LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

FALL 2014:
VOL. 13, NO. 2

Changes are coming to the electric grid, and in this issue of *EETD News*, you'll read about research that is helping to make some of those changes possible. The Environmental Energy Technologies Division and its many partners are developing technology to better measure the reliability of the distribution grid in near real time. Elsewhere in EETD, policy experts have assessed the impacts of the growth of rooftop solar on utilities.

New software is available for those who are designing and assessing the impacts of adding a microgrid to their generation resources. And we tell the story of how a new algorithm, developed by a team of EETD building researchers, for real-time fault detection and diagnostics, could help building operators diagnose problems in real time.

Also, don't miss the chance to learn about a new tool available for building commissioning in small commercial buildings, or our interview with EETD's William Miller, a long-time program manager at Pacific Gas and Electric, on how improving measurement and verification could vastly increase energy efficiency investment.

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

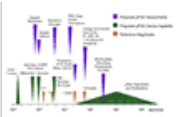
Don't forget to like us on Facebook, https://www.facebook.com/eet.div.lbnl, and visit our Vimeo channel, https://vimeo.com/eetd .

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

—Allan Chen







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

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

Fall Newsletter: Vol. 13, No. 2 [http://eetd.lbl.gov/newsletter/nl49/]
Environmental Energy Technologies Division News [http://eetd.lbl.gov/newsletter/]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Searching for Real-Time Measurements of Electric Grid Health

Today's electric grid faces an array of threats and opportunities—threats from aging equipment, catastrophic weather, and other factors, and opportunities from clean, customer-sourced power such as solar and wind generation and demand response (DR). A key to managing the new grid is to be able to measure its health in real-time—faster than second to second. Measuring a key grid parameter, "synchrophasors," offers a solution to the real-time measurement problem.

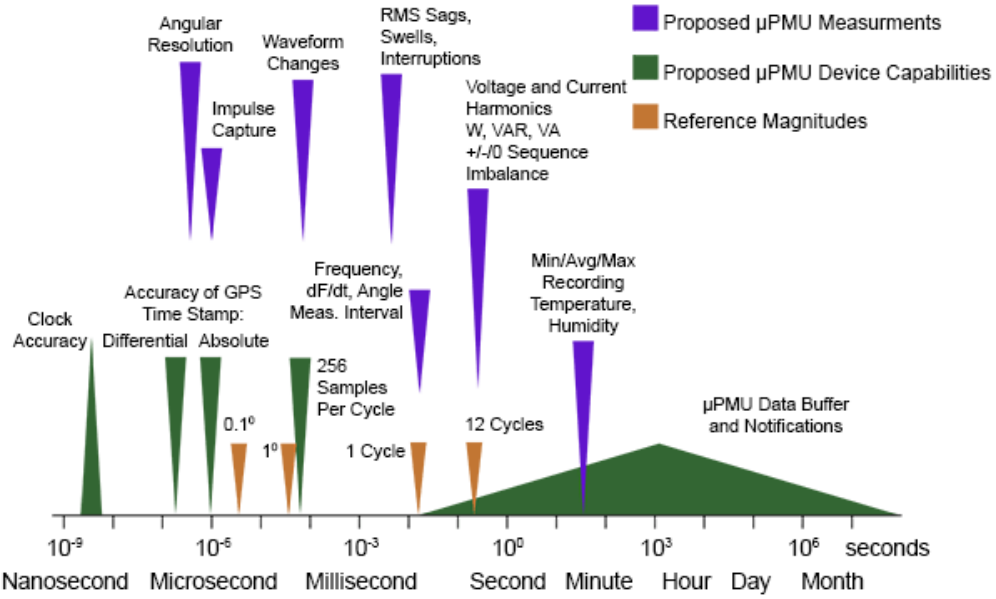


Figure 1: Timescale for μPMU Performance (Source: Alexandra Von Meier, CIEE).

A new project, funded by the Advanced Research Projects Agency-Energy (ARPA-E), aims to give electricity grid operators a futuristic, microsecond-to-microsecond measurement of the state of electric distribution lines using "microsynchrophasors." Scientists at the University of California, Lawrence Berkeley National Laboratory (Berkeley Lab), the California Institute for Energy and Environment (CIEE), and Power Standards Lab of Alameda, California, are performing the research.

The project's goal," says Emma Stewart, an engineer in the Environmental Energy Technologies Division (EETD) of Berkeley Lab, "is to learn how to use phase angles [phasors] on distribution systems to better understand what's happening on these systems."

Transmission and distribution lines carry our power from sources to consumers. Transmission lines carry power over long distances at high voltages. The distribution transformers and lines step down this power, sending it to homes, businesses, and industrial facilities. Synchrophasors are already beginning to be deployed on transmission lines. The groundbreaking ARPA-E research seeks to bring this real-time measurement capability to the electrical distribution system.

From One-way to Multi-Directional Power Flow

Just 20 years ago, most of the power flowing through the electricity grid was traveling from mainly utility-owned power plants to customers. Those plants were usually coal- or natural gas-fired, or nuclear. Almost all of the customers, except some large industrial facilities with onsite power generation, were consumers, not producers of power.

Things changed in one generation. Today, renewable power sources provide a growing percentage of power on the grid, helping to reduce climate change by lowering greenhouse gas emissions. These sources are intermittent—the power flows when the sun shines or the wind blows.

Another change from the past is that customers have options to interact with the grid. They can reduce their power consumption during periods of high power prices through DR programs. Demand response is becoming automated (AutoDR) and widely adopted thanks to R&D at Berkeley Lab's Demand Response Research Center (DRRC [http://drrc.lbl.gov/]).

Industrial and commercial power consumers are creating microgrids—producing power for their own facilities distributed through small grids that can be disconnected from the larger electric grid, and reconnected to the grid when the consumer needs additional power or has an excess to sell.

The electric power industry is more complicated today, but it offers more opportunities for clean energy and customer engagement.

These changes require electric system operators (known as independent system operators, ISOs) to have a more accurate read of the state and the health of the power grid in real-time. Instabilities in power, caused by fluctuations in supply and demand from the intermittency of renewables; sudden changes in demand response availability; demand changes caused by weather, catastrophe, or equipment failure; and the general aging of the grid infrastructure mean that there are more threats to delivering power reliably and continuously. The electric power industry needed a better way to know what's happening on the grid in real time, to respond more quickly to these threats.

Synchrophasors: A Revolution in Grid Measurement

The electric power industry found a solution in the form of synchrophasors.

Power is traditionally transmitted in the form of an alternating current. The current looks like a sinusoidal wave, with peaks and troughs. However, the waveform produced by each plant will not peak and bottom out at the same time as any other plant—the power that plants produce is not perfectly synchronized. Phase angle is a measure of the difference between two sinusoidal waves—it measures how far the peaks and troughs are from one another.

Power engineers know how to measure a quantity called a *phasor* at any point on an electrical grid with an instrument called a *phasor measurement unit* (PMU). Phasors are a measure of the phase angle and the magnitude of voltage at a certain point on the grid. Measuring a large number of phasors at exactly the same time, a measurement known as a *synchrophasor* tells grid managers something about the health of the grid.

Synchrophasors can tell them, for example, whether the demand for power matches supply, whether the power is flowing in the correct directions from supply to demand, and if there are any fluctuations in power that might cause grid instability. The precise, nearly simultaneous measurements are made possible by GPS systems, which can provide timing down to the microsecond timescale (one one-millionth of a second).

Today, synchrophasor measurements on the transmission lines of the electric power grid are becoming more common. Thanks in part to research and demonstration projects [http://certs.lbl.gov/certs-rtkey-spm.html] managed by the Consortium for Electric Reliability Solutions (CERTS), based at Berkeley Lab, ISOs [https://www.naspi.org/] throughout the U.S. are expanding their use of synchrophasors.

Measuring conditions on distribution lines, however, provides a distinct challenge; one that the ARPA-E project is addressing.

Distribution Systems Need More Accurate Measurements

Distribution systems are the portions of the grid where electric power is stepped down from a transmission line's high voltages to voltages appropriate to household, commercial, and industrial customers by transformers at substations, and is transmitted to homes, businesses, and industrial facilities.

"We think that measurements of 'microsynchrophasors' will provide a better visualization of what's going on, and it will allow ISOs to detect problems on the distribution system and plan their responses before problems run out of control," says Stewart.

Because the power flow through transmission lines is smaller, the equipment must be able to measure phase angles that are at least an order of magnitude smaller than on transmission lines. The signal will also be noisier because of interference from the devices connected to the grid by consumers and from utility equipment at transformer stations. One of the research partners, Power Standards Lab, has developed a microsynchrophasor measurement unit (μPMU) capable of making the accurate measurements required on the distribution grid. Synchrophasors are typically measured 24 times per cycle. The prototype μPMU can take 512 measurements per cycle.

Multiple Program Elements

The research partners are each leading a different research activity. University of California (UC) Berkeley team members are developing a network capable of recording and processing data and communicating with μPMUs installed in the field. They are also studying how the data can support diagnostics of problems on distribution systems. Power Standards Lab developed the μPMU device and is evaluating its performance. The California Institute for Energy and the Environment is studying how μPMU can be used in controlling applications on the grid such as managing microgrid connection to the larger grid. Berkeley Lab leads field-testing of μPMUs on several utility grids.

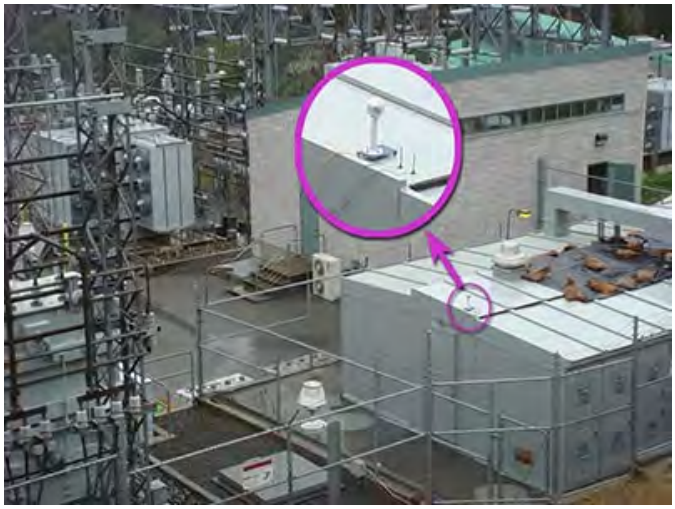


Figure 2. Microsynchrophasor test unit installed at a Berkeley Lab transformer station.

With ARPA-E's funding, Berkeley Lab is testing μPMUs in four electric utilities' service territories. When the pilot installations are complete, there will be one at each partner utility. About 10 μPMUs will be split over one or two distribution feeders at each site. In addition, seven μPMUs have been or will be installed on one of Berkeley Lab's distribution feeders (Figure 2). Data from the devices are collected wirelessly and sent via a 4G network to a database on the UC Berkeley campus. The testing will last two years. Stewart and her colleagues are also modeling distribution circuits, and will use data from the field tests to validate their model.

"One application of this research will be to understand what happens when a microgrid synchronizes and desynchronizes from the electric grid," says Stewart. The measurements can help coordinate resources between microgrids and the electric grid.

The research will also evaluate whether the systems could improve the management of demand response. "A goal of the study is characterizing the loads during demand resources," Stewart notes. "When customers turn loads on and off at the same time, it could affect the state of the grid."

Microsynchrophasor measurements are ideal for detecting and locating faults that might lead to instabilities on the grid resulting from sudden imbalances in supply and demand. They also have the potential to help system operators better manage the use of intermittent renewable sources of power, and to help match supply to demand through demand response programs and grid storage.

"Utilities are excited about this research," says Stewart. "They are always looking for more information about the state of the grid."

— Allan Chen

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Project page [http://pqubepmu.com/]

More information from UC Berkeley [http://i4energy.org/index.php?option=com_content&view=article&Itemid=206&id=475:micro-synchrophasors-in-distribution-systems]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Berkeley Lab Report Quantifies the Financial Impacts of Customer-Sited Photovoltaics on Electric Utilities

Installing rooftop solar panels

A new report prepared by analysts from Lawrence Berkeley National Laboratory (Berkeley Lab) examines the potential impacts of customer-sited solar photovoltaics (PV) on electric utility profitability and rates. The report, entitled *Financial Impacts of Net-Metered PV on Utilities and Ratepayers: A Scoping Study of Two Prototypical U.S. Utilities*, shows that these impacts can vary greatly depending upon the specific circumstances of the utility and may be reduced through a variety of regulatory and ratemaking measures.

Adoption of distributed PV by residential and commercial customers has expanded rapidly in recent years, driven in part by the prevalence of net metering, a billing arrangement that allows customers to offset their usage with PV generation and receive credits against future usage for excess generation. Although distributed PV generation currently represents roughly 0.2 percent of the nation's electricity supply, and no more than 1 to 2 percent in most states, widespread debates have surfaced about the financial impacts of distributed PV on utilities and their customers.

According to Berkeley Lab's Galen Barbose, one of the report's authors, "This work is intended to fill a gap in those debates by providing some concrete information about the potential magnitude of the financial impacts, by identifying the key conditions under which they may become more or less severe, and by evaluating possible strategies for reducing their severity."

The analysis, using a financial model developed by Berkeley Lab and funded by the U.S. Department of Energy's SunShot Initiative, is based on two prototypical utilities—a vertically integrated utility in the southwest and a wires-only utility in the northeast—and estimates the possible financial impacts of distributed PV on both utility shareholders and ratepayers.

At PV adoption levels equal to 2.5 percent of total utility retail sales, which is greater than levels that currently exist in all but one state, Berkeley Lab found that distributed PV resulted in about a 4 percent reduction in shareholder earnings for each of the two utilities. The impacts on average retail electricity rates, however, were considerably smaller, with increases of 0.1 and 0.2 percent, with respect to the southwest and northeast utilities.

The study also includes a large number of sensitivity cases with alternate assumptions about the two utilities. As Andrew Satchwell, a co-author of the report, adds, "One important contribution of this work is to highlight the degree to which the impacts of distributed PV on utility shareholders and ratepayers can depend on particular details of the utility's operating and regulatory environment."

In considering a future in which distributed PV increases to reach 10 percent of total utility electricity sales—which is much greater than current adoption rates—the report estimates that shareholder earnings might be reduced by anywhere from 5 to 13 percent for the southwestern utility and by 6 to 41 percent for the northeastern utility. Those ranges reflect alternate assumptions about the utilities' underlying load growth, rate structure, and other factors, as well as uncertainty about the degree to which distributed PV defers the need for utility capital investments in new generation, transmission, and distribution infrastructure.

A core purpose of the study was to evaluate measures that could be pursued by utilities and regulators to reduce the financial impacts of distributed PV. The report considered a large number of such measures, including changes to utility rate design and ratemaking processes, mechanisms that allow utilities to recoup revenues lost due to distributed PV or to earn profits on distributed PV, and a variety of other strategies.

As the report shows, a number of these measures could restore utility profitability to levels similar to what would occur in the absence of distributed PV, or could offset rate increases associated with distributed PV, or both. However, as Andrew Mills, another co-author of the report, explains, "The effectiveness of these measures often depends critically on how they're designed, and in many cases, they involve important trade-offs—either between utility ratepayers and shareholders or among competing policy objectives."

As such, the report does not offer specific recommendations, but rather seeks to highlight important issues for utilities and regulators to consider as they weigh issues surrounding distributed PV and net metering.

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Financial Impacts of Net-Metered PV on Utilities and Ratepayers: A Scoping Study of Two Prototypical U.S. Utilities
[http://emp.lbl.gov/publications/financial-impacts-net-metered-pv-utilities-and-ratepayers-scoping-study-two-prototypica]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Berkeley Lab Studies Find Significant Declines in Solar Prices; Local Regulations Impact System Prices

The price of solar energy in the United States continues to fall substantially, according to the latest editions of two annual reports produced by Lawrence Berkeley National Laboratory (Berkeley Lab).

A third Berkeley Lab report, written in collaboration with researchers at Yale University, the University of Texas at Austin, and the U.S. Department of Energy (DOE) shows that local permitting and other regulatory procedures can significantly impact residential photovoltaic (PV) prices.

According to the second edition of the *Utility-Scale Solar* [http://emp.lbl.gov/publications/utility-scale-solar-2013-empirical-analysis-project-cost-performance-and-pricing-trends] report, larger utility-scale solar projects in the United States have made great strides in delivering competitively priced renewable electricity in recent years.

Utility-Scale Solar 2013 cover.

"The price of electricity sold to utilities under long-term contracts from large-scale solar power projects has fallen by more than 70 percent since 2008, to just $50 per megawatt-hour on average within a sample of contracts signed in 2013 or 2014 and concentrated among projects located in the southwestern United States," explains Berkeley Lab's Mark Bolinger, one of the report's authors.

Meanwhile, the average, up-front installed price of utility-scale PV projects dropped by more than one-third since the 2007–2009 period, and average project-level performance has also increased recently.

The report tracks data on installed project costs or prices, operating costs, capacity factors, and power purchase agreement prices. It focuses on ground-mounted solar projects larger than 5 megawatts in size, and covers both PV and concentrating solar power.

"With the growth in this segment of the solar market in recent years, we are now able to systematically review actual market data to directly observe what large-scale solar projects cost to build, how they are performing, and at what price they are selling electricity," notes report co-author Samantha Weaver.

According to the latest edition of *Tracking the Sun* [http://emp.lbl.gov/publications/tracking-sun-vii-historical-summary-installed-price-photovoltaics-united-states-1998-20], an annual PV cost tracking report produced by Berkeley Lab, installed prices for residential and commercial PV systems completed in 2013 fell by roughly $0.70 per watt (W) or 12 to 15 percent from the prior year.

Tracking the Sun VII cover.

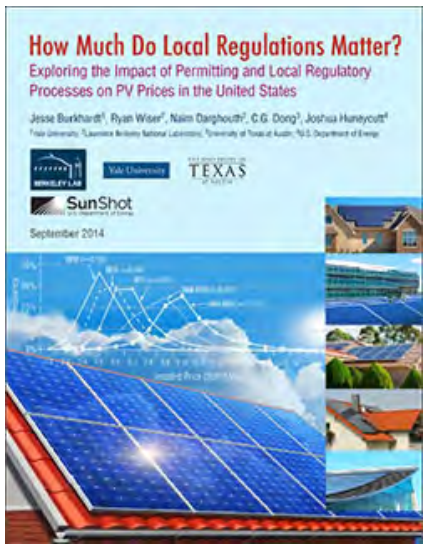
"This marked the fourth consecutive year of significant price reductions for residential and commercial systems in the U.S.," explains Galen Barbose, one of the report's authors. Within the first six months of 2014, prices for such PV systems in many of the largest state markets have continued on their downward trajectory.

The continued decline in PV system pricing is especially noteworthy given the relatively steady price of PV modules since 2012. In recent years, reductions in the installed price of PV systems have been driven largely by the falling price of PV modules, but that dynamic appears to be shifting. In particular, the report points to the increasing importance of reductions in 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 module prices have fallen, industry and policymakers have increasingly targeted soft costs for further reductions. As Berkeley Lab's Naïm Darghouth, another of the report's authors, notes, "The fact that system prices have continued to fall, despite the flattening of module prices, suggests that the various initiatives targeting soft costs are beginning to bear fruit."

The two Berkeley Lab cost-tracking reports released today also highlight 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. For example, roughly 20 percent of all residential systems installed in 2013 were priced at or below $3.90/W, while an equal proportion was above $5.60/W.

Based on a third Berkeley Lab report, *How Much Do Local Regulations Matter?* [http://emp.lbl.gov/publications/how-much-do-local-regulations-matter-exploring-impact-permitting-and-local-regulatory-p], some of this variation in residential PV pricing is driven by differences in local permitting and other regulatory procedures.



How Much Do Local Regulations Matter? cover.

In particular, based on data from Vote Solar and Berkeley Lab, variations in permitting among cities can drive differences in average residential PV prices of as much as $0.18/W, or $900 for a typical residential PV installation. Based on data from DOE, meanwhile, variations in not only permitting but also a wide range of other local procedures (interconnection, planning and zoning, net metering, and financing) can drive even-larger PV price differences among cities: two different statistical models estimate maximum city-level average price differences of $0.64/W and $0.93/W, or approximately $3,000 for a typical PV system.

"A variety of efforts are under way to make local procedures less onerous, and more conducive to solar market growth," explains Ryan Wiser of Berkeley Lab. "These results highlight the magnitude of PV price reductions that might be possible through streamlining burdensome local regulatory procedures."

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This research was supported by funding from the U.S. Department of Energy SunShot Initiative.

The three reports, along with related summary slide decks, two-page fact sheets, and data files (as applicable), are available for download.

Utility-Scale Solar [http://emp.lbl.gov/publications/utility-scale-solar-2013-empirical-analysis-project-cost-performance-and-pricing-trends]

Tracking the Sun VII [http://emp.lbl.gov/publications/tracking-sun-vii-historical-summary-installed-price-photovoltaics-united-states-1998-20]

How Much Do Local Regulations Matter? [http://emp.lbl.gov/publications/how-much-do-local-regulations-matter-exploring-impact-permitting-and-local-regulatory-p]

Electricity and Markets Group publications [http://emp.lbl.gov/reports/re]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

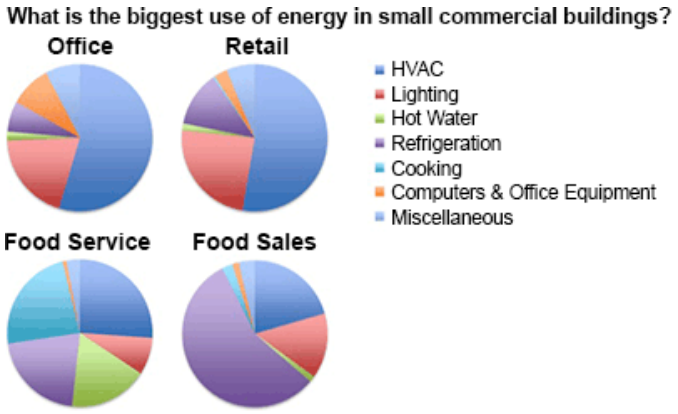
Berkeley Lab Develops Kit to Help HVAC Contractors Bring Energy Management to Small Commercial Buildings

In the commercial buildings sector, there is no shortage of opportunities to improve building performance and energy efficiency. According to U.S. Energy Information Administration statistics from the Commercial Buildings Energy Consumption Survey, 95 percent of commercial buildings in the United States are 50,000 square feet or less. These small buildings account for 44 percent of all commercial buildings energy use.

Because large commercial buildings and multi-building facilities are more likely to have dedicated energy or facilities managers, large buildings are most likely to benefit from the considerable growth in energy management systems and from commissioning and building energy performance services—the industry that has grown up around improving both the bottom line of the energy bill and the operations and comfort of commercial-sector facilities. However small buildings are unlikely to have dedicated building operations staff who know how to take advantage of these services. The average energy bill of a small commercial building is about $23,000 annually. Often, the decision to implement energy-saving measures is based on simple payback period: if energy savings are 10 percent, the budget for energy efficiency services at these sites may only be $2,000–5,000.

Now, scientists at Lawrence Berkeley National Laboratory (Berkeley Lab) have developed a package of simple analytical steps—and a strategy—designed to bring better energy management and efficiency improvements by way of the service providers who are already taking care of these buildings: the HVAC contractors.

The Energy Management Package (EMP), developed with the help of contractors and small building owners, is now available for free at this website [http://eis.lbl.gov/smallcomm.html]. The EMP can help HVAC contractors expand the business they do with small building owners by providing a simple step-by-step guide to provide basic energy management services. The selling point to small commercial building owners is lower energy costs, with minimal financial investment. The package focuses on offices, retail, food service, and food sales buildings, where large opportunities for low-cost energy savings exist. The project targets 3 to 5 percent energy savings per building through low-and no-cost measures.



Energy use in small commercial buildings.

Scoping Study Reveals Needs

Erin Hult, Jessica Granderson, and Paul Mathew of Berkeley Lab's Environmental Energy Technologies Division (EETD) conducted R&D for the Commercial Buildings Integration Program in the U.S. Department of Energy's (DOE's) Building Technology Office to develop a better approach to bringing energy management into small commercial buildings. They began by listening to the voices of those involved in this market segment for a scoping study. They talked with contractors, utility energy efficiency program managers, and vendors of energy information systems (EIS), the technology used in commercial buildings that helps managers understand real-time consumption patterns and monitor building energy use.

"We found that while some small building owners want to reduce their energy use, there are very few energy management tools and services specifically targeted to this market. Many of the existing tools are too complicated and expensive for small buildings," says Hult.

The scoping study also discovered that there is no single tool that provides a simple, systematic way for anyone—contractors or knowledgeable owners—to complete the key energy analysis steps for small commercial buildings recommended by the research team. Owners need simple, easy-to-understand information about their buildings that is actionable. "Two of the contractors we spoke to suggested that a one-page report for owners would be more effective than an online tool in motivating them to take action," says Hult.

The research team considered several different approaches to creating a process for expanding energy management to small commercial buildings that would succeed in the marketplace, ranging from providing software for building owners to buy to using utilities as the delivery channel. They settled on developing a package for HVAC contractors that shows them how to expand their existing services to the small commercial market to include energy management to improve whole-building energy performance.

"Contractors have existing relationships with small commercial customers," says Hult. "They regularly visit these buildings to provide maintenance." This keeps the transaction cost of providing energy management services low—something that emerged in the scoping study as a high priority.

Package Emphasizes Benchmarking, Operational Efficiency Opportunities

With guidance from the study, the research team developed the Energy Management Package, and recruited a group of 16 contractors nationwide to participate in a demonstration study to determine how well the package worked, and what improvements were needed. Contractors have identified 24 demonstration sites totaling over 400,000 square feet. Participating contractors included AAA Air Care, Advanced Energy Efficiency, Air Comfort Corporation, Bay Air Systems, Burch Corporation, Cooper Oates Air Conditioning, Dynamic Air Services, Eric Kjelshus Energy HVAC, Energy Conservation Pros/Syntrol, Johnson AC, Gilbert Mechanical Contractors, Marina Mechanical, Mid MO Inspectors, Murphy & Miller Inc., Peterson Service Company, and Zero Energy Associates. The demonstration program is ongoing; results should be available early in 2015.

"The package provides step-by-step guidance to contractors to minimize required training. For analyzing energy data, it leverages existing, free software tools. There are guidelines, worksheets, a simple reporting tool, and a business model for the user," says Hult.

The process consists of five steps: benchmarking the energy use of the target building against similar buildings; analyzing from 3 to 12 months of hourly or sub-hourly electric interval data (two to three hours of contractor time); performing a walkthrough of the building (one hour); discussing findings with the owner; and checking results (every 6 to 12 months).

Five steps for providing energy management services

The package shows the user how to get the building's total and monthly energy use from utility bill data, and how to use an existing online program such as the ENERGY STAR Portfolio Manager [http://portfoliomanager.energystar.gov/] to determine how well or poorly the building performs compared to others of its type. It explains how interval data can reveal spikes in a building's energy usage that they can use to diagnose problems with equipment. The data can reveal opportunities to use temperature setpoints, overnight setbacks, and other strategies to actively manage energy costs.

The EMP user is guided through the building walkthrough process by a checklist of what to look for, learning how to find simple low- or no-cost measures such as adjusting thermostat setpoints and lighting controls that can lower energy use with little impact on activities within the building.

The package's focus on communicating with the customer helps demonstrate the bottom-line advantages of energy performance improvement, as well as other benefits such as better indoor environmental quality and lower maintenance costs. Its model for

incorporating energy management into a contractor's business is designed to help make this a successful service offering that adds to the contractor's business success. The model provides a detailed approach to calculating costs and benefits to the contractor and the customer.

Initial feedback from the demonstration indicates that contractors are deriving value from deploying this approach at small commercial buildings. Obtaining access to clients' energy data can be a challenge for contractors, however, according to Hult. She believes that wider implementation of the Green Button data formatting standard and Green Button Connect data transfer protocol, in conjunction with utility smart meter deployment, are critical to enable the broad adoption of energy management strategies in the small commercial sector.

The free Energy Management Package is available now to all interested users at the website below. The project team plans to explore other channels for delivering the EMP to users, including the Architecture 2030 Small Commercial Toolkit [http://www.2030districts.org/toolkit/smallcommercial.html] (currently being developed with funding from DOE's Building Technologies Office), and to work with building software vendors to better tailor their products to the small commercial sector.

— Allan Chen

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Small Commercial Energy Management Package [http://eis.lbl.gov/smallcomm.html]

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Environmental Energy Technologies Division

NEWS

Energy Efficiency Measurement 2.0: An Interview with William Miller

William Miller

Ratepayer-funded energy efficiency programs have become an important tool for meeting electricity demand and addressing climate change issues in the United States. But methods for measuring and verifying those energy savings—justifying the current expenditure of $4.8 billion annually on utility efficiency programs—can be cumbersome, expensive, and, in some areas, do not provide a high level of trust. How can evaluation, measurement, and verification (EM&V) take advantage of the new era of efficiency technologies, big data, and the Smart Grid to reassure policymakers, ratepayers, and investors and help move the industry toward even larger goals for investment in efficiency?

With more than 26 years working at California utility Pacific Gas and Electric (PG&E), many years as the head of the energy efficiency evaluation group, and the last few years working at Lawrence Berkeley National Laboratory (Berkeley Lab), William Miller is in a unique position to explore and help to resolve these questions. We caught up with Bill just before he left for Jordan on a consulting job to help further develop that country's efficiency programs. Miller is based in Berkeley Lab's Environmental Energy Technologies Division (EETD).

Q: To meet the challenges of new electricity demand, not to mention to challenges of climate change, what goals for energy efficiency are realistic, and how will we meet them?

In 2010, investment in ratepayer-funded efficiency programs was roughly $4.8 billion, and indications suggest funding will rise to almost $10 billion and greater by 2025.

This investment translates to roughly 18.4 terawatt-hours saved in 2010—or about 0.5 percent of total retail electricity sales. We want to look at how we can get to even $100 billion spent on these programs.

What's it going to take to scale this up? Who are the audiences whose concerns we need to address so that they say "yes" to spending the additional money?

One of the concerns people have is how we measure the energy savings coming out of the programs. The U.S. Department of Energy (DOE) has a number of goals to meet this particular challenge, in three main categories: improving credibility and cross jurisdiction comparability; looking at emerging issues and technologies; and building capacity using best practices.

Q: To meet these goals, what kinds of projects are you and others working on?

I work on a number of specific projects—most come out from the DOE's Building Technology Office. I serve on the U.S. Technical Advisory Group for energy management. That gives me a perch to be involved in the development of international energy standards, on the measurement side of that. I've helped draft several international standards arising from ISO 50001—standards for energy management systems. These are standards that increase trust for buyers. For example, if manufacturers say they are complying with these standards, buyers can have some understanding of what that means.

I just finished a project for the American National Standards Institute (ANSI)—a roadmapping exercise [http://www.ansi.org/standards_activities/standards_boards_panels/eescc/overview.aspx?menuid=3] for efficiency measurement standards for energy use in buildings. I co-chaired the chapter on measuring energy efficiency. This was a collaborative process with a dozen experts, and it was just published in June. Now we're looking for ways to get the word out about this roadmap, which points to lots of specific things that will help move us toward a standard.

One example of something the roadmap pointed to was a gap in the use of common language when talking about and measuring energy performance. Berkeley Lab's effort on the BEDES database is a good step forward with this. The Building Energy Data Exchange Specification [http://energy.gov/eere/buildings/building-energy-data-exchange-specification-bedes] (BEDES) is a working "dictionary" of terminology and definitions that provides a common data format, definitions, and an exchange protocol for building characteristics, efficiency measures, and energy use. This is helpful on so many levels. For one example, states like to compare their performance to other states. So, is California doing better or worse than Massachusetts? If they don't agree on the data input, there is no way to know.

I've also been the primary architect of a process that DOE is still pursuing—the Uniform Methods Project [http://energy.gov/eere/about-us/uniform-methods-project-determining-energy-efficiency-program-savings/about-uniform-methods]. The idea was that if you look at how different states measure energy efficiency savings in utility programs across the country, results differ dramatically. This is because states use different methods of measurement. Was the difference due to weather? To the engineering or statistical modeling? Is it the total building square footage or conditioned space square footage? Our thought was that if we use essentially the same calculation process, we could break down what caused the difference. We could see where the difference came from.

If we move to a national climate policy, and if efficiency is going to be included, we need to have confidence in the way it is measured and reported. The Uniform Methods Project is laying out a common reference, and states are starting to pick it up, including Hawaii and about a dozen other states. Iowa, for example, has three large utilities and a bunch of small co-ops. Iowa is interested in its utilities having a standard way to measure their energy progress. I am an in-house advisor to the UMP process.

Q: You have talked about the "new paradigm" of energy efficiency EM&V. What do you mean?

In the new paradigm, there is a change in emphasis—we can quickly look at actual data from technology (from smart meters, energy management systems, and smart technology). This is saving people money—in the past, three to five percent of a utility program budget might go for measurement, with specialists tracking down numbers and analyzing them. Now, with all the technology, costs for measurement can be negligible, and they can be built into the building control system.

We have a lot of opportunity to take advantage of this big data now, with data coming in hourly and even more frequently, and there is a lot of excitement around taking advantage of the investments in Smart Grid technologies we've made nationally that give us quick trend lines for energy use information.

This is exciting because it means that we have an opportunity do energy efficiency savings calculations faster, cheaper, and at least as accurately as we did them 10 or 20 years ago. We take advantage of new technology and data coming from it, with ways to get information that allow us to meet our objectives. I'm open to the fact that we might actually change the paradigm about what energy is and how we measure it.

Q: You have a lot of experience in real-world applications of these issues. How is the private sector working with EM&V?

Businesses look at it very practically to determine if company investments were worthwhile—they do not have agendas for technologies or methods. I spoke to a manager from Walmart who said that for a while they were installing solar panels, but then they took them off and started experimenting with daylighting. In the commercial sector, they care about actual performance.

What companies say, and what is built usually into their internal standards is simple: performance now compared to performance a year ago. They spend less time constructing and arguing about baselines.

I think we'll see innovation in the private sector—there are fewer stakeholders. Decisions are made quickly, with fewer stakeholders to work with. Think about the State of California and how many stakeholders there are to satisfy.

Q: What was the biggest change for you coming from the utility side to the government side?

One of the biggest challenges we face is that the methods we use are hard to explain to policy makers; they use complicated calculations and sometimes require long time delays for measurement and analysis. The delay raises costs for energy efficiency, above the pure technology improvement, compared to other "clean technologies" like wind and solar. That additional cost, or "premium," that energy efficiency incurs (the extra time, expense, and uncertainty introduced by the calculations) was called the "EM&V tax." I took on this issue as a challenge to address and try to overcome.

Q: What do you most hope to accomplish in your work at Berkeley Lab and DOE?
I think the heartbreak of this and many other labs is how slowly the information and technologies flow into the marketplace and are adopted for common use. We have good information and methods: what I'm most interested in accomplishing is helping to accelerate this process in the realm I've been working in. The sooner all the work we're doing gets out into the utilities and public, the faster efficiency can scale up and the better we'll be on addressing climate change and reaching our goals.

— Kyra Epstein

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Additional information:

The Standardization Roadmap: Energy Efficiency in the Built Environment [http://www.ansi.org/standards_activities/standards_boards_panels/eescc/overview.aspx?menuid=3#Overview]

Building Energy Data Exchange Specification [http://energy.gov/eere/buildings/building-energy-data-exchange-specification-bedes]

Uniform Methods Project [http://energy.gov/eere/about-us/uniform-methods-project-determining-energy-efficiency-program-savings/about-uniform-methods]

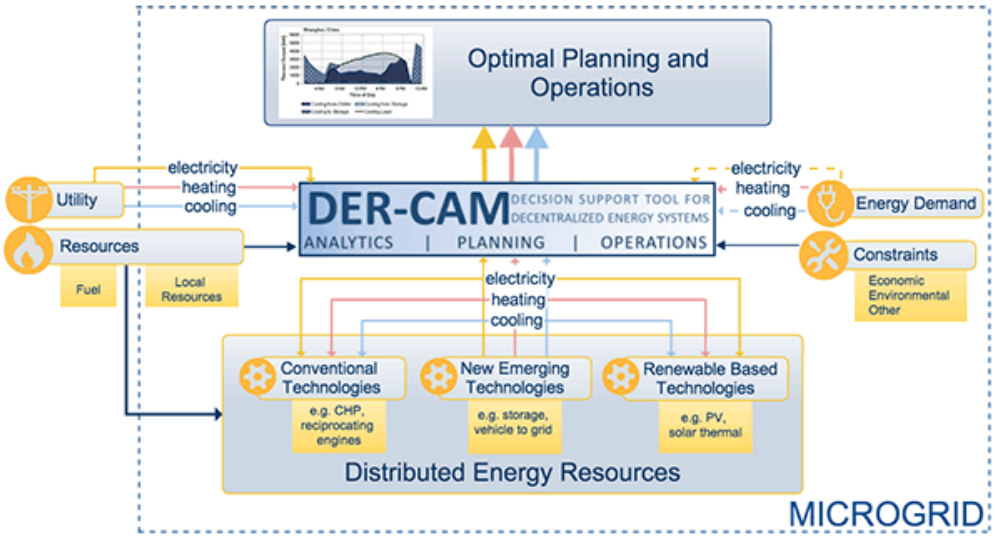
LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Microgrid Version of Distributed Energy Resource Software Is Now Available

Lawrence Berkeley National Laboratory (Berkeley Lab) has released DER-CAM 4.1.3, the latest version of the Distributed Energy Resources-Customer Adoption Model (DER-CAM). This new version, released on October 1, 2014, improves on previous DER-CAM versions by bringing new capabilities focused on some of the key issues pertaining to microgrids and the planning process used to develop them.



DER-CAM

DER-CAM 4.1.3 optimizes generation resources and loads within the boundaries of the microgrid in both grid-connected and islanded operational modes and provides a useful microgrid design tool. This latest version accounts for the synergies between grid-connected and islanded conditions, showing maximized benefits between the wide varieties of technologies possible in a microgrid: internal combustion engines, fuel cells, gas turbines, wind, photovoltaics and other solar, heat pumps, electric and heat storage, combined heat and power, bio-fuel, natural gas, diesel, electric vehicles, demand response, and storage. It also considers facility energy efficiency improvements such as windows and walls that directly affect changes in electric and heating loads and impact the generation technologies within the microgrid. Zero net energy building conditions can be considered as well. Further, DER-CAM considers policy measures and incentives that affect microgrid development and design, thus supporting a high penetration of renewable energy resources while maintaining reliability, offering resiliency, and achieving economic and environmental objectives.

DER-CAM 4.1.3 introduces a value-added feature for resiliency: the capability to define utility outage events of varying durations, from a few minutes to several days or weeks. During these events, when the microgrid is forced into islanding, DER-CAM now provides a way to determine the size of the equipment required to withstand the period of disconnection, whether hours, days, or weeks.

Another valuable feature is the ability to model different load priorities, enabling the user to define critical loads. The management of priority loads is particularly important when managing limited generation resources (including storage) during periods of extended outages. As load priorities are linked to outage valuation, DER-CAM can be used to quickly assess site costs in the event of an outage. By introducing back-up specific technologies, it can be used to analyze the trade-off between adding additional reserve capacity of standard generation and storage equipment or adding equipment solely for the purpose of backup during outage events.

A new web-based graphical user interface specifically for version 4.1.3 is under development and will be available on-line starting November 1, 2014. Companies will be offered an opportunity to use it and test its usability. With this web interface, users will be able to run the model and interpret its results without installing DER-CAM locally. For more information please refer to http://building-microgrid.lbl.gov.

Different versions of DER-CAM have been used for academic and commercial studies on distributed energy resources by universities, research institutions, utilities, and commercial companies for over ten years, as noted in more than 150 public reports, journal papers, and project reports. Now this same proven model can be used for microgrids.

— Michael Stadler

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

DER-CAM website [http://building-microgrid.lbl.gov]

DER-CAM in the *IEEE Smart Grid Newsletter* [http://smartgrid.ieee.org/september-2014/1147-der-cam-an-optimal-tool-for-microgrid-design]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

If Buildings Could Tell Us What's Wrong

Fault Detection and Diagnostics Moves into the Buildings Sector

When a commercial building doesn't work properly, its occupants suffer, it wastes energy, and expensive equipment can fail if a small problem spirals out of control.

The buildings industry has taken big steps in recent years towards better systems to monitor and control energy use in buildings, but it is still struggling to develop software that can pinpoint and diagnose a problem quickly and precisely, and to provide building managers with actionable information.

"The current tools are limited in scope, hard to use, and incomplete. They provide little or no ability to provide feedback and diagnostics," says Michael Sohn, Deputy Leader of the Sustainable Energy Systems Group at Lawrence Berkeley National Laboratory (Berkeley Lab).

Sohn and his colleagues are developing methods of applying Fault Detection and Diagnostics (FDD), a technology used routinely in industrial process control and automotive and aerospace engineering, to rapidly diagnose problems in buildings and inform human operators what needs to be fixed before they turn into bigger problems. Sohn's group is a part of Berkeley Lab's Environmental Energy Technologies Division (EETD), but research addressing sensors and controls at Berkeley Lab is broad. Sohn's collaborators are in the Simulation Research Group, while related research on energy information systems is based in the Commercial Building Systems Group.

The FDD technology that this team is developing offers many new benefits to building applications. It can provide guidance even when the data are noisy or incomplete. It can identify numerous simultaneous faults, not just one at a time, and it can operate in near real-time to reveal those faults quickly. It functions under both steady-state and dynamic conditions, which is what the electric grid is evolving towards. Changing conditions on the grid, including the increased use of demand response to hedge power availability, and varying prices and demand resulting from highly variable weather, will increasingly force building managers to adjust energy consumption in real time.

Complexity of HVAC Systems a Big Concern

Heating, ventilation and air conditioning (HVAC) systems are usually a building's most complex system, as well as its biggest energy consumer. When they are not working properly, the consequences are expensive. According to research at Berkeley Lab, the 13 most common faults in commercial buildings in the U.S. caused $3.3 billion in annual energy waste.

Unfortunately, faults in building systems are not uncommon.

Other studies have surveyed air conditioning units in commercial buildings, and found that substantial numbers of them, sometimes more than 90 percent, were operating with one or more faults.

Keeping HVAC systems in good repair is a full-time job for a building manager. Ensuring that HVAC systems provide peak performance and comfort to building occupants while minimizing their energy use is only now becoming possible, thanks to the increased use of sensors and controls in the form of energy information systems (EIS) and energy management systems (EMS).

"The idea is called sensor-data fusion," says Sohn. "It's become current in the buildings industry, and it means the merging of big data with data analysis." Accomplishing this transition requires the development of new mathematical techniques and software that can deal with building data that are less than perfect and can handle the needs of building managers for quick, easy-to-understand information about the sources of problems.

Sohn, Marco Bonvini, and their colleagues have developed an algorithm that can reliably detect and estimate the magnitude of multiple, simultaneous fault conditions in buildings, in spite of messy or incomplete data. "What's unique about this algorithm is that it works in real time—it can detect faults on the fly," says Bonvini. Their algorithm can tell building operators such things as the probability that the fault is real, its causes, and its impact on energy use in the building.

"As meters pick up fouling in HVAC system pumps, for example, the data become noisier," says Sohn. "The algorithm we developed is statistical in nature, so it incorporates the variability error that's in the measurements. Without this technique, the monitoring system could indicate too many false positives, or what's worse, it would miss too many false negatives—real problems in the system. That would result in building managers being less trusting of the results."

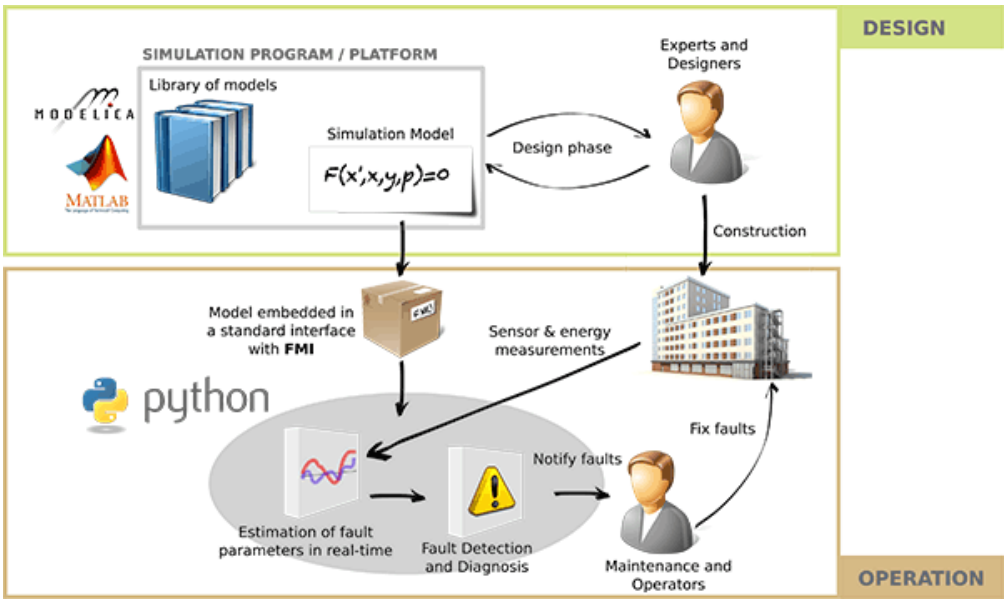
A Physics-based Approach

The FDD approach used in these tools is not only statistically robust, it is grounded in the real behavior of these systems. "With the tools online, we can consider a physics-based approach to system optimization," says Michael Wetter, Deputy Leader of the Simulation Research Group, and a Computational Staff Scientist at EETD.

The software presents various options, such as using a sequence of chillers to get the desired result, or a sequence of on-off commands, or both. It allows users to consider whether pre-cooling or pre-heating the building would work. It opens up new options for managing the energy use of and comfort within buildings.

Bonvini, a postdoctoral scholar scientist in the Simulation Research Group, worked on the programming that allows the algorithm to work within an energy management software tool chain for the design and operations phases of buildings. The software is model-based. It compares the real data from building sensors to what the data should look like if the building equipment were to be functioning properly—data generated by its internal model of the equipment. The software can be used during the design phase of the building's HVAC system, and the system specification data captured during the design phase can then be used during the operation of the building.

In the model-based FDD workflow (Figure 1), a building designer uses the model library embedded within a simulation program to design a building and test its energy performance. The building is built and occupied. "An energy information system records the performance of the building, which is available to building managers," says Bonvini. "During its operation, the same model used in the design phase can be reused by the FDD algorithm to reduce the impact of faults on energy consumption and avoid serious damage to equipment."



The model-based FDD workflow. A building designer uses the model library to design a building and test its energy performance. The building is built and occupied. An energy information system records the performance of the building, which is available to building managers. During operation, the same model used in the design phase can be reused by the FDD algorithm to reduce the impact of faults on energy consumption and avoid serious damage to equipment.

This software tool chain is one of the first to incorporate FDD for buildings that can be used in both the design and operational phases of buildings. It uses both the Functional Mockup Interface (FMI) standard and the Modelica open modeling language—two standards that the international building community is using to ensure that a variety of next-generation building software tools are all able to communicate with each other. Berkeley Lab and RWTH Aachen, Germany, co-lead an international project, Annex 60, under the auspices of the International Energy Agency to develop open-sourced next-generation building and energy system software tools based on the Modelica and FMI standards. "The connection between the algorithm and the simulation software, which could be any of several existing programs like OpenModelica or MATLAB/Simulink, is made possible by the FMI standard interface," says Bonvini. "It expands the software tool chain available to the building industry, and is one of the first to combine models with real data to support building operations."

"The Modelica Buildings Library is a free, modular, open-source library of components and systems models," says Wetter. "It allows users to rapidly prototype innovative HVAC systems, and in particular, design and test the performance of actual supervisory control algorithms which can be deployed directly to building automation systems. Modelica can also be used for the analysis of the operation of existing building systems." Wetter leads the team developing the Modelica Library in EETD and in Annex 60.

The Modelica Buildings Library has more than 300 models and functions. Wetter's team is now extending the library with another 100 models that will allow users to develop systems and controls for buildings to smart-grid integration. The team is also using the library to test how the EnergyPlus simulation engine can be improved to make it more flexible in assessing low-energy technologies and control sequences at reduced computing time. "With these rapid prototyping capabilities, we will put building designers in a position where they can invent new HVAC configurations and new ways for controlling buildings, test them in a variety of simulation scenarios, and then use the same computer code to operate actual buildings without the cost of reprogramming control sequences in a building automation system," says Wetter.

Proving the Algorithm in the Field

The development work on the algorithm is part of a larger three-year EETD project (now in its second year) to demonstrate and test real-time FDD in the field. Mary Ann Piette, Principal Investigator and Head of EETD's Building Technology and Urban Systems (BTUS) Department, is leading the effort to test the FDD software developed in this project. Jessica Granderson, Co-PI and BTUS Deputy Head, is overseeing the installation and development of the energy management systems for the buildings. Field tests are now under way at a large U.S. university, in partnership with facilities managers there, to study the performance of the algorithm. The team has also submitted software disclosures for two algorithms in the software package—a prerequisite to offering the software for licensing.

The team will modify and correct the algorithm and software to meet the needs of the facilities managers and address any problems they find. If the initial testing is successful, they will deploy the software to many U.S. Department of Defense (DoD) buildings. The DoD, along with other agencies, is working to meet federal requirements to reduce the energy intensity in their buildings by 3 percent annually through the end of fiscal year (FY) 2015 or 30 percent total by FY 2015 compared to FY 2003 baseline levels.

"What we have found is that deploying the algorithm into buildings can be the biggest challenge because it has both managerial and technical dimensions," says Granderson. Ensuring that facilities managers understand how to interpret information from the tools, and that the information they are receiving is what is they need, will be a key outcome of the field-testing and deployment.

However, success will bring rewards. "We believe that implementation of a software system with this algorithm will result in building energy savings in the U.S. of more than 10 percent per year," says Sohn.

— Allan Chen

Additional information:

Marco Bonvini, Michael D. Sohn, Jessica Granderson, Michael Wetter, and Mary Ann Piette. "Robust on-line fault detection diagnosis for HVAC components based on nonlinear state estimation techniques." *Applied Energy* 124(1) 156-166, July 2014. DOI: 10.1016/j.apenergy.2014.03.009 [http://dx.doi.org/10.1016/j.apenergy.2014.03.009].

Marco Bonvini, Mary Ann Piette, Michael Wetter, Jessica Granderson, and Michael D. Sohn. Bridging the Gap Between Simulation and the Real World: An Application to FDD [http://aceee.org/files/proceedings/2014/data/index.htm]. Presented at 2014 ACEEE Summer Study on Energy Efficiency in Buildings.

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Los Angeles Air Force Base Demonstrates First Working Vehicle-to-Grid Interconnection in the U.S.

Miranda Ballentine greets vendors during the unveiling of the first federal facility to replace its entire general-purpose fleet with plug-in electric vehicles November 14, 2014, at the Los Angeles Air Force Base in El Segundo, California. The base's electric vehicle fleet, consisting of 42 vehicles, including sedans, pick-up trucks, and mini vans (of which 36 will be vehicle-to-grid capable) is the largest operational V2G demonstration in the world. Ballentine is the assistant secretary of the Air Force for installations, environment, and energy. (U.S. Air Force photo/Sarah Corrice)

Soon, for the first time, a group of researchers will connect a fleet of plug-in electric vehicles (PEVs) to the electricity grid in Southern California in a test of the connected fleet's ability to provide the grid with power and excess storage capacity.

The fleet of 42 PEVs at the Los Angeles Air Force Base (LA AFB) will be controlled by a sophisticated system using technologies developed by Lawrence Berkeley National Laboratory (Berkeley Lab), Akuacom, and Kisensum. The use of vehicle batteries to help buffer the needs of the electricity grid is called Vehicles-to-Grid (V2G), and its use is expected to grow as electric vehicle use expands in California and the rest of the United States.

A team of scientists at Berkeley Lab's Environmental Energy Technologies Division (EETD) is leading the work, with funding from the U.S. Department of Defense's (DoD's) Environmental Security Technology Certification Program (ESTCP), the California Energy Commission, and the U.S. Department of Energy.

"This project is the first time that cars will be used in very fast electric wholesale power markets to address the needs of the electric grid," says Douglas Black, a mechanical engineer in the EETD.

The LA AFB is the first federal facility to replace 100 percent of its general-purpose vehicles with plug-in electric vehicles. This fleet is the largest plug-in electric vehicle fleet on a federal facility and the largest V2G demonstration in the world. The fleet can provide more than 700 kilowatts (kW) of electric power—enough to run 140 typical American homes on a summer afternoon.

At a recent public roll-out of the fleet, Secretary of the Air Force Deborah Lee James said: "Everything we do to fly, fight, and win requires energy, whether it's aviation fuel for our aircraft or power to run the bases that support them. This vehicle-to-grid pilot is a great example of how Airmen are driving the Air Force forward and finding new and innovative ways to make every dollar count."

The operators of the electric grid need to bring additional supplies of electricity online or ramp down power production at any time to match demand; otherwise, an unbalanced electric grid will fail, and blackouts will cascade across the system. The grid's conditions are always changing. On hot summer days, air conditioning causes demand to increase, and it falls as day turns to evening. Electric lights go on at night; toasters and coffeemakers during breakfast in the morning. Factories may operate at any or all hours of the day and night. Demand fluctuates, often unpredictably, and one of the grid operator's tasks is to match supply to demand as it changes.

With the addition of more renewable electricity from solar and wind sources, balancing demand will become even more critical. Renewable power sources are intermittent, and their output does not necessarily match demand. The California Independent

System Operator (CAISO) expects that by 2015, the growth in power available from renewable sources, especially solar, will require the grid operator to manage a 14,000-megawatt (MW) swing in load during the 5 to 6 pm hour, when the sun sets (reducing power from renewable sources) and lights start to go on in buildings for the evening. That is twice the load swing in 2013. Consequently, CAISO is searching for additional *ancillary services*—power that it can bring online quickly to help match demand on the grid.

These V2G technologies offer one solution to this need, and they also offer a solution to another need in the transportation sector. Plug-in electric vehicles are clean vehicles. Their greenhouse gas emissions (from battery charging) and emissions of particulates and nitrogen oxides are much lower than the direct emissions from conventional automotive fleets. California's 2013 *ZEV Action Plan* goal is to put 1.5 million zero emission vehicles on the road by 2025. However, plug-in electric vehicles have higher purchase prices and operating costs (because of battery pack replacement) than conventional cars.

The higher cost to buy and operate PEVs has slowed their adoption in the marketplace. Using the electricity storage capacity of PEV fleet batteries can help make their economics more favorable. Bidding power from PEV fleets' batteries into the CAISO power markets could help meet rapid load swings load on the grid, and provide a revenue stream to fleet owners that offsets their high costs.

Enter the U.S. Department of Defense. An Executive Order requires federal agencies, including DoD, to reduce their fleet's total consumption of petroleum products by two percent annually, and to use plug-in hybrid vehicles when available at a reasonably comparable cost. Another federal mandate requires DoD to prefer the lease or procurement of motor vehicles using electric or hybrid propulsion systems, if comparable in cost. The DoD has identified V2G as a key technology for development in its efforts to meet these requirements. Its current non-tactical fleet totals 200,000 vehicles.

Los Angeles AFB as Test Case

Charging equipment for the Los Angeles Air Force Base's new electric vehicle fleet during a training demo October 31, 2014, in El Segundo, California. When not in use, the vehicle's batteries can switch charging direction and feed their energy back to the base's power grid. (U.S. Air Force photo/Sarah Corrice)

Setting up this research project has required a significant effort to bring together many players—the LA AFB is located in Southern California Edison service territory. Although designated an Air Force base, it consists primarily of buildings. The mission of LA AFB's staff is to manage defense contracts with the nearby aerospace industry—there are no runways or aircraft at the base, but there is about 90,000 square meters of office space.

The project has other participants, all of whom are working together to pioneer the V2G solution. Selling ancillary services into the California electric grid requires CAISO oversight. The hardware to manage the scheduling of the fleet's power sales into the CAISO power market is provided by Akuacom's DRAS (Demand Response Automation Server), which uses software that follows the Open Automated Demand Response protocol developed by Berkeley Lab's Demand Response Research Center to allow grid operators, utilities, and customer sites to communicate in a common language.

Software provided by Kisensum will manage fleet and charging services. The software schedules services requested of the fleet and collects data about fleet status, including the charge state of each vehicle. The software also manages the charge stations, and charging and discharge of vehicles. When the CAISO requests that power from the fleet be discharged into the electric grid, this software manages that process.

Finally, Berkeley Lab's DER-CAM (Distributed Energy Resources Customer Adoption Model) software uses data about the state of the fleet and the opportunities in the ancillary services market to forecast the market's prices and grid energy requirements, weather, and other factors, and generate optimal scheduling for the fleet. Collectively these technologies are called the PEV Fleet Optimization Model (PEV2GOpt).

There are technological challenges to making this system function, as well as policy and regulatory challenges that must be overcome. Southern California Edison has worked to address the regulatory barriers and to establish the V2G interconnection.

"This is pioneering research," says Black. "We are paving the way for a diverse set of stakeholders to work together. What we're doing will provide a model for expanding V2G throughout the U.S."

A portion of the PEV fleet of 42 cars has been delivered to LA AFB. The research team is installing equipment for testing throughout the month. The Air Force's PEV fleet at the LA AFB will include both electric and hybrid vehicles, and will consist of 19 sedans, 5 pick-up trucks, 13 vans, 4 medium-duty trucks, and one 12-passenger bus.

The goal of this research is to assess how much the revenue from providing electricity services to the grid can offset the cost of buying and managing a PEV fleet, as well as the potential benefits to the grid of V2G services. The researchers also hope to assess the economic viability of converting more of DoD's non-tactical fleet to PEVs. The V2G installations are best suited to smoothing out small discrepancies between electric demand and supply that require extremely quick responses—within seconds of being called up, what the CAISO terms "regulation." They are not currently considered as operating reserves, which provide sustained back-up power in the event of, for example, a power plant failing—PEV fleets currently cannot discharge enough power for several hours to make up for a large shortfall of that sort.

"If we are successful, we will show that the increased cost of electric vehicles can be offset with the value they can extract from the marketplace, which will increase their adoption and accelerate the reduction of greenhouse gases from transportation," says Black.

— Allan Chen

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U.S. Air Force press release [http://www.af.mil/News/ArticleDisplay/tabid/223/Article/554343/af-tests-first-all-electric-vehicle-fleet-in-california.aspx]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Research Highlights

Sila Kiliccote Honored for Energy Leadership

Sila Kiliccote

As part of the U.S. Clean Energy Education and Empowerment (C3E) program, run by the U.S. Department of Energy (DOE) and the MIT Energy Initiative (MITEI), Sila Kiliccote, leader of the Grid Integration Group at the Lawrence Berkeley National Laboratory (Berkeley Lab), was recognized for her accomplishments in the area of research leadership at the annual C3E Women in Clean Energy Symposium [http://c3eawards.org/symposium/].

"I'm honored to receive the C3E award for research leadership," said Kiliccote. "All kinds of clean energy technologies —energy-efficient, renewable, and Smart Grid-related—have a bright future, and women in science, engineering, policy, business, law, and other fields have a considerable opportunity to help shape these technologies and increase their adoption. I look forward to participating in Clean Energy Education and Empowerment's global network to strengthen both the reach of clean energy technologies and the role of women professionals in this field."

One of eight mid-career women recognized by the C3E program, Kiliccote was selected from a nationwide pool of nominations and chosen by distinguished energy experts who are part of the C3E Ambassadors [http://c3eawards.org/about-c3e/c3e-ambassadors/] program. Along with the recognition, she will receive an $8,000 cash prize from MITEI for her clean energy work.

Kiliccote has held several positions at Berkeley Lab. Prior to this position, she was a part of the automated demand response team developing OpenADR, which is a communication protocol currently adopted as an international automated demand response standard between utilities and their customers. Her areas of interest include integration and optimization of behind-the-meter assets, using distributed energy resources (loads, electric vehicles, etc.) to provide grid services and sensing and measurement technologies for distribution systems. She has an MS in Building Science from Carnegie Mellon University and a BS in Electrical Engineering from the University of New Hampshire.

The U.S. Clean Energy Education & Empowerment (C3E) program [http://cleanenergyministerial.org/OurWork/Initiatives/WomeninCleanEnergy] is an effort to advance the careers and leadership of professional women in the field of clean energy. The program is part of the international C3E Initiative within the 23-government Clean Energy Ministerial framework.

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Additional information

2014 C3E Award winners [http://mitei.mit.edu/news/201409-doe-mit-partnership-awards-women-energy-leadership]

The U.S. Clean Energy Education & Empowerment (C3E) program [http://cleanenergyministerial.org/OurWork/Initiatives/WomeninCleanEnergy]

Lawrence Berkeley National Laboratory Wins 2014 ACEEE Champions of Energy Efficiency Award

Mary Ann Piette (right) accepts ACEEE Champions of Energy Efficiency Award on behalf of Lawrence Berkeley National Lab, with other winners.

Lawrence Berkeley National Laboratory (Berkeley Lab) was named a 2014 Champion of Energy Efficiency at the 18th biennial Summer Study on Energy Efficiency in Buildings by the American Council for an Energy-Efficient Economy (ACEEE).

Berkeley Lab was cited for "four decades of leadership on energy efficiency R&D, helping to improve buildings technology and systems in extensive collaboration with industry and states." Energy efficiency research and development at Berkeley Lab is based in its Environmental Energy Technologies Division (EETD [http://eetd.lbl.gov/news/article/58150/lawrence-berkeley-national-labo]).

The EETD was founded in 1973, and celebrated its fortieth anniversary in November 2013. Its mission is "to be a global innovation hub for science, technology, and policy solutions to the world's most critical energy and environment challenges." It has developed energy-efficient technologies that today are routine elements of buildings. These include energy-efficient windows with low-emissivity coatings, electronic ballasts for fluorescent lighting systems, cool roofing materials that save on air conditioning energy use, and energy simulation programs that help architects and engineers design more efficient buildings.

EETD's energy analysis activities include providing technical assistance to the U.S. Department of Energy's appliance efficiency standards process, and EETD researchers also give technical assistance to the states and to governments around the world developing energy efficiency programs and standards. Its other research activities include the environmental impacts of energy use, advanced energy storage technology development, and Smart Grid technologies. It is also the home of *FLEXLAB*, the world's most advanced building efficiency testbed.

ACEEE is a Washington D.C.-based organization whose mission is to "act as a catalyst to advance energy efficiency policies, programs, technologies, investments and behaviors." According to the Council, the Champions of Energy Efficiency awards "recognize leadership and accomplishment in the energy efficiency field. Winners are selected based on demonstrated excellence in program implementation, research and development, energy policy, or private sector initiatives."

— Allan Chen

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ACEEE press release 2014 Champions of Energy Efficiency [http://www.aceee.org/press/2014/08/aceee-presents-2014-champions-energy]

New Website Focuses on Applying Lessons of Berkeley Lab's Energy-Efficient Glazing and Façades Research

Visit http://facades.lbl.gov/

A new website intended to help architects, building engineers, and manufacturers develop and make better use of energy-efficient glazing and façade systems in commercial buildings is now available. Developed by the Windows and Envelope Materials Group of the Environmental Energy Technologies Division (EETD) at Lawrence Berkeley National Laboratory (Berkeley Lab), "Low Energy, High Performance Building façade Solutions" is designed to help the building industry apply lessons learned from EETD's advanced research to façade design best practices. It is the result of a collaborative multi-year program funded by the U.S. Department of Energy and the California Energy Commission's Public Interest Energy Research Program.

"New fenestration technologies and systems that optimize the synergies between the façade, lighting, and mechanical systems can deliver high performance throughout a building's lifespan," says Eleanor Lee, Staff Scientist and Deputy Group Leader in the Building Technology and Urban Systems Department. "These 'integrated' solutions represent a key opportunity to significantly reduce energy and demand, helping to move us toward our goal of zero net energy buildings by 2030."

Glazing and façade systems have very large impacts on all aspects of commercial building performance. They directly influence peak heating and cooling loads, and indirectly influence lighting loads when daylighting is considered. In addition to being a major determinant of annual energy use, they can have significant impacts on peak cooling system sizing, electric load shape, and peak electric demand. Because façades are prominent architectural and design elements, and because they influence occupant preference, satisfaction, comfort, and health, the design optimization challenge is more complex than with many other building systems.

Learn more about EETD's research on low-energy, high-performance building façade solutions at facades.lbl.gov [http://facades.lbl.gov]. The site includes downloadable guidebooks, research reports, and windows- and facades-related design software.

— Allan Chen

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Building Façade Solutions [http://facades.lbl.gov]

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division NEWS

Sources and Credits

Sources

Energy Efficiency & Renewable Energy's Energy Savers

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

DOE's Energy Information Administration (EIA)

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

DOE's Fuel Economy Guide

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

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

EERE's [http://energy.gov/eere/office-energy-efficiency-renewable-energy] 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/]

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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.

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LBNL/PUB-821 Vol. 13, No. 2 [http://eetd.lbl.gov/newsletter/nl49/], Fall 2014

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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.
