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NEWS

ADVANCED ENERGY TECHNOLOGIES | ATMOSPHERIC SCIENCES | BUILDING TECHNOLOGIES | ENERGY ANALYSIS | INDOOR ENVIRONMENT

Figure 1. Picture of the Windows Testbed Facility at LBNL.

Energy-Efficient Electrochromic Windows on the Threshold

A small, curious building began to rise on a hillside parking lot at Lawrence Berkeley National Laboratory (Berkeley Lab) in 2002. The exterior walls of the 953-square-foot structure were plain enough—corrugated sheet metal. But as the building went up, a distinctive feature appeared: the south-facing wall, with a spectacular view of the San Francisco Bay area, held three large picture windows, each 10 feet wide by 9 feet high and composed of a mosaic of 15 smaller rectangular windows in three columns and five rows (Figure 1).

Those who looked closely enough once the building was complete in late 2003 saw numerous sensors—some circular and button-like, some wiry—attached to the glass of each small window. Curious passersby who lingered, especially on sunny weekdays, sooner or later saw some windows gradually darken to a deep blue and later lighten to their original clear state. In partly cloudy conditions, the windows might repeat the cycle of lightening and darkening several times a day.

This mysterious building was the Advanced Windows Testbed, funded by the U.S. Department of Energy (DOE) and the California Energy Commission (CEC) Public Interest Energy Research Program. It hosted a long-term study of electrochromic (EC) windows, which have coatings that allow them to darken and lighten in response to low electric voltage. EC windows are an advanced technology that is just appearing on the U.S. market. They hold much promise to be the next significant energy efficient and comfort-enhancing window technology. Early studies at Berkeley Lab suggested these windows could reduce a commercial building's annual energy use by 15 to 25 percent.

However, EC windows are still in an early stage of technological development. Only a few manufacturers offer them commercially, architects and engineers don't have much experience designing with them, and the technology is still expensive (although costs are expected to decline as companies refine the manufacturing process).

To help EC windows realize their potential to save energy in California and throughout the U.S., DOE and CEC funded Berkeley Lab's Environmental Energy Technologies Division (EETD) to conduct a three-year field test of EC windows in a realistic office-building setting. This test, along with other tests and computer simulations, was designed to quantify the performance of EC windows and help researchers improve the windows' performance and reliability.

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Figure 2. Installing windows

"The project's aim was to advance EC windows as a viable marketplace solution for energy savings and electricity load management," says Co-Principal Investigator and Project Manager Eleanor Lee. "Before EC windows can become widely accepted in the marketplace, market movers—developers, facilities managers, architects, and engineers—need to see realistic data on performance and energy impacts. They need to have confidence that these windows will operate properly, save energy, and improve the comfort of the occupants of buildings."

Thus, in the fall 2003, a manufacturer supplied the lab with prototype EC windows, which were then available only in small rectangular sizes, and lab researchers installed the windows in the new testbed facility.

How EC Windows Work

Electrochromic windows dynamically control daylight and solar heat gain (the sun's heat passing through the window to the interior) by dimming to a dark tint while maintaining a transparent view to the outdoors. The multi-layer EC coating can be deposited on glass or plastic windows. The coating is made up of a transparent outer conductive layer, an active electrochromic layer, a passive counter-electrode layer, and an ion-conducting electrolyte layer (see Figure 3).

When a low electric voltage is applied to the outer conductive layer, lithium ions migrate from the counter electrode layer across the ion-conducting layer to the electrochromic layer, tinting the window Prussian blue (see Figure 4). Reversing the voltage causes ions to flow in the opposite direction, making the window transparent. Chemically, the layers act much like a battery. The electricity required to switch the window back and forth between transparent and tinted states (e.g., 0.07-0.15 Watts/ft^2-glazing) is orders of magnitude less than the electricity required for commercial lighting systems.

With the proper control algorithms and sensors, an EC system in a large commercial building would automatically darken windows and reduce solar heat gain and thus the need for air conditioning when the sun is high and its rays are heating the building's interior. As the sun sets or clouds cover the sky, the windows would shift back toward their untinted state, maximizing daylight passing through the window and reducing the need for electric lighting in the building's interior. This dynamic control of the windows would save both lighting and air conditioning energy.

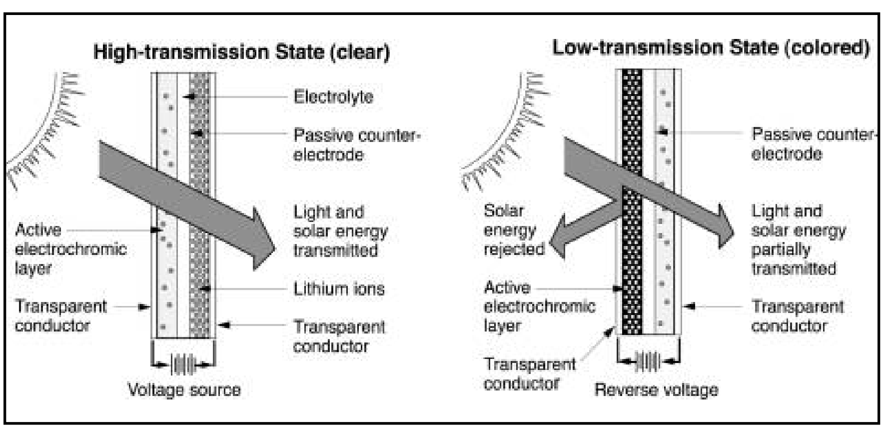

Figure 3. Diagram of a typical tungsten-oxide electrochromic coating

A properly designed control algorithm could also help improve occupants' comfort by reducing glare on computer screens and work surfaces and automatically reducing solar heat gains. One of the goals of the Berkeley Lab research was to test occupant comfort in an

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office with EC windows and develop both the hardware and software for an improved control system.

The Window Testbed

Within the test structure at Berkeley Lab are three identical offices, each thermally isolated from the others, with south-facing window walls. Each room is outfitted as a typical window office might be, with dimmable fluorescent lighting, office furniture, and carpeting. More than a hundred sensors in each room measured interior light levels ("illuminance"), surface brightness ("luminance"), temperatures, plug loads, EC window and lighting control status, and exterior weather conditions from minute to minute. The windows were controlled at first by a prototype device provided by the window manufacturer; later in the project, researchers and the manufacturer developed a system to more precisely control light transmittance.

The 18 x 35-inch window panels forming the window wall take about six to seven minutes to switch from clear to full color when the temperature is more than 50°F. The windows switch more slowly at colder temperatures (the larger the window, the slower the switching.

Over 20 months, the project team engineered, tested, and refined a daylight- control system for the facility with the goal of maximizing energy saved. Using the Radiance lighting simulation software (developed by Berkeley Lab researchers) and the Mathematica computer program, team members performed simulations to determine the window control strategy that would maximize energy savings and interior comfort.

"Our optimal solution," says Lee, "was to divide the EC window wall into two zones, an upper daylighting zone and a lower view zone." Researchers controlled the upper daylighting zone to minimize the use of supplemental electric lighting. The lower view zone was controlled to allow daylight into the room during diffuse sky conditions or to switch to fully colored during periods of direct sun to reduce glare and brightness on work surfaces like desks and computer screens.

The Field Test

Two of the three rooms in the testbed were equipped with EC windows; the third was a reference room, outfitted with energy-efficient low-emissivity (low-e) windows, so the EC windows were compared against a state-of-the-art energy-efficient technology that is widely available. The reference room was equipped with manually operated venetian blinds and daylighting controls.

The results of this effort, which are now available and posted on the project's website (http://windows.lbl.gov/comm_perf/Electrochromic/electroSys-cec.htm), demonstrate that EC windows save energy compared to state-of-the-art static low-e

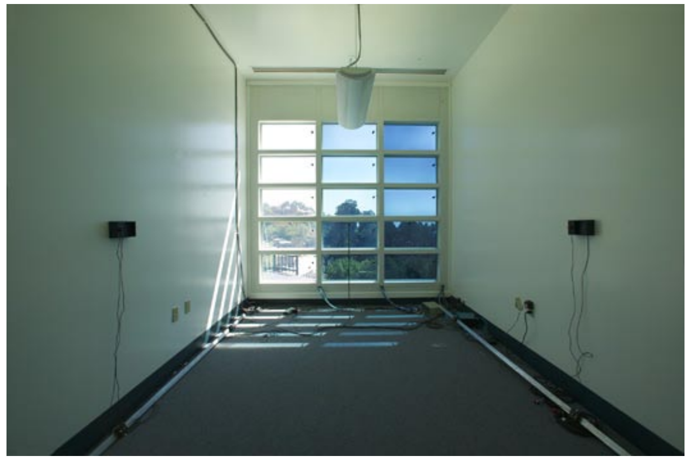

Figure 4. Inside the Windows testbed

Figure 5. Field test with office occupant

windows. Compared to the reference room case with the static, energy-efficient low-e windows and the blinds down, the two zone EC windows system saved +/-10 to 15 percent of daily lighting energy use during the test period. Simulations of these test results using Radiance and Mathematica to correct for manual operation of blinds and conditions that change with the seasons indicated that the total annual lighting energy savings would be 48 to 67 percent compared to the reference case.

The EC system also reduced peak demand power for cooling by 19 to 26 percent—potentially a big help to the electricity grid on hot summer days when air-conditioning use is high.

The researchers note that energy savings from EC windows will be affected by climate differences. Compared to Berkeley's relatively mild climate, inland areas of California are much hotter. In those and other areas with similar climates, such as

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the southwest U.S., energy and peak power demand savings should be larger than in Berkeley because EC windows significantly reduce solar heat gains. EC technology would also save more in large-area windows than in smaller ones, and in south-, east- and west-facing windows than in north-facing ones.

The Test Subjects Speak

In addition to quantifying the performance of EC windows, the researchers also wanted to learn what users thought about rooms with EC windows and dynamic daylighting control: were occupants more or less comfortable than they would be in rooms with conventional window and manual shade systems? User input is important because EC windows cannot succeed in the marketplace if building occupants don't like them.

To get an indication of user response, the research team brought in 43 volunteers who sat in the EC window test room and worked for several hours at a desk equipped with a PC. Occupants were exposed to three different lighting conditions for 40 to 60 minutes each: a reference episode, during which the user operated lights and shades manually; a semi-automatically controlled period; and a fully controlled period when the lighting and windows were controlled for daylight and glare. At the end of each period, occupants filled out a questionnaire (see Figure 5).

The majority of occupants preferred the automatically controlled conditions over the reference episode by a significant margin. The automatically controlled EC system resulted in less use of the blinds and more access to an unobstructed outdoor view. Subjects chose to face the window to do computer-related tasks when the EC windows were controlling automatically for glare. The subjects reported less glare, fewer reflections on their computer monitors, and more satisfaction than in the reference case. They also did not complain about thermal discomfort in the room.

These results indicate that, in addition to providing energy savings benefits, EC window systems, when controlling for daylight and glare, provide occupants a more pleasant work environment than rooms with conventional windows; EC windows have the advantages of year-round access to views and comfortable visibility of computer screens and work surfaces.

Needed: Better Control Devices

Overall, EC windows performed very well in the study. However, first on a list of recommendations to EC manufacturers for improving the windows' commercial viability, the research team suggests focusing on developing an improved control system, to allow facilities staff to manage recalibration and diagnose problems effectively.

A better "supervisory control system" for the windows will make the daylighting system more responsive to occupants' needs and visual comfort. Better control of the windows will also allow facilities departments to take maximum advantage of EC windows' ability to save energy and peak power and regulate interior spaces for overall environmental comfort.

"This technology promises to help California meet its aggressive energy-savings and greenhouse-gas reduction goals in the next ten years if manufacturers can continue to make improvements in the technology and cost of manufacturing," Lee says.

— Allan Chen

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http://windows.lbl.gov/comm_perf/Electrochromic/electroSys-cec.htm

The final report, "Advancement of Electrochromic Windows," LBNL-59821, is available at:
http://windows.lbl.gov/comm_perf/Electrochromic/ec_reso_tero.html

More on Radiance simulation software:

http://radsite.lbl.gov/radiance/HOME.html

What Can Models Tell Us About Risk?

Some environmental pollutants pose known health risks to human beings. Manufacturing, energy generation, and other activities release these pollutants to the air, water, and soil. We may eat or drink something containing these substances, breathe them in, or absorb them through our skin.

How do we know which pollutants pose health risks and which need to be regulated to prevent health impacts? Scientists use computer models to find out how pollutants will move in the environment. But how far can we trust these models? How much can they tell us about health risks? What are the limits of models?

Measuring exposure to environmental pollutants and assessing health hazards is a complicated endeavor that poses interesting scientific and non-scientific challenges. Numerous scientists at Lawrence Berkeley National Laboratory (Berkeley Lab) investigate the scientific issues associated with environmental health.

Thomas McKone is one of them. A senior staff scientist in the Environmental Energy Technologies Division (EETD), McKone leads the Environmental Chemistry, Exposure, and Risk Group and is an Adjunct Professor in UC Berkeley's School of Public Health. He and his colleagues study the physical processes by which pollutants migrate through the environment. McKone's own work focuses on developing computer models of pollutant migration to understand pollutant transport and to help policy makers decide whether and how to regulate chemicals. Other researchers conduct field studies on pollutants ranging from particulates and other airborne substances to hazardous chemical and radioactive wastes.

In the early 1990s, McKone's group developed the CalTOX model to help California's Department of Toxic Substances Control develop clean-up goals for contaminated soils and sediments, air, and surface and ground water. The model incorporates multimedia transport (movement or pollutants to or from ground, air, and water) and can estimate multiple-pathway exposures in humans. This model continues to be widely used not only for setting clean-up goals but also for comparative risk and life-cycle impact assessments.

McKone has also worked with colleagues at Trent University, Canada and the Swiss Federal Institute of Technology to develop a multimedia fate and transport model called BETR (Berkeley-Trent). BETR-North America addresses continental-scale transport and distribution of persistent pollutants, and BETR-Global incorporates features of general circulation models of the atmosphere to study long-range pollutant transport.

What is a Risk? A Hazard?

Understanding the field of risk assessment, which is fraught with collisions between science and value-laden issues not within the realm of science, means taking care with terminology. One example is the use of the terms "risk" and "hazard." A risk is the possibility of experiencing harm; a hazard is defined by its ability to cause harm. "Here's an example of a risk," McKone explains. "'What is the probability that a human will get cancer?' A hazard, however, involves human possibility. If you can show that a chemical causes cancer, then you have shown that it is a hazard." Everyone is at some risk of getting cancer. But exposure to a carcinogen (a cancer-causing chemical) is a hazard because it could increase a person's risk of developing disease.

"Science can measure exposures and set up experiments to demonstrate hazard based on occupational or other exposed groups or based on animals studies, for example, in rats," he says, "but you cannot do a scientific experiment to assess human risk. Risk assessment is not a science, but it does have a foundation in toxicology and chemistry."

Participating on National Advisory Panels

One whose expertise is frequently sought by various U.S. science advisory bodies, McKone currently sits on two National Academy of Sciences Panels: "Environmental Decision Making: Principles and Criteria for

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Models" and "Improving Risk Analysis Approaches Used By the U.S. EPA." The former will release its report early next year, and the latter has just started work; its reports are expected in 2008. In 2006, McKone sat on a National Academy Panel that released a revised assessment of the health risks from exposures to dioxin and dioxin-like chemicals. The work of these committees is typically influential, helping guide risk assessment studies throughout the U.S.

The "Improving Risk" committee is one of a series of National Research Council committees formed during the past 25 years to issue guidelines about the application of risk analysis. These guidelines are for federal agencies such as the U.S. Environmental Protection Agency (U.S.EPA) that must assess the risks of environmental pollutants. The NRC first issued risk-assessment guidelines in 1986 and revised and extended them in 1996. Another review of risk analysis science is currently in progress.

Help from Computer Models

Scientists conduct field studies to understand how a pollutant disperses in the environment and travels from one medium to another, for example how polychlorinated biphenyls (PCBs), which are classified as persistent organic pollutants (POPs), move into soil, water, sediments, and organisms. Raw field data hint at the mathematical relationships that characterize pollutant movement. For example, a particular POP is characterized by, among other things, its half-life in a medium such as air or water. Half life is the time it takes for the POP to decrease in concentration by one-half its value at the time of measurement.

But scientific field studies are always limited by time and location. To get the bigger environmental picture, scientists create computer models that estimate where chemicals will go; how much of a pollutant will get into the air, water, or ground ("partitioning"); and how long a chemical will persist before break down into simpler chemicals or combines with others. POPs attract considerable scientific and regulatory attention because they take so long to break down, which means they have time to diffuse all over the earth and for humans to build up exposure to these sometimes carcinogenic and mutagenic substances.

Scientists can incorporate into a computer model everything they know about the chemical properties of a pollutant under investigation: the equations governing transport within and among different media and the measurements or statistics regarding the substance's abundance in the environment. Turning the crank on the computer model results in snapshots in space and time of what pollutant concentrations might look like (if the model is constructed accurately), and potential human exposure. The model can also hint at what intervention might be most successful in reducing pollutant concentration and the potential for human exposure.

Models do not Predict

Models have limitations. "Models are not very useful if you don't have something with which to anchor them," says McKone. "As in the case of theory, you need observations to confirm the model and move it closer to a representation of reality."

What can a model do? "This is a big issue," he says. "A lot of people think models provide predictions, but they don't do this."

McKone sees a model as a description of the physical and chemical processes that govern the behavior of chemicals in the environment. "You can build relationships between factors that you can't otherwise do without a model," he explains. "Because of complexity, you can relate things in a model that you couldn't in your mind because there is too much to keep in your head.

"A model puts all these pieces together. But just because you understand how the pieces fit together, it doesn't mean that you get the correct results at the other end. You can still get results that don't correlate to the real thing. So models are both potentially powerful, and potentially dangerous."

Too Much Information

What, then, is the proper way to interpret the results of a model? One caution is to not regard the model's results uncritically. "Policy makers don't like to make choices involving uncertainty," says McKone. "But a danger is that they may just use model results to tell them what to do." If a model's performance isn't properly evaluated (compared against real measurements in the field), it may not provide accurate information on which to base regulations.

He continues: "Adding more detail into a model doesn't necessarily get you a better result if you don't understand the basic science. Model development has to be paced with the science."

McKone cites an example: "Years ago, when I was a graduate student, I saw a regional pollutant model for radionuclide transfer from soil to vegetation. It was a square grid with lots of detail – airflow, crops growing in specific areas – and it was used to calculate crop uptake. But there was only one experiment done that provided data, and that didn't account for the uptake to plants by species type; seasonal uptake of some species could vary by a factor of 10 to 50.

"The spatial variation was less than a factor of 10, but the uptake by crops was uncertain by more than a factor of 10, so the added detail did not improve the model result. The reliability of the calculation depends on the reliability of the least-well-known element. If you don't know how uncertain this weak link is, then you are making the model results look more accurate then they really are."

This is why the performance evaluation of existing models, especially those currently in use by federal agencies to provide guidance in the regulation process, has become a hot research area.

Thanks to continuing support from the U.S.EPA, McKone conducts regular research and development to improve models

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for use in experimental studies and risk assessment. "Some of the questions we ask are: What are the critical uncertainties? What processes do you need in a model, and what can you do without?

"A important quality in a good model is called 'parsimony'; this is defined as making the model as complicated as needed to solve a problem, but not more so. You don't want to add details that make the model overly complicated."

A Model Model Study

Recently, McKone, his Berkeley Lab colleagues, and research teams at universities and government research laboratories throughout the world assessed whether existing models of the persistence and long-range transport of POPs were truly parsimonious and whether each produced output similar to that of all the other similar models. The outcome of the study was the development of a consensus model that described the minimum set of model components needed.

Study participants were McKone, Matthew MacLeod, formerly of Berkeley Lab's Earth Sciences Division and now at the Swiss Federal Institute of Technology in Zurich, and researchers at nine universities and institutions in Switzerland, Germany, Canada, France, Italy, and Japan. "To my knowledge, no study of this kind has been undertaken before," says McKone.

The study was intended to make one type of risk assessment model more useful to the policy-making community.

The participants compared their models to see whether the models produced consistent results. "We ran all nine models on various persistent organic pollutants to characterize them and to compare the models' output for the same chemical against one another, to see how well each model characterized these chemicals.

"Then we realized we needed to create a 'surface of possible properties.' We found that there were four important properties that characterized these chemicals. We created 4,000 'chemicals' – not real ones, but imaginary chemicals with idealized properties – and we ran all the models through this 'space' of chemical properties. Then we compared the output of the various models against each other.

"We found that there was a lot of commonality in the model results, but also there were subtle differences. There were areas where the models had the same results, and areas where they diverged from one another. So, all nine teams proposed a model that included the elements of all nine models that led to common results. And we resolved elements that produced divergent results.

"This process seemed to be leading to the simplest model possible for solving the problem that nonetheless had enough detail and complexity to accurately model the result properly. " There were four chemical properties that determined the behavior of POPs in all models. Two were solubility ratios: the solubility of the POP in air divided by its solubility in water, and the octanol/water solubility ratio. The latter is one indicator of the POP's mobility based on how much it sticks to soils, sediments, and the lipids (fat) in biological organisms. A POP that accumulates rapidly in fat tissue is cause for concern because human tissues will build up high levels over a lifetime.

The two other properties involved are chemical half-life in air and chemical half-life in water. The latter is a good measure of persistence in surface waters, soils, and sediments.

Figure 1 shows an example of the output of the study: a page of color chemical space plots run on output from McKone's own CalTOX model. Each individual plot shows how a chemical's overall persistence (environmental half-life), as reflected by the color range, depends first on its water-to-air solubility ratio on the vertical axis versus its octanol-to-water solubility ratio on the horizontal axis. The outer horizontal and vertical axes reflect increased half-life in air and water.

From the upper left of the page to the lower right, the POP becomes increasingly persistent in the environment. But some POPs, even if they are persistent, can be volatile, meaning that they will cycle through different media rapidly. A persistent, volatile POP needs to be treated differently than a persistent, stable POP.

Such classifications of hypothetical POPs helped to evaluate and classify the performance of the nine models by showing that they produced results similar to one another. The study also showed that this classification scheme can help policy makers single out POPs with specific qualities because of how these pollutants behave in the environment.

Says McKone, "We are not just developing more models, or refining them, or improving the user interface. Our group's goal is to ask 'how do decision makers use models, what is it that they need to do their work effectively?' and then we determine what it is you can do to make the models more effective."

What Makes A Good Model Result?

In addition to parsimony, McKone mentions two other qualities that make a useful model: "One of the things decision makers want is transparency. They need to know how the model works—the method has to be transparent to the world.

"Another is 'fidelity,' the need to be true to reality by including elements in the model that answer the relevant science and policy questions. So in addition to making the model transparent and as simple as possible, you must incorporate all the processes that are important in linking the final result to the factors that, if changed, will alter that result.

"You are always walking a fine line between how much detail you need to get fidelity while not incorporating so much detail that it overwhelms the final users."

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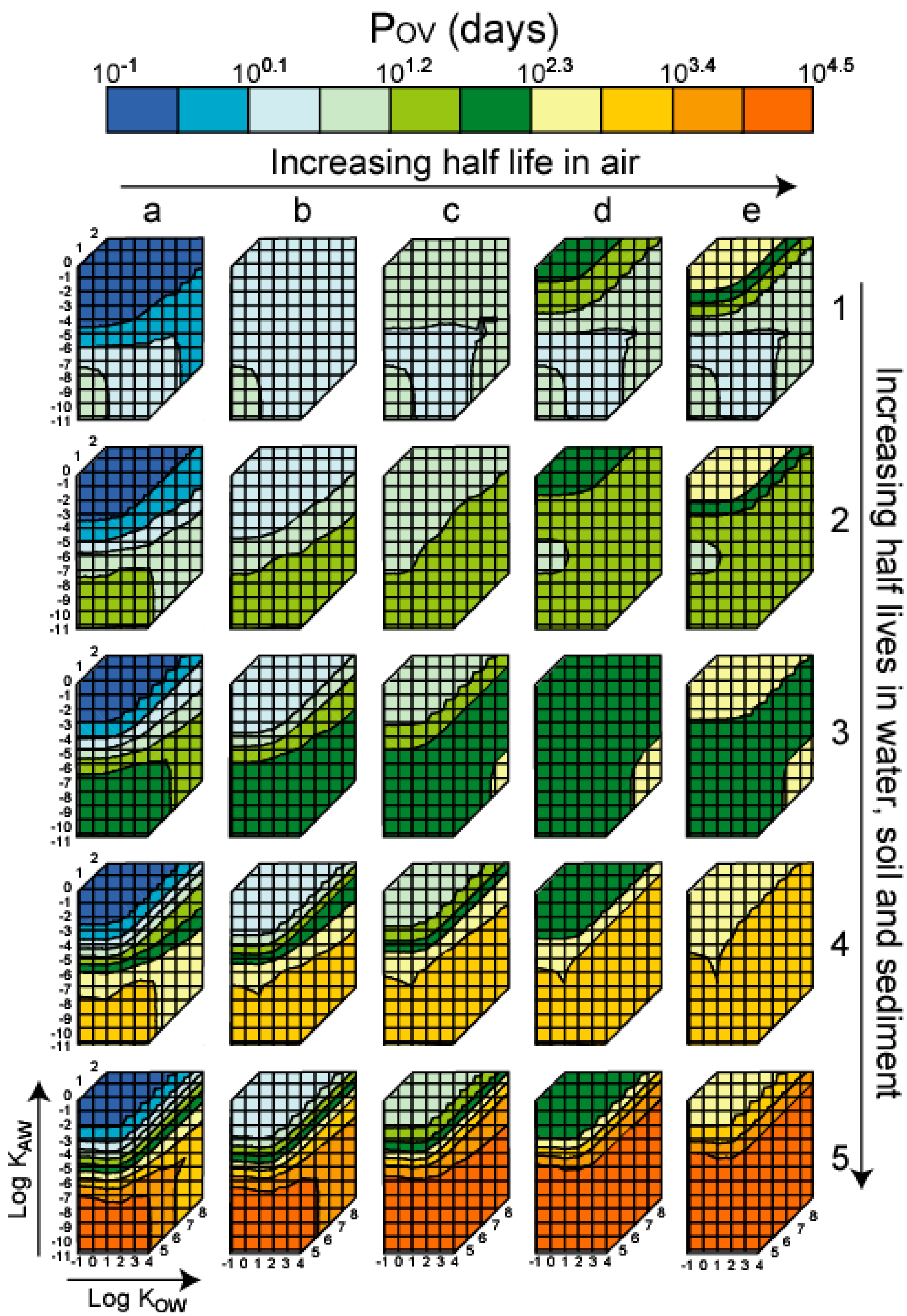

Figure 1. A page of chemical space plots from the CalTOX model. Each plot on the page shows how a chemical's overall persistence in the environment depends first on its water-to-air solubility ratio (vertical axis) versus its octanol-to-water solubility ratio (horizontal axis). From upper left to lower right, the modeled pollutants become increasingly persistent in the environment.

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An Inexpensive Wireless Lighting Control System to Improve Energy Efficiency

WiLight, a new wireless lighting control system developed by two researchers in the Lawrence Berkeley National Laboratory (Berkeley Lab) Environmental Energy Technologies Division (EETD), was a finalist for the 2006 Technology Breakthrough Award. The award competition is managed by the University of California, Berkeley College of Engineering's Center for Entrepreneurship and Technology.

Developed by EETD's Francis Rubinstein and Dennis DiBartolomeo, WiLight dims or switches overhead lighting according to occupant preference or a building-wide demand-response signal. The system was designed to be low cost to encourage building owners to retrofit facilities with this energy-efficient technology. Using a battery-less transmitter instead of a normal wall switch, the occupant can turn on and off or dim overhead lighting wirelessly. Using a radio bridge, a building manager can manually control the lighting system, or the lights can dim or switch off automatically in response to a signal from a demand- response server. Figure 1 is a picture of the system's control circuitry.

The WiLight transmitter uses a clever energy-scavenging technique developed by EnOcean Inc. to eliminate the need for batteries. The transmitter harvests the mechanical energy of the user's clicking of the switch to charge up a radio transmitter that signals the transceiver to dim or switch the lights. This strategy avoids the maintenance headache of replacing batteries and reduces the system's environmental impact.

Figure 1. Francis Rubinstein with the transceiver of the WiLight wireless lighting control system. (Photo by Anthony Ma, EETD)

WiLight and Demand Response

WiLight can read a wireless signal from a building's demand response system to automatically dim lighting during a power grid emergency or when electricity prices are high. To accomplish this, the WiLight system works with CLIR (client logic integrated relay) technology currently being developed at Berkeley Lab with support from the California Energy Commission's Demand Response Research Center. CLIR is a demand-response client that allows buildings to automatically read a signal, sent from a utility server on the internet, indicating electricity grid status. If the grid is nearing an overloaded, emergency state, the CLIR box uses the WiLight radio bridge to send a radio frequency (RF) signal to the building indicating the level of crisis (moderate or severe). WiLight can read the signal and automatically reduce specified non-essential energy uses, for example by lowering lighting intensity to pre-set levels or raising air-conditioning unit thermostat settings. See schematic in Figure 2.

Many buildings in California now have bi-level switching, as required by Title 24 energy-efficiency standards. This means that all, half, or none of the lights in a room can be on. WiLight works with the bi-level circuitry so that the demand-response technology can automatically choose lower light levels during a grid emergency. If a user turns on lights during the emergency, WiLight allows the lights to illuminate at the pre-specified lower lighting level but not at the maximum level until the grid emergency is over.

WiLight is compatible with existing lighting products and protocols and can work with emerging wireless technologies. "This makes WiLight an extremely inexpensive control system for retrofitting large commercial buildings," says Rubinstein, "since the cost of additional wiring has been the major disincentive to lighting control systems in large existing commercial spaces."

Commercial Building Energy Use

Berkeley Lab studies suggest that lighting controls could reduce energy used for lighting in commercial buildings by nearly one-half, by automatically turning off or lowering electric lighting when there is sufficient daylight to make electric lights unnecessary.

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The problem of making models useful to non-scientist users is not specific to environmental pollutants. From his conversations with colleagues, McKone has learned that it comes up elsewhere, including in weather forecasting. He notes that there are plenty of sophisticated, supercomputer-based weather models, but many daily forecasts are based on simple plug-in PC-based models that incorporate rules of thumb, and judgment.

The bottom line is that no one wants to be overwhelmed with data; we all want just the few basic results that are useful to us.

—Allan Chen

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This research was funded by the U.S. Environmental Protection Agency.

Web sites for National Academy of Science Panels and model information:

Environmental Decision Making: Principles and Criteria for Models
http://www8.nationalacademies.org/cp/projectview.aspx?key=50
Committee membership:
http://www8.nationalacademies.org/cp/committeeview.aspx?key=50

Improving Risk Analysis Approaches Used By the U.S. EPA
http://www8.nationalacademies.org/cp/projectview.aspx?key=48693
Committee membership:
http://www8.nationalacademies.org/cp/committeeview.aspx?key=48693

Review of EPA's Exposure and Human Health Reassessment of TCDD and Related Compounds
http://www8.nationalacademies.org/cp/projectview.aspx?key=103
http://www.lbl.gov/today/2006/Jul/13-Thu/07-13-2006.html

Read more about Thomas McKone's research here:
http://eetd.lbl.gov/ied/ERA/

BETR:
http://www.lbl.gov/Science-Articles/Archive/EETD-BETR-Chen.html

http://www.lbl.gov/Science-Articles/Archive/sabl/2005/November/01-gold-rush.html

An Inexpensive Wireless Lighting Control System to Improve Energy Efficiency

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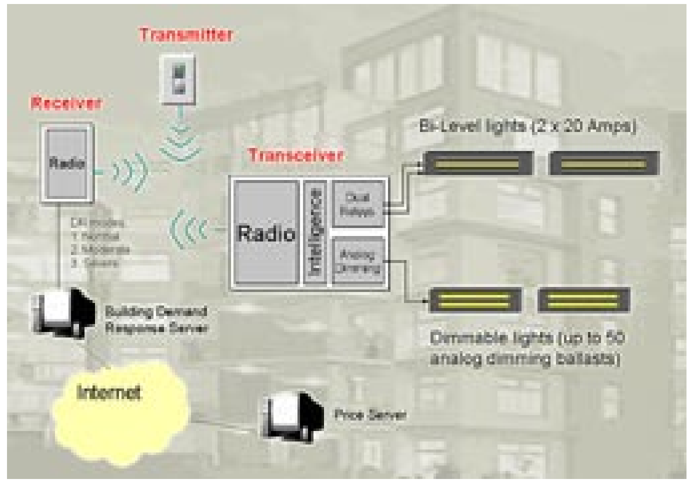

Figure 2. The economical WiLight system accepts a variety of inputs to increase efficiency and reduce energy use of building lighting.

Nationwide, there are 60 billion square feet of commercial floor space. Rubinstein estimates that if 30 percent of those buildings adopted lighting control systems by 2025, the nation could reduce its energy use by 700 billion kilowatt-hours, saving about $50 billion and reducing greenhouse gas emissions by 140 million metric tonnes, equivalent to the emission of 93 million automobiles.

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Technology Transfer

RECENT RELEASES

The Lawrence Berkeley National Laboratory (Berkeley Lab) Technology Transfer Department licenses a wide range of cutting-edge technologies to companies that have the financial, R & D, manufacturing, marketing, and managerial capabilities to successfully commercialize Lab inventions. The Technology Transfer Department develops and manages an array of partnerships with the private sector. These technologies were developed by researchers in (or associated with) the Environmental Energy Technologies Division.

Dry Polymer Electrolytes with High Conductivity for Secondary Lithium Metal Batteries

Nitash Balsara and his research team have developed a dry polymer electrolyte that may remove a significant barrier to the development of reliable, secondary lithium metal batteries. The electrolyte has a high elastic modulus (~0.1 GPa), which should deter the dendrite formation that has hampered lithium metal battery development in the past, while still demonstrating high conductivity (~10 -3 S/cm at 85°C), a necessity if the high energy density potential of these batteries is going to be fulfilled. The Berkeley Lab electrolyte has been cycled with lithium metal electrodes over 80 times at 50% limiting current and 85°C with no evidence of dendrite formation.

The Berkeley Lab invention is a diblock, copolymer electrolyte consisting of soft, nanoscale, ionically conducting channels embedded in a major phase, hard nonconducting matrix. The properties of this system have been tested using a series of diblock copolymers with varying polystyrene (PS)/polyethyleneoxide (PEO) molecular weights and volume fractions. The conductivity of the Berkeley Lab PS-PEO copolymer is only a factor of two lower than that of bulk PEO. In addition, since the electrolyte is a dry polymer, it can be fabricated into an ultra thin layer to optimize conductivity. Research on this aspect of the technology is ongoing.

Many lithium metal battery technologies currently in development require a separation layer to isolate the anode from liquid electrolytes. The Berkeley Lab electrolyte serves both as an ion conductor and a dielectric separator between the electrodes, making these layers unnecessary and thereby avoiding additional interfacial resistance and promising simpler battery design and construction.

This technology is available for licensing or collaborative research.

For more information, contact:

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http://www.lbl.gov/Tech-Transfer/techs/lbnl2200.html

Air-stable Nanomaterials for Efficient OLEDs and Solar Cells

The Technology Transfer Department recently released two promising inventions from the Environmental Energy Technology and Materials Sciences division scientists for licensing.

Berkeley Lab researchers have developed two approaches for increasing the charge efficiencies of electrodes used to produce flexible organic light emitting diodes (OLEDs) and solar cells. Both approaches will reduce manufacturing and packaging costs. These technologies have patents pending and are available for licensing or collaborative research.

Solvent Processed Nanotube Composites

IB-2044

Applications

Composites for transparent electrodes and/or light emitting layers used in

- OLED displays for consumer electronics, digital video, and medical imaging devices, or built into architectural and automobile windows and flexible plastics
- Organic photovoltaics
- OLEDs for lighting

Advantages

- Solvent processed, ink jet printable
- More efficient charge injection and higher conductivity than conventional conducting polymers

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Technology Transfer Column

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Solvent Processed Nanotube Composites (continued)

- Transparent (= ITO film)
- Reduced drive voltage
- Compatible with flexible substrates
- Longer material lifetimes than devices made with active metals

Description

A new class of conductive polymers developed at Berkeley Lab uniformly suspends and disperses carbon nanotubes, enabling them to function efficiently as charge injectors in the electrodes and light emitting layers of OLEDs and organic solar cells. Currently, OLEDs cathodes are thermal vacuum evaporated due to the use of reactive metals for electron injection. The use of calcium or lithium also requires air-impenetrable packaging. In contrast, devices made using Berkeley Lab's air stable cathode materials can be solvent processed and applied using ink jet printing or spin coating. They also have relaxed packaging requirements.

Unlike most OLEDs that incorporate metals in the cathode, the Berkeley Lab OLEDs are transparent. Transparent OLEDs can be used to display video, images, and other information in applications where the user still can see through the substrate, such as with windshields and windows. While ITO films are also transparent, they are brittle and require plasma deposition. The Berkeley Lab materials are flexible and promise to be low-cost – making inexpensive, roll-up, digital display technology a near-future possibility.

Lab scientists have demonstrated initial efficiencies of three percent for OLED devices incorporating the poly(di(oxytrio xadecane)fluorine)(PFO)/nanotube composites, with a clear research path towards significant increases. The nanotubes have remained suspended in the PFO for over four months, far exceeding the six day limit achieved in other nanotube/polymer systems. The suspension is sustainable because the polymer is amphiphilic and wraps its polar side chains around the nanotube. Both the backbone and side chains of the polymer can be adapted to accommodate various applications.

This technology was invented by Stephen Johnson, John Kerr, Gao Liu, Sam Mao, and Andrew Minor.

OLEDs with Air-stable Structured Electrodes

IB-2231

Applications

- OLED displays for consumer electronics, digital video, and medical imaging devices, or built into architectural and automobile windows and flexible plastics
- Organic photovoltaics
- OLEDs for lighting

Advantages

- Enhanced charge injection efficiency and increase conductivity
- Reduced drive voltage
- Relaxed packaging and manufacturing requirements
- Lithographically defined nanostructures
- Longer material lifetimes than devices made with active metals
- Can be applied to flexible substrates

Description

Stephen Johnson, Gao Liu, and Sam Mao have developed electrodes with nanostructured geometry to improve the electrical-optical energy conversion efficiency of flexible OLEDs and solar cells. The new transparent electrodes are less reactive to water and oxygen than their metal counterparts, which will reduce the costs of fabrication and packaging.

The researchers employ ordered arrangements of nanotubes or stable nanoclusters at the cathode-organic layer interface as charge injectors to efficiently overcome the large energy barrier at that interface. These structured electrodes promise to significantly reduce the drive voltage necessary to induce light emission inside organic materials and thereby increase the energy conversion efficiency of the resulting devices.

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http://www.lbl.gov/Tech-Transfer/techs/lbnl2044,2231.html

Monitoring of Western Electricity Markets

Econometric methods show promise for market monitoring screening in the absence of organized Independent System Operator markets

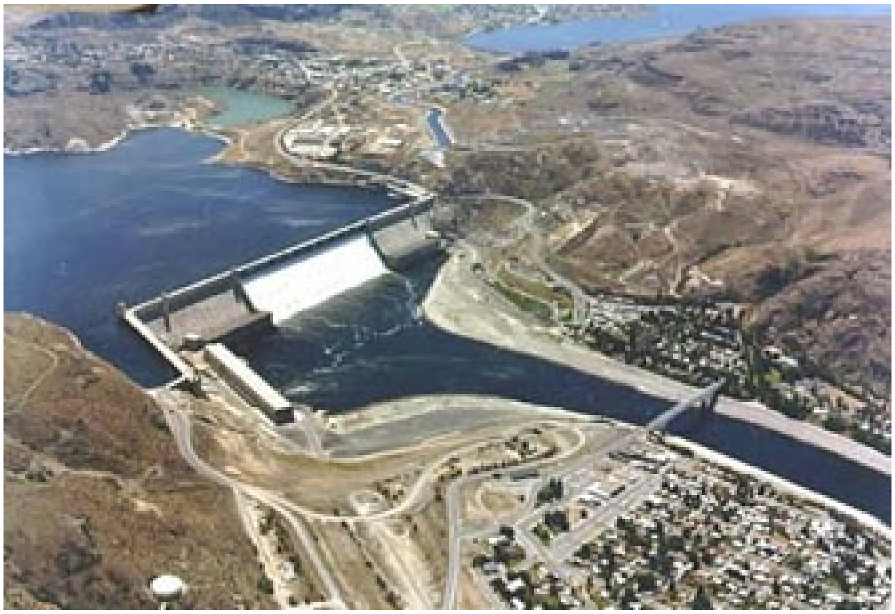

Figure 1. Electricity from the Grand Coulee Dam on the Columbia river is a contributor to the power flows modeled in a new study of the Western electricity market by Charles Goldman of Berkeley Lab, and colleagues at the Analysis Group, a San Francisco consulting firm.

A new study by the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has evaluated methods for monitoring power markets that should allow market monitors and regulators to more quickly identify unusual fluctuations in the price of power in the Western Interconnection.

"This study is another important step to ensure that the failures in monitoring power markets that contributed to the 2000-01 western electricity crisis are not repeated," said Joanna Prukop, Chair of the Western Interstate Energy Board (WIEB). "Implementation of the study findings by an effective independent market monitoring system would also serve as a deterrent to such behavior in the first place. Western states appreciate the Department of Energy's support of efforts to improve western power markets."

WIEB's board members include policymakers and representatives of utility regulatory bodies from 12 Western states and three Western Canadian provinces.

Berkeley Lab's researchers, who worked with the Analysis Group, found econometric price prediction methods can provide a benchmark screen for identifying possible instances of uncompetitive pricing in western power markets. The study surveyed analytical methods that could be applied to market monitoring in the West, where there are few organized wholesale markets and individual wholesale transactions are often opaque.

Charles Goldman of Berkeley Lab's Environmental Energy Technologies Division (EETD), a co-author of the report, explains that "in the electric industry, market monitoring involves the systematic analysis of prices and behavior in power markets to determine when and whether potentially anti-competitive behavior is occurring. Our study was designed to explore different methods of doing this, using readily available data."

Ed Kahn, another of the report's co-authors, adds that "the basic goal is to develop a benchmark for wholesale prices in a well-functioning competitive market. Once you've done that, you can compare actual prices to the benchmark and identify 'outliers'—instances where suppliers may have manipulated prices and further investigation is warranted."

The study was co-funded by the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability and the Western Interstate Energy Board, with the assistance of members of the former Market Monitoring Work Group of the industry's Seams Steering Group-Western Interconnection (SSG-WI). WIEB's Committee on Regional Electric Power Cooperation (CREPC) supported the study because of its desire to foster the expansion of an independent capability to monitor wholesale electricity markets in the west.

"DOE is pleased to provide technical assistance to states and regions on electricity issues. These issues are typically very complex and we do our best to add value through the development of tools such as

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Monitoring of Western Electricity Markets

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this." said Kevin Kolevar, Director of DOE's Office of Electricity Delivery and Energy Reliability.

The researchers reviewed five potential analytic methods to test their feasibility for market monitoring. They selected the two most promising methods—econometric analyses and production cost modeling—and tested them using day-ahead market data from two electricity trading hubs in the west: Palo Verde in Arizona, and the Mid-Columbia hub in the Pacific Northwest.

Kahn explains that "production cost models are detailed simulations of the operation of power systems that are often used for resource planning." He adds that "when adapted for market monitoring purposes, their complexity is both a blessing and a curse. They provide a lot of detail that simpler models cannot handle, but their workings are somewhat of a 'black box' and they are time-consuming and data-intensive to implement." In the end, the researchers found that production cost simulations based on several discrete scenarios of future supply/demand conditions in the west did a relatively poor job of predicting seasonal variations in actual wholesale electricity prices at the Palo Verde or Mid-Columbia hubs.

"The results for the econometric analyses were much more promising," notes Goldman. Econometric analyses are well established statistical methods that can be applied to model the relationship between a set of fundamental price drivers (such as weather and fuel prices) and wholesale power prices.

"For the Palo Verde hub data, we developed a model that predicts over 90 percent of the observed price variations," says Goldman. He adds, "We were able to link all the outliers we found in the Palo Verde data to well-defined events—such as outages of major coal generation plants—that were not captured by variables in our model."

However, the report's authors caution that econometric methods do have some pitfalls. For the mid-Columbia hub, the results were not as compelling. Kahn says, "We suspect that the problem lies in capturing the effects of spring runoff on the hydroelectric system. If this type of model was actually used for market monitoring screening, it would require more attention to the unique dynamics of hydroelectricity in the Pacific Northwest."

Overall, the researchers are optimistic that econometric analyses could provide a promising market monitoring screening tool for the west, but they caution that it must be "implemented and interpreted with care."

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This research was funded by the U.S. Department of Energy and the Western Interstate Energy Board.

The report is titled *"A Regional Approach to Market Monitoring in the West"* (LBNL-61313), and is authored by Matthew Barmack, Edward Kahn and Susan Tierney of the Analysis Group, and Charles Goldman of Berkeley Lab. Download it at: http://eetd.lbl.gov/ea/EMS/rplan-pubs.html

http://www.lbl.gov/Science-Articles/Archive/EETD-elec-mrkt-mntrng.html

The study examines how monitoring power markets can keep electricity price manipulation under control.

Research Highlights

A Visit to the California Governor's Inaugural

On January 4, staff members of the Environmental Energy Technologies Division (EETD) of Lawrence Berkeley National Laboratory (Berkeley Lab), and other Lab staff journeyed to Sacramento to participate in the pre-inaugural festivities marking the second term of California's Governor Arnold Schwarzenegger. An all-day fair held on the lawn in front of the state capital was an opportunity for the public to learn something about California's industries, agriculture, and educational and research institutions.

Berkeley Lab's EETD was invited to show off some of the energy-efficient technologies it has developed, which not only reduce energy use and greenhouse gas emissions efficiently, but also help the state's industries create jobs and maintain a competitive edge in the world marketplace. These technologies include cool roofing materials to reduce air conditioning energy use, lighting and automatic control systems to increase building energy efficiency, and technologies to reduce standby power loss in appliances.

Development of these technologies were funded by the California Energy Commission's Public Interest Energy Research program, the U.S. Department of Energy, and private partners, among other sources.

During the course of the day, EETD volunteers met the general public, and a few notable figures, including the Governor's wife, Maria Schriver, Patti Garamendi, wife of Lieutenant Governor John Garamendi, and former Secretary of State George Schultz.

Honors for Alan Meier

Alan Meier received an Alliance to Save Energy "Unsung Hero" of Energy Efficiency Award on February 13. Kateri Callahan, ASE President, presented the award and made some remarks, including the following:

"If there is one characteristics that qualifies Alan as an unsung hero, according to his colleagues at Lawrence Berkeley National Lab, it is his unerring ability to identify important energy-saving opportunities that are so far ahead of their time that they are typically unfundable for the first few years, while Alan manages to get the rest of us to pay attention. But his ideas have been great for the country – and the world."

Some recent examples of Alan's ideas and work:

Home Energy Magazine
http://www.homeenergy.org/

Standby Power
http://standby.lbl.gov/
http://www.lbl.gov/Science-Articles/Archive/res-energy-growth.html

Real-time status of the electric power grid
http://currentenergy.lbl.gov/

Saving Electricity in a Hurry
http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1481

Figure 1. Alliance to Save Energy President Kateri Callahan congratulates Alan Meier.

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Sources

DOE's Consumer Information Fact Sheets
These web pages provide information about energy efficiency and renewable energy for your home or workplace.
http://www.eere.energy.gov/consumer/

DOE's Energy Information Administration (EIA)
EIA 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.
http://www.eia.doe.gov/

DOE's Fuel Economy Guide
This website is an aid to consumers considering the purchase of a new vehicle.
http://www.fueleconomy.gov/

DOE's Office of Energy Efficiency & Renewable Energy (EERE)
EERE's 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.
http://www.eere.energy.gov/

DOE's Office of Science
http://www.er.doe.gov/

U.S. EPA: Energy Star Program
http://energystar.gov/

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

Environmental Energy Technologies Division

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

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

With more than 3,800 employees, Berkeley Lab's total annual budget of nearly $500 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 10 Nobel laureates. EETD is one of 17 scientific divisions at Berkeley Lab, with a staff of 400 and a budget of $40 million.

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