LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division NEWS

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Research that examines how homes can save 70 percent or more of their energy use is this issue's cover story. EETD researchers studied several northern California homes whose owners implemented their own plans to make extreme reductions in energy consumption and found that there are many pathways to achieving this goal.

Vasileia Zormpa's research to extend laser-based chemical analysis to the nanometer-scale range is explored in a feature article.

We also look at EETD's new Demand-to-Grid Lab, which is studying the impacts of demand response in a residential setting; we have a talk with EETD's Max Sherman on making indoor air quality standards health-based; we bring you a guide for school districts on implementing and financing energy-efficiency programs, and much more.

EETD also has a new Facebook page—you can see it at https://www.facebook.com/eet.div.lbnl

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

—Allan Chen

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

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

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Saving 70 Percent or More of Energy Use in Your Home—Berkeley Lab Scientists Study the Deep Energy Retrofit

Houses in the deep energy retrofit study were a wide variety of types from an upgraded beach house...

Cutting your home's energy use by more than two-thirds of what it presently uses is increasingly a topic of discussion, and a goal, in the home energy performance industry. While everyone from contractors to building researchers have been attempting and studying the so-called "deep energy retrofit" since the 1970s, right now the building industry is searching harder than ever for the right combination of strategies, technologies, and approaches to achieving deep energy cuts at a reasonable cost.

Currently, weatherization programs save 10 to 15 percent of a home's energy use, and some utility programs can save 20 to 25 percent. But to make a dent in the greenhouse gas emissions of the residential sector and make housing more sustainable requires much larger reductions.

"A problem we need to solve," says Iain Walker, leader of a Lawrence Berkeley National Laboratory (Berkeley Lab) research team that evaluated a group of deep energy retrofits in northern California, "is determining how we measure the success of these projects. Do we measure energy, carbon, or cost savings? Do we consider percent savings per house, per person, or per square foot? Do we use site energy or source energy in these comparisons? Is performance based upon a reduction in energy use, a comparison to a reference design, or an absolute post-retrofit energy target?" Walker is a scientist in Berkeley Lab's Environmental Energy Technologies Division.

...to a historically significant structure.

The complexity of these projects, and the variety of energy performance measures that a homeowner can take to reach these goals, is such that a reduction in energy use at the home in question does not necessarily translate to a similarly deep reduction in energy use at the source of energy generation, or to a deep reduction in greenhouse gas emissions. "There isn't even a consensus definition on what constitutes a deep energy retrofit," says Walker. "They can range from 50 to 90 percent."

Another problem is that deep energy retrofits are relatively untried and expensive. Only a few homeowners today commit to such a large home renovation project focused solely on energy bill savings, particularly given the risks they perceive with doing anything out of the ordinary with their homes. Are there particular energy-efficiency measures or packages of measures that do a better job of improving a home's energy performance at lowest possible cost?

Today there are about 20 million home remodels a year—usually to expand the home's size, to replace worn-out interiors and poorly functioning heating and cooling equipment, or to meet aesthetic goals. Homeowners spend more than $150 billion per year on these remodels, and every year more than a million homeowners spend more than $100,000 on their homes. The majority of remodeling is not done to achieve high energy performance. The home performance industry's challenge is to figure out how to motivate homeowners to spend some of this investment on energy and comfort upgrades.

How was the study set up?

Berkeley Lab's Walker, Jeremy Fisher, and Brennan Less located eleven deep energy retrofit projects around northern California that were initiated by their owners. They convinced the owners to allow Walker's team to monitor the energy use of these homes in great detail. Walker's team had no input into how the projects were done—the owners and their contractors had made all the decisions on their own.

The researchers installed wireless energy monitoring equipment that provided energy use data once a minute for every electrical and gas energy end use in these homes—space heating, air conditioning, water heating, lighting, appliance and equipment plug loads, and miscellaneous loads. The team also measured human comfort parameters such as temperature, humidity, and indoor air quality to determine whether the energy measures had an effect on the home's livability. The data stream was available to both researchers and homeowners, who were curious to see how well their home was performing.

What was done to the homes?

No single home project was like any other. One home had been small and was significantly enlarged. Another was a tract house whose owners decided to correct mistakes and failures to meet building codes during the original construction. Another home started as a shack near the coast and was built up into a larger, modernized house.

Yet another home started life as two houses on adjacent lots, with a passageway added to connect the two. Two homes were moved across town to adjacent lots as part of an affordable co-housing scheme. The owner of another decided to stage gradual improvements to the house over a decade. Another home was historically significant, so its exterior and most of the interior could not be modified—so the owners decided to create a kind of house within a house.

The costs of the energy upgrade portions of these projects—not the total remodeling cost—ranged from $10,000 to $57,000, averaging $30,000.

Many of the energy performance upgrades to these houses fell into one of three basic categories: an extensive rebuild of the home to meet the Passive House standard or Net Zero Energy goals; an upgrade of an older home to meet energy building codes; or energy-aware occupants upgrading a relatively modern house to a higher energy-efficiency level.

The extensive rebuild of one home to Passive House-level included blowing in insulation (R-30/38 in the walls and R-68 in the ceiling), adding rigid foam insulation around the foundation, and installing R-8 triple-pane windows, a heat pump and solar hot water heater, a gas-powered tankless hot water heater, compact fluorescent (CFL)- and light-emitting diode (LED)-based lighting, and 2 kilowatts (kW) of solar photovoltaic (PV) panels. Post-retrofit, this house used 75 percent less energy than the average California home.

In another case, bringing an older home up to code involved similar measures, such as blown-in insulation (R-19 wall and R-43 ceilings) and double-pane argon low-e windows (R-3). The occupants added a condensing gas furnace, gas tankless hot water heater, CFL and LED lights, and 2.5 kW of solar PV power. These measures saved more than 70 percent of site energy use (more than 90 percent of source energy use), even with the addition of 1,000 square feet of conditioned space in the basement.

In a third case, performing upgrades in a modern home, contractors replaced poorly installed batt insulation, adding new insulation to R-13 (wall) and R-40 (ceiling) levels. They sealed and insulated ducts and added a condensing gas furnace, an evaporative cooler, an insulated 40-gallon gas hot water heater, CFL and LED lighting, smart power strips, and ENERGY STAR appliances. These measures saved 55 percent of site energy use and 57 percent of source energy use, with no addition of solar PV.

Full descriptions of each retrofit project are available in the Berkeley Lab report by the project team.

Overall, how much energy was saved?

The research team concluded that overall, the deep energy retrofits were a success—the site energy reductions ranged from 31 to 74 percent. But, source energy reduction—the translation of site energy savings to energy saved at the source of power generation—varied widely. One house actually used 12 percent more energy at the source because it switched from gas to electric heating. The largest source energy savings was 96 percent, and the average saving over 11 houses was 43 percent. Reductions of carbon dioxide emissions-equivalent ranged from 19 to 80 percent, averaging 54 percent.

Metrics used to evaluate the energy retrofit can result in a distorted sense of a retrofit's success. For example, measuring the energy use per square foot tends to reward larger houses that use more energy than smaller houses for the same number of occupants.

Also, houses with a lot of occupants can look like energy hogs, even if those homes showed a large net energy use decrease after a retrofit.

Another example of a metric's misleading impression results from whether a house is all-electric or a mix of gas and electric use. Two houses in the study performed at about the same on a percent site-energy savings basis. One house switched from gas to electric heating during its retrofit, while the other stayed with its gas and electric energy mix. The result: the all-electric house's percent source energy savings was around 5 percent, while the other house's savings weighed in at 90 percent.

"When pursuing a deep energy retrofit, we recommend choosing fuels carefully and doing so only after evaluating energy performance on a source-energy basis," says Walker.

How was comfort and indoor air quality affected?

Another finding of the study is that using our standardized notions of comfort produces misleading estimates of energy use—in several homes occupants chose widely varying indoor temperatures.

Also, in many homes, indoor air quality may be compromised: "None of the homes in the study complied with the national minimum standard for ventilation, ASHRAE 62.2," says Walker. The team's measurements of fine particles in the indoor air spiked during cooking. "Most of the standard compliance issues related to a lack of proper kitchen venting," he explains. "Good house ventilation can reduce the concentration of these particles in the air, but what these and other homes really need is a good range hood that the occupants use reliably."

What's next?

Walker's team is looking for funding to follow this first study with new research that would identify homes with common problems by the way houses are built and by their geographical region. The goal would be to recommend a package of retrofit measures that would solve these problems. For example, in northern California, a common set of problems appears to be leaky, uninsulated walls and floors, poorly insulated attics, single-pane windows, 25- to 50-year-old heating technology, leaky uninsulated ducts, wasted hot water, incandescent lighting, and poor or nonexistent ventilation.

Identifying a package of standard changes for these homes would help contractors reduce the cost of deep retrofits—repeating the same steps in the same types of houses leads to savings in labor, material costs, training, and consulting. Such a strategy could reap large benefits and encourage the "mass production" of home energy performance improvements.

"These relatively simple and straightforward approaches reduce perceived risk because they use commonly available construction practices, control costs, and use readily available technologies—so we can do this right away," says Walker. "Climate scientists say we can't wait anymore to cut carbon emissions."

What a Standardized Deep Energy Retrofit Package for California Might Look Like:

- Air-seal the ducts and building envelope (to meet new construction requirements).
- Insulate walls to R-13 and attics to R-38.
- Replace windows with energy-efficient models.
- Add:
  - A sealed combustion furnace.
  - A new gas tank hot water heater.
  - CFL and LED lighting.
  - Smart power strips to reduce energy use of always-on appliances.
- Replace appliances with ENERGY STAR models.
- Improve kitchen and bath exhaust and whole-house ventilation, to meet the ASHRAE 62.2 standard.

—Allan Chen

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Deep Energy Retrofits [http://homes.lbl.gov/projects/deep-energy-retrofits]

LAWRENCE BERKELEY NATIONAL LABORATORY
Environmental Energy Technologies Division
NEWS

Moving Toward a Health-Based Ventilation Standard: A Conversation with Max Sherman

Max Sherman is a senior scientist in the Residential Building Group at Lawrence Berkeley National Laboratory (Berkeley Lab). As part of the group's Healthy Efficient Homes project, he and other project researchers examine the interrelationships among HVAC and indoor pollutants. In recent years, the group has advanced knowledge in this area by not only identifying the most prevalent indoor pollutants, but also by developing methods to better quantify health effects from those substances. Max draws on that knowledge when considering building envelope tightness and ventilation standards for energy-efficient homes to improve indoor air quality and occupant health. He serves on the ASHRAE Standing Standard Project Committee 62.2, which provides input for revisions to the ASHRAE 62.2 residential ventilation standard.

Some years ago, the Residential Building Group identified the nine highest-priority pollutants in U.S. homes. However, the health impacts from exceeding each pollutant's standard differ from one another, correct? How did you resolve that?

The Top Nine Indoor Contaminants

- Acetaldehyde
- Acrolein
- Benzene
- 1,3-butadiene
- 1,4-dichlorobenzene
- Formaldehyde
- Naphthalene
- Nitrogen dioxide
- Particulate matter with a diameter smaller than 2.5

The first task was to identify the most important non-biological airborne contaminants of concern, which we did in 2009. Then it was important to determine what kind of impact each of these contaminants have on people. A lot of work had already been done in this area, although it had not been applied to look at the impacts of indoor air in homes. We used existing knowledge of the health impacts of exposure to pollutants to determine impact of air in homes on occupants. Beyond that we needed to find a metric that would allow us to compare the impacts of these different substances, because the health outcomes of exposure were not all equal. Not all standards are created equal. The levels of contaminants deemed to be "safe" do not necessarily correspond to the same chance of disease occurring and the same health outcomes. They also don't necessarily result in the same impact on quality of life, for exposure to different pollutants are very different.

Your group chose "disability adjusted life years," or DALYs, as the measure of how indoor chemicals can affect human health. Could you explain this concept and how it applies to this work?

DALYs are a metric for quantifying the harm from disease, illness, or injury. In our case we used them to quantify the health burden of illness resulting from exposure to a pollutant. They're based on an optimal life span based on good heath and the difference from that condition as the result of factors that affect one's health. So, for example, if a substance in your home causes a person to die two years before the time they otherwise would, that is measured as 2 DALYs. The higher the number, the more serious it is. But it doesn't only address mortality; DALYs can be used to measure reduced quality of life as the result of an illness as well. So if a person experiences a five-year illness that reduces their quality of life to four-fifths of a what it would be in a healthy year, that is considered one DALY lost. By using the DALY metric, we're able to see which of the priority indoor air pollutants are causing the most health problems and focus our attention on those first, to achieve the greatest overall impact.

From this work, you've concluded that fine particulates—$PM_{2.5}$—cause the most health damage. Is that because they are more widespread than other pollutants, or are there other reasons? What health problems does $PM_{2.5}$ cause?

Particle emissions are clearly at the top of the list. Both of the reasons you mentioned contribute to this—$PM_{2.5}$ is more widespread than the other pollutants, and it also creates more health problems. Our most recent study found that $PM_{2.5}$ contributed significantly to DALYs lost due to stroke, chronic bronchitis, and premature death. Particulates exist in both inside air and outside, air, although not necessarily from the same sources. Indoor $PM_{2.5}$ stems mostly from indoor combustion; cooking or burning candles, that kind of thing. Outdoors, it comes from other sources, such as diesel vehicles or power plants or fires. Because it's so ubiquitous, it's difficult to set a standard that can be reasonably met, but standards-setting organizations do their best, based on the information available.

What additional research needs to be done to better understand $PM_{2.5}$, to protect public health?

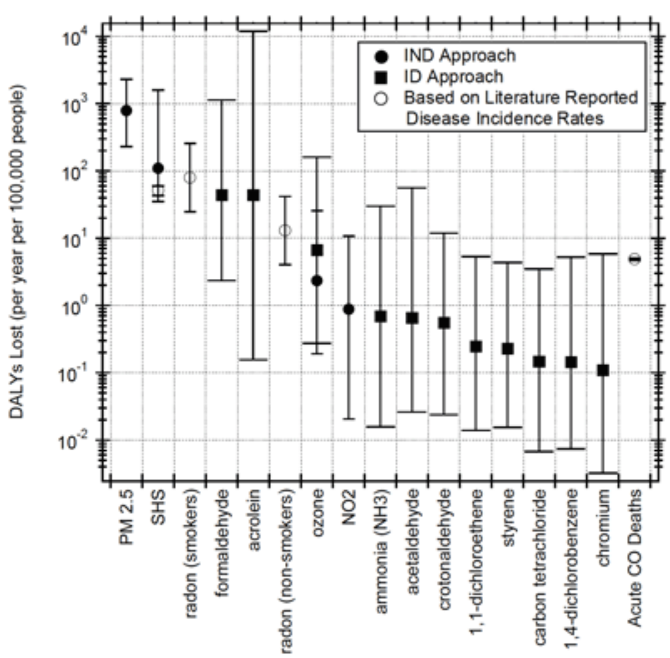
Data on outdoor $PM_{2.5}$ is plentiful, but those on indoor $PM_{2.5}$ are less so. Until recently, most researchers didn't think it mattered. The question now is whether or not the indoor $PM_{2.5}$ may react differently than that outdoors. It may, or it may not—future studies will tell us that. Particles larger than 2.5 microns do not go into the lung, so they are not as big a health problem, but particles smaller than that can get into the lung and cause serious problems. Particles smaller than 0.1 microns (which are referred to as ultrafine particles) can even go through the lung wall and into a person's body. Those may even have different biological mechanisms—we just don't know yet. So it would be helpful to have better health impact data on those very small particulates. Berkeley Lab doesn't conduct that kind of research, but we'll certainly take that kind of information into account when it's available.

From a ventilation perspective, we can filter particulates larger than 0.3 microns fairly effectively and inexpensively, but below that size it's more difficult and more expensive to filter them out. So when we consider indoor air quality, it's important to know: do most of the harmful health effects come from the very small particulates or from that range of 0.3 microns to 2.5 microns? Where is the most damage coming from? If it's the former, then we need to develop more effective and cost-effective means of reducing those extremely fine particulates. But if it's the latter, the technology is already available, and we just need to find the best ways to apply it.

Next on the list of the worst pollutants are acrolein and formaldehyde. Why are these present in people's homes, and what kinds of health effects result from their presence?

In our study, formaldehyde and acrolein were estimated to have the largest number of DALYs, so they're a major problem. Inside the home, acrolein is most often the result of incomplete combustion, from cooking foods (especially oils), burning biomass (such as wood), and secondhand smoke. It irritates the lungs; in fact, it was used as a chemical weapon in World War I, and is the only gas used as a weapon that has not been banned, because it's a natural combustion by-product and so is difficult to isolate and regulate in that way.

Formaldehyde is emitted by materials used in home construction, such as particle board and paneling. It can also come from foam insulation and tobacco smoke. It is a lung irritant and can trigger asthma attacks. It also causes cancer in other animals, and may cause cancer in humans.



Estimated population-averaged annual cost, in DALYs lost, of chronic air pollutant inhalation in U.S. residences: Results for the 12 pollutants with highest median DALY loss estimates

These studies also identified three contaminants—secondhand smoke, ozone, and radon—that were not on the original list of priority indoor contaminants but cause site-specific health problems in homes. In the homes where they are a problem, where do these stand in comparison to the priority pollutants?

Although our studies showed that in the majority of U.S. residences $PM_{2.5}$, acrolein, and formaldehyde dominated the health impacts attributable to non-biological air pollutants, second-hand smoke and radon contribute to contribute significantly to DALYs in the homes where they're a concern. In those instances, they are a priority, and are more important to deal with than, say, formaldehyde.

Of course, ventilation is a primary method for improving indoor air quality because it can reduce or dilute environmental pollutants. However, ventilation standards such as ASHRAE 62.2 don't consider specific removal of the priority pollutants. How would we benefit from revising the ASHRAE 62.2 standards to incorporate a health-based indoor air quality standard, and how might that work?

ASHRAE 62.2 provides guidance for a ventilation rate based on a particular type of building and other factors, but a health metric isn't part of that calculation. Incorporating a health metric such as DALYs into the standard would allow designers and builders to consider the building materials used and other factors when determining ventilation rates. If it were clear that those factors showed lower indoor emissions, then a lower ventilation rate could be used; if not, you'd use a higher rate.

You could also consider the trade-off between contaminants to find a balance of emissions that is acceptable. That is, if formaldehyde emissions were predicted to be low because of the materials used, a higher level of another contaminant might be acceptable. If post-construction levels were higher than estimated, or if subsequent occupants used furnishings that emitted higher levels of contaminants, then the standard could allow for additional air filtering.

The goal is to find a health-based ventilation standard that is flexible enough to address site-specific differences while ensuring healthy indoor air quality and optimal energy efficiency. In a mild climate it might be appropriate to use a lot of air for ventilation, because it doesn't need much conditioning. But in Alaska, you want to use less ventilation, because it's going to be energy intensive and expensive to condition it, and rely on other strategies for improving indoor air quality.

I'm part of the committee that revises ASHRAE standard 62.2. The most recent standard is being released in the summer of 2013, and revisions are made on a three-year cycle, so we'll incorporate the health-based approach in the next version. It may even take a couple of revision cycles.

What is the most important conclusion of this work?

There are two I think. First, that DALYs from $PM_{2.5}$, acrolein, and formaldehyde combined are much greater than those attributable to all the rest of the remaining 67 indoor air pollutants that we've identified combined. That certainly makes a strong case for focusing attention on those contaminants when addressing indoor air quality.

The second point is that, although there's still much to be learned about indoor air quality, we've made significant progress in recent years, and we need to act on that wealth of new information. Whether it's revising standards or evaluating the best building materials, this new health-based information gives us a much better picture of what constitutes healthy indoor air, and we can develop more energy-efficient, healthier homes by targeting the biggest problems.

—Mark Wilson

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Healthy Efficient Homes website [http://homes.lbl.gov/projects/healthy-efficient-homes]

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Lawrence Berkeley National Laboratory

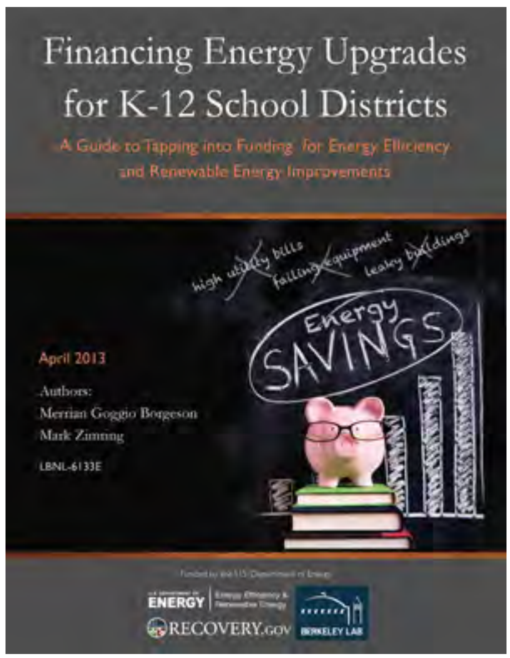
Environmental Energy Technologies Division

NEWS

Berkeley Lab Guide Helps School Districts Finance Energy Upgrades

Energy costs K-12 schools in the U.S. $6 billion dollars annually; however, researchers at Lawrence Berkeley National Laboratory (Berkeley Lab) show that much of that money could be saved by implementing energy upgrades, leaving more for funding-constrained school districts to spend on educating students.

Researchers Merrian Borgeson and Mark Zimring, in Berkeley Lab's Environmental Energy Technologies Division (EETD), have released a guide on planning and financing comprehensive energy upgrades that involve multiple measures and are designed to achieve significant and persistent energy savings.



Financing Energy Upgrades for K-12 School District

Public and private financing is available, but navigating the complicated landscape of grants, bonds, leasing arrangements, and other types of financing can be difficult for school administrators and facilities managers, who are unlikely to be experts in financing for energy efficiency and renewables.

Written for School District Administrators

The guide is written explicitly for school administrators, facilities managers, and others in K-12 education management. It covers various options for public and private financing approaches, and contains numerous case studies of school district projects. The authors provide explanations of financial terms and mechanisms.

"The money spent on energy for schools is their second-highest operating expenditure after personnel costs—more money than is spent on textbooks and computers combined," says Borgeson. "Comprehensive energy-efficiency upgrades for schools bring them a lot of benefits, The biggest might be that lower energy bills allow them to spend more money on hiring teachers and buying supplies."

Another significant benefit is that energy efficiency upgrades result in modernized infrastructure and lower maintenance costs; for example, through improved heating and cooling systems, energy-efficient windows and roofs, and better ventilation.

These energy upgrades also improve the comfort, health, and safety of school buildings. Fixing the hot and cold spots, leaky walls and roofs, and broken windows not only reduces energy costs, it improves the indoor environmental quality of the building and enhances the ability of students to learn and teachers to teach. Chosen carefully, energy-efficient equipment, for example, can be quieter, and do a better job at removing indoor pollutants that can affect human cognitive ability. Removing mold and toxic materials provides a safer learning environment.

Case Studies Provide Guidance to Overcoming Obstacles

Six case studies drawn from the experience of school districts around the U.S. tell the stories of how district policymakers overcame obstacles, built consensus, and chose funding mechanisms for energy efficiency upgrades that were widely accepted by their districts' stakeholders—parents, taxpayers, and political leadership.

Williamson County School District in Tennessee, for example, entered into an energy savings performance contract (ESPC) with an energy services company (ESCO) and completed a $5.7 million lease-purchase agreement to fund a range of energy-related improvements across 27 school facilities.

The lease-purchase agreement helped reduce the barrier of up-front costs of the upgrades, and refinancing a year later benefitted both the district and taxpayers. The project will pay for itself in six-and-a-half years, and continue saving money for the district long after that time.

Douglas County School District, in Nevada, used a combination of financial mechanisms to fund $10.7 million in upgrades. They tapped into federal Qualified School Construction Bonds, an American Recovery and Reinvestment Act grant, and voter-approved General Obligation bonds to fund a range of equipment and facility improvements.

"Most schools already have access to many of the financing tools they need to invest in these improvements," says Borgeson. "We think that every school has the potential to become a high-performance school—one that has an improved student learning environment *and* saves energy, resources, and money. They just need to understand what the opportunities are and tap into those opportunities."

—Allan Chen

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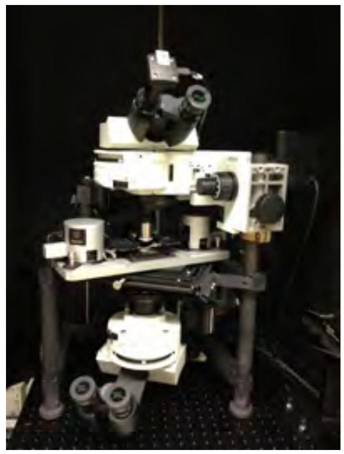
Financing Energy Upgrades for K-12 School Districts, by Merrian Borgeson and Mark Zimring, is available for download [http://emp.lbl.gov/sites/all/files/lbnl-6133e.pdf]. The work was funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy and the American Recovery and Reinvestment Act.

Lawrence Berkeley National Laboratory
Environmental Energy Technologies Division
NEWS

Laser Chemical Analysis: Berkeley Lab Breakthrough Using Near-Field Optics



Dual near-field probe system developed to carry out chemical analysis at the nanometer scale.

For 30 years or so, researchers in the Laser Spectroscopy and Applied Materials Group at Lawrence Berkeley National Laboratory (Berkeley Lab) have been studying laser beams.

Berkeley Lab's Rick Russo—a pioneer in the field—has been working with a technology called *Laser-Induced Breakdown Spectroscopy (LIBS)*, refining and expanding the technology for many applications. Famous for its use on Mars by the rover *Curiosity* in 2012, LIBS uses a laser beam to vaporize a small sample of material (called *laser ablation*), uses a telescope to view the vapor, or plasma, and then uses a spectrometer to analyze the light emitted from the plasma.

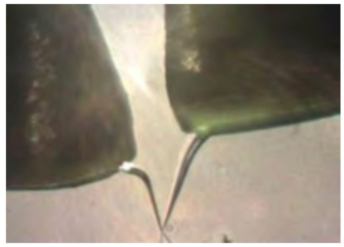
Since every material has a unique spectral signature, thanks to its chemical components, this "light signature" is like a fingerprint, allowing researchers to identify components in the material.

Out of this research at Berkeley Lab was born another technology called LAMIS—or *Laser Ablation Molecular Isotopic Spectrometry*. Both LIBS and LAMIS use laser ablation to analyze samples in just a few seconds. But where LIBS only measures the optical emission spectra of atoms and ions, LAMIS measures the emission spectra of molecules and molecular ions. This enables LAMIS to identify the specific isotopes of a chemical element within the plasma plume. Russo won an R&D 100 award in 2012 for his work using the LAMIS technology.

Five years ago, a new researcher at Berkeley Lab, Vasileia Zormpa, joined the Energy Storage and Distributed Research Department to take their chemical imaging work even further. Based on the original LIBS technology, and refined through LAMIS, Zormpa is the first person to advance this capability to use laser ablation to analyze very small samples—on the nanometer spatial scale.

Focusing the Beam

Taking smaller samples requires more tightly focused laser beams, the greatest challenge of this research. Basic laws of physics limit spatial resolution: light cannot be focused to dimensions lower than roughly half the wavelength of the laser beam used, which for conventional laser systems is on the order of a few hundred nanometers. To circumvent these limits, Zormpa and her team are incorporating a more sophisticated concept called "near-field optics" and combining it with ultra-fast (*femtosecond*) lasers, which pulse at a duration of a millionth of a billionth of a second.



Near-field excitation/Near-field detection chemical imaging scheme.
Excitation probe coupled to femtosecond laser.

Near-field optics allows them to focus the femtosecond laser beams to the microscopic size of a few tens to a few hundred nanometers. Moving the laser beam very close to the sample material—5 to 10 nanometers from the sample—allows them to focus the beam very tightly, achieving high spatial resolution, which means that the laser ablates a much smaller amount of material during each pulse.

As a comparison, an average human hair measures about 75,000 nanometers, a virus measures 30-50 nanometers, and DNA measures about 2.5 nanometers.

"My job is to get the beam focused," Zormpa said. "When the lasers interact with the surface of the material, it will vaporize a portion of the material. We are interested in how small a sample size we can take, the best spatial resolution we can achieve."

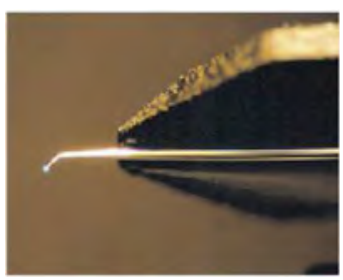
But a smaller sample size, with less vaporized plasma, creates other challenges to overcome. As the material is vaporized, it generates a tiny spark of light—a specific spectrum that is captured and analyzed. If the amount of material is very small, less light is available. Zormpa's research looks at the most efficient way to balance the goals of focusing the beam while still being able to read and analyze the chemical information needed.

"We have been able to still get chemical information with beam sizes less than 500 nanometers, which is a world record in laser ablation optical chemical imaging," Zormpa said. "The amount of material we vaporized was 200 attograms—a billionth of a billionth of a gram," she said.

Why So Small?

In the past, laser ablation technologies have been used to test long-distance for explosives, test toys and paint for lead contamination, and assess contamination at hazardous waste sites—without the chemicals to dissolve samples or vacuum chambers that other sampling techniques require.

In addition, LAMIS represents what may be the only practical means of determining the geochronology of samples on Mars or other celestial bodies in the solar system. Strontium isotope ratios have been a focus in the field of medicine for both treatment and diagnostic purposes. Measuring these ratios can provide valuable information about atmospheric chemistry. They also can be used to trace the origins and movements of early humans. Perhaps the most immediate and important application of LAMIS will be in nuclear forensics aimed at non-proliferation and terrorism.



Near-field excitation/Near-field detection chemical imaging scheme.
Detection probe (coupled to optical spectrometer).

But this new near-field technology is used in other applications that require careful and precise—and very small—samples. Over the past few years, Zormpa and her group have been applying these ultra-focused (near- and far-field) femtosecond beam technologies to analyzing solar and battery research.

For example, working with Robert Kostecki's battery group at Berkeley Lab, Zormpa is using femtosecond laser ablation technology to help improve batteries for electric vehicles. In their research, they are studying a thin, interfacial layer on the batteries that is very important for the performance and safety of the system. Because the layer is very thin, only about 50 nanometers thick, using lasers with lower depth resolution (sampling thick slices of material at a time) does not work.

"Let's say you have a small particle, only a few nanometers wide, next to another particle, one of silicon and one of aluminum," she said. "If you use a larger beam size, you vaporize both materials, and you don't have a clear picture of where each individual particle was," she said.

The main strength of the near-field ablation technology has to do with true three-dimensional imaging. Using the ultra-focused lasers, Zormpa can determine the composition of the material and how elements are distributed in the layer, and test for impurities.

"We have been successful because we were able remove thin slices with laser pulses, about seven nanometers at a time," Zormpa said. "Each layer is analyzed so that we have a three-dimensional 'picture' of the elements and composition of the sample."

Zormpa and her group are also working with solar cells, developing the technology to test and analyze whether materials have impurities—which decreases the efficiency of the electricity output. In addition, they are in the process of developing a portable tool that can provide the three-dimensional image of the constituents of materials like solar cells and batteries, to help with research and development.

"Solar manufacturers want to know the concentration of impurities or dopants in the cell, and their exact location," Zormpa said. "If they know, they can figure out how to manage and improve the efficiency."

Looking to the Future

While current research has allowed Zormpa and her team to use near-field optics to ablate smaller and more precise masses in their samples (a process known as *excitation*), the detection of the material's chemical signature has been based on traditional far-field optics.

"In our current work we are developing a new and unique system that allows us to both excite *and* detect in the near-field," Zormpa said. "We expect that this approach will help us improve the spatial resolution and limits of detection significantly."

—Kyra Epstein

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Lawrence Berkeley National Laboratory

Environmental Energy Technologies Division

NEWS

The D2G Lab: Testing and Demonstrating Smart Grid and Customer Technologies

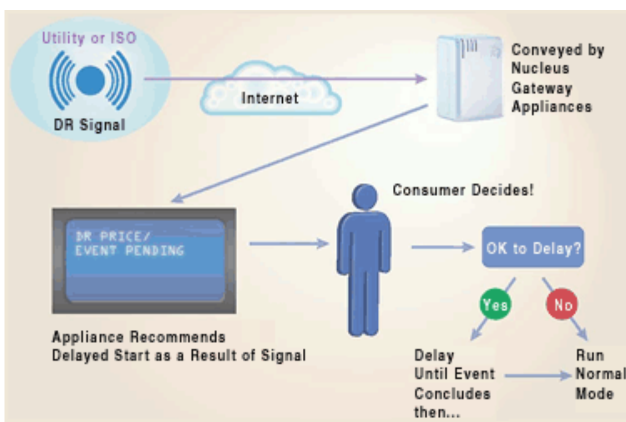
At the Lawrence Berkeley National Laboratory (Berkeley Lab) Guest House, guests who have business with Berkeley Lab can get a comfortable night's sleep while experiencing a living example of some of the laboratory's scientific research. The Guest House is one of the demonstration sites and the testing site (or *test bed*) for the Demand to Grid (D2G) Lab in the Demand Response Research Center (DRRC).

Over the past year, the D2G Lab has been testing and improving strategies and standards for demand-side interoperability, wired and wireless communications, communication architectures, devices, and monitoring and controls technologies. All of these strategies and standards are part of research that will improve the efficiency of the nation's electric grid and the way it responds to fluctuations in demand or supply of electricity.

Responding to Electricity Demand

In fact, demand response is one of the biggest challenges faced by electric grid operators—balancing the moment-to-moment demand from consumers and industry with the shifting loads of incoming and stored electricity. Demand response can be manual, semi-automated, or fully automated depending on the market and customer choice, and customers can use advanced control systems to moderate how their facilities, equipment, or appliances respond.

As the electric grid has become more complex and diverse, automated demand-response programs have been increasingly studied and tested in demonstration sites and cities. These programs have been used commercially in utility programs over the last decade. Fully automated demand response does not involve human intervention but is initiated at a home, building, or facility when an external communications signal triggers pre-programmed load-shedding strategies.



How customers receive and respond to demand response signals

In 2004, the California Energy Commission's Public Interest Energy Research (PIER) program initially funded the DRRC, which is managed by Berkeley Lab. The DRRC's research, development, and demonstration led to a communications technology called *Open Automated Demand Response Communication Standards* (*OpenADR*) that standardizes the way demand-response technologies work and interoperate within a "Smart Grid."

"OpenADR helps manufacturers of building automation equipment design products for Smart Grid implementation, and power aggregators incorporate demand response into their work," said Mary Ann Piette, the research director for DRRC. "OpenADR builds on more than 10 years of research to develop automated demand response technology and demonstrate it in buildings with utility, independent systems operator, customers, and commercial partners. The OpenADR specification uses open, non-proprietary, industry-approved data models. Any interested party can develop products around it."

The initial goal of the OpenADR research was to explore the possibility of developing a low-cost communications infrastructure to improve the reliability, repeatability, robustness, and cost-effectiveness of automated demand response. After the formal release of OpenADR 1.0 specifications in 2009 and their implementation, the OpenADR standards are taking hold in the United States and around the world:

- Hundreds of sites use OpenADR with more than 250 megawatts (MW) of electricity load automated in California.
- OpenADR version 2.0 is in full-scale commercial deployment. Advanced OpenADR pilots are under way with government, utilities, vendors, and customers to evaluate high-speed communications for advanced demand-response programs.
- More than 10 countries are reviewing and conducting pilot tests to use OpenADR for automated demand response.
- The OpenADR Alliance, established in 2010 to foster the adoption of the OpenADR standard, is growing, with more than 100 members, including research organizations, utilities, controls vendors, demand response aggregators, and service providers.

Residential Research: The D2G Lab

Early in 2011, Berkeley Lab's Grid Integration Group took the work one stop further—from commercial and industrial applications to residential demonstration through the D2G Lab at the Guest House.

The Berkeley Lab Guest House

"Our team has been doing other research on commercial and industrial facility grid integration and demand response and its market transformation," Rish Ghatikar, deputy leader for the Grid Integration Group, said. "We decided to use the Guest House as a residential appliance research lab since the infrastructure we needed for the setup was there."

Demonstrations include communication between a multitude of end-use devices such as smart appliances, revenue-grade smart meters, and a home area network (HAN) gateway to receive demand response reliability pricing signals using OpenADR. Within the demonstration test bed, wireless and wired Internet (Wi-Fi) and in-home protocols and standards such as ZigBee Smart Energy Profile 1.0 and other proprietary protocols are used to interoperate with OpenADR and respond with a change in energy use.

The Guest House features appliances (heat pump water heater, refrigerator, washer, and dryer, loaned by General Electric), an electric vehicle charger, programmable communicating thermostats, smart plugs, and dimmable light-emitting diode (LED) lighting fixtures—all controlled by the HAN using DR signals and with Web-based energy visualization tools to provide information on energy choices being made during demand response events.

The Guest House's heat pump water heater is part of the demonstration. It has two modes of heating: resistive heating (where a heating coil heats the water) for everyday operation, and a heat exchanger that is used during a demand response event. The heater uses 4,500 watts (W) of electricity during standard electric mode, powering down to 550 W using the heat exchanger during demand response events.

Like the water heater, General Electric's other appliances—a washer and dryer used by the guests and a staff refrigerator—are "smart" appliances that communicate and switch to low-power operations in response to demand response signals.

The Guest House also features a Coulomb Technologies electric vehicle charger, which will switch to lower charge levels during a demand response event. Before and during the demand response event, a message is displayed on the charger's screen letting consumers know what is happening and if they have to take any action.

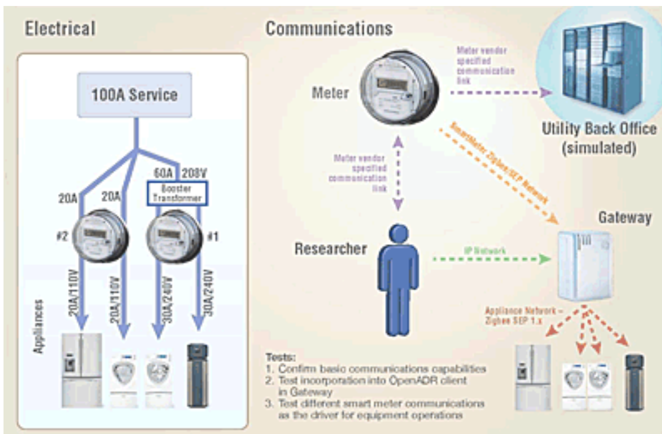
Ghatikar and his team have preprogrammed all of these appliances to operate in a low-power-using mode when test signals are sent to emulate a demand-response event.

D2G Lab Residential Demonstration Activities

Demonstration Area	Solution Providers and Vendors
Residential appliances, thermostats, plug-load meters, HAN integration, data analysis	GE, CloudBeam, Radio Thermostat, NEST, Itron, SilverSpring
OpenADR technologies and auto-demand response systems for end uses, strategies	Akuacom, AutoGrid
Lighting controls, communication, and technologies	Lunera and NEXT Lighting, CloudBeam
Electric vehicle chargers and grid integration	Coulomb Technologies, Auto-Grid
Analytics and visualization	GE, CloudBeam, Akuacom, AutoGrid

Communication and Monitoring

"Smart" appliances are one piece of the puzzle, but the way information moves between consumers and the electric grid—and the way it can be viewed and monitored—is the foundation for demand response success. The D2G Lab is demonstrating and testing a variety of communication architectures, including the Energy Service Interface, a generic interface between the service provider and the customer that can be a Smart Meter, a gateway, or devices in residential settings, building management systems for commercial buildings, and energy management and control systems for industrial facilities.



OpenADR signals are used at the D2G Lab, and can be sent over a variety of networks and transports (including the Internet) from a variety of entities (including the utility).

OpenADR signals are used at the D2G Lab, and they can be sent over a variety of networks and transports (including the Internet) from a variety of entities (including the utility). Once the demand response event signal is sent, the appliances and equipment respond by changing the power use for a short period of time. Customers can always override the changes and continue using the appliances normally, though likely at a higher energy cost and compromised reliability of the electricity supply.

These signals are monitored, and energy usage information for each appliance and end-use device is collected (for example, at 10-second intervals). The performance information is stored locally or in the "cloud" for easy access, available from any web browser on a computer or smart phone.

"We want consumers to be able buy these kinds of devices and appliances inexpensively and then use them with any demand response service providers," Ghatikar said. "Let's say a homeowner buys a smart thermostat or appliances in the Bay Area and then wants to move to Southern California. They will want to take their thermostat or the appliances with them and for them to be able to communicate with and respond to the demand response signals from another utility as well."

Moving Forward: Integration with the FLEXLAB

First-year operations of the D2G Lab have effectively demonstrated the target goal research areas, identified new areas of research and development, and validated findings and conclusions that benefit the wider demand response community. In addition to continuing existing demonstrations, the D2G Lab's second-year goals include conducting new demonstrations that provide a suitable grid integration research and demonstration framework for Berkeley Lab's new FLEXLAB—a research facility opening later in 2013 to study energy efficiency technologies in buildings.

FLEXLAB provides a set of tools to allow research in how buildings components and systems can be designed and controlled to support the U.S. Department of Energy's (DOE's) Energy Efficiency and Renewable Energy Grid Integration initiatives. Improving the flexibility of electric loads in buildings will allow the electric grid to be more cost effective as more intermittent renewables are used in the supply systems.

D2G Lab Demonstrations at the FLEXLAB

D2G Capabilities	Performance Parameters and Benefits
Lighting system control, energy, and peak demand	System energy use, and peak demand; energy savings relative to non-controlled 1980s retrofit base-case in twin cell
HVAC control, energy, and peak demand	Zonal load measurement, hydronic or air
Robust data acquisition system to accommodate additional instrumentation	Flexibility to integrate experiment-specific measurement hardware with existing testbed instrumentation
Demand response automation server and client designs	Client-server capabilities, price and reliability signals, latency testing
Energy and demand response models	EnergyPlus and Modelica tools to model control strategies, HVAC, lighting, and whole "testbed" energy use

—Kyra Epstein

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More About FLEXLAB

The FLEXLAB, or the Facility for Low Energy Experiments in Buildings, offers researchers a unique opportunity to collaborate in development, simulation, and validation of efficient building technologies. FLEXLAB will provide structures for manufacturers to conduct focused research and product development on single components or whole-building integrated systems. Building industry researchers can investigate building envelopes, windows and shading systems, lights, HVAC, energy control systems, roofs and skylights, or interior components such as furniture, partitions, and raised floors. The building loads can be controlled with electric batteries or integrated with Electric Vehicle chargers. The FLEXLAB will expand the DRRC's demand response research.

The D2G Lab Team:

Rish Ghatikar, Deputy Leader, Grid Integration Group and Project Lead

Janie Page and Chuck McParland, Lead for the Appliances and the HAN

Sila Kiliccote and Vish Ganti, Lead for the D2G

Vish Ganti, Project Coordinator, Technologies Demonstration and Analysis

LAWRENCE BERKELEY NATIONAL LABORATORY
Environmental Energy Technologies Division
NEWS

Research Highlights

Berkeley Lab Researcher Wins ITRI-Rosenfeld Fellowship

The ITRI-Rosenfeld Fellowship selection committee recently announced the fellowship's 2013 winner: Joshua Apte, a Research Associate in the Electronics Lighting and Network Group of the Environmental Energy Technologies Division.

Left to right: Paul Alivisatos (Berkeley Lab Director), Art Rosenfeld, (EETD Scientist Emeritus), Joshua Apte (winner of the Fellowship), Ashok Gadgil (EETD Director), and Dr Hsin-Shen Chu, (former Executive Vice President, ITRI), Taiwan.

Apte is also a PhD candidate in the Energy and Resources Group [http://erg.berkeley.edu/] at the University of California, Berkeley. He conducts research on the environmental and health impacts of energy, transportation, and other urban infrastructure systems. His dissertation employs mathematical models and field measurements to characterize human exposure to motor vehicle air pollution, emphasizing conditions in developing countries.

The ITRI-Rosenfeld Fellowship allows its winner to engage in innovative research leading to new energy-efficiency technologies or policies and reduction of adverse energy-related environmental impacts.

The fellowship committee received 17 outstanding applications. Through a rigorous selection process, the Scientific Selection Committee scrutinized the applications over several months and narrowed the field to three finalists. Those applicants presented their work to the committee and were interviewed by the committee to determine a winner.

The award was announced in a ceremony attended by a group that included Lawrence Berkeley National Laboratory's (Berkeley Lab's) Scientist Emeritus Art Rosenfeld, Lab Director Paul Alivisatos, Deputy Director Horst Simon, Environmental Energy Technologies Division Director Ashok Gadgil, and Deputy Division Director Robert Kostecki. The delegation from the Industrial Technology Research Institute of Taiwan (ITRI) included Dr. Hsin-Shen Chu (Former Executive Vice President, ITRI), Dr. Wu-Chi Ho (Deputy General Director of Green Energy Labs, GEL), Dr. Chia-Ming Liu (Manager of Planning Division, GEL), Dr. Shoung Ouyang (Technical Director of Resource Division of GEL), Dr. Ren-Chain (Joseph) Wang (Deputy Director of Planning Division, ITRI), and Dr. Shao-Hwa (Sean) Wang (President, ITRI International).

The fellowship is provided with support from the Industrial Technology Research Institute of Taiwan. It honors the contributions of Arthur H. Rosenfeld, Ph.D., fondly known as the Father of Energy Efficiency for his work toward the advancement of energy efficiency on a global scale. In the 1970s, Dr. Rosenfeld pioneered energy-efficiency technology research at what would become the Berkeley Lab's Environmental Energy Technologies Division.

Links:

ITRI-Rosenfeld Fellowship website [http://eetd.lbl.gov/about-us/itri-rosenfeld-postdoctoral-fellowship]

Joshua Apte's website [http://www.ocf.berkeley.edu/%7Eapte/index.html]

About Art Rosenfeld [https://sites.google.com/a/lbl.gov/cool-white-planet/]

Wind Power Still a Cost-effective Long-term Hedge Against Natural Gas Prices

Expanding production of U.S. shale gas reserves has helped to reduce natural gas prices across the nation, prompting many power producers to switch from coal to natural gas. Though arguably a near-term positive for both consumers and the environment, this "dash for gas," and its corresponding suppression of wholesale power prices, has made it harder for wind and other renewable power technologies to compete on price alone (despite recent cost and performance improvements). As wind power finds it more difficult to compete with gas-fired generation on a price basis, it may need to rely on other attributes, such as its "portfolio" or "hedge" value, as justification for continued deployment in the power mix.

Mark Bolinger

Against this backdrop, Lawrence Berkeley National Laboratory's (Berkeley Lab's) Mark Bolinger released a report that investigates the degree to which wind power can still serve as a cost-effective hedge against rising natural gas prices. Berkeley Lab hosted a webinar in March to present the research.

The report, funded by the U.S. Department of Energy, draws on a sizable sample of long-term power purchase agreements (PPAs) between existing wind projects and U.S. utilities. It compares wind power prices that have been contractually locked in for decades with a range of long-term natural gas price projections. The report finds that—even within today's low gas price environment—wind power can still provide a cost-effective long-term hedge against many of the higher-priced future natural gas scenarios being contemplated. This finding is particularly evident among more-recent contracts, whose power sales prices better reflect recent improvements in the cost and performance of wind power.

With shale gas likely to keep a lid on domestic natural gas prices in the near-term, the report focus is decidedly long-term. "Short-term gas price risk can already be effectively hedged using conventional hedging instruments like futures, options, and bilateral physical supply contracts, but these instruments come up short when one tries to lock in prices over longer durations," notes Bolinger, of Berkeley Lab's Environmental Energy Technologies Division. "It is over these longer durations where inherently stable-priced generation sources like wind power hold a rather unique competitive advantage."

A copy of the report, *Revisiting the Long-Term Hedge Value of Wind Power in an Era of Low Natural Gas Prices*, along with a slide deck summary, can be downloaded here [http://emp.lbl.gov/publications/revisiting-long-term-hedge-value-wind-power-era-low-natural-gas-prices].

Super-efficient Air Conditioners Show Potential for Significant Savings

A new assessment of the potential benefits from deploying super-efficient air conditioners has found significant untapped potential for air conditioner efficiency. The study estimates that, in the countries studied, more than 120 Rosenfelds (i.e., 120 medium-sized [500 megawatt] power plants) could be saved by 2020. The International Energy Studies group at Lawrence Berkeley National Laboratory (Berkeley Lab) and Navigant Consulting, Inc., conducted the study.

This landmark finding may have a significant impact on energy-efficiency strategy for countries such as India and China as they attempt to cope with high energy demand and the capacity required to address peak loads. The study found that air conditioning efficiency can be cost-effectively improved by 20 to 40 percent in most major economies.

"The main significance of this study is that the estimated future electricity footprint of air conditioners is on par with or surpasses the electricity to be generated from renewable sources such as wind and solar," says Berkeley Lab scientist Nihar Shah, the report's lead author. "This implies that policies to promote more efficient air conditioning equipment should be pursued with a similar seriousness and concern."

In India, China, and Brazil alone, electricity demand to power room air conditioners is expected to equal the output of five Three Gorges Dams by 2020—more than 500 terawatt-hours (TWh/yr)! Adoption of cost-effective efficiency levels would save more than 140 TWh per year by 2020.

"The information collected in the study can be used by governments and utilities to design a variety of air conditioner efficiency improvement policies and programs," said Amol Phadke, a coauthor of the study and Deputy Leader of the International Energy Studies Group at Berkeley Lab.

The study is the basis for a new strategy in development by the Super-efficient Equipment and Appliance Deployment (SEAD) initiative of the Clean Energy Ministerial to address the rapidly growing electricity demand from air conditioners. It was funded by the U.S. Department of State and administered by the U.S. Department of Energy in support of the SEAD initiative.

The countries analyzed in the study were: Australia, Brazil, Canada, China, the European Commission, France, Germany, India, Japan, Korea, Mexico, Russia, South Africa, Sweden, the United Arab Emirates, the United Kingdom, and the United States.

About SEAD

Through the collaborative efforts of its 16 participating governments, the Super-Efficient Equipment and Appliance Deployment initiative under the Clean Energy Ministerial aims to accelerate global progress on the energy efficiency of equipment and appliances. Governments participating in SEAD include Australia, Brazil, Canada, France, Germany, India, Japan, Korea, Mexico, Russia, South Africa, Sweden, United Arab Emirates, United Kingdom, United States, and the European Commission.

Links

Download the report [http://www.superefficient.org/Activities/Technical%20Analysis/SEAD%20Room%20Air%20Conditioners%20Report.aspx], *Cooling the Planet: Opportunities for Deployment of Superefficient Room Air Conditioners*.

Super-efficient Equipment and Appliance Deployment (SEAD) Initiative [http://www.superefficient.org]

Low Natural Gas Prices Effect Energy-Efficiency Program Selection

A new policy brief by Ian Hoffman, Merrian Borgeson, and Mark Zimring of Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division describes the challenges that low gas prices pose for the cost effectiveness of energy-efficiency programs. Using an electric-gas efficiency program and portfolio as an example, it quantifies options available to regulators and program administrators who want to evaluate the trade-offs among multiple policy choices and objectives. It also illustrates the implications of applying a range of cost-effectiveness screening options, including different discount rates, levels of test application, various benefit-cost tests, and the inclusion of non-energy resource benefits.

The analysis suggests that both low natural gas prices and the cost-effectiveness screening policies that are prevalent in many states are likely to challenge the viability of residential efficiency upgrade programs that are natural gas saving-only offerings and some programs that target both electricity and natural gas savings opportunities. This finding suggests that regulators and administrators of gas-only and electric-gas programs will have difficult choices ahead if several types of gas energy-efficiency programs are to remain part of their energy savings and public policy strategies. However, the brief offers regulators and administrators a range of options to consider in their choices of screening practices.

Download the policy brief, *Implications of Cost-Effectiveness Screening Practices in a Low Natural Gas Price Environment: Case Study of a Midwestern Residential Energy Upgrade Program*, at the link below.

Links

Download the policy brief [http://emp.lbl.gov/sites/all/files/lbnl-6167e.pdf]

Other publications of the Electricity Markets and Policy Group [http://emp.lbl.gov/reports]

New Online Forum to Help Homeowners Reduce Energy Use

Scientists at Lawrence Berkeley National Laboratory (Berkeley Lab), in partnership with the staff of *Home Energy* magazine [http://www.homeenergy.org/], have launched the Home Energy Saver Community, an online forum that homeowners and remodelers can use as a resource to improve household energy use.

Home Energy Saver Community website

This online forum is part of the Berkeley Lab's popular Home Energy Saver [http://hes.lbl.gov/] interactive home energy assessment tool. According to Berkeley Lab's Evan Mills, "the Home Energy Saver Community harnesses the popularity of social media, both to motivate homeowners to engage more in the process of remodeling their homes, and to help them make those homes more comfortable and energy efficient."

The Home Energy Saver Community, which launched in March, features rich content from *Home Energy* magazine's forthcoming guidebook, *No-Regrets Remodeling*, 2nd Edition. It also features case studies, energy-expert blogs, videos, a Google calendar with energy-saving actions that users can import into their calendars, and more. The book highlights areas where readers can use the do-it-yourself Home Energy Saver online energy assessment tool to obtain a list of energy-saving upgrades tailored to their home, climate, and local energy prices. Hard copy and electronic versions of the book will be published later this spring.

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Links

Home Energy Magazine on the Home Energy Saver Community [http://www.homeenergy.org/show/blog/id/396/nav/blog]

Home Energy Saver Community [http://hes.lbl.gov/community]

Berkeley Lab Helps NASA Ames Sustainability Base Optimize Its Energy Use

As reported in the Fall 2011 *EETD News*, the Buildings Technology Department at Lawrence Berkeley National Laboratory (Berkeley Lab) has been contributing to the energy management of the NASA Ames Sustainability Base—possibly the best-performing building in the federal fleet. Berkeley Lab is helping NASA ensure that the building meets its energy-efficiency design goals by implementing a real-time building energy simulation tool and installing additional instrumentation to measure its energy performance and the weather data.

The real-time building simulation tool incorporated EnergyPlus, the U.S. Department of Energy's energy-performance simulation model, into the mix, to help NASA optimize the building's energy operations. EnergyPlus is used to estimate energy use based on design intent, and Fault Detection and Diagnosis (FDD) algorithms developed by NASA compare that against real-time energy use data to identify and address equipment and systems that use more energy than intended.

Data sensors and meters will soon be installed, and the data gathering will begin. Based on the experience and the data collected, Berkeley Lab will publish an implementation guide this summer that discusses the lessons learned and guides similar efforts in the future.

"We're really enjoying our partnership with NASA," says Xiufeng Pang, of the Building Technologies Department. "They have some great technologies to improve building performance, and we hope to be able to continue this collaboration into the future."

For more information about Sustainability Base, visit the NASA Sustainability Base [http://www.nasa.gov/centers/ames/greenspace/sustainability-base.html] website.

For more information about LBNL's Building Science program, visit the Environmental Energy Technologies Division [http://eetd.lbl.gov] website.

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NEC Laboratories Supports Berkeley Lab Microgrid Research

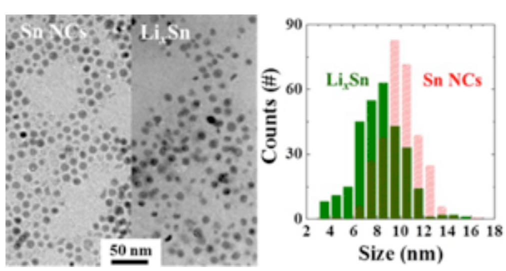
NEC Laboratories America, Inc., has provided Michael Stadler, of Lawrence Berkeley National Laboratory's Grid Integration Group, a gift of $60,000 to support his research in microgrids and energy storage.

Previous gifts from NEC also have supported Stadler's research; one study resulted in the report, *Electric Storage in California's Commercial Buildings* (LBNL-6071E). That project examined whether buildings could serve as the hub for electric vehicles and serve as a resource in a building energy management system (EMS) for demand response or strategies that reduce carbon dioxide emissions. It was also funded by the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability.

Download the report [http://der.lbl.gov/publications/electric-storage-californias-commercial-buildings], *Electric Storage in California's Commercial Buildings*.

Berkeley Lab Researchers Evaluate Tin Nanocrystals for Li-ion Battery Electrodes

The energy density in lithium-ion (Li-ion) batteries enables them to store and provide considerable energy in a small package. Powering devices from pacemakers to smart phones, these small, lightweight, rechargeable batteries have become a ubiquitous part of modern electronics. Using materials such as tin and silicon give Li-ion even a higher energy density—enough for a battery to power an electric vehicle—but the electrochemical reactions with those metals produce extremely high volume changes, which lead to mechanical stress and failure.



High-resolution transmission electron microscopy images and micrographs illustrate the morphological cracking observed in tin nanocrystals after lithiation.

Many battery researchers have suggested that by using nanocrystals, this mechanical damage may be avoided, so researchers at Lawrence Berkeley National Laboratory's (Berkeley Lab's) Environmental Energy Technologies Division (EETD) and Molecular Foundry tested that theory with tin nanocrystals. They studied mechanical cracking on homogenous 10 nanometer (nm) tin crystals from electrochemical cycling with lithium.

The nanomaterial exhibited better cyclability than commercially available particles; however, an *ex situ* transmission electron microscopy (TEM) examination of the sample showed significant damage after the first lithiation, proving that a size reduction at a 10 nm scale does not prevent the material from cracking.

These results could refocus the research in this area. Because this work suggests that particle damage may be inevitable when using tin nanocrystals for Li-ion battery electrodes, future research may be better directed toward the creation of self-healing structures or strategies to make the surface of the particles unreactive with the electrolyte. The researchers noted, however, that this work may not apply to silicon, which has already been shown to resist cracking during expansion.

This project was conducted by EETD researchers Linping Xu, Chunjoong Kim, Alpesh K. Shukla, and Jordi Cabana and Molecular Foundry researchers Angang Dong, Tracy M. Mattox, and Delia J. Milliron.

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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/]

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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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