LAWRENCE BERKELEY NATIONAL LABORATORY

SUMMER 2006
VOLUME 6 NUMBER 4

Environmental Energy Technologies Division NEWS

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

Civil war in the Sudan has made the Darfur area of western Sudan into one of the world's largest refugee zones. Aid organizations estimate that two million people are in refugee camps in the Darfur area. Since 2003, between 200,000 and 300,000 people have been killed there. The complex reasons for this humanitarian crisis stem from the region's ethnic and religious differences.

A Mission to Darfur

As international organizations struggle with the region's crises, the refugees face serious problems leading their everyday lives. One problem is a critical lack of cooking fuel, which drives women to leave the safety of the camps daily and walk increasing distances to find firewood. Outside camp boundaries, they are often unaccompanied and are subject to attack and rape by the roaming raiders known as the Janjaweed.

Darfur is about the size of France and is divided into North, West, and South regions; its vastness makes it difficult for peacekeepers to patrol effectively. The land near the camps has been so stripped of firewood and trees that a one-way journey of three hours is now the norm for most women gathering firewood in South Darfur. In North Darfur, there is no wood within walking distance from many camps, so refugees sell their food rations to townspeople or middlemen to earn cash to purchase wood fuel, also from middlemen, to cook what little food remains.

Darfur is in the western part of Sudan, bordering on Libya, Chad, and the Central African Republic.

High-efficiency cookstoves that have been developed in India and elsewhere can efficiently cook meals using substantially less fuel than the "three-stone" fires that are traditional in Darfur. Ashok Gadgil and Christina Galitsky were part of a team of researchers from the

Continued on Page 2

In this Issue

Mission to Darfur

Continued from Page 1

Lawrence Berkeley National Laboratory (Berkeley Lab) Environmental Energy Technologies Division (EETD) who recently went to Darfur to test simple cookstoves made of sheet metal or cast iron that use less wood than traditional fires or use alternative fuels such as animal dung.

With minimal modifications, these stoves could save the women in Darfur's camps from the wood-gathering expeditions that make the women vulnerable to attack. Use of the stoves could also reduce pressure on the environment surrounding the camps.

Ashok Gadgil and Christina Galitsky

Gadgil, who is the leader of the EETD Airflow and Transport group, is familiar with finding solutions to help address the problems of developing countries. He developed the UV Waterworks device for disinfecting drinking water using very little energy as well as a very low-cost technology for removing arsenic from drinking water, which is a problem in many areas of the world, especially Bangladesh.

Galitsky is a chemical engineer who worked with Gadgil on the arsenic-removal technology and has developed tools and guides for improving the energy efficiency of industrial processes, both in the U.S. and internationally.

Gadgil and his team were able to travel to Darfur in November, 2005 thanks to financial support from several sources including EETD and private donors, and the U.S. Agency for International Development's Office of Foreign Disaster Assistance via CHF International, a nonprofit corporation investing in community, habitat, and financial assistance worldwide.

Was it safe to go?

"There were two big uncertainties before we left," says Gadgil. "First, we needed to know what kind of wood the refugees use for fuel; what are the common shapes and sizes of the pots they use; what foods they eat; and what their cooking method is. All this affects the stove performance. Information on these matters was very hard to find. What little we learned from others here in the U.S. or even from contacts in Khartoum was either incorrect or missing some crucial details." In view of this limited information, the team decided that it was necessary to visit the camps and learn about the situation for themselves.

A second big uncertainty, says Gadgil, "was the security situation. Just before we left, the United Nations pulled their aid workers out of the West Darfur area, citing violence and unsafe working conditions. In South Darfur, where we were headed, some local aid workers, including several with CHF International, were abducted, but they were later released. We monitored the situation as closely as we could on a daily basis. We were not going there to prove our bravery!"

The journey to the camps meant flying to Khartoum, Sudan's capital, and then taking local flights. Overland travel was too dangerous, as rail and road attacks by warring parties are common. The team traveled safely and stayed in the camps in living quarters provided by CHF for aid workers, and the visit turned out to be incident-free.

Because the refugees' problems urgently need solving, the team attempted to gather data and identify appropriate solutions during one intense field visit.

In mid-November Gadgil and Galitsky visited the Otash and Kalma camps near the town of Nyala. Kalma is said to be the largest refugee camp in the world, with an estimated population of between 90,000 and 150,000 people. Upon arrival, Gadgil and Galitsky set about meeting the local officials, aid workers, and community members in the camps.

While Gadgil and Galitsky worked at Kalma, two other members of the team, Berkeley Lab guest scientists Mark Jacobs and Yoo-Mi Lee, traveled north to investigate camps in North Darfur near El-Fasher.

Continued Next Page

Mission to Darfur

Continued from Page 2

Figure: Cooking over a three-stone fire

"One of our objectives was to gather information," Gadgil explains. "We talked informally to refugees to learn about conditions there. Another task was to organize side-by-side demonstrations of the standard method of cooking next to one of our stoves."

Refugees in the camps typically use a "three-stone" fire. Wood burns in the space formed by three stones arranged in a triangle, and the stones support a pot over the fire.

Cooking the main part of the meal involves bringing to a boil a thin mixture of water and flour. The flour is a mix of sorghum, millet, wheat, and corn, supplied by the United Nations World Food Program. More flour is gradually added to the boiling mixture while it is on the fire until it forms a thickly cooked dough called assida. The stove must support the pot firmly enough to stand up to continuous, vigorous stirring of the very viscous dough.

After the dough is cooked, it is moved to the center of a large plate, and a previously prepared hot sauce, mulah, is poured around it. This sauce is made of fried vegetables including onions, tomatoes, meat or yogurt or both, plus spices and dry okra.

Gadgil and Galitsky had brought with them three different models of energy-efficient cookstoves, all of which were available off the shelf from commercial sources or could be manufactured easily in a light industrial setting. One of these designs was rejected early on because it could not stand up to the vigorous stirring.

To prove that the stoves could cook a typical meal using half or less of the amount of fuel needed for a three-stone fire, Gadgil and Galitsky arranged demonstrations with the help of aid workers and camp leaders.

"We laid out an equal number of same-weight bundles of wood in front of each stove," Gadgil explains. As the team cooked meals on both stoves, the audiences could see how much faster the wood bundles in front of the three-stone fire disappeared. "It was a dramatic way for them to understand they could achieve 50-percent savings; there was tremendous excitement during these demonstrations."

Invariably the demonstrations were greeted with enthusiasm and requests to make the stoves available immediately. At the second of two demonstrations in Kalma, 250 women attended along with 100 sheikhs, men with governing authority over family and clan groups. The leader of the entire camp made an appearance, even though he was running a fever and had to come from his sickbed, underscoring the high importance the refugees and their leaders attach to the matter of reducing the burden of fuel wood collection for the women.

Gadgil and Galitsky confirmed that women do virtually all of the cooking and fuel wood collection. Men do not leave the camps; they say that if they were found outside the camps, they would be killed by the Janjaweed raiders.

Figure. Women in a Darfur refugee camp attend a school

Fuel and food — the tragic trade-off

In the course of meeting with the camp inhabitants, Gadgil and Galitsky conducted systematic surveys with the help of translators. They traveled through the camps accompanied by the local sheikhs and aid group personnel, who provided them with credibility and ensured that interviews were conducted with appropriate introductions, exchange of formalities, and explanations of why the questions were being asked.

Continued Page 4

Mission to Darfur

Continued from Page 3

Figure: Areas near the Darfur camps are denuded of vegetation.

In North Darfur, Jacobs and Lee carried out a similar informal survey. Because there is no fuel wood left within walking distance of the North Darfur camps, aid agencies are planning to provide both fuel and food to refugee camps. The fuel situation is so desperate that trees are gone from much of the landscape, and refugees have dug out even woody root balls and residual tree stumps.

The situation is only slightly better in the south. The walking distance to fuel-wood collection areas had increased from two hours in late 2004 to three hours in late 2005. Clearly, the fuel situation in South Darfur camps is unsustainable.

Figure: Christina Galitsky prepares to demonstrate a cookstove.

"Over one-half of the women have stopped collecting fuel wood and are buying it now, in South Darfur," says Galitsky. "Others still collect fuel wood. Many families sell a fraction of their food ration to buy wood, but this food ration is already inadequate. Of the refugees interviewed in Otash Camp, 38 percent sell food for fuel, as did more than 80 percent in the northern camps. In Otash, almost 50 percent of the families we interviewed had missed meals, even though they had food, because they did not have fuel to cook their meal." She adds, "We estimate the stoves can save the equivalent of $150 in fuel wood per year for an average household of seven people."

Next steps — development and roll-out

Two stoves, one made of sheet metal and one of steel plate and cast iron, successfully passed the team's tests.

"We think that the sheet-metal stoves can be manufactured locally fairly easily at a cost of about 10 dollars," Galitsky says. (One U.S. dollar is worth about 230 dinars, the local currency.) "When we asked the refugees what price they would consider fair for these stoves, they answered 10 to 20 dollars."

The problem is that the camps have no metalworking capability. To establish local manufacturing there, aid agencies would either have to help build workshops in the camp or have stoves built in nearby towns. Nearby towns do have small metal shops capable of working sheet metal although there are no iron-casting facilities. Aid agencies are now considering establishing sheet-metal-working capabilities within the camps, which would help create a local economy and provide employment along with meeting the goal of making the stoves available.

Figure: A child in one the camps before a bundle of firewood gathered in the bush.

Continued on Page 12

Lighting it Right with Smart Dust

The next time you walk into a sunlit, empty meeting room or office, notice whether the lights are on. If the answer is yes, you might wonder why someone — or some automatic system — hasn't turned them off to save energy.

An inexpensive wireless system that can do just that is being developed by Lawrence Berkeley National Laboratory (Berkeley Lab) researchers collaborating with industry. This new lighting management network is made up of tiny wireless sensors called "motes." The system can dim electric lighting in response to daylight levels, can easily be retrofitted into existing lighting systems, and could save hundreds of millions of dollars annually in lighting energy costs.

Why Dim the Lights?

Lighting of commercial buildings in the United States currently consumes about 3.7 quadrillion British thermal units (Btus) of primary energy a year, equivalent to the output of more than 175 modern power plants. According to Berkeley Lab estimates, if buildings in the U.S. could automatically dim electric lights in daylit spaces, and building occupants could manually dim local lighting according to preference, the energy savings could amount to more than half a quadrillion Btus per year — about 14 percent of total annual energy use for lighting in commercial buildings.

However, the effective use of these strategies requires a smart-building infrastructure — properly located sensors to measure how much daylight is available in a room, lighting fixtures that can respond quickly and reliably to on-demand user control, automated systems with software-based control algorithms, and a network to tie all of these devices and systems together.

The Dust Networks mote shown here is part of a prototype lighting control system being tested to demonstrate wireless control of office fluorescent lighting for greater energy efficiency and occupant comfort.

First-Generation Daylighting Technology

The wireless lighting management solution that is being designed today is the second generation of lighting sensor and control technology. The first generation, which depends on a wired network, is just now on the verge of appearing in the marketplace, decades after scientists first recognized the large potential for saving energy by taking advantage of daylighting.

Francis Rubinstein, an EETD scientist, has been applying networking systems to daylighting and lighting control problems for years. Starting in 2000, Rubinstein's team of researchers at Berkeley Lab began developing an integrated-building equipment system (IBECS) to allow facilities managers to automatically control devices such as lighting in commercial buildings, using a computer workstation and a wired network.

The team developed a set of prototypes, including a digital interface for dimmable lighting fixtures, a light sensor, switches, and a user interface for controlling the network from a personal computer. Their research demonstrated that automated network control of lighting systems could be cost effective in new construction and major renovation projects where is it relatively easy and inexpensive to run the necessary wiring.

IBECS was recently expanded to allow control of off-the-shelf Digitally Addressable Lighting Interface (DALI) ballasts, which are available in the marketplace now. This enhancement of IBECS allows facilities engineers to customize control systems for their buildings using commercially available lighting products.

If advanced controls are to expand from the new construction and remodel market into the much larger existing-building market, control wiring would have to be eliminated altogether, and the effectiveness of wireless solutions would have to be demonstrated in real settings.

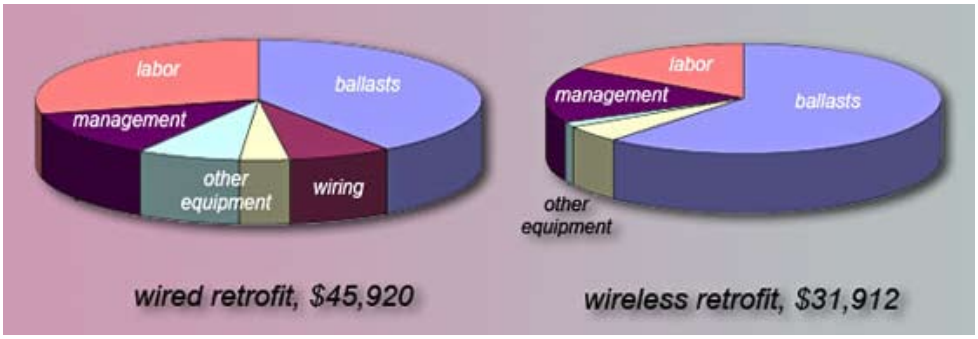
Dust Settles on the Problem

Rubinstein and David Watson of EETD have been working with Dana Teasdale of Dust Networks and Steve Purdy of ELB Electronics Inc. (formerly SVA Lighting Design) on a Department of Energy-funded research project to develop wireless networking technology that can effectively take advantage of daylight to reduce electric lighting energy use in buildings.

Continued on Page 6

Lighting it Right with Smart Dust

Continued from Page 5



A wireless network installation is estimated to cost 30 percent less than a wired network installation. Much of the savings is in labor (and there is no cost for wire).

"The reason we began looking at wireless technology for lighting control is that wiring and installation costs are barriers to deploying control systems in existing buildings," says Rubinstein. "Existing commercial buildings use over 95 percent of all electricity for lighting, but it is not cost effective to add control wiring to the ceiling to control lighting loads. To capture the energy savings possible from daylighting and other strategies in these buildings requires technology that is reliable and inexpensive enough to be retrofitted to commercial buildings."

Dust Networks provides a wireless mesh networking technology consisting of "smart motes," tiny sensors that create a low-power, connected network of sensors, control devices, computers and other related devices. The company was founded by in 2002 by a team including Kristofer Pister, a professor of electrical engineering and computer sciences at the University of California at Berkeley, who first coined the expression "smart dust" as a way of describing the tiny, expendable sensors that are used in the network.

Smart-mote technology is now finding its way into commercial and industrial applications for making buildings more comfortable, reducing energy costs, and optimizing materials and energy use in industrial processes. Wireless motes can be used in a wide variety of applications to control and monitor systems and processes. Researchers expect them to be widely used to enhance energy efficiency and environmental comfort in buildings once these products appear on the marketplace—which could be in just a few years.

Components for Smart Wireless Daylighting

The project team developed several components for lighting control using Dust Networks' SmartMesh™ technology. These include an analog control module and "mote-integrated dimmable ballasts" (MDBs), which will work in existing lighting systems.

The ballast is the unit in a fluorescent lighting system that provides power to the fluorescent tube at the proper frequency. Located in the lamp's housing, the ballast is a plain metal box containing electronic circuitry. Dimmable ballasts allow lights to be tuned continuously from full brightness to a very low level (usually about five percent of total brightness), to save electricity when less light is needed or to reduce lighting glare.

Berkeley Lab researchers worked with the lighting industry during the 1970s to develop and test the first electronic ballasts as replacements for the less-efficient magnetic versions that prevailed in the market at the time. Today, energy-efficient, nondimming electronic ballasts are common off-the-shelf products, accounting for a majority of the market share of fluorescent lighting ballasts.

Rubinstein's team built prototype MDBs, standard dimmable ballasts that embed Dust Networks' mote technology as an integral component. An antenna on the mote extends outside the fixture, allowing the building control system to communicate wirelessly with that particular mote.

No Wiring Makes the System Cheaper

With mote-embedded MDBs, no low-power wiring is needed, which reduces the cost of installing the control system and makes the technology easier to incorporate in existing buildings. Facilities staff can replace old ballasts with new MDBs over time, adding economical lighting-control capability to the building during routine maintenance.

The lights are controlled wirelessly by the motes, which receive instructions from Dust Networks' SmartMesh Manager, a single-board computer that connects the entire network of motes to a PC running lighting-control software.

"The cost of wiring in advanced lighting systems has traditionally been a major economic impediment to their widespread adoption. The use of wireless technology substantially reduces the installed cost of these systems," says Watson.

An Environmental Sensor Too

The research team has also developed a wireless environmental sensor that measures the lighting level in a room, tells whether the room is occupied or empty, and transmits this information to the control system through a mote. The multisensor version of this device also contains a temperature sensor to help manage the room's heating and cooling needs.

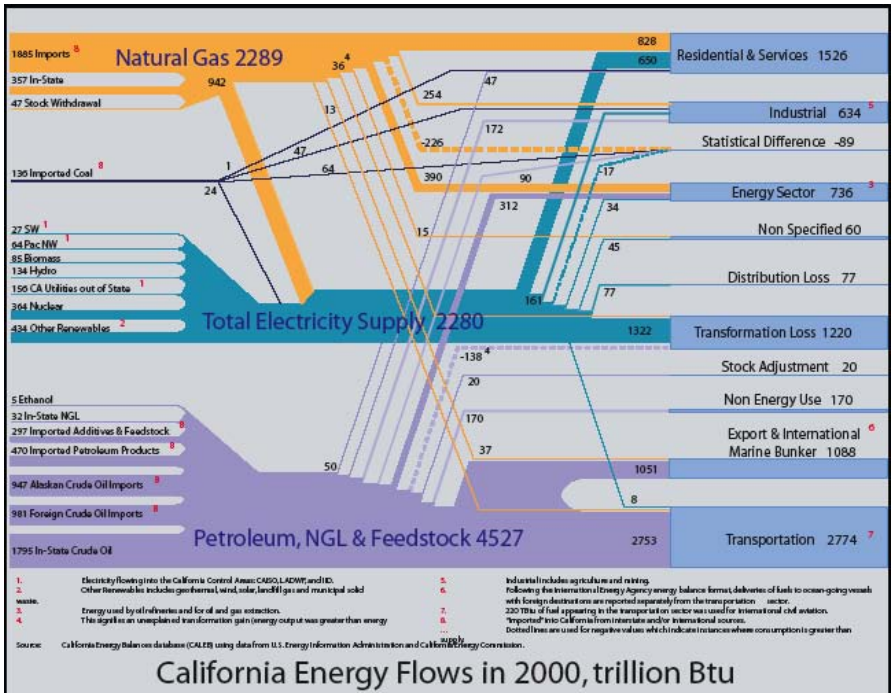
With the initial phase of technology development completed, the research team will now turn its attention to developing more advanced, second-generation systems and testing these devices in buildings.

Preliminary analysis of the costs and benefits indicates that installing the wireless control system in an existing 16,000-square-foot building costs about 30 percent less than installing a

Continued on Page 14

Balancing California's Energy

How much energy does the California economy use, how is the energy supplied, and what is it used for? For economic, environmental, and energy security reasons, many people are interested in the answers to these questions. The California Energy Commission (CEC) recently funded scientists in the Environmental Energy Technologies Division (EETD) at Lawrence Berkeley Laboratory (Berkeley Lab) to help find the answers. The results are the California Energy Balances Database (CALEB) and a report that features the California Energy flow chart as its centerpiece.



To download a PDF of this California Energy Balances Flow Chart, go to http://www.lbl.gov/Science-Articles/Archive/sabl/2005/November/06-cal-energy.html

To compare energy sources, researchers converted them all from the units in which they are typically expressed —e.g., kilowatt hours for electricity, therms for natural gas—to trillions of British thermal units (Btus).

One reason for the state's interest in these questions about energy use is that accurate energy consumption data are prerequisite to an accurate inventory of California's greenhouse gas emissions and emissions inventory is currently being conducted by the CEC. The data are also prerequisite to developing effective plans for reducing those emissions. California Governor Arnold Schwarzenegger recently issued an Executive Order requiring the state to develop such a plan.

This is not the first time that someone has looked at how California's energy supply is used. However, this comprehensive effort attempts to resolve gaps in our knowledge about energy flows. These gaps are a result of different methods of gathering statistics.

CALEB's data are largely based on statistics gathered by such agencies as the CEC, the U.S. Department of Energy's Energy Information Administration, the U.S. Geological Survey, and the California Air Resources Board. Because different counting methods can lead to slightly different results, it is essential to make data from these different sources compatible. For the EETD study, all the basic inputs — coal, petroleum, natural gas, nuclear, and renewable sources — had to equal all the outputs, plus losses caused by the basic physics of energy conversion and transmission.

The flow chart presented here is Berkeley Lab's answer to this problem. "We had to make sure there was no glaring inconsistency on the supply side compared to the figures the state is using on the demand side," says Scott Murtishaw, primary author of the study.

The sizes of the colored bars in the chart and where they start and end reveal a lot about energy in California. A quick look at the chart confirms some expected results and yields some surprises.

One fact that's not surprising is that in a state with so many motor vehicles (nearly 30 million registrations, of which more than 18 million are automobiles), petroleum and miniscule amounts of other transportation fuels, mainly ethanol and natural gas, account for half of the state's total energy use.

What may be surprising, however, is how much of that is figure is accounted for by marine bunker fuel, used by maritime vessels—just under one-fourth of the petroleum input. "That's a consequence of having three of the United States' largest ports [Long Beach, Los Angeles, and Oakland] in California," Murtishaw points out.

Another interesting observation is that burning of natural gas provides a substantial amount of electricity in California. This is shown by the yellow bar at the top of the chart, which branches out and merges into the blue "Total Electricity Supply" bar that goes from left to right.

Continued on Page 12

Cost to Reduce Carbon Emissions in Developing World Higher than in Indsutrial Nations

Knowing the costs of reducing carbon emissions from power plants and other sources is crucial to calculating the overall costs of mitigating climate change. Previous calculations used by the Intergovernmental Panel on Climate Change (IPCC), the United Nations-sponsored organization that studies the issue, suggested that reducing carbon emissions in the developing world was cheaper than reducing them in the industrial world.

A new study by researchers at the Environmental Energy Technologies Division (EETD) at Lawrence Berkeley National Laboratory (Berkeley Lab) suggests the opposite. The study, published in the journal *Energy Policy*, looked at the cost of replacing electric power generation from coal-fired plants with generation from lower-emission combined-cycle gas turbines that use liquid natural gas (LNG) as the fuel source. The study compared the costs for this replacement in India and in the U.S.

Figure. An example of a combined cycle gas turbine project in Assam, India.

Jayant Sathaye, leader of EETD's International Energy Studies Group, primary author of the study says, "The IPCC's Third Assessment Report assumed that reducing the cost of carbon emissions would decline with the increase in global emissions trading, which allows large-emitting nations to buy carbon credits from smaller emitters. This decline assumes that it costs less to reduce emissions in developing countries. We tested this assumption by comparing the costs in India and the U.S. of a common type of carbon reduction project: building cleaner combined-cycle gas turbines in place of coal-burning plants."

Knowing the costs, according to Sathaye, helps us determine where the least-expensive reductions in emissions are likely to come from and what strategies can maximize those reductions at the lowest cost.

Developing Interest in Gas Turbines

"Indian power generators and the Indian government have shown considerable interest in building new gas turbine plants," says Sathaye. "Because reserves of natural gas in India are thought to be modest, we assumed that these plants would be fueled with imported liquefied natural gas."

Sathaye and Amol Phadke of the University of California, Berkeley, compared the capital costs of power plants and equipment as well as fuel and operations and maintenance costs in the two countries. They also analyzed the sensitivity of total cost of electricity generation to changes in each of these components and studied the changes in cost between new and mature markets.

Gas Turbines More Expensive in India

"Our conclusion is that the cost of carbon emissions reduction from fuel switching in the electric power sector is higher in India than in the U.S., and each major component of cost is higher in India," says Sathaye. The study shows that capital, fuel, and other costs of Indian coal plants differ only slightly from the costs in comparable U.S. plants, but the costs of all components are higher for combined-cycle units in India. Therefore, the cost of shifting electricity production from coal to gas turbines would be higher in India than in the U.S.

"We believe that this conclusion is true not only for India but for other developing countries," says Sathaye. "Capital costs of combined-cycle gas turbines are reported to be higher in many developing countries, and this may translate to higher generation costs, depending on whether the natural gas is available in country or has to be imported."

The paper, which appears in the September 2005 issue of *Energy Policy*, is titled "Cost and carbon emissions of coal and combined cycle power plants in India: Implications for costs of climate mitigation projects in a nascent market," by Jayant Sathaye and Amol Phadke.

—Allan Chen

For more information, contact:

Jayant Sathaye
(510) 486-6294; Fax (510) 486-6996
JASathaye@lbl.gov

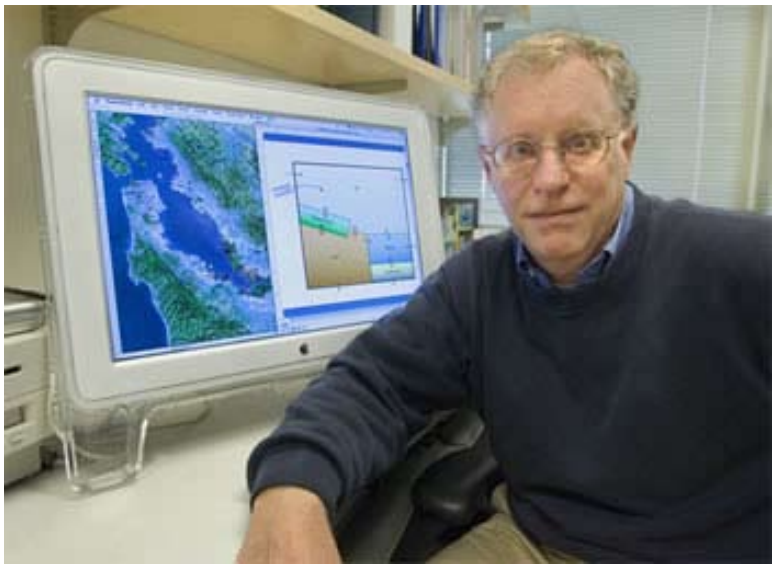
This research was supported by the U.S. Environmental Protection Agency.

Gold Rush Still Haunts San Francisco Bay

More than 150 years ago, California's Sierra Nevada foothills echoed with the jubilant cry, "There's gold in them thar hills!" Today, those words have morphed into a more subdued but equally urgent warning: there's mercury in the San Francisco Bay, and it isn't going anywhere soon.

The lingering problem dates back to the Gold Rush, when miners used mercury by the wagon load to extract gold flecks from sediment. This toxic legacy is still finding its way into tributaries that feed the San Francisco Bay. How long it remains in the Bay once it arrives has been difficult to pin down, but an innovative new study indicates that it takes as long as 50 years for the Bay's mercury concentrations to respond to changes in input.

"The good news is the San Francisco Bay is getting cleaner; the bad news is it will take a long time to flush mercury out of the system," says Tom McKone, a staff scientist in Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (EETD) and an Adjunct Professor at UC Berkeley's School of Public Health. He collaborated with former Berkeley Lab scientist Matthew MacLeod and Donald Mackay of Canada's Trent University on the study, which appears in a recent issue of the journal *Environmental Science & Technology*.



Tom McKone and his colleagues devised a mass-balance model to account for how mercury reacts with air, soil, vegetation, water, and sediment. (Photo Roy Kaltschmidt)

"Our work also demonstrates that we have to live with the messes we make for a long time. It's been 150 years since the Gold Rush, and we're still paying for it," says Mckone.

For the past several years, McKone and his colleagues have developed ways to model the ebb and flow of harmful chemicals such as polychlorinated biphenyls (PCBs) and pesticides across large regions of North America. They track a chemical's movement and accumulation by taking into account the chemical's ability to reach equilibrium with a region's soil, water, air, and vegetation. These chemical mass-balance models allow the scientists to determine the extent to which a harmful chemical is absorbed into the environment, and how much is free to ride the winds and currents to other regions.

The team's San Francisco Bay research began as part of a UC Berkeley Superfund Basic Research Program project to develop methods for reconstructing historical exposures to metals in estuaries. They turned their attention to mercury after meeting with scientists from the San Francisco Estuary Institute, which, along with several regulatory agencies, is working to understand and resolve this longstanding problem.

Mercury, however, is especially challenging to model because it readily converts among three different species, each of which reacts with the environment in a different way. There's elemental mercury, which is the volatile liquid metal used by the 49'ers, who called it liquid silver. There's salt-like divalent mercury. And there's organic or methyl mercury, which is a potent neurotoxin that is known to be detrimental to developing fetuses and young children. It is passed from prey to predator along the food chain, which is why the California Office of Environmental Health Hazard Assessment issues fish consumption advisories for the San Francisco Bay.

"You can pick any part of the environment — water, air, and soil — and find all three mercury species in some kind of chemical balance," says McKone.

Modeling these permutations in the San Francisco Bay area is especially difficult because the region represents the largest estuary on the West Coast, encompassing roughly 1,600 square miles of central California and draining almost one-half the land area of California. Complicating matters, the bay is composed of a north and south estuary, with a huge flux of water moving through each system. Every year, an estimated 2,450 million kilograms of sediment enter the Bay, some of which is deposited in the bay and some of which exits the Golden Gate.

Continued on Page 10

Gold Rush Still Haunts San Francisco Bay

Continued from Page 9

Mining devastated California's environment in the 1850s; its toxic effects persist.

To track the behavior of this constantly changing toxin in a large and dynamic body of water, the team started with a mass balance model that accounts for how the three mercury species react with the region's air, soil, vegetation, water, and sediment. Based on previous research, they also assumed that mercury exits the San Francisco Bay via the Golden Gate at a rate that is slower than its conversion rate among the three different species. This allowed them to assume a constant ratio among the three species in each type of environmental medium (air, soil, etc.).

They applied this model to the entire Bay Area, extending as far east as the Carquinez Strait, where the Sacramento and San Joaquin rivers empty into the bay. The resulting mass-balance calculations revealed that continental and global background levels of mercury are largely responsible for the Bay Area's airborne mercury concentrations. But they found a much more localized source of mercury in the waters of the San Francisco Bay: contaminated sediments from long-ago mining activities. In addition, they determined that it takes decades for the bay's mercury concentrations to respond to changes.

"If we alter the amount of mercury that enters the bay, it doesn't reach a new equilibrium until about 50 years later," says McKone. "We are learning that it takes a long time to clean up the bay. Unfortunately, the upstream input of mercury is very large and will remain large for a long time."

That's because California is littered with thousands of defunct mercury mines that date back to between 1850 and 1900 when miners used mercury-lined sluices to capture tiny grains of gold from sediment. Over the years, tailings from the mercury mines that supplied this process leached into the watershed and eventually into the San Francisco Bay. These mines have been largely cleaned up and no longer pose a threat to the environment, but the mercury they released is still cycling through the sediment carried by the Sacramento and San Joaquin rivers.

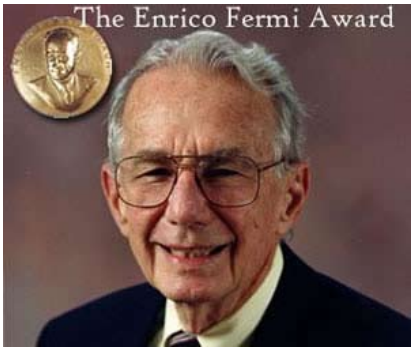
"Gold mining was really hard on California's environment, and the harm remains apparent even now," says McKone. "But we are using the mistakes of the past to learn more about the life cycles of persistent chemicals in the bay, and to learn how to protect the bay for the future."

—Dan Krotz

Continued on Page 14

Rosenfeld Wins Fermi Award

Arthur Rosenfeld, 80, acclaimed high-energy physicist turned energy-conservation savant, veteran researcher/educator for Lawrence Berkeley National Laboratory (Berkeley Lab) and the University of California at Berkeley, and two-time appointee to the California Energy Commission, has won the Enrico Fermi Award, the nation's oldest and most prestigious awards for scientific achievement. Administered by the U.S. Department of Energy (DOE) on behalf of the White House, this presidential award carries an honorarium of $375,000 and a gold medal. In winning the Fermi Award, Rosenfeld joins an august pantheon of other Berkeley recipients that includes Ernest and John Lawrence, Robert Oppenheimer, Glenn Seaborg, Martin Kamen, and Luis Alvarez.



"Art Rosenfeld is our 'poster child' of a scientist who moved from a thriving career in basic research in order to address a problem of immediate national need," said Berkeley Lab director Steven Chu. "He embodies the finest spirit of scientific inquiry applied to solving real-world problems. Besides being the founder of Berkeley Lab's highly regarded environmental energy technologies program, he moved on to become a senior advisor at the Department of Energy and, today, a member of the California Energy Commission. He was personally responsible for saving this country billions of dollars in energy costs since the 1970s through his work on the frontiers of energy analysis, standards, and technologies. In Sacramento, he has led the transformation of this state's policy framework to energy efficiency, with dramatic results."

Chu added that, on this 75th Anniversary of Berkeley Lab's founding, it is appropriate to honor someone of the stature of Rosenfeld "whose achievements have brought distinction to our institution and pride to our profession."

In his announcement of the award, Secretary of Energy Samuel Bodman said, "Dr. Rosenfeld's career provides an example of the breadth of science — from the fundamental to the practical — that the Department of Energy supports. Dr. Rosenfeld is one of the founding fathers of energy efficiency, and the legacy of his research and policy work is an entire new energy-efficiency sector of our economy, which now yields an astounding annual savings of around $100 billion and growing."

The Enrico Fermi Award honors the late great Nobel laureate who designed and built the first nuclear reactor and led the epochal experiment that demonstrated the first self-sustained nuclear chain reaction. Rosenfeld was a graduate student of Fermi's at the University of Chicago, where Rosenfeld received his Ph.D. in physics in 1954. Rosenfeld joined the UC Berkeley physics department the following year and became a staff scientist at Berkeley Lab (then known as the "Rad Lab"). He became a protégé of the Nobel laureate (who has also received a Fermi Award) Luis Alvarez. As a member of Alvarez's particle physics group, Rosenfeld played a key role in the development of the bubble chambers used to analyze the data coming out of "atom smashers," as particle accelerators were called back then. Rosenfeld would go on to assume the leadership of Alvarez's group.

In October of 1973, the Organization of Petroleum-Exporting Countries (OPEC) oil embargo hit, resulting in huge lines of cars at the gas pumps and a thrashed U.S. economy. Rosenfeld was quick to realize that the best long-term solution to the crisis was for the U.S. to stop wasting so much energy. He helped organize a month-long workshop at Princeton University that drew top scientists and engineers who were experts on energy and utilities, transportation, and building design and utilization. The building sector consumes one-third of the primary energy and two-thirds of the electricity used in the U.S. each year.

Speaking about that workshop, Rosenfeld once said: "We realized we had found one of the world's largest oil and gas fields. The energy was buried, in effect, in the buildings of our cities, the vehicles on our roads, and the machines in our factories. A few of us began to suspect that the knowledge we gained during that month would change our lives."

In 1975, he founded the Center for Building Science at Berkeley Lab where over the next 20 years a broad range of energy efficiency technologies was developed, including electronic ballasts that led to compact fluorescent lamps, and low-emissivity "Smart windows," which have a coating that allows light in but blocks heat from either entering (in summer) or escaping (in winter).

As an energy scientist, Rosenfeld is perhaps best known for his role in developing the DOE-2 whole building simulation program, which continues to serve as the international benchmark for energy-efficiency simulation codes; and for his start-up of the cool surfaces and heat islands research programs,

Continued on Page 14

Mission to Darfur

Continued from Page 4

"One of the next steps," Gadgil says, "is to raise money to fine-tune the sheet-metal stove for Darfur. Its performance degraded in breezes, so it needs adequate wind shielding. Darfur is a windy place, and people cook outside about half the time." The stove also needs minor changes to offer more sturdy support to the pots for making the doughy assida.

The Berkeley Lab team and its supporters are planning a program to get the cookstoves into the hands of refugees. In the next phase of the work, they recommend a roll-out of 50 stoves, with which families will cook for a month. During this phase, the team will determine what works and what doesn't technically. The follow-up phase now being planned by aid agencies would involve selling up to 500 stoves to families and establishing metal workshops.

"We are in strong agreement with the aid organizations that the stoves are not to be given away for free," says Gadgil. "If free, they will be undervalued. They could be sold for scrap or otherwise used inappropriately." Microlending programs could help ease the financial burden of buying the stoves. For example, a revolving fund within the community could finance the purchase of more stoves as loans for earlier purchases are paid off and could also support development of stove-building skills and entrepreneurship.

"The educational component of the program will be important to [the program's] success," says Galitsky. "We were present and running the stoves during our demonstrations, showing audiences how to operate the new stoves. Even though the operation is extremely simple, an overstuffed woodstove will still consume all of the overstuffed wood. Educating the refugees needs to be replicated during the roll-out."

Gadgil says, "This is a Band-Aid, not a fundamental solution to the problem, but this is what we can do. We are trying to tap into the existing knowledge, to see if we can make a substantial difference, to reduce the misery in Darfur. Before we went, we weren't sure if we could, given what was happening there. But we have now shown that we can make a difference."

—Allan Chen

http://www.lbl.gov/Science-Articles/Archive/sabl/2006/Mar/01-Darfur.html

Balancing California's Energy

Continued from Page 7

"This large dependency means that a rise in natural gas prices will not only affect winter heating bills but electricity prices as well," says Murtishaw.

Also worth noting is that, for reasons of basic physics, large energy losses result when fuel input is converted to electricity, for example by burning coal or gas. This is evident in the light blue bar on the center-right labeled "Transformation Loss." At an estimated 2,280 trillion Btus, transformation losses represent more than half of the total electricity supply. Consumers don't get to use the lost energy, but they still pay for it in the sense that the cost of building power plants is embodied in the utility rate structure, and laws of physics limit the efficiency of energy conversion in these power plants.

There are still some statistical uncertainties, indicated by flows into the "Statistical Differences" box. Negative numbers indicate instances where consumption appears to be greater than supply, for example in petroleum and natural gas use. These uncertainties need to be researched further.

Some features of California's energy balance are only evident in comparison to energy use in other states. For example, California's mild climate means that less energy is used for space heating in the winter than is true in colder states. The bar on the top right labeled "Residential and Services" is proportionally smaller than it would be for a state with harsh, cold winters. And because California, relative to Midwestern states for example, does not have much energy-intensive heavy industry such as steel, concrete, or aluminum manufacturing, the "Industrial" energy bar is also proportionately smaller.

Murtishaw notes that the bar representing energy from "CA Utilities Out of State" in the far left center of the chart, although small, is interesting. "California investor-owned utilities are among the few that own large out-of-state power plants," he says.

The study, "Development of Energy Balances for the State of California," was prepared by Scott Murtishaw, Lynn Price, Stephane de la Rue du Can, Eric Masanet, Ernst Worrell, and Jayant Sathaye.

—Allan Chen

For more information, contact:

Scott Murtishaw
(510) 486-7553; Fax (510) 486-6996
SGMurtishaw@lbl.gov

Download the study from:
http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-068.html

This research was supported by the California Energy Commission's Public Interest Energy Research program.

A Visit to China

China's rapidly growing economy, its need to meet mounting energy demand, and its increasing greenhouse gas emissions have raised interest in energy efficiency among Chinese government officials. In November 2005, Environmental Energy Technologies Division (EETD) Director Mark Levine and several other EETD members accompanied Lawrence Berkeley National Laboratory (Berkeley Lab) Director Steven Chu on a week-long visit to China to discuss energy efficiency.

Levine is a frequent visitor to China. In addition to his responsibilities as EETD Director, he leads EETD's China Energy Group and advises the Chinese government on how to increase the role of energy efficiency in China's economy. The EETD staff members who accompanied Chu and Levine were Lynn Price, Nan Zhou, Nathaniel Aden, and Joe Huang.

The purpose of the first meeting with Chinese scientists and researchers was to discuss the current state of sustainable energy technology development in China as part of an InterAcademy Council study of how the world can make a transition to carbon-neutral, sustainable energy systems that Director Chu is co-leading with Jose Goldemberg of Brazil. Topics for discussion included energy energy-efficient technologies, renewable energy sources, and carbon-neutral energy sources.

"We spent two days in discussions with the Chinese on energy technologies," says Levine. "These were discussions, not presentations, so it was possible to get some insight into their perceptions of the issues with these technologies."

Levine also participated in three days of meetings with the Energy Foundation's China Sustainable Energy Program, an annual event. "The program is a unique one; it funds Chinese, U.S., and European energy analysts to study energy efficiency and renewable energy policy in China. I helped create this program, and we receive some funding from it for our own research," says Levine.

Chu delivered a talk on optimizing clean and efficient energy technologies, Levine spoke on the need to dramatically increase energy efficiency investment in

Continued on Page 14

Figure. Left to right: EETD's Lynn Price and Nate Aden, EET Division Director Mark Levine, Berkeley Lab Director Steven Chu, EETD's Joe Huang, Vice President, Energy Foundation Yang Fuqiang, and EETD's Nan Zhou.

Lighting it Right with Smart Dust

Continued from Page 6

comparable wired system. The wireless system will pay for itself in three years.

If tests of the wireless technology in buildings prove successful, energy management and control in buildings will join the wireless revolution, and the marketplace will have a new wireless solution for saving energy in commercial buildings.

—Allan Chen

For more information contact:

Francis Rubinstein
(510) 486-4096; Fax (510) 486-4089
FMRubinstein@lbl.gov

David Watson
(510) 486-5562; Fax (510) 486-4089
DSWatson@lbl.gov

This research was sponsored by the California Energy Commission's Public Interest Energy Research program.

http://www.lbl.gov/Science-Articles/Archive/sabl/2006/Jan/06-smart-dust.html

http://www.lbl.gov/Science-Articles/Archive/sb-EETD-internet-controls.html

http://www.dust-inc.com/flash-index.shtml

http://lighting.lbl.gov/l_controls.html

Rosenfeld Wins Fermi Award

Continued from Page 11

which are credited with yielding energy savings and reducing air pollution.

In 1994, he left Berkeley to become the senior advisor to DOE's Assistant Secretary for Energy Efficiency and Renewable Energy. He also served on President Clinton's National Science and Technology Council. In 2000, he was appointed to the California Energy Commission by Governor Gray Davis; he was reappointed in 2005 by Governor Arnold Schwarzenegger on January 26, 2005. As a Commissioner, Rosenfeld has worked with the California Public Utilities Commission to institute time-dependent prices for electricity and "smart meters" to record electricity use hour by hour.

For more information:

The Fermi Award press release:
http://www.energy.gov/news/3553.htm

More about Arthur Rosenfeld:
http://www.energy.ca.gov/commission/commissioners/rosenfeld.html

A Visit to China

Continued from Page 13

China, and Lynn Price spoke on international best practices related to environmental policies for industry. They were on the program with former President George Bush and California Governor Arnold Schwarzenegger; Schwarzenegger was there to establish closer trade relations between China and California.

Levine found the Energy Foundation meeting valuable, explaining that, "We had a chance to engage the Ministry of Finance in energy issues; this is typically difficult to do under normal circumstances. Many representatives of the Ministry of Finance at this meeting were showing an interest in energy and energy efficiency as a way to help meet some of China's energy goals. This is crucial at the present time as energy demand has been outstripping economic growth for the past several years after 20 years of significant success for energy efficiency."

Levine notes that "both sets of meetings help us further goals that we have in our China Energy Group, to point out to the Chinese government where there might be problems right now in energy-efficiency investment and how they might be corrected. These meetings also help meet lab goals because they will help the world achieve a transition to a sustainable energy society; improving energy efficiency in China is an essential ingredient in meeting this goal."

—Allan Chen

For more information contact:

Lynn Price
(510) 486-6519; Fax (510) 486-6996
LKPrice@lbl.gov
http://industrial-energy.lbl.gov
http://china.lbl.gov/

China Sustainable Energy Program:
http://www.efchina.org/

InterAcademy Council:
http://www.interacademycouncil.net/

Gold Rush Still Haunts San Francisco Bay

Continued from Page 10

For more information contact:

Thomas McKone
(510) 486-6163; Fax (510) 486-6658
TEMcKone@lbl.gov

Research Highlights

Contamination Control Technology

Environmental Energies Technology Division staff member Dr. Tengfang (Tim) Xu was quoted recently in *CleanRooms Magazine* as saying, "Broader participation is needed within contamination-control industry to aid in the process of developing recommended practices (RPs). In addition to professionals, we're looking for people representative of the entire user community including pharmaceuticals, biotech, semiconductor, as well as healthcare facilities."

Xu, technical vice president of the Institute of Environmental Sciences & Technology (IEST) Contamination Control Division, sees healthcare facility requirements, in particular, as an area that is underexplored, and he encourages both current IEST members and anyone considering joining the association to become active in working group meetings and in helping to develop the RPs.

Since being elected to the IEST post in July 2004, Xu says he's given particular attention to the need to expand and facilitate the RP development process. "Sometimes the process has tended to be slow, in some cases taking a decade or more to develop a document. The goal is to establish a routine of bringing revised RP versions forward every three years." Anyone interested in joining an IEST working group or obtaining more information about IEST can visit the organization's website at www.iest.org.

—Julia Alter

For more information:

Tim Xu, TTXu@lbl.gov, (510) 486-7810

Traffic Physics

The physics of traffic safety is the subject of an article in the January 2006 issue of *Physics Today*. Authored by Tom Wenzel of the Environmental Energy Technologies Division along with Marc Ross and Deena Patel of the University of Michigan Physics Department, "Vehicle Design and the Physics of Traffic Safety" examines how cars, light trucks, and sport utility vehicles might be re-engineered to share the road safely with other vehicles.

Benner Award goes to Mary Ann Piette

At the 8th Annual Benner Awards in San Francisco this spring, The National Conference on Building Commissioning presented the Benner Award to Mary Ann Piette, Staff Scientist and Deputy Leader of EETD's Commercial Building Systems Group, and the Research Director of the Demand Response Research Center.

The Benner Award (named in memory of Nancy Benner), recognizes outstanding achievement in making building commissioning "business as usual." Benner Award recipients are selected by a committee of national experts on building commissioning from both the public and private sector.

EETD, Jordanians Sign Energy MOU

The Environmental Energy Technologies Division hosted an official delegation of Jordanian energy leaders at the request of the State Department in April. The four-person delegation met with researchers to discuss energy efficiency standards and labeling programs, water, demand response, cool color roof technology, and industrial energy efficiency. They toured the Advanced Windows Test Facility and the Advanced Light Source. Pictured above, Division Director Mark Levine (right) signed a Memorandum of Understanding with Malek Kabariti, president of Jordan's National Energy Research Center, to explore cooperative research and training programs in energy and water efficiency.

Environmental Energy Technologies Division News — **Lawrence Berkeley National Laboratory**

Published Quarterly
Vol. 6, No. 4

Sources

DOE's Consumer Information Fact Sheets
These fact sheets provide information about energy efficiency and renewable energy for your home or small business.
http://www.eere.energy.gov/redirects/consumerinfo.html

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/

Office of Science, U.S. DOE
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.

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 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.

Ordering Information

EETD News
Lawrence Berkeley National Laboratory
University of California

Tel: (510) 486-4835
Fax: (510) 486-5394
Email: JMLambert@lbl.gov

LBNL/PUB-821 Vol. 6. No. 4,
Summer 2006

The current and all past issues of EETD News are available on the World Wide Web at:
http://eetd.lbl.gov/newsletter/.

Sign up for an "e-mail" subscription and get on our Electronic Notification list. You will receive e-mail four times each year when a new issue is available:
http://eetd2.lbl.gov/sub/form_mail.php/

Readers are free to reprint or otherwise reproduce articles at no charge, with proper attribution to the Environmental Energy Technologies Division News. Download text and graphics from:
http://eetd.lbl.gov/newsletter/