funding from DOE's Building Technologies Office (BTO). Twelve teams from different colleges and universities have been selected to participate—a 50 percent increase in the number of schools participating and the university teams funded since the competition was inaugurated in 2010. The winners will be announced in August 2014.

Additional information:

Contact the program organizers at maxtech@dante.lbl.gov .



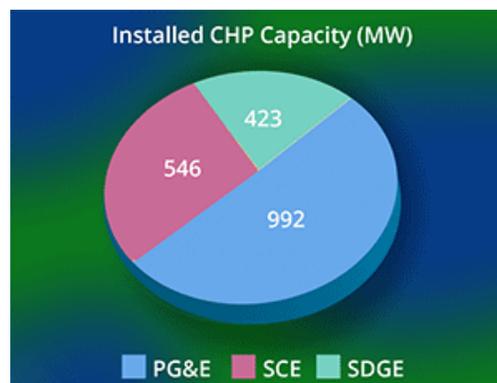
Environmental Energy Technologies Division

NEWS

Berkeley Lab Study Evaluates Potential CHP Penetration in California

Part of California Governor Brown's Clean Energy Jobs Plan is the goal of increasing combined heat and power (CHP) generation in the state by an additional 6.5 gigawatts (GW) by 2030. In 2009, the California Public Utilities Commission's Self-Generation Incentive Program (SGIP) database identified only 0.25 GW of small-scale CHP. With the financial incentives of the SGIP program expiring in early 2016, Lawrence Berkeley National Laboratory (Berkeley Lab) researchers evaluated scenarios to identify the optimal paths to meet the remaining CHP generation goal in the commercial sector.

Using the Distributed Energy Resources Customer Adoption Model (DER-CAM) [<http://microgrid.lbl.gov/der-cam>], a Berkeley Lab researcher team lead by scientist Michael Stadler evaluated an integrated approach that optimizes the adoption of distributed energy resources (DER). This study focused on commercial-sector CHP, especially those above a 50 to 100 kilowatt (kW) peak electricity load, and its potential contribution by 2020 and by 2030. The study looked at 147 representative sites and in particular concentrated on restaurants because they consume 25 percent of the natural gas in California. The research team conducted more than 8,000 individual optimization runs, with different assumptions for electric tariffs, natural gas costs, marginal grid carbon dioxide (CO₂) emissions, nitrogen oxide treatment costs, SGIP, fuel cell lifetime, fuel cell efficiency, photovoltaic installation costs, and payback periods.



Installed CHP capacity by utility service territory for 2030.

Results from assuming an extension of the SGIP to 2020 were encouraging. The most optimistic CHP potential contribution in 2020 was found to be 2.7 GW, given a 46 percent average electric efficiency for fuel cells, a 10-year payback period for investments, and a focused CO₂ approach by building owners.

Results for 2030 were more complicated, because those runs assumed that the SGIP had expired and that carbon-based utility generation sources had decreased. By 2030, the most optimistic modeling scenario showed a 2.5 GW CHP contribution, assuming a 60 percent electric efficiency and 20-year lifetime for fuel cells, a 10-year payback period, and building owners implementing a CO₂ minimization strategy. However, the results of CHP potential in 2030 showed a wide range, which demonstrated that the interactions between technologies, policies, and customer objectives would need to be well aligned to achieve the optimal result.

Additional information:

Download the Berkeley Lab report, *Encouraging Combined Heat and Power in California Buildings*. [PDF [<http://eetd.lbl.gov/sites/all/files/lbnl-6267e.pdf>]]

This research was funded by the California Energy Commission Public Interest Energy Research (PIER) Program.



Environmental Energy Technologies Division

NEWS

Research Highlights**Berkeley Lab Researchers Share in 2013 Supercomputing Award**

In June, at the International Scientific Computing Conference in Leipzig, Germany, the German Gauss Center for Supercomputing bestowed its 2013 Gauss Award to a paper titled "TUE, A New Energy-Efficiency Metric Applied at ORNL's Jaguar." Authors of the paper included Environmental Energy Technologies Division researchers William Tschudi and Henry Coles, along with other Members of the Energy Efficient High Performance Computing Working Group (EE HPC WG): Michael K. Patterson (Intel), Stephen W. Poole, Chung-Hsing Hsu, and Don Maxwell (Oak Ridge National Laboratory), David J. Martinez (Sandia National Laboratories), and Natalie Bates (EE HPC WG). The award is presented each year for the most outstanding paper in the field of scalable supercomputing.

The EE HPC WG was conceived of and is led by Lawrence Berkeley National Laboratory to promote energy-efficient green computing best practices.

The paper is available for download [http://eetd.lbl.gov/sites/all/files/isc13_tuepaper.pdf].

Building4Change Names EETD Researcher a 2013 Star of Building Science

Stephen Selkowitz of the Environmental Energy Technologies Division is one of 13 people who have been named a Star of Building Science for 2013 by Building4change, a website that addresses sustainability, innovation, and best practices in the built environment. Selkowitz, who also headed EETD's former Building Technologies Department for many years, was cited as an "internationally recognised expert in window technologies, façade systems, and daylighting." Descriptions of all 13 individuals who constitute Building4change's 2013 Virtual Academy of Excellence can be seen on their website [<http://www.building4change.com/page.jsp?id=2006>].



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. 2 [<http://eetd.lbl.gov/newsletter/nl45/>], Fall 2013

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.

Readers are free to reprint or otherwise reproduce articles at no charge, with proper attribution to the *Environmental Energy Technologies Division News*.

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.

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof nor The Regents of the University of California nor any of their employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed or represents that its use would not infringe on privately owned rights. Reference therein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or The Regents of the University of California and shall not be used for advertising or product endorsement purposes.

Fall Newsletter: Vol. 12, No. 2 [<http://eetd.lbl.gov/newsletter/nl45/>]

Environmental Energy Technologies Division News [<http://eetd.lbl.gov/newsletter/>]

©2013 Environmental Energy Technologies Division [<http://eetd.lbl.gov/>]

E.O. Lawrence Berkeley National Laboratory [<http://www.lbl.gov/>]

Disclaimer [<http://www.lbl.gov/Disclaimers.html>]