



# Environmental Energy Technologies Division

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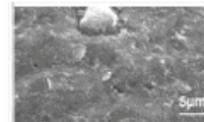
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The fall issue of the *EETD News* covers, as usual, a wide variety of research in the energy sciences that crosses many disciplines, as well as a prominent award and a change in leadership. We congratulate our former Division Director Arun Majumdar on his becoming the first leader of the Department of Energy's ARPA-E, an agency created to fund high-risk, high-reward energy research. We also congratulate Ashok Gadgil on winning a Heinz Award, as well as assuming the office of Acting Director of the Environmental Energy Technologies Division. Another story in this issue reports on the first Recovery Act funding received in EETD, which will help us help federal agencies improve energy efficiency.

—Allan Chen



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

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

Fall Newsletter: Vol. 8, No. 2 [\[http://eetd.lbl.gov/newsletter/nl29/\]](http://eetd.lbl.gov/newsletter/nl29/)

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

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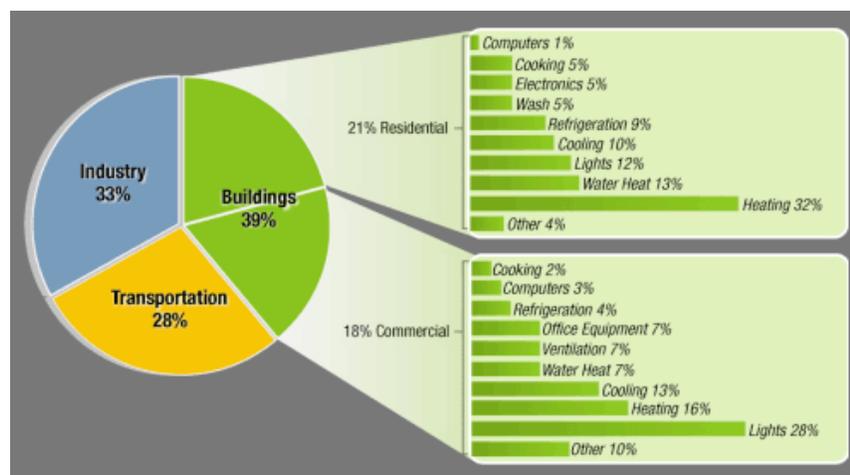
# Environmental Energy Technologies Division

## NEWS

### Closing in on Zero-Energy Buildings

Producing new commercial buildings that use 80 percent less energy than today's buildings is a new target in the fight against global climate change. If such a building's remaining energy consumption were supplied by clean, carbon-neutral renewable energy, it would be responsible for little or no greenhouse gas emissions. Lawrence Berkeley National Laboratory (Berkeley Lab) researchers are developing technologies to help make this possible.

Buildings in the United States today consume 72 percent of electricity produced, and 55 percent of U.S. natural gas use. They account for about 40 percent of both total U.S. energy consumption (costing \$350 billion per year) and greenhouse gas emissions. Therefore, reducing the GHG emissions associated with buildings is essential to reducing overall U.S. emissions.



Buildings account for about 40 percent of total U.S. energy consumption and greenhouse gas emissions. Residential and commercial application totals do not sum to 100% because of rounding.

Before such ultra-efficient buildings become commonplace, researchers will need to develop new, more cost-effective technologies. Demonstration projects dating back to the 1990s suggest that it is possible to build these ultra-efficient buildings currently, but at great expense. Berkeley Lab research is aimed at developing advanced new technologies so that such buildings can be constructed economically and in large numbers.

Scientists at Berkeley Lab's Environmental Energy Technologies Division—in partnership with United Technologies Corporation's Research Center and the University of California at Berkeley, Merced, and Santa Barbara—have embarked on research aimed at developing computer models and building control algorithms and performance monitoring systems for the low energy buildings of the near future. The research is funded by the U.S. Department of Energy and the California Energy Commission's Public Interest Energy Research Program.

The research teams are performing field testing and demonstration work of new technologies on the campus of the University of California, Merced. The UC Merced campus has five buildings which have received Leadership in Energy and Environmental Design (LEED) ratings—four gold and one silver—for sustainable design. The campus has been designed to be a living laboratory, with sensors and instrumentation to support the development and demonstration of energy-efficient technologies and practices.



The University of California at Merced's LEED Gold-rated Science and Engineering Building.

Some of these campus buildings already achieve a high degree of energy efficiency. "We have a goal that buildings consume half the energy and demand of other university buildings in California," says John Elliott, UC Merced's Manager of Engineering, Energy, and Sustainability Facilities. "We have statistically significant benchmarks based on data from other campuses, and we have been phasing in this goal." The campus's first round of buildings were designed to use 80% of the energy benchmark, and the current round of buildings are being designed to use 65% of that benchmark. The next phase of buildings will be designed to use 50% of the benchmark. However, according to Elliot, through careful design and energy management, many campus buildings have already surpassed those performance goals. The campus is therefore the perfect place to begin testing new hardware and software technologies designed to drive building energy efficiency to even higher performance levels.

### **The Ultra-Low Energy Strategy**

When buildings are designed so that their systems work together to maximize energy efficiency, they can use substantially less energy than they do on average today—even as they provide heating, ventilation, air conditioning, lighting, and electrical power at the outlet. For this enhanced performance level to be achieved, however, the building needs to be constructed according to specification, which is not always the case currently.

"Today, there is usually no transfer of knowledge and design specifications from the design phase to operations," says Philip Haves, Leader of Environmental Energy Technologies Division's (EETD's) Commercial Building Systems Group. "Very few new buildings are commissioned and most building facilities management staff don't have access to the design specifications of building systems they maintain."

*Commissioning* is originally a naval term applied to the process of ensuring a ship's seaworthiness. Newly constructed buildings need to be commissioned to determine if the energy savings and performance intended for the building in the original design has actually been achieved. When a building is commissioned, a team of engineers start the various building systems, test them to ensure they are operating according to design specifications, and make adjustments if they are not. Commissioning of both new and existing buildings could save billions of dollars in U.S. energy costs, according to Berkeley Lab research estimates.

Finally, buildings need to be operated by a facilities staff trained in the use of sensors and monitoring systems that provide accurate, real-time information about the energy performance and environmental conditions within the building.

This approach to improving building efficiency selectively applies systems-engineering methods that have transformed other industries, including the aircraft and automobile industries.

### **Wanted: Real-Time Building Energy Use**

PC-based monitoring systems could reveal a new world of real-time information to facilities staff about how energy is being used in buildings. However, no standard hardware and software building design and operating platform exists—nothing comparable to the operating system software common to many personal computers, for example.



Mary Ann Piette is the Deputy Head of the Building Technologies Department for Berkeley Lab's Environmental Energy Technologies Division.

A problem today is that "we don't measure the energy use of buildings in real-time," says Mary Ann Piette, the Deputy Head of EETD's Building Technologies Department. "Most energy management systems in buildings are geared toward controlling energy use, but without much feedback about how buildings are actually using energy."

Further, there is no performance standard for buildings—not for energy use, occupant comfort, average maintenance cost, or any other building metric one could imagine. Most LEED standards are design oriented—the builder obtains a LEED rating by specifying various energy efficiency, water, materials, and transportation-related measures. These elements are addressed during construction, however, it is rare for the building to be monitored once it is occupied, to determine how well it really performs relative to the initial goals.

Performance benchmarks would help facilities managers do a better job of operating buildings for energy-efficiency, as well as for other qualities such as occupant comfort. A *performance benchmark* is a data set of performance metrics for a building's operation, energy use, and conditions.

Comparison of the performance metrics in different buildings of roughly the same size and type can help a facilities manager identify specific problems in a building. For example, perhaps the lighting is efficient, but air conditioning energy use during the summer months is higher than normal for a building of that type, leading to the deduction that a chiller plant is underperforming. Benchmarks for each energy-using system in the building provide managers with the target data they need to ensure that each system is operating efficiently.

Another need is for a broad, deep data set about performance of many (preferably thousands) of buildings in real-time—known as a *building informatics repository*. This repository would not only help building managers do a better job, it would help building scientists develop better control strategies for managing building energy use.

Berkeley Lab researchers are conducting three preliminary research and development projects aimed at developing a building design and operating platform and a building informatics repository.

### **Model Predictive Control**

Berkeley Lab EETD researchers Philip Haves and Michael Wetter, the University of California's Francesco Borelli, John Elliot of UC Merced, and team members from the United Technologies Corporation Research Center are testing a *model predictive control* (MPC) of a central chilled water system that provides cooled air to campus buildings.

Using the model predictive control method, a computer model of the chilled water plant simulates the effect of various control options on the performance of the system and provides input to the real-time control system for the chilled water plant so that it can properly supply the cooling needed to maintain comfortable conditions while minimizing energy costs.

The computer models of the chillers, the cooling towers, the storage tank and the pumps are based on the manufacturers' performance data and then fine-tuned to the measured system performance. The team estimates that energy savings of 10 to 20 percent of total HVAC energy use is possible using MPC. Data from 2009 summer field tests at UC Merced will be used to determine the actual savings and demonstrate the technology.

### **Occupancy-Based Controls**

Michael Sohn, Group Leader of EETD's Airflow and Pollutant Transport Group, along with colleagues from UC Merced and United Technologies, are studying the use of sensors and occupancy-estimating methods to control a building's lighting and heating, ventilation, and air conditioning (HVAC) systems.

The guiding concept behind this work is that if the occupancy density of a building is well known, its lighting and HVAC energy consumption in a typical office building during the cooling season may possibly be reduced by 10 to 20 percent. What is

needed is a hardware and software tool that determines the occupancy in different parts of the building accurately in real time.

Currently, motion sensors only tell you if a space is occupied, not how many people are there. Carbon dioxide (CO<sub>2</sub>) sensors are better indicators of how many people are in a room, but they are relatively slow to react—people come and go quickly, but CO<sub>2</sub> levels change slowly.

Sensors that can estimate quickly how occupancy is changing in a space may be able to provide data that allow a control system to reduce lighting and HVAC services to unoccupied spaces quickly. For example the control system could allow room temperatures to float beyond their occupancy-based set points and rapidly increase services in time to meet anticipated needs.

The research team will build smart, low-resolution sensor networks and develop data processing algorithms, occupancy dynamics models, and energy control methods. They will test whether these technologies can provide sufficient data on building occupancy to make intelligent HVAC and lighting control possible at buildings on the UC Merced campus. The research will also benchmark the energy savings possible in buildings at different occupancy levels.

### **Visualizing Building Energy Performance**

Piette and her colleagues are also developing visual tools for communicating the energy performance of buildings in real time so that improved information can help facilities staff better manage their buildings. Collaborating institutions include United Technologies, UC Merced, and UC Santa Barbara.

The team is developing tools to compare the measured energy performance of buildings to baselines derived from computer simulation, benchmarking, and previous performance measurements. They plan to develop new methods of estimating quantities that are not measured in the building, such as space heating and cooling loads (the power demand to keep the building properly heated and cooled), to help building facilities staff diagnose problems.

The methods and tools will correct for uncertainties in measurements and simulations systematically, something that is typically not done in the building industry today. The researchers are also developing software for visualizing building conditions and performance designed for decision-makers at different facilities management levels.

Piette's team will test the prototype monitoring system in the Science and Engineering I building and on the central plant on the UC Merced campus.

The goal of this technology development is to reduce energy consumption and electricity demand by 20 percent or more in large commercial buildings, by providing actionable energy performance information to facility managers and operators.

— Allan Chen

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For more information about commercial buildings research at Berkeley Lab visit the Commercial Buildings Research and Development [<http://buildings.lbl.gov/>] web site.

Demand Response Research Center [<http://drcc.lbl.gov/>]

Model Predictive Control [<http://sites.google.com/site/mpclaboratory/>] at UC Berkeley

LEED-rated buildings [<http://administration.ucmerced.edu/environmental-sustainability/green-buildings-and-lead>] at UC Merced

UC Merced Efficiency Testbed [<https://eng.ucmerced.edu/soe/facandres/intra-campus/eng-res-meri>]

United Technologies Research Center [[http://www.utrc.utc.com/pages/our\\_company.html](http://www.utrc.utc.com/pages/our_company.html)]

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## Environmental Energy Technologies Division

### NEWS

#### Heinz Award Honors Berkeley Lab's Ashok Gadgil

Ashok Gadgil, a scientist at Lawrence Berkeley National Laboratory (Berkeley Lab), is one of 10 recipients being recognized for environmental achievements through the 15th annual Heinz Awards announced by the Heinz Family Foundation.

Gadgil is the deputy director of Berkeley Lab's Environmental Energy Technologies Division, as well as University of California (UC) Berkeley professor of civil and environmental engineering and faculty senior scientist at Berkeley Lab. He will receive \$100,000 for the strides he has made toward a more sustainable, cleaner environment.



Heinz Award-winning scientist Ashok Gadgil with the Berkeley Darfur stove, a simple cook stove made of sheet metal or cast iron, designed to use less wood or alternative fuels such as animal dung.

"It is humbling for me to see what august company I am in, when I see the names of past Heinz Award winners," said Gadgil. "I also feel tremendously honored and pleased. This award brings attention to the often desperate needs of the poorest half of humanity whom technological research and innovation commonly leave in the dust."

The Heinz Awards were created in memory of U.S. Senator John Heinz, and have traditionally been given to individuals in the categories of arts and humanities; environment; human condition; public policy; and technology, the economy and employment. This year the awards focused on the environment, to commemorate the late senator's long-standing commitment to sustainability.

"These awards honor those guardians of our future who value our natural resources, work to remove toxic chemicals from our air and water, and create policies and the new technology that will ensure a sustainable planet for generations to come," said Teresa Heinz, widow of Senator Heinz and chairman of the Heinz Family Foundation, in a statement. "In highlighting the work of some of our country's most thoughtful, innovative, and creative individuals, we are pleased to shine a deserving spotlight on their extraordinary achievements."

Gadgil, 58, was recognized for his work as a researcher, inventor, and humanitarian. The foundation cited his efforts to understand airflow and pollutant transport in buildings (which helps to reduce health risks) and to improve energy efficiency and enhance the quality of life in developing countries. His knack for creating simple inventions to solve fundamental problems in developing countries was also highlighted.

#### Disinfecting Water in Developing Nations

In the 1990s, Gadgil led a team which developed an inexpensive and reliable water purification system using ultraviolet light, called UV Waterworks. He undertook the work originally in response to a cholera epidemic that struck India. However, an inexpensive, robust, and energy-efficient way to disinfect drinking water is urgently needed in many developing nations—the World Health Organization estimates that two million people, mostly children, die every year from preventable waterborne

diseases. UV Waterworks was commercialized by WaterHealth International, a company Gadgil advises, and the technology is now an increasing presence in the developing world. UV Waterworks won a *Discover* magazine award and a Best of What's New award from *Popular Science* magazine.

Most recently, Gadgil has been working on ways to inexpensively remove arsenic from drinking water in Bangladesh using simple, inexpensive, and locally available materials such as ash from coal burning. Arsenic in drinking water occurs naturally in high concentrations in certain areas of the world, including Bangladesh, and is causing a slow mass poisoning of as much as 10 percent of that nation's population.

### **The Berkeley Darfur Stove**

In 2005, as the strife in the Darfur region was capturing worldwide attention, Gadgil was asked by the U.S. Agency for International Development to help find a solution to reduce the exposure of women living in the Darfur refugee camps to violence. As the women were foraging outside the camps for wood to cook with, they were being attacked and raped. In response, Gadgil led the effort to develop a more fuel-efficient cook stove that significantly reduced the amount of firewood that refugees in that war-torn area needed to collect.

The Berkeley Darfur Stove is four times more efficient than the traditional three-stone fires used in the region, and two times more efficient than clay stoves. Women spend less time outside of the camps collecting fuel wood, reducing their risk of being raped. The stove's fully enclosed flames reduce the likelihood that the dense straw and stick shelters will catch fire, and the reduction of smoke from the stove (as compared to other stoves) decreases the amount of smoke inhaled, thereby reducing lung disease. A nongovernmental organization is now working to set up local manufacture and distribution of the stove. In 2007, the stove won the *Popular Mechanics* "Breakthrough" award.

### **Other Achievements**

As a researcher conducting experimental and modeling research as part of the Airflow and Pollutant Transport Group, Gadgil has contributed to numerous studies to help reduce the health risks and improve the comfort of building occupants. This work has included finding ways to minimize the risks to occupants from toxic releases of chemical and biological agents within buildings.

He has also pioneered utility-sponsored compact fluorescent lamp leasing programs that are being successfully implemented by utilities in several east-European and developing countries.

In addition, Gadgil teaches a class at UC Berkeley called "Design for Sustainable Communities," which helps students imagine and design technological solutions to environmental problems.

Each recipient of the Heinz Award will receive a \$100,000 unrestricted award along with a medallion on October 28, 2009, at a private ceremony in Washington, D.C.

— Allan Chen

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For more information, see Ashok Gadgil's web page [<http://eetd.lbl.gov/staff/gadgil/agadgil.html>] .

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## Environmental Energy Technologies Division

## NEWS

## Green Chemistry: Lasers Detect Explosives and Hazardous Waste

Lawrence Berkeley National Laboratory (Berkeley Lab) scientists are pioneering laser ablation techniques that can detect explosives and hazardous waste in seconds, with no chemical waste. The technology can save the lives of soldiers, keep children safe from toys illegally coated with lead paints, and protect workers from chemical poisoning.

A soldier in a Humvee aims a portable device at an abandoned car 50 meters (more than 150 feet) away. Pressing a button, a laser in the device fires. She reads a screen and beckons her patrol to move away quickly.



Tests of a military prototype field version of the laser ablation-based explosives detection system at the Yuma Proving grounds in 2008. The detector was able to discriminate with 85 percent accuracy whether more than 100 samples contained residues of several types of explosives from between 30 to 50 meters (90 to 150 feet) away, or whether the composition was of materials such as rock, wood, metal, or plastic.

In a lab, a technician is inserting a fragment of a toy into a sample case, placing the case into a machine, and pressing a button. He inserts one fragment after another—each test takes only a few seconds. The paint on some of the toy fragments test positive for lead.

Another technician, this time at an abandoned industrial facility, is collecting samples of concrete, metal, and other building materials to bring back to an analysis lab. He's part of a team looking for beryllium contamination. Beryllium is a light metal—number four on the periodic table—that is extremely poisonous to living things. He'll collect hundreds of samples in just a few days. Analyzing each one will require less than a minute.

Although they may sound like it, none of these scenes is science fiction. And each one is an example of *green chemistry*—quick chemical analysis that results in no chemical waste generation. The key is a technology developed by scientists at the U.S. Department of Energy's (DOE's) Berkeley Lab using laser ablation—a process that involves aiming a laser beam at the material sample to be tested, causing a tiny amount of it to be vaporized so that spectroscopic (optical and mass) analysis techniques and unique computer software can analyze the sample in seconds.

### Pure Science to Practical Application

Rick Russo, a scientist in Berkeley Lab's Environmental Energy Technologies Division began studying the physics of laser ablation 28 years ago. "I was interested in the fundamental physics of what happens when you fire a laser at a solid sample and ablate the material into a vapor. There's so much physics involved that it's phenomenal," he says.

More than 200 publications, nine patents, and an R&D 100 award later, Russo and his research group are the pioneers of a new chemical analysis technology based on laser ablation. The two most common approaches to laser ablation chemical analysis are LIBS (laser-induced breakdown spectroscopy), in which the light from a tiny plasma is directly measured and related to the chemical element and its concentration, and LA-ICP-MS (laser ablation inductively coupled plasma mass spectrometry), in which tiny particles from the ablation are measured. On average, LIBS provides part-per-million sensitivity, whereas LA-ICP-MS provides parts-per-billion sensitivity. Both approaches allow the measurement of the entire chemical composition of a sample target using a single laser pulse. Although he never entered his field to create a practical application, Russo realized that LA-ICP-MS and LIBS have many possible uses in the world.

In 2004, with the help of Small Business Innovation Research grants, he created a company called Applied Spectra to bring the technology and its many potential life-saving applications to the marketplace. It sold its first LIBS device in 2008. The company's corporate offices are in Fremont, California, and a small manufacturing facility produces the equipment in Aberdeen, Maryland. The jobs created by the company are "green" jobs, since the technology is a waste-reducing one.

"Most of the samples in the world that we want to analyze are solid," says Russo. "The conventional method of analysis requires an entire analysis infrastructure that is based on dissolving these solids in strong acid so that the resulting liquid can be analyzed using standard methods. This is very dirty, generates a lot of chemical waste, and requires a lot of labor and time."

In contrast, laser ablation requires no acid dissolution and so generates no hazardous wastes. "Laser ablation is green technology," says Russo. "Besides eliminating chemical waste, it saves energy. My goal is to change the paradigm for the way that chemical analysis is done."

Laser ablation is very fast, allowing technicians to conduct more tests on samples in real time. And laser ablation testing is cheaper—only a technician is needed to place the sample and operate the machine; each test takes less than 30 seconds. No PhDs are needed.

### **Remote Military Explosives Detection**

Russo's basic research has been funded for many years by the DOE's Office of Basic Energy Science. But his application research for laser ablation has been funded by many other offices, such as the Nuclear Non-Proliferation and Security Agency of DOE (which was interested in laser ablation's potential for quick identification of nuclear wastes at nuclear manufacturing sites) and the Department of Defense (which was looking for a way to remotely and quickly identify explosive residues that might provide telltale hints of car bombs and other terrorist weapons).

Russo and his co-workers tested a military prototype field version of the LIBS system at the Yuma Proving grounds in 2008. The detector was able to discriminate with 85 percent accuracy whether more than 100 samples contained residues of several types of explosives from between 30 to 50 meters (90 to 150 feet) away, or whether the composition was of materials such as rock, wood, metal, plastics or, in one case, food materials—salami and cheese.

Applied Spectra has developed several commercial versions of this tool and is planning to release a hand-held version later in 2009.

### **Detecting Lead and Other Heavy Metals**

With so many news stories circulating about imported toys and other products contaminated by lead, testing labs and consumer safety authorities need faster, accurate ways of determining which products to target.

Many European and Asian nations have adopted regulations—called Restrictions on Hazardous Substances (RoHS) and Waste Electrical and Electronic Equipment (WEEE)—requiring the removal of hazardous materials from new and to-be-recycled electronic components. More stringent U.S. regulations are also being considered. Lead, cadmium, mercury, hexavalent chromium, and organic materials polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) are among the dangerous materials that these regulations are seeking to remove from the products we use daily. Research has demonstrated that LIBS testing is more accurate than today's X-ray fluorescence technology for quick screening of these materials.

Laser ablation-based testing can also be used in a variety of other "green" and "green policing" applications. For example, one manufacturer of electronic components is using it to check the solder of electronic components, to ensure that they are lead-free, which many countries now require. It can also analyze the purity of silicon used in solar photovoltaic panels, for quality control.

### **Assisting with Waste Detection at Contaminated Sites**

Those performing clean-up of old mining sites will find LIBS technology useful in identifying contaminants at the sites; information that can guide waste management experts to determine the best methods to use to clean up and isolate what is present.

Russo has been discussing the possible use of LA-ICP-MS and LIBS methods to assist in hazardous waste reduction programs at several of DOE's National Laboratories, including the Idaho National Laboratory and Lawrence Livermore National Laboratory. In Livermore, program managers are conducting about 4,000 to 5,000 tests for beryllium contamination per year, although more than 90 percent of those tests turn up negative. The testing takes time and generates its own hazardous waste. LA-ICP-MS testing would require less than 30 seconds per test, far less than what the current test requires, and would generate no waste.

Some research also has been oriented toward using LA-ICP-MS to detect residues of nuclear weapons development for use in nuclear non-proliferation programs.

### **The Laser Ablation Process**

Thanks to years of study, Russo's group now has time-resolved images, analyses of ablated material, and a mathematical model of the laser ablation process. At the start of the laser pulse until one nanosecond later, violent evaporation takes place at the material's surface (see Figure 1).

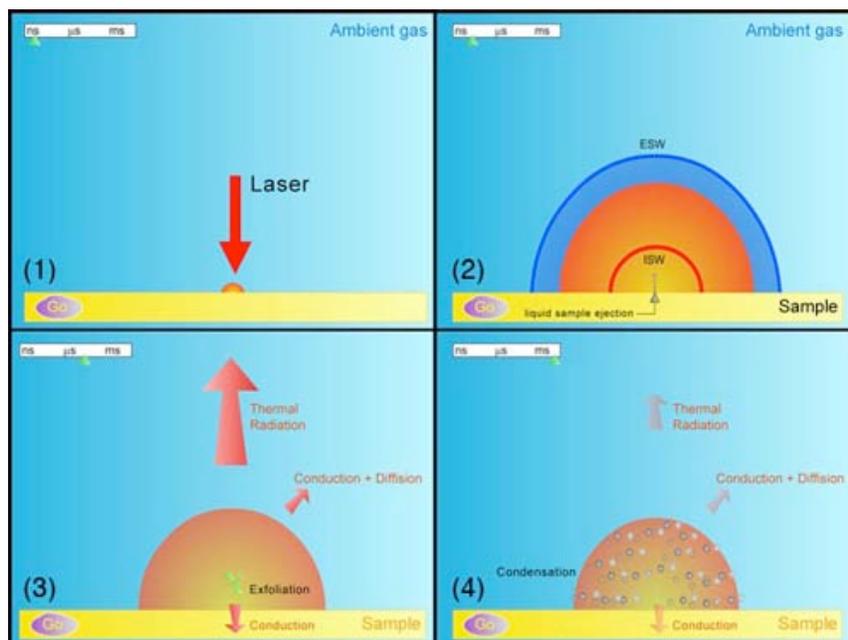


Figure 1. The laser ablation process

From one nanosecond to one microsecond (1,000 ns) after the end of the pulse, the high-temperature plume expands outward. From one microsecond to 1,000 microseconds (1 millisecond) after the end of the pulse, the heat leaks away through radiative heating and the plume cools. At the end of this interval, about one millisecond after the end of the pulse, the vapor plume drops to the boiling temperature of the sample and condenses back to its solid form—albeit as a tiny dusting of particles (nanoparticles). The formation of nanoparticles in these laser ablation plumes was the basis of the discovery of buckyballs from graphite.

In LIBS, the plasma emission from the ablated sample is gathered using special optics. A spectrometer analyzes the white light emitted from the plasma, separating the light into its colors (wavelengths). Every sample has a unique spectral signature, thanks to its chemical components. An ICCD (intensified charge coupled device) camera records the signature, converting the light into pixels of information.

In LA-ICP-MS, the ablated material itself, in the form of fine particles, can be gathered by a stream of a carrier gas such as argon and heated to a high temperature in order to be converted to a plasma (where atoms are stripped of their electrons). The chemical composition of the plasma is then analyzed using a mass spectrometer.

Russo says that "We understand the fundamental physics of it, and we better understand which parameters to use to make the most effective measurements with laser ablation." His group's research serves as an example of fundamental research to better understand a natural phenomenon that led to an unexpected, but useful application in the industrial and commercial world.

— Allan Chen

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Funding for the basic science research has come from DOE's Office of Basic Energy Science and DOE's National Nuclear Security Administration. Funding for Applied Spectra has come from the Department of Defense Small Business Innovation Research program.



## Environmental Energy Technologies Division

### NEWS

## Photocatalytic Oxidation (PCO) Air Cleaners: Reducing Energy Use While Clearing the Air

The concentrations of volatile organic compounds (VOCs) found in offices, classrooms, and homes could be greatly reduced in the coming years as the result of indoor air cleaner research being conducted at Lawrence Berkeley National Laboratory's Indoor Environment Department. Begun by Berkeley Lab's William Fisk and Alfred Hodgson, the department's indoor air cleaner research is now led by Hugo Destailats and is focused on photocatalytic oxidation (PCO)—a promising technology for reducing VOCs and energy use simultaneously.

The need for VOC reduction is great. "Indoor air measurements typically find twenty high-concentration VOCs, fifty low-concentration VOCs, and many more very low concentration VOCs," says Destailats. Depending on exposure levels, several of these compounds may have health consequences individually, and some of them the potential to react with reactive atmospheric species (such as ozone) to form a secondary pollutant.

The compounds come from a variety of sources—some avoidable and some less so. One VOC, cancer-causing benzene, for example, is found in tobacco smoke, and it can be reduced by maintaining a smoke-free environment. Because it is also a product of motor vehicle exhaust, however, it can enter through open windows or through air vents. Formaldehyde, a carcinogen, irritant, and possible source of asthma exacerbation in indoor air often comes from pressed wood products as they off-gas, so avoiding the excessive use of pressed wood furniture can reduce indoor formaldehyde concentrations. However, formaldehyde can also be produced as a secondary pollutant, when ozone and other substances from outdoor air react with those indoors.

Indoor air cleaners eliminate some pollutants, but most concentrate primarily on filtration of particles, rather than on gaseous VOC removal. Overall, particulate filtering has become efficient and cost-effective, but as VOC measurements show, most air cleaners' ability to reduce indoor VOCs is much less advanced. Destailats, along with Berkeley Lab's Michael Apte, William Fisk, and Mohamad Sleiman are looking at more-effective air cleaning strategies for commercial and residential applications. Photocatalytic oxidation is offering some promising results.

The Indoor Environment Department's research addresses the dual challenge of reducing both VOCs and energy use. If energy efficient photocatalytic oxidation reductions of VOC are effective, then energy use can be reduced, because less outdoor air, which must be heated or cooled, will be needed to "dilute" the indoor air to healthy levels.

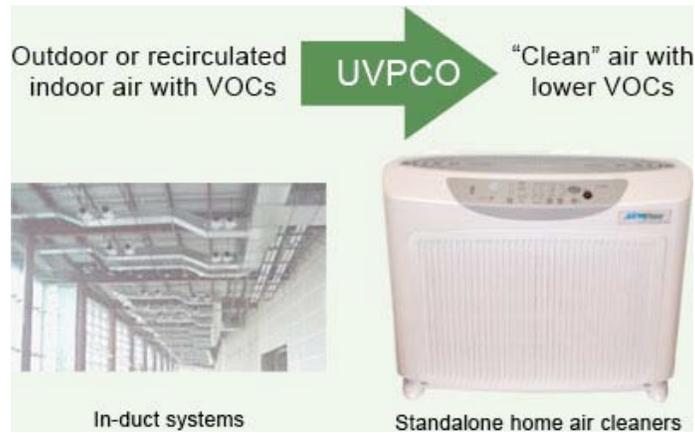
### Two Means to the Same End

Broadly, photocatalytic oxidation systems can be divided into two categories: active PCO and passive PCO. Each system takes a different approach to eliminating indoor air pollutants, but they differ in their complexity and cost.

### Active PCO for Indoor Air Systems

In active PCO systems, a high-surface area support irradiated with UV light captures the VOCs as they are entrained in the intake air of a heating, ventilating, and air conditioning (HVAC) system. A photocatalytic coating applied to the support then interacts with the compound under UV irradiation, converting it to end products such as carbon dioxide and water, or to other reaction intermediates.

One configuration being evaluated by Berkeley Lab is an in-duct air cleaner that circulates air through a series of honeycomb monolith filters coated with titanium dioxide ( $\text{TiO}_2$ ) as a catalyst. Ultraviolet lamps (either UVA or UVC) irradiate the coated filters to activate the  $\text{TiO}_2$ , and as air passes through the system, VOCs are adsorbed on the catalyst and react.



UV photocatalytic oxidation air cleaners.

To better understand the potential for PCO technology, Berkeley Lab measured conversion efficiencies and clean air delivery rates for individual VOCs in several indoor mixtures likely to occur in commercial buildings. The research team also investigated the formation of gas-phase products of incomplete conversion.

Researchers estimated that conversion efficiencies of the PCO installed in an office building HVAC system would have to surpass 17 percent to enable a 50 percent reduction in building ventilation. The Berkeley Lab experiment showed conversion of most VOCs surpassing 19 percent, confirming its effectiveness. In several cases, conversion was as high as 75 percent.

However, the test also showed generation of formaldehyde and acetaldehyde from partial oxidation of VOCs. In follow-up research, the Indoor Environment Department conducted an experiment to determine if generation of those compounds could be reduced by using a chemisorbent oxidizer—sodium permanganate—downstream of the PCO device. They found that a four-panel, folded, media bed installed downstream of the reactor removed formaldehyde with greater than 90 percent efficiency and removed acetaldehyde at about 70 percent efficiency—resulting in net formaldehyde and acetaldehyde reductions of 50 to 70 percent. As a result, the combined PCO air cleaner and chemisorbent system appears to have sufficient VOC removal efficiency to reduce ventilation rates by 50 percent without increasing indoor aldehyde concentrations.

"It worked beautifully," says Destailats, "but there is a cost problem because it's expensive. Not everyone would be able to afford it." However, cost is not the only issue—in indoor air applications, the PCO catalysts can become poisoned and deactivated.

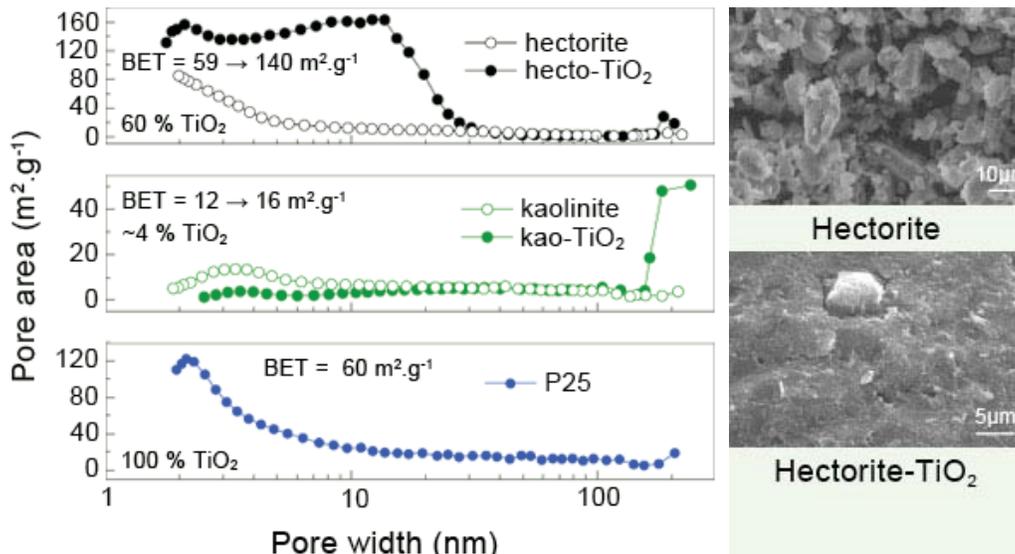
### **Passive PCO: Invisible but Potentially Effective**

Passive PCO air cleaning approaches could also use catalysts to reduce VOC concentrations, but rather than using them in the HVAC system, they would be incorporated into the building surfaces themselves and use catalysts that are activated by ambient light rather than UV. For example, they might be incorporated into a building's painted surfaces. Although passive PCO systems are still in the experimental stage right now, some early results have shown promise and have led to a supporting material that may be effective in both passive *and* active systems: clays.

### **The Quest for More Effective Photocatalyst Coatings**

The performance of PCO systems may be improved through supporting the TiO<sub>2</sub> nanoparticles in matrices that increase the effective dwelling time of VOCs in the proximity of the photocatalyst. This knowledge prompted Berkeley Lab to examine different clays as a support of a TiO<sub>2</sub> catalyst. Clays often present a large surface area for adsorption of organic pollutants, and can also interact directly with VOCs through redox and acid-base interactions.

"You need to find a material where the compound can penetrate a porous structure," says Destailats. The porous material ensures that the VOC resides there long enough for the catalyst to work. "Most VOCs can be absorbed very efficiently with clay."



Porosity of clay-TiO<sub>2</sub> nanocomposite photocatalysts.

Source: Kibanova et al. 2009 — *Applied Clay Sci.*

Collaborating with clay experts Daria Kibanova, Martin Trejo, and Javiera Cervini-Silva of the National Autonomous University of Mexico, Destailats conducted a bench-scale test looking at the effectiveness of using hectorite and kaolinite clays combined with TiO<sub>2</sub> to remove toluene. The research revealed that reaction rates were comparable to a reference TiO<sub>2</sub> material (P25) in dry air for the best performing clay-TiO<sub>2</sub> composite, but showed lower removal of a model hydrophobic pollutant under high relative humidity conditions. Destailats sums up the findings: "Competition of hydrophobic VOCs with an excess of water on the surface of the catalyst is an important factor affecting overall conversion."

### Air Cleaner Readiness

Small, stand-alone active PCO units are available commercially, but Destailats warns buyers that the performance of current products is uncertain. It is possible that some units produce harmful aldehydes and that catalysts become deactivated.

Berkeley Lab's current research addresses only the large systems that can be incorporated into a building's HVAC system. These systems are still in the experimental phase. Ideally, in-duct air cleaners should include several stages (such as the use of a chemisorbent after the PCO), but the cost of a multi-stage system may be cost-prohibitive for some.

With a basic PCO system, maintenance is fairly easy and inexpensive. Users need to replace the UV light bulbs once every few years, and the catalyst-coated surfaces may need to be replaced periodically. However, if the system is using a chemisorbent, which is expensive, maintenance will be more costly. It is not clear yet how often the chemisorbent would need to be changed, but it could require replacement two or three times per year.

### Next Steps on the Road to Cleaner Indoor Air

Because of Berkeley Lab's successful tests on both types of air cleaner system, Hugo Destailats would like to keep the department's air cleaner research alive on all fronts.

"I would like to explore further active PCO cleaners and passive methods such as photoactive paints," he says. "I would also like to explore other support materials, such as carbon nanofibers, and to experiment with other catalysts. TiO<sub>2</sub> is not the only one."

But PCO is only one avenue of research in what he sees as a much larger field, and he's eager to explore other possibilities as well. "There are other options to clean indoor air that don't involve photochemistry at all."

— Mark Wilson

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# Environmental Energy Technologies Division

## NEWS

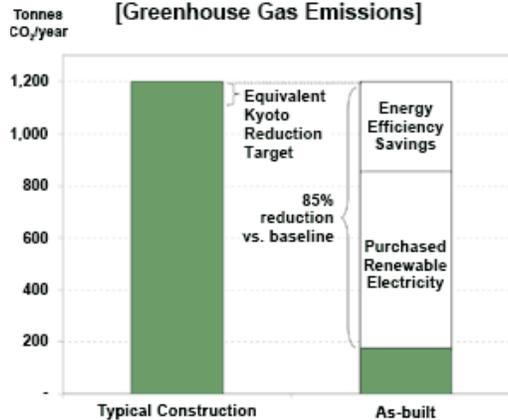
### Energy Reduction for Energy Research

Scientists have unearthed efficiencies in technologies and processes for sectors as diverse as agriculture and telecommunications, saving untold gigawatts and dollars in the process. However, does a self-assessment reveal the same efficiency gains from the researchers themselves? Where are the efficiencies waiting to be gained from the laboratories, computer facilities, and clean environments where research occurs? Evan Mills recently considered this question in this cover article "Sustainable Scientists," in *Environmental Science & Technology Viewpoint* [*Environ. Sci. Technol.*, 2009, 43 (4), pp 979-985]. Mills is a scientist in the Environmental Energy Technologies Division of the Lawrence Berkeley National Laboratory.

Through a synthesis of more than a decade of work by Berkeley Lab's "high-tech" facilities program, Mills found that, in the United States, some \$10 billion of research money flows not into the research itself, but into the energy required to conduct it. Therefore, every efficiency that can be gained in the laboratory redirects existing funding to more staff, better facilities and equipment, and the myriad other daily wish list items of the researcher. These facilities also emit greenhouse-gas emissions equivalent to that of 15 million cars.



**LBNL's Molecular Foundry  
[Greenhouse Gas Emissions]**



This nanotechnology research facility at Lawrence Berkeley National Laboratory (LBNL) achieved a Leadership in Energy and Environmental Design (LEED) Gold Rating, thanks to extensive green and energy-efficient features and renewable power purchases. Estimated carbon-dioxide emissions are 85% less than standard practice (which includes aggressive California building codes), vastly more than national average reductions called for by the Kyoto Protocol. (\$/m<sup>2</sup>-y)

Mills asserts that remarkable savings can be achieved in the research setting. "By following commercially proven best practices in facility design and operation, scientists—and the sponsors of science—can efficaciously halve these costs and so do their part to put society on a low-carbon diet."

Much of this savings can be built into the system when designing facilities, by focusing on future electrical, heating, ventilation, and air conditioning needs, as well as efficient research equipment and plug loads. For example, Berkeley Lab's Molecular Foundry, a new state-of-the-art nanotechnology research lab, achieved substantial savings (and a LEED Gold rating) over a comparable standard-practice facility type, with no net increase in construction costs. Systems efficiencies can be greatly enhanced by involving owners, occupants, and service providers when designing the building, and by establishing a focused operations and maintenance program from the outset.

However, even if a facility is not state of the art, much can be done to reduce energy costs. Here are some suggestions for laboratories, computing facilities, and clean environments:

- **Laboratories.** Benchmarking from laboratories shows an eight-fold variation in energy intensity, so energy-saving opportunities obviously abound. Berkeley Lab's high-tech team has identified some prime strategies to achieving those savings: "specifying premium-efficiency fume hoods and laboratory equipment, avoiding overventilation, minimizing pressure drop in the ventilation system, energy recovery, minimizing simultaneous heating and cooling, and properly sizing space-conditioning equipment to match actual loads."
- **Computing.** Power and cooling costs for computing facilities routinely eclipse the cost of the equipment, and those costs are expected to rise precipitously in the future. Researchers can reduce energy demand and rein in costs by using improved IT equipment, uninterruptible power supplies, and more efficient cooling strategies. Other strategies include improving computational efficiency and consolidating and virtualizing underutilized machines. Users also benefit from changing fundamental processes: shifting to a direct-current infrastructure in one Berkeley Lab demonstration project yielded a 10% facility-wide savings compared to the best-available AC configuration, and a more than 25% savings compared to conventional practice.
- **Clean Environments.** Like laboratories, an analysis of clean environments revealed an eight-fold variation in floor-area-normalized ventilation costs. The most impressive savings will come from premium-efficiency air-movement equipment and design, more efficient tools, and process changes. For example, mini-environments can isolate the work area to a smaller, more easily controlled space, allowing for a more relaxed particle count in the surrounding space. Real-time particle counting can enable researchers to modulate ventilation speeds to meet current needs and reduce energy demand.

Practical information on how to reduce energy use in research spaces is available on the web, from the following organizations:

- Berkeley Lab's High-Performance Buildings for High-Tech Industries [<http://hightech.lbl.gov>]
- DOE's Industrial Technologies Program [<http://www1.eere.energy.gov/industry>] (ITP)
- The U.S. EPA and DOE's Laboratories for the 21st Century [<http://www.labs21century.gov/>] (Labs21®) Initiative
- California Energy Commission's Public Interest Energy Research [<http://www.energy.ca.gov/research/index.html>] (PIER) Program
- New York State Energy Research and Development Authority [<http://www.nyserda.org/>] (NYSERDA)
- The Green Grid Alliance [<http://www.thegreengrid.org/>] (for IT)

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To read the article, "Sustainable Scientists" in *Environmental Science & Technology*, go to ACS Publications [<http://pubs.acs.org/doi/full/10.1021/es801496g>] .

This work was sponsored by the Director, Office of Science, Office of Basic Energy Sciences, U.S. Department of Energy; U.S. EPA; California Energy Commission, Public Interest Energy Research; Pacific Gas and Electric Company; and New York State Energy Research and Development Authority.

Mark Wilson is a freelance science writer and editor and Assistant Editor of the *EETD News*.

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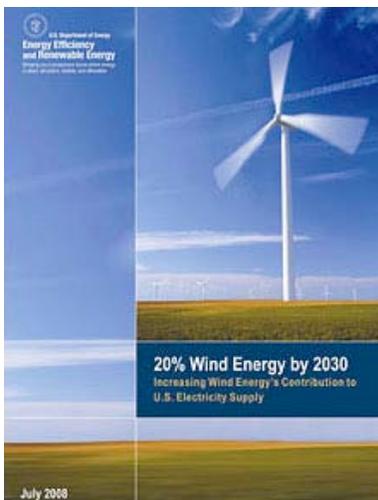


## Environmental Energy Technologies Division

## NEWS

## New Study Sheds Light on the Growing U.S. Wind Power Market

For the fourth consecutive year, the United States was home to the fastest-growing wind power market in the world in 2008, according to a report released by the U.S. Department of Energy and prepared by Lawrence Berkeley National Laboratory (Berkeley Lab). Specifically, U.S. wind power capacity additions increased by 60 percent in 2008, representing a \$16 billion investment in new wind projects. "At this pace, wind is on a path to becoming a significant contributor to the U.S. power mix," notes report author Ryan Wiser, of Berkeley Lab. Wind projects accounted for 42% of all new electric generating capacity added in the U.S. in 2008, and wind now delivers nearly 2% of the nation's electricity supply.



The 2008 edition of the *Wind Technologies Market Report* provides a comprehensive overview of developments in the rapidly evolving U.S. wind power market. The need for such a report has become apparent in the past few years, as the wind power industry has entered an era of unprecedented growth, both globally and in the United States. At the same time, the last year has been one of upheaval, with the global financial crisis affecting near-term growth prospects for the wind industry, and with federal policy changes enacted to push the industry toward continued aggressive expansion. "With the market evolving at such a rapid pace, keeping up with trends in the marketplace has become increasingly difficult," notes report co-author Mark Bolinger. "Yet, the need for timely, objective information on the industry and its progress has never been greater...this report seeks to fill that need."

Drawing from a variety of sources, this report analyzes trends in wind power capacity growth, turbine size, turbine prices, installed project costs, project performance, wind power prices, and how wind prices compare to those of conventional generation. It also describes developer consolidation trends, current ownership and financing structures, and trends among major wind power purchasers. Finally, the report examines other factors affecting the domestic wind power market, including grid integration, transmission issues, and policy drivers. The report concludes with a preview of possible near- to medium-term market developments.

The report includes the following key findings:

- The United States is the fastest-growing wind market worldwide. It has led the world in new wind capacity for four straight years and has overtaken Germany to lead in cumulative wind capacity installations.
- Growth is distributed across much of the United States. Texas leads the nation with 7,118 megawatts (MW) of new wind capacity, but 13 states each had more than 500 MW of wind capacity as of the end of 2008, with seven topping 1,000 MW, and three topping 2,000 MW. Over 10% of the electricity generation in Iowa and Minnesota now comes from wind power.
- Market growth is spurring manufacturing investments in the United States. Several major foreign wind turbine

manufacturers either opened or announced new U.S. wind turbine manufacturing plants in 2008. Likewise, new and existing U.S.-based manufacturers either initiated or scaled-up production. The number of utility-scale wind turbine manufacturers assembling turbines in the U.S. increased from just one (GE) in 2004 to five (GE, Gamesa, Clipper, Acciona, CTC Energy/DeWind) in 2008.

- Wind turbine prices and installed project costs continued to increase into 2008. Near the end of 2008 and into 2009, however, turbine prices weakened in response to reduced demand for wind due to the financial crisis.
- Wind project performance has improved over time, but it has leveled off in recent years. The longer-term improvement in project performance has been driven in part by taller towers and larger rotors, enhanced project siting, and technological advancements.
- Wind remained economically competitive in 2008. Despite rising project costs, in recent years wind has consistently been priced at or below the price of conventional electricity, as reflected in wholesale power prices. With wholesale prices plummeting in recent months, however, the economic position of wind in the near-term has become more challenging.
- Expectations are for a slower year in 2009, in large part due to the global recession. Projections among industry prognosticators range from 4,400 MW to 6,800 MW of wind likely to be installed in the U.S. in 2009. After a slower 2009, most predictions show market resurgence in 2010 and continuing for the immediate future.

Berkeley Lab's contributions to this report were funded by the Wind and Hydropower Technologies Program, Office of Energy Efficiency and Renewable Energy of the U.S. Department of Energy.

— Allan Chen

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"2008 Wind Technologies Market Report" [PDF <http://eetd.lbl.gov/ea/ems/reports/2008-wind-technologies.pdf> ]

A PowerPoint presentation summarizing key findings from the report. [PDF <http://eetd.lbl.gov/ea/ems/reports/2008-wind-technologies-ppt.pdf> ]

The Department of Energy's press release <http://www.energy.gov/news2009/7653.htm> .

This research is sponsored by the U.S. Department of Energy, Wind and Hydropower Technologies Program, Office of Energy Efficiency and Renewable Energy.

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## Environmental Energy Technologies Division

**NEWS****Recovery Act Funding Enables Berkeley Lab to Help Federal Agencies Improve Energy Efficiency**

The U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has received \$1.8 million in American Recovery and Reinvestment Act (ARRA) funding to provide technical expertise to federal energy managers. The funding will enable Berkeley Lab scientists to provide technical expertise to help federal energy managers perform projects and monitor their performance. Work will focus on advanced energy-efficient technologies in lighting, HVAC (heating, ventilation, and air conditioning), and control systems for the buildings, laboratories, and data centers of several federal agencies.

"This funding will help implement energy efficiency projects across the federal government and will support training programs for energy managers to ensure the equipment is operating as effectively as possible," said Arun Majumdar, Director of Berkeley Lab's Environmental Energy Technologies Division (EETD). "The Recovery Act funding will also go to developing and delivering advanced energy assessment tools that will provide energy managers with the resources and training to launch additional efficiency improvements in their facilities for years to come."



At least eight Department of Energy's Federal Energy Management Program (FEMP) technical assistance projects will help five civilian agencies and facilities in all branches of the Armed Services achieve their energy reduction and renewable energy goals. The Berkeley Lab EETD Applications Team will provide technical assistance, with a dual mission of transferring energy-efficient building technologies from the laboratory to the real world and stimulating the use of underutilized, high-performance technologies through innovative deployment programs. The Team has improved laboratory energy efficiency for decades, beginning with energy management efforts at Berkeley Lab that reduced its energy costs by 40% in the 1970s and 1980s.

The FEMP's mission is to facilitate the federal government's implementation of sound, cost-effective energy management and

investment practices to enhance the nation's energy security and environmental stewardship. Its activities include retrofitting federal facilities to improve energy efficiency and working with agencies to deploy renewable energy technologies.

Berkeley Lab will support the following projects:

### **Improving Efficiency in Federal Data Centers**

Berkeley Lab researchers are playing a key role in national efforts to reduce data center energy use, a rapidly growing demand source. Experts from EETD will train data center staff at several agencies in energy-efficient technologies and practices and apply DCPro, a Berkeley Lab-produced software tool that assesses energy savings opportunities in data centers.

Agency staff also will receive training in data center design, energy management, and best practices, as well as guidance documents, best practices guides, and design assistance documentation produced by Berkeley Lab and its affiliates for the Data Centers for the 21st Century program. Recipient agencies will include the U.S. Department of Energy for its own data centers, the U.S. Marine Corps, and the U.S. Pacific Command, which represents facilities of all four armed services in Hawaii and elsewhere in the Pacific.

### **Energy Efficiency Retrofits for Department of Agriculture Labs**

Berkeley Lab's Applications Team will provide the Department of Agriculture's Agricultural Research Service (ARS) with design assistance for remodeling and retrofitting its Albany, California, regional research center and for other identically designed regional research centers across the United States.

"ARS will be one of the earliest beneficiaries of a screening tool the A-Team has developed for identifying efficiency opportunities in laboratories. It will receive not only a number of pilot assessments using the tool, but also training of USDA personnel on how to use the tool for conducting their own assessments," says Charles Williams, an energy expert in Berkeley Lab's Applications Team.

### **Healthy Lighting for the National Institutes of Health (NIH)**

Applications Team staff will help the National Institutes of Health evaluate and install energy-efficient light-emitting diode (LED) lighting. The Team will work with NIH staff to develop and quantitatively evaluate test-beds for programmable spectral lighting for hospital rooms, animal vivaria, offices, and labs.

In these test-beds, they will study how to optimize health and productivity by programming the spectrum and timing of solid-state LED light sources. Berkeley Lab researchers will also work with the General Services Administration to set up demonstrations and evaluations of six to ten pilot projects for smart building technologies, such as testing integrated controls for building systems. They will use enterprise management software to help design a regional operation center for buildings. EETD's Francis Rubinstein will participate in this project.

### **Helping the Armed Forces be as Energy-Efficient as They Can Be**

The Applications Team will help the Navy accelerate its use of Energy Savings Performance Contracts (ESPC) to implement energy conservation measures through third-party financing. It will develop a template for site data packages that accelerate selection of an ESPC contractor and guidance for energy audits that are required by the Energy Independence and Security Act of 2007 (EISA), so that these audits lead directly to the implementation of identified ESPC energy saving opportunities. These templates and guidance will be coordinated with similar efforts being conducted by the National Renewable Energy Laboratory for the State Department and by FEMP staff for DOE sites, with the aim of providing a standard, streamlined approach for all federal agencies to use in procuring ESPC services.

With \$663,000 in Department of Defense (DOD) funding, including \$455,000 from the Recovery Act, EETD researchers, including Philip Haves and Mary Ann Piette, working with United Technologies Research Center, will cooperate on a project to test a whole-building monitoring system at two DOD sites in partnership with the Navy and the Air Force. The system will continuously measure the energy performance of the HVAC, lighting, and water systems and compare these measurements in real time to a reference simulation model that represents the design intent for each building.

"Identifying the causes of water and energy waste in buildings can be challenging because energy flows and water usage are largely invisible," says Haves, leader of EETD's Commercial Buildings Group. "The aim of this project is to present building and facility managers with actionable information on equipment faults and operational problems so that they can improve the performance of their buildings, often at little or no cost."

The comparison will allow building operators to identify and quantify places within their facilities that are operating below their targeted efficiency levels. Building managers can use this information to compare various solutions and their effects on the whole building, as well as to measure improved performance once the issue is resolved. The system will be based on open-source, publicly available software that can be run on personal computers and make use of existing sensing and control systems within buildings.

The two facilities scheduled for the demonstration are a building at the Naval Facilities Engineering Center in Port Hueneme, California, and a facility at McGuire Air Force Base in New Jersey.

Finally, the Army's Fort Detrick in Maryland will receive an assessment of the viability of supplying all or part of the electric

load in selected areas with photovoltaic solar panels.

"We look forward to helping these agencies make the progress on energy efficiency and renewable energy that America needs to address global climate change as well as meeting the goals of the Recovery Act by helping to jumpstart the economy," says Williams.

EETD's Williams and Rick Diamond are serving as liaisons to recipient agencies. Numerous EETD staff will participate in these efforts, including Francis Rubinstein, Dale Sartor, Bill Tschudi, Rich Brown, Geoffrey Bell, Paul Mathew, Anthony Radspieler, Mike Holda, and Peter Biermayer.

— **Charles Williams**

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Berkeley Lab's Recovery Act [<http://www.lbl.gov/Publications/recovery/>] website.

This work is being funded by the Federal Energy Management Program (FEMP) and the Department of Defense's Environmental Security Technology Certification Program, which provided \$1.4 million and \$445,000, respectively. Funding is from the American Recovery and Reinvestment Act.

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## Environmental Energy Technologies Division

## NEWS

**Research Highlights****Majumdar Confirmed as First Head of DOE's ARPA-E**

The U.S. Senate has approved the nomination of Arun Majumdar, director of the Lab's Environmental Energy Technologies Division and a professor at UC Berkeley, as the first director of the Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E). ARPA-E's goals are to create technologies that have the potential to reduce the nation's reliance on foreign energy supplies, reduce energy-related greenhouse gas emissions, and improve energy efficiency. The nomination was approved by unanimous consent in the Senate on October 21, 2009.

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**Building a Net-Zero Home: The \$20 Million Energy Challenge**

Iain Walker, a scientist in Lawrence Berkeley National Laboratory's (Berkeley Lab's) Environmental Energy Technologies Division, has collaborated with his colleagues in environmental energy research to help the Siebel Foundation develop the criteria for its Energy Free Home Challenge™. The Challenge, which comes with a \$20 million global incentive prize, is a competition to create a new generation of systems and technologies for homes that achieve a net-zero, non-renewable energy footprint without increasing ownership costs.

"For several years we've been able to build zero-energy homes, but they always cost several thousand of dollars more—sometimes tens of thousands of dollars more—than a regular home," says Walker. This contest seeks to overcome that barrier.

Over the last two years, Walker worked with numerous colleagues at Berkeley Lab, the University of California at Berkeley, the University of Illinois, and elsewhere to develop the criteria. Now that those criteria have been developed, the Challenge will begin later this year. It is open to everyone.

The Challenge itself will consist of two parts: finding the technologies that will bridge the cost and energy gap, and then designing and building homes based on the most promising designs. Once built, those homes will be monitored for a year, and the overall winner will be replicated 90 to 100 times in a subdivision.

For more information, see the 2008 Siebel Foundation Annual report ([http://www.fvgroup.com/Siebel\\_08AR\\_web.pdf](http://www.fvgroup.com/Siebel_08AR_web.pdf)).

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**China Energy Group Helps Chinese Cement Companies Reduce GHG Emissions**

In July 2009, Lawrence Berkeley National Laboratory's China Energy Group joined other international team members in Beijing, China, to launch a three-year project to help 42 of China's largest cement companies reduce their greenhouse gas (GHG) emissions.

These 42 companies produce about 400 million metric tons of cement each year—more than 30% of China's total cement production. Their goal is to reduce the companies' energy use and GHGs by 10% to 15% by 2012. The entire Chinese cement industry produces about 9% of the country's carbon dioxide emissions.

"This is a comprehensive project that goes beyond measurement to benchmark cement plants against both Chinese and international best practice, as well as to provide practical energy efficiency options that can be implemented in the plants," explained Berkeley Lab's Lynn Price, Staff Scientist at the China Energy Group.



Berkeley Lab participated in a four-day workshop, training cement company personnel to use its Benchmarking and Energy Saving Tool for Cement (BEST-Cement), which was developed with the China Cement Association (CCA), Energy Research Institute, and China Building Materials Academy (CBMA). The tool benchmarks cement plants to Chinese best practices and international best practices and identifies actions that could be taken to improve the plant's energy efficiency.

This event launched the beginning of the Asia Pacific Partnership (APP) project, funded by the U.S. State Department. Total project funding for the partnership is about \$1.8 million for three years, with \$1 million going to China and the remainder to Berkeley Lab, the World Resources Institute, and E3M, Inc.

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# Environmental Energy Technologies Division

## NEWS

### Sources and Credits

#### Sources

##### DOE's Consumer Information Fact Sheets

These web pages [<http://www.eere.energy.gov/consumer/>] provide information about energy efficiency and renewable energy for your home or workplace.

##### DOE's Energy Information Administration (EIA)

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

##### DOE's Fuel Economy Guide

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

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

EERE's [<http://www.eere.energy.gov/>] mission is to pursue a better energy future where energy is clean, abundant, reliable, and affordable; strengthening energy security and enhancing energy choices for all Americans while protecting the environment.

##### U.S. DOE, Office of Science [<http://www.er.doe.gov/>]

##### U.S. EPA, Energy Star Program [<http://energystar.gov/>]

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

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

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LBNL/PUB-821 Vol. 8, No. 2 [<http://eetd.lbl.gov/newsletter/nl29/>] , Fall 2009

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This work was supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

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

With more than 4,000 employees, Berkeley Lab's total annual budget of nearly \$600 million supports a wide range of unclassified research activities in the biological, physical, computational, materials, chemical, energy, and environmental sciences. The Laboratory's role is to serve the nation and its scientific, educational, and business communities through research performed in its unique facilities, to train future scientists and engineers, and to create productive ties to industry. As a testimony to its success, Berkeley Lab has had 11 Nobel laureates. EETD is one of 14 scientific divisions at Berkeley Lab, with a staff of 400 and a budget of \$40 million.

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