LAWRENCE BERKELEY NATIONAL LABORATORY

FALL 2006
VOLUME 7 NUMBER 1

Environmental Energy Technologies Division NEWS

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

Energy-Efficient Direct-Current Powering Technology

Reduces Energy Use in Data Centers By Up to 20 Percent

Figure 1. Flywheel uninterruptible power supply (UPS)

Researchers in the Lawrence Berkeley National Laboratory (Berkeley Lab) Environmental Energy Technologies Division (EETD) have teamed with Silicon Valley giants, including Sun Microsystems, Intel, and Cisco, to demonstrate technologies that could save billions of dollars a year in data center energy costs as well as improve data center reliability and lengthen equipment life. The demonstration took place this summer at a test facility at Sun Microsystems in Newark, CA. More than 20 high-technology companies participated.

Eliminating power conversion losses by using direct current (DC) instead of alternating current (AC) from the electricity grid to power data centers can trim energy use by an estimated 10 to 20 percent. Preliminary measurements from the Newark demonstration center are consistent with this estimate. Figure 1 through 5 show a selection of technologies that were on view.

The Berkeley Lab team of William Tschudi and Evan Mills, conceived the project and oversaw the demonstration's planning and design, which is being executed by private-sector firms ECOS Consulting and EPRI Solutions under a contract with Berkeley Lab. The partner companies provided technical advice, equipment, and staff to set up the demonstration at Sun Microsystems' Newark, CA facility, which was open to interested parties from June through August. The California Energy Commission's Public Interest Energy Research (PIER) program sponsored the project.

Growing Energy Use in Data Centers

Data centers are the backbone of the internet, providing data storage for websites and databases accessible over the World Wide Web and supporting virtually every large private corporation and institution.

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Data center managers say that the rapid growth in their power and cooling requirements as well as electricity costs have become significant concerns.

Data centers typically operate 24 hours a day, seven days a week. According to a recent report published by Berkeley Lab ("High-Tech Means High Efficiency"), SEMATECH and other industry-leading data centers have among the highest density of energy-consuming equipment of any modern building.

"They can use 100 times the electricity of a typical office building on a square-foot basis," says Tschudi, EETD's principal investigator for this project. "Energy costs of $1 million per month are not uncommon in large data centers that require megawatts of electricity."

Factors such as the rapid growth of the web, the increase in use of networks to help geographically dispersed teams, and increases in server power have led to rapid growth in data centers and their energy use. Facilities managers, corporate information services departments, and internet service providers are searching for ways to reduce energy costs.

"We're excited to be able to demonstrate and evaluate the efficiency merits of two different data center DC-power-delivery approaches and expect our results can inform data center operators, facility designers, and this global industry regarding efficient options for future designs," says My Ton of ECOS Consulting.

DC Power Increases Efficiency and Enhances Reliability

A number of strategies are increasingly being used by data center facilities managers to decrease their electricity consumption. These include optimizing airflows to get the most out of cooling systems, upgrading the energy efficiency of cooling systems, or shifting to liquid cooling.

Figure 2. Servers modified to accept 380V DC

Using DC power is a complementary strategy for improving energy efficiency. In a typical data center, the redundant power distribution system provides 480-volt AC power through an uninterruptable power supply (UPS) and then to a transformer, which then steps it down to 208-volt AC at a power distribution unit (PDU) to feed racks of servers. Within the UPS system, the 480 volt AC is converted to DC and charges batteries and then is converted back to 480 volt DC.

Individual power supplies (typically redundant) within each server convert the 208-volt AC into a voltage appropriate for the unit's needs. These individual supplies are often inefficient, generating substantial heat that the room's air conditioning system must remove at great expense. This heat can also limit the number of servers that can be housed in a data center and can jeopardize data center reliability if not handled properly.

Some servers on the market operate on DC power, typically 48 volts DC, which is the standard in the telecommunications industry. The Newark, CA demonstration shows that a DC-powered data center can skip the conversion from DC power

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Figure 3. AC and DC distribution systems in side-by-side comparison

Laser Ultrasonic Stiffness Sensor Wins R&D 100

R&D Magazine has bestowed four of its prestigious R&D 100 Awards for 2006 on researchers at Lawrence Berkeley National Laboratory and their colleagues. One award went to the laser ultrasonic stiffness sensor (LUS), developed by Rick Russo and Paul Ridgway (Figure 1) of the Environmental Energy Technologies Division (EETD) along with colleagues Emmanuel Lafond, Chuck Habeger, and Ted Jackson of Georgia Tech's Institute of Paper Science and Technology. The R&D 100 awards honor the magazine's choices for the 100 most significant proven technological advances of the year.

Figure 1. The Berkeley Lab's Laser Ultrasonic Sensor team — Paul Ridgway (left) and Rick Russo (right)

The LUS will substantially improve the cost effectiveness and efficiency of paper manufacturing (Figure 2). Paper is often engineered to exceed minimum stiffness specifications. This results in the use of more raw materials, chemicals and energy than necessary to produce the end product.

In some cases, process engineers manually test each three-ton paper roll after it has been made and reject and discard the whole roll if doesn't meet specifications. The LUS reduces waste on the manufacturing line by measuring the stiffness of 30 meters of paper per second without touching the product. The LUS works by measuring the speed of laser-induced ultrasonic waves in the sheet.

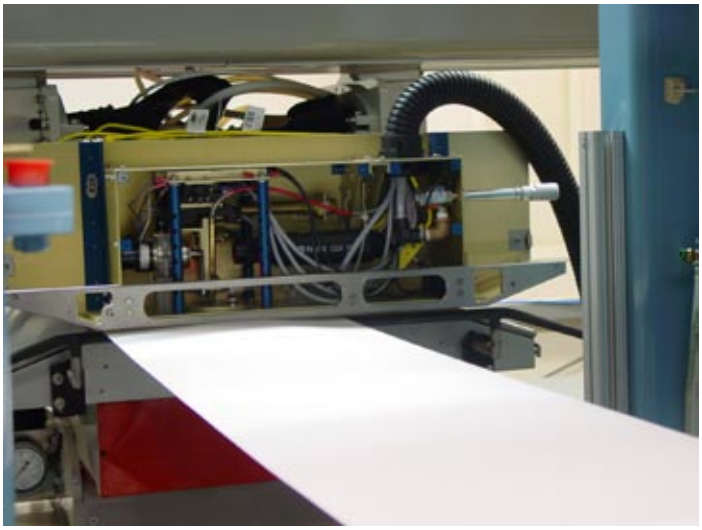

Figure 2. The Laser Ultrasonic Sensor

A detection beam is reflected from a rotating mirror in a circular pattern, briefly traveling with the paper as it courses along the production belt. When the beam is perpendicular to the paper, a laser fires a nanosecond pulse that causes a microscopic thermal expansion, too small to mar the paper or affect how it absorbs ink but strong enough to send ultrasonic waves through the sheet. The waves propagate until they're registered by the detection beam. The velocity at which the ultrasound waves travel from the excitation point through the paper to the detection point is related to two elastic properties of importance in paper and other sheet materials: flexural rigidity (or bending stiffness) and out-of-plane shear rigidity.

Flexural rigidity is a property that is of great importance to a wide variety of paper grades. For example, flimsy paper will jam in copiers and printers. Shear rigidity is important in packaging grades because it strongly influences downstream operations such as fluting, scoring, creasing and bending.

Software developed as a part of this project analyzes the LUS signals in real time to measure the flexural rigidity in lightweight papers, and the flexural rigidity and shear rigidity in heavier paperboard grades.

A significant advantage of the LUS is that it does not require any contact with the paper, so it does not

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directly to the servers. The DC demonstration system converts high-voltage AC directly into high-voltage DC power; the high-voltage DC is stepped down to low voltage within the information technology equipment. By skipping conversion steps, this approach can save 20 percent or more of overall electricity use.

However, the idea of substituting DC power for conventional AC power has not yet made significant inroads into many data centers because the technology is unfamiliar to many facilities engineers and standardization of distribution voltage and DC connectors would be needed. The industry is reluctant to switch to new technologies without field experience showing that the switch can be done safely and produce operational and economic benefits.

Figure 4. DC connectors need to be standardized similar to AC connectors.

The Applications Team Steps In

The Applications Team (A-Team) is an EETD group that tackles demonstration projects involving advanced, energy-efficient technologies that are not yet mainstream in the marketplace. The group targets technologies that have great energy-efficiency potential and other advantages (e.g., improved comfort or safety, lower maintenance and operating costs) but need field testing or demonstration under real conditions to prove the benefits to users. DC-powered data centers were an ideal project for the A-Team.

"This project is meant to show that energy savings are possible by minimizing energy conversions within the data center and its equipment. Many well known companies have been involved, including vendors who are eager to sell DC technology solutions to the marketplace," says Tschudi.

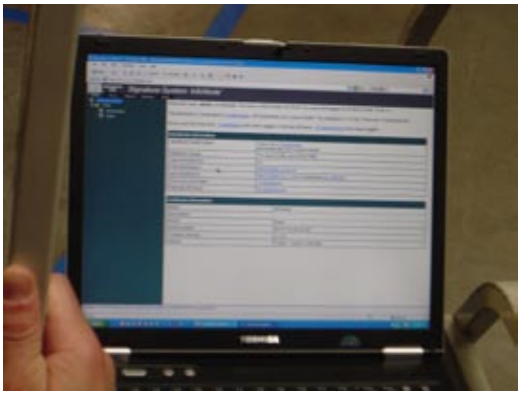

Figure 5. On-line monitoring of energy performance.

All of the demonstration DC equipment was loaned by the manufacturers. This project is actually two demonstrations: one shows off DC architecture at a facility level, distributing 380 volts DC, and the other converts to 380 volts DC within the rack of servers.

The industry participants and the California Energy Commission have formed a stakeholder group that evaluated the results of the demonstration, provided a summary of energy savings, and compared the performances of DC-powered and conventional data centers. This group is working to standardize distribution voltages and DC connectors to enable the technology to become adopted.

—Allan Chen

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http://hightech.lbl.gov/dc-powering/about.html
http://hightech.lbl.gov/datacenters.html
http://hightech.lbl.gov/dc-powering/videos.html

Download "High Tech Means High Efficiency" from:
http://eetd.lbl.gov/emills/PUBS/PDF/HT_BusinessCase.pdf

Silver Anomalies in Jerusalem Pottery

What they Reveal about the Second Temple Period

Researchers in the Environmental Energy Technologies Division (EETD) of the Lawrence Berkeley National Laboratory (Berkeley Lab) and at Israel's Bar-Ilan University have discovered high concentrations of silver in samples of pottery from excavations in Jerusalem (see Figure 1) dating from the late Second Temple period, i.e., the first century BCE (Before the Common Era) through 70 CE (Common Era).

This is the first study ever conducted on silver in archaeological ceramics.

The research team—David Adan-Bayewitz, Associate Professor at Bar-Ilan in Ramat-Gan, Israel and guest at Berkeley Lab, and Frank Asaro and Robert D. Giauque of EETD—performed measurements on 1,200 pottery vessels from 38 sites in Roman Judea (present-day Israel)(see Figure 2).

They used high-precision X-ray fluorescence (HPXRF) and instrumental neutron activation analysis (INAA). The Berkeley Lab team developed a variation of INAA, the INAA coincidence technique, specifically for measuring silver concentrations in archaeological samples, to check the results of HPXRF and conventional INAA.

The research was funded by the U.S. National Science Foundation and the United States-Israel Bi-national Science Foundation.

The major finding is that samples of pottery from Jerusalem during this era show anomalously higher concentrations of silver than samples from all other non-urban sites dating from the same period (see Figure 3). Many samples from Jerusalem and other sites were otherwise indistinguishable in date, shape, and chemical composition. Although high silver content was also detected in pottery found at other urban sites, many of the Jerusalem samples had higher silver values than any of the samples from other cities.

"Because pottery samples containing larger amounts of silver were all recovered from sites in cities, and because the cities were distant from one another, we concluded that the silver anomalies are associated with human activity," Asaro says. Natural causes do not explain the geographical distribution of samples with high silver content. The researchers also concluded that silver was washed into the pottery through the action of groundwater.

"One of the most important results of our silver work is that our findings suggest that the

Figure 1. Major Jerusalem thoroughfare alongside the western wall of the Temple Mount dating to the late Second Temple period. Many of the analyzed samples were found on this street and below the huge Herodian stones toppled by the Romans from the wall of the Temple Mount. Photo: Yoram Lehman (used with permission)

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measurement of silver in pottery may be a useful tool for evaluating archaeological remains and patterns of urban contamination in antiquity," says Adan-Bayewitz.

Jerusalem In the Second Temple Period

The researchers note that Jerusalem and its temple were the religious and national focus of Jews throughout the Roman Empire during the Second Temple Period, leading to substantial growth of the city. The Roman scholar Pliny the Elder, who lived during this time, called Jerusalem "by far the most famous city of the East." Jewish pilgrims to Jerusalem contributed to the city's wealth, and continual donations to the temple made it a target for plunder.

Josephus, the first-century Jewish historian who witnessed the siege and conquest of Jerusalem in 70 CE, wrote "Of the vast wealth of the city, no small portion was still being discovered among the ruins. Much of this the Romans dug up, but the greater part they became possessed of through the information of the prisoners, gold and silver and other most precious articles, which the owners in view of the uncertain fortunes of war had stored underground."

The researchers suggest that the silver values they measured in Jerusalem pottery samples may be analytical evidence of the city's wealth during the Second Temple Period.

The results of this research were published in the August 2006 issue of the journal *Archaeometry* in an article titled "The discovery of anomalously high silver abundances in pottery excavated in Jerusalem."

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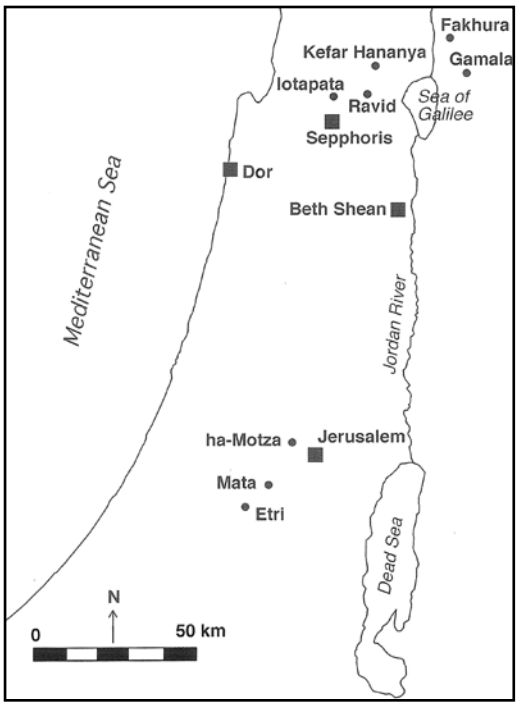

Figure 2. Map showing some of the main excavation sites from which pottery was analyzed.

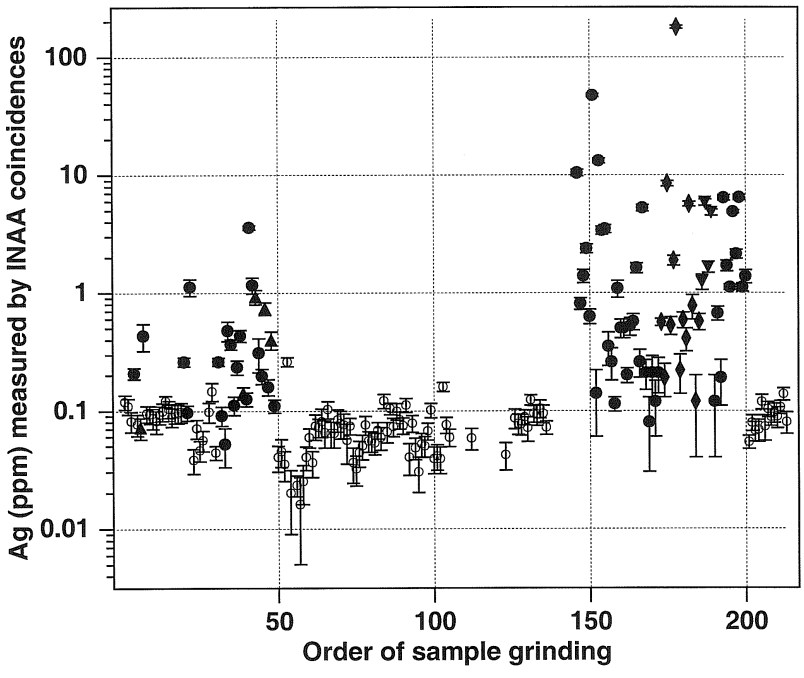

Figure 3. Graph showing silver (Ag) concentrations (in parts per million) in some of the analyzed pottery samples. Symbols in black show silver concentrations in pottery excavated in Jerusalem. The different black symbols each represent a different pottery type; all include examples with high silver concentrations. The empty circles show silver concentrations in pottery from 8 rural sites outside Jerusalem.

Figure 4. Dr. Frank Asaro (left) and Prof. David Adan-Bayewitz standing with the Luis W. Alvarez Iridium Coincidence Spectrometer used to make silver measurements. Photo: Anthony Ma

GSA's Cool Coup at the Philadelphia Custom House

Figure 1. General Service Administration's Custom House, Philadelphia, Pennsylvania.

The U.S. General Service Administration's (GSA) Philadelphia Custom House saved almost $70,000 in demand payments during 2005-2006, and expects savings of nearly $100,000 (about 15 percent of the facility's annual electricity bill) in 2006-2007, thanks to a study of load management and demand response approaches conducted by the Environmental Energy Technologies Division of Lawrence Berkeley National Laboratory (Berkeley Lab). The study was sponsored by GSA and the Federal Energy Management Program (FEMP). By adopting Berkeley Lab's key recommendation and making a few targeted operational changes (with no capital expenditures), the Custom House has substantially reduced its summer peak demand and thereby a significant portion of its yearly energy costs.

GSA pays roughly $27 per kilowatt (kW)—two to three times the national norm—in demand charges for the 570,000-square-foot Custom House (see Figure 1). The facility is also subject to a demand "ratchet" so that 80 percent of its summer peak power draw (i.e., its highest single 30-minute-interval reading) becomes its minimum billed demand for each of the next eight months (October through May).

Because the Custom House generally experiences a summer period (June - September) peak of about 2,000 kW, GSA is obligated to pay for at least 1,600 kW per month (80 percent of the summer peak, per the ratchet clause), during off-peak months. However, the Custom House is a conventional federal office building with a low load factor and typically peaks at less than 1,000 kW per month from December to March. Thus, the Custom House regularly pays its utility (PECO Energy) about $15,000 per month during these four off-peak months (as well as additional sums in the "shoulder" months of October, November, April, and May) for power it does not draw.

GSA commissioned EETD's Phil Coleman, with partial funding also from FEMP, to research ways to cost-effectively reduce the Custom House's peak demand. The study recommended a "pre-cooling" strategy—inspired by similar efforts led by EETD's Peng Xu—in which, on hot summer days, the

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chilled water plant would be turned on very early in the morning. Simultaneously, the chilled water valves in the building's roughly 1,000 perimeter induction units would be tripped to a "fail-open" position using solenoid valves (a contribution from EETD's Dave Watson) so that the facility would actually be somewhat over-cooled (as well as de-humidified). The idea was to utilize the circa-1934 building's substantial mass as a thermal storage medium, which could absorb heat and provide cool-temperature radiation throughout the day, mitigating the customary afternoon power peak.

Working with GSA and its operations and maintenance contractor, Brooks Range Contract Services, EETD helped develop a multi-part plan to reduce the building's peak by using the morning pre-cooling strategy combined with an afternoon "demand-limiting" approach. The key elements are:

- If the outside air exceeds 70°F at 2 a.m., one of the facility's 650-ton chillers is turned on and programmed to produce 42°F chilled water;
- All induction unit chilled water valves are set to a full-open position during the early morning;
- At 9 a.m., the chilled water temperature is raised to 46°F, and induction unit control reverts to the tenants (the units have no reheat coils, but controls can be set to "warmer" to reduce or eliminate the flow of chilled water through the units);
- If demand reaches 1,500 kW and is still rising by noon, the chilled water temperature is raised again, to 48°F;
- Only one of the two 650-ton chillers is allowed to operate at any given time.

At the beginning of the summer of 2005, the Brooks Range team executed the strategy manually, using control system overrides for chiller operation and bleeding air out of the pneumatic lines to open the induction unit valves. Once the team gained confidence in the strategy, the building's controls contractor automated it within the energy management control system (installed in 2003 as part of a FEMP Super Energy Savings Performance Contract).

Using this approach, the operations team was able to keep the facility's peak demand down to 1,766 kW during the summer (defined by the PECO tariff as June though September), in contrast to an expected minimum of 2,050 kW. (The previous four summers' average peak had been 2,080 kW; Berkeley Lab researchers conservatively estimated 2,050 kW would have been 2005's peak draw, despite the fact that the summer of 2005 was unusually hot in the mid-Atlantic). (See Table 1).

GSA benefited directly from the reduced summer demand, saving an estimated $26,000 (see Table 1). GSA also reaped considerable savings during the winter months, because 80 percent of the 1,766 kW summer peak set the winter's minimum demand at 1,413 kW under the terms of the facility's ratchet clause. If the summer demand had reached the expected 2,050 kW, the ratchet figure would have been 1,640 kW. The 227 kW reduction (1,640–1,413) translated to more than $30,000 in savings for the five months of December through April; additional ratchet savings in October, November, and May made for a total annual savings (including the direct summer months' savings) of roughly $68,000.

The EETD researchers expected that there would be a slight–perhaps 5 percent–energy (kWh) penalty from the pre-cooling because some of the coolth generated by the chiller in the early mornings would escape from the building envelope without affecting occupant comfort. Although this effect unquestionably took place, the building's summer electricity usage does not appear to have gone up. Next to the most comparable recent summer (2002), summer 2005's usage was only 0.5 percent higher even though there were 4.3 percent more cooling degree days in summer 2005. Moreover, a regression plot of the four previous summers' kWh consumption against the number of cooling degree days in each revealed that summer 2005's actual consumption was 2 percent less than the model predicted.

Table 1. Custom House Demand Reduction and Savings – 2005-2006

Month	Expected Peak (kW)*	Actual Peak (kW)	Billed Peak (kW) **	Peak Rdctn. (kW)	kW Value
June, '05	1,900	1,766	1,766	134	$ 3,410
July, '05	2,050	1,692	1,692	358	$ 9,109
August, ‹05	2,050	1,692	1,697	353	$ 8,982
September, '05	1,900	1,711	1,711	189	$ 4,809
October, '05	1,640	1,604	1,604	36	$ 916
November, '05	1,640	1,448	1,448	192	$ 4,885
December, '05	1,640	1,015	1,413	227	$ 5,776
January, '06	1,640	992	1,413	227	$ 6,134
February, '06	1,640	961	1,413	227	$ 6,134
March, '06	1,640	953	1,413	227	$ 6,134
April, '06	1,640	1,393	1,413	227	$ 6,134
May, '06	1,850	1,646	1,646	204	$ 5,512
Total Savings					**$ 67,934**

* June - Sept., '05 and May, '06 figures are projected, without pre-cooling; October through April numbers represent 80% of projected summer peak maximum (see orange-shaded cells)

** Dec., '05 – April, '06 figures represent 80% of actual summer peak maximum (see green-shaded cells)

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Chang's New Technique to Clean Up Fossil Fuel Emissions

The Lawrence Berkeley National Laboratory (Berkeley Lab) Technology Transfer Department licenses a wide range of cutting-edge technologies to companies that have the financial, R & D, manufacturing, marketing, and managerial capabilities to successfully commercialize Lab inventions. The Technology Transfer Department develops and manages an array of partnerships with the private sector.

A team of researchers at the Lawrence Berkeley National Laboratory (Berkeley Lab) Environmental Energy Technologies Division (EETD) has developed a technology that removes mercury from coal-fired power plant emissions.

The EETD team, which includes Shih-Ger (Ted) Chang and visiting professors Nai-Qiang Yan from Shanghai Jiao Tong University, Shou-Heng Liu from Taiwan Cheng-Kung University, and Zhao-Rong Liu from Beijing University, say the primary advantages of their new technology are its simplicity and affordability. On March 15, 2005, the U.S. Environmental Protection Agency (EPA) issued the first Clean Air Mercury Rule (CAMR) to control emissions from coal-fired power plants. The CAMR requires an overall average emissions reduction of about 70 percent by 2018.

Coal-fired power plant emissions can affect human health and the environment. To reduce these effects, air quality regulations significantly restrict emissions of nitrogen oxides (NOx), sulfur dioxide (SO_2), particulate matter, and mercury (Hg) from coal plants. The overall project goal was to develop low-cost approaches for controlling Hg, SO_2, and NOx emissions from power plants using air pollution control devices (APCDs).

Elemental mercury can be transported over long distances in the atmosphere because of its insolubility, and oxidized mercury is deposited near the point of emission because of dissolution in fog, cloud, or rain. Once mercury is deposited on land or in water, it can transform into methyl mercury, an organic form, and enter the food chain. Humans are most likely to be exposed to methyl mercury by consuming fish.

Mercury in power plant flue gases is present in varying percentages in three basic forms: elemental mercury in gas form, or oxidized mercury in either particle-bound or gas form. Existing APCDs, including particulate collectors and SO_2 scrubbers, can readily remove oxidized mercury. However, elemental mercury is difficult to remove because it is volatile and insoluble in water. Several technologies have been developed that can control mercury. Currently, the leading one involves injection of powder-activated carbon to adsorb mercury at a cost of about $60,000/lb of mercury removed.

Chang's approach is to inject gas oxidants such as bromine to oxidize the elemental mercury in flue-gas ducts ahead of the existing APCDs. To keep the reagent cost to a minimum, the key was to find a gas oxidant that can selectively oxidize elemental mercury without oxidizing other flue-gas components, such as SO_2, NO, and CO. Also, the oxidation rate had to be very rapid because flue gas remains for less than 10 seconds between the port of injection and the APCD.

Berkeley Lab has applied for a patent on this technology, and Mobotec USA, Inc., located in Walnut Creek CA, has recently negotiated a license with Berkeley Lab's Technology Transfer Department to use the gas-oxidant injection technology to remove mercury from power plant emissions. This technology will help reduce the approximately 48 tons of mercury that U.S. coal-fired power plants emit each year.

—Julia Alter

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Technology Transfer

Laser Ultrasonic Sensor Wins R&D 100

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break or create defects in the paper. This is important because papermaking machines move the sheet at speeds up to 30 meters per second (60 miles per hour), and the slightest contact could break a sheet, cause costly machine downtime, and mar lightweight grades such as copy paper and newsprint.

An additional groundbreaking feature of the LUS is that it enables the integration of feedback process controls based on real-time stiffness data: LUS measurements can be fed back into the paper machine's process control system allowing it to continuously adjust process variables to keep bending stiffness adequate while minimizing use of fiber feedstock. This saves energy, chemicals, and natural resources.

If this technology were to be widely adopted by U.S. paper mills, the researchers estimate it could save more than 30 million trees, eight trillion watt-hours of electricity, and about five hundred millions dollars annually.

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http://sensors.lbl.gov/sp_laser.html

http://www.lbl.gov/Science-Articles/Archive/EETD-paper-sensor.html

http://www.lbl.gov/Science-Articles/Archive/EETD-papersensor-Ridgway.html

GSA's Cool Coup at the Philadelphia Custom House

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Why was consumption lower than expected? One reason might be that, because only one chiller was run at a time, average chiller operation was at much higher load conditions than in previous summers, which increases efficiency. Another small effect might be from the cooling towers, which purge their heat into 70-degree night air more efficiently than into 95-degree sunny daytime conditions.

Despite the impressive savings, GSA was adamant that any decrement in occupant comfort would not be acceptable. Both FEMP and GSA were concerned that the pre-cooling would generate tenant complaints about cold in the mornings, and complaints about heat during the hottest afternoons when GSA used only one chiller as part of the "demand-limiting" strategy. However, "Thermal complaints went down," asserts John Kleaver, the GSA building manager. "The tenants have never been happier," agrees Brooks Range's Rich Ponticelli, head of the operations team that implemented the pre-cooling. GSA's complaint logs corroborate these accounts, showing that hot complaints went down from 41 in 2004 to 26 in 2005 (despite the much hotter summer of 2005). Interestingly, cold complaints went down slightly also, from 10 in 2004 to six in 2005.

In previous summers, the shutting off of the facility's chilled water system from 5:00 each evening until 6:00 the following morning meant that some tenants, particularly early birds, found the building too warm and humid upon arriving for work on the hottest summer days. The pre-cooling strategy appears to have resolved this problem without overcompensating. The 2 a.m. start time seems to have been an effective choice.

In sum, the Custom House's pre-cooling thermal storage experiment was an enormous success. The GSA avoided almost $70,000 in demand charges for the cost of a visit from the controls contractor and two solenoid valves. GSA manager Tom McGarry concluded at a "lessons learned" meeting that the GSA should "declare victory" and commit to repeating the strategy in the summer of 2006. Indeed, though final savings results will not be available until the 2006-7 ratchet period is over (i.e., at the end of May, 2007), GSA was able to suppress demand even further in the summer 2006, from an expected 2,100 kW to 1,684 kW. This 20% reduction is expected to generate savings of roughly $100,000.

—Phil Coleman

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Development of Coincidence INAA

Asaro and his colleagues have for decades been applying neutron activation analysis and X-ray fluorescence techniques to study the origin of archaeological artifacts. Asaro has collaborated with Adan-Bayewitz on artifacts from the Jerusalem region since the early 1990s. In 1985, Asaro was instrumental in finding the iridium anomaly that first hinted that dinosaurs became extinct because of an asteroid impact, and in providing evidence that "Drake's Plate" (a metal plate purportedly left by explorer Sir Francis Drake on the Pacific coast of North America) was an archaeological forgery.

In neutron activation analysis, a sample is bombarded by neutrons in a research reactor. Artificial radioactive isotopes of certain elements are formed that can be identified by their characteristic gamma-ray signatures. In the X-ray fluorescence technique, a sample is exposed to X-rays. Atoms in the sample absorb the energy, knocking away an electron from an inner shell. The atom emits a unique X-ray signature when an outer shell electron drops to the inner shell to replace the missing electron.

When Asaro and Giauque began applying these techniques to the Second Temple-era samples and measured anomalously high silver concentrations, they began taking a closer look. "I was mistrustful of INAA measurements of abundances with a single detector and X-ray fluorescence measurements to measure silver accurately in archaeological samples," says Asaro, "so we developed a new and more reliable way of detecting silver using coincidence measurements with INAA."

Their method involves using two detectors to measure the radiation emitted by samples subjected to neutron activation at two gamma-ray energy ranges. When the single detector and the coincidence INAA and HPXRF methods all agreed on the silver anomaly, the research team was satisfied that their data were correct.

—Allan Chen

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A report on the development of coincidence instrumental neutron activation silver analysis is titled "High-Sensitivity Measurement of Silver in Pottery by Coincidence INAA," by Frank Asaro, David Adan-Bayewitz, Fred Stross, Frank Garcia, and Alan Smith, LBNL-55396.

More on Frank Asaro's work on provenance of ancient artifacts:
http://www.lbl.gov/Science-Articles/Archive/nuclear-archaeology.html

On dinosaur extinctions and neutron activation analysis:
http://csee.lbl.gov/asteroid_impact/
http://www.lbl.gov/nsd/education/ABC/wallchart/chapters/13/5.html

On the Drake's Plate forgery:
http://www.lbl.gov/Science-Articles/Archive/NSD-Drakes-plate.html

More on Bar-Ilan University's Martin Szusz Department of Land of Israel Studies and Archaeology:
http://www.biu.ac.il/JS/le/index.htm

Institute of Archaeology:
http://www.biu.ac.il/js/archaeo/main1.htm

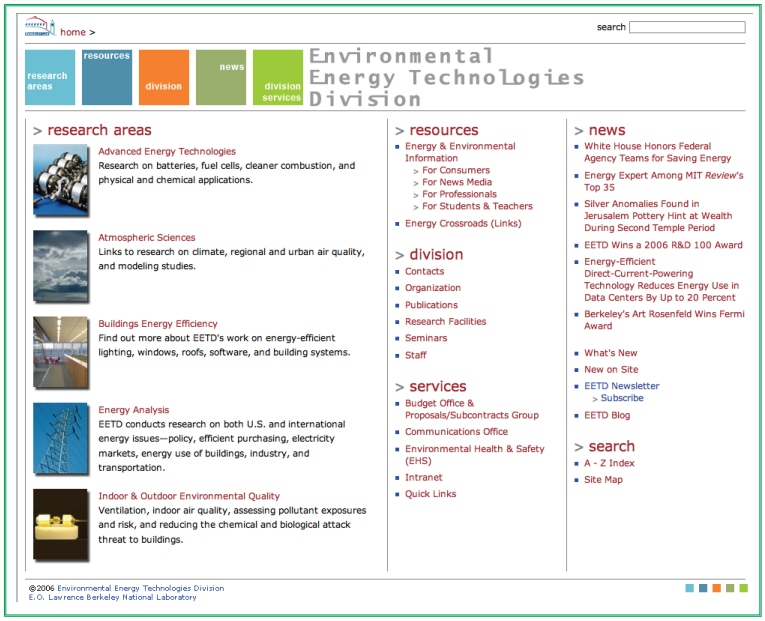
Darfur Stoves Effort in Progress

A recently launched Global Giving web page describes a plan to reduce hardship in the Sudan. EETD Researchers developed, in cooperation with local inhabitants and aid organizations, the Berkeley-Darfur Stove, a low-cost technology that will help minimize violence against women, increase disposable incomes, and reduce environmental degradation (http://darfurstoves.lbl.gov/). The stoves require 75% less fuel than current stoves, and reduce exposure to rape, hunger, physical hardship, and humiliation.

Please visit the Global Giving website:
http://www.globalgiving.com/pr/1700/proj1632a.html

Research Highlights

EETD's New Website



The Environmental Energy Technologies Division has a brand-new website with an updated look and content and easy navigation. New sections of the site are addressed to consumers, news media, professionals in energy efficiency and environmental science, and students and teachers. The site has updated news, descriptions of the division's research, contact information, and easy access to the *EETD News* archives.

EETD has been a leader in establishing a presence on the World Wide Web. The division's first site, developed in 1994, is thought to be one of the first hundred sites on the web. The site that was just retired was state of the art for its time—1998, the Web's "age of dinosaurs."

If you have suggestions for improving the site, please email: EETDwebmaster@lbl.gov.

Fan Filter Unit Test Method

Dr. Tengfang (Tim) Xu of the Environmental Energy Technologies Division is using the first-ever standard laboratory test method, developed at Lawrence Berkeley National Laboratory (Berkeley Lab), to characterize performance of 2 x 4-foot (61 x 122 cm) fan filter units (FFUs) currently on the market.

The FFU energy and airflow test method quantifies total pressure efficiency and power consumption across a range of operable conditions, defined in terms of actual airflow rates (or velocity) and pressure loss throughout the fan recirculation system.

Using this extensively peer-reviewed method, Berkeley Lab has tested 17 different FFUs from manufacturers in Asia, Europe, and North America. Numerous anonymous industry participants donated the units for the testing.

Berkeley Lab researchers found huge variations in efficiency among the units. Researchers quantified a factor of three or more variations in energy efficiency levels from unit to unit for a given operating condition.

—Julia Alter

Berkeley Lab Fume Hood is Licensed for Manufacture

Esco Micro Pte Ltd. has recently concluded an exclusive license to design, manufacture, and sell energy-efficient laboratory fume hoods that are based on the Berkeley Hood developed at Lawrence Berkeley National Lab.

The technology, invented by researchers in the Facilities and Environmental Energy Technologies Divisions, could save up to 75 percent of energy used by traditional hoods and reduce the need for expensive control systems.

For more information, contact:

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Lawrence.Ng@esco.global

http://www.escoglobal.com/
http://hightech.lbl.gov/htnews/htn-issue2.html
http://ateam.lbl.gov/hightech/fumehood/fhood.html

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

Published Quarterly
Vol. 7, No. 1

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

DOE's Energy Information Administration (EIA)
EIA offers official energy statistics from the U.S. Government in formats of your choice, by geography, by fuel, by sector, or by price; or by specific subject areas like process, environment, forecasts, or analysis.
http://www.eia.doe.gov/

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

DOE's Office of Energy Efficiency & Renewable Energy (EERE)
EERE's mission is to pursue a better energy future where energy is clean, abundant, reliable, and affordable; strengthening energy security and enhancing energy choices for all Americans while protecting the environment.
http://www.eere.energy.gov/

Office of Science, U.S. DOE
http://www.er.doe.gov/

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http://energystar.gov/

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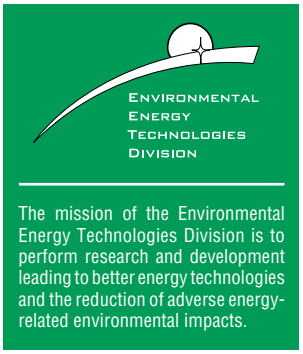
http://energy.ca.gov/



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.

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LBNL/PUB-821 Vol. 7. No. 1,
Fall 2006

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