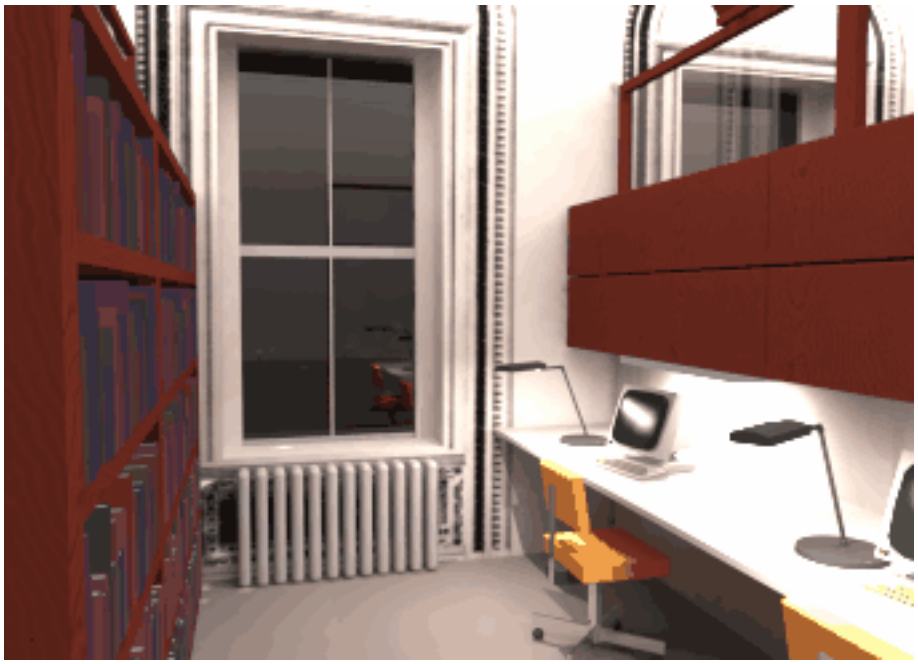
FEMP at LBL

DOE's Federal Energy Management Program is "operations central" for coordinating the federal effort to reduce its own energy use. FEMP plans to use 30% less energy by 2005 then it used in 1985 and conserve water as well. Director Mark Ginsberg has transformed FEMP into a visible resource for federal energy reduction efforts. It helps agencies implement effective programs of their own by creating partnerships, leveraging resources, transferring technology, and providing training and support.

These photorealistic RADIANCE simulations of a retrofitted Old Executive Office Building workspace (daytime above and nighttime below) are part of LBL's efforts in the FEMP-supported Greening of the White House project.



Lab Support Role

FEMP relies on three national labs-LBL, PNL, and NREL-to provide strong technical support, such as expertise in energy technologies; protocols, tools, and guidelines necessary for the program's information base; and effective dissemination programs. The labs also play direct field-support roles by coordinating demonstration projects. FEMP sought LBL's expertise in advanced building technologies, analysis capabilities, and the newly formed Applications Team. FEMP's needs were taken into account in developing the A-Team, making the program the "founding client."

Support Activities

LBL's support activities fall into two categories: (1) for the FEMP knowledge base, developing an "infrastructure" of underlying methods, protocols, guidelines, techniques, models, and the means for their dissemination; and (2) designing, coordinating, and managing demonstration projects to motivate the widespread adoption of FEMP's concepts for saving energy. These are implemented in four program areas:

Energy-efficient Procurement

Jeff Harris and others in E&E's Washington Project Office have been identifying "off-the-shelf," cost-effective, energy-efficient products to encourage their purchase through standard or innovative procurement channels. They are also developing

strategies to use large-volume federal purchasing to acccelerate the commercialization of more advanced "state-of-the-shelf" technologies. One of the effort's major accomplishments was implementing the Federal Procurement Challenge, a voluntary, governmentwide commitment inaugurated by a White House ceremony.

Design Assistance

FEMP is working to remove a major stumbling block for facility managers-not knowing how to define and design a project successfully-by providing design assistance. E&E's Rick Diamond is coordinating LBL's effort to develop information guidelines on specific subjects (e.g., window films) that discuss the issues, pitfalls, recommended courses of action, product vendors, and additional sources of information. Another design assistance project is to evaluate existing energy resource centers, established by utilities to support customers in DSM programs, to determine what is most useful to the federal sector.

Advanced Technology Demonstrations

These include performance measurement and accelerate acceptance by the federal community. LBL's Francis Rubinstein and Steve Selkowitz are helping design and implement lighting and windows technology demonstrations.

Measurement and Verification

Energy Savings Performance Contracts with third parties are an important way of providing necessary capital for facility retrofits. Energy service companies make their profits from a share of the energy and cost savings streams. Recent work by Steve Kromer in the Energy & Environment Division's Washington D.C. office, and now Brad Gustafson, is establishing for those contracts a sound financial basis for both parties through measurement and verification protocols that reliably measure pre- and post-retrofit performance.

Projects, Projects, Projects

Highly visible success stories are a major FEMP strategy, and LBL, with significant involvement of its A-Team, is working on the following:

Presidio

The transition of the Presidio of San Francisco from the U.S. Army to the National Park Service provides a major opportunity to design and implement a comprehensive energy performance

upgrade, in keeping with the NPS's intention to develop the Presidio into a community of tenants and activities supporting sustainable development. Last October, during the transition ceremonies, DOE and NPS signed an agreement giving FEMP responsibility for providing technical support.

The A-Team's Dale Sartor spent a year on assignment at the Presidio, where he developed a comprehensive energy plan for the site and negotiated a major DSM contract with Pacific Gas & Electric Co. to provide funding for the energy overhaul and a role for LBL in coordinating the effort. Early efforts involve site energy audits and the design and implementation of a measurement and verification data backbone. The first retrofit projects will include buildings housing the Gorbachev Foundation and the Tides Foundation, along with parts of the Letterman medical research complex. They will also demonstrate how such projects can be financed through Energy Savings Performance Contracts.

Greening of the White House

LBL was part of an audit and design strategy team tasked with retrofitting the White House and adjacent Old Executive Office Building. Specialized audits of lighting and windows and design recommendations followed, based in part on analysis performed with the Radiance model (also).

FEMP's efforts have already reduced federal energy costs by half a billion dollars in two years, and these numbers can be improved substantially. California's large federal presence and progressive utilities make the state a major FEMP regional target, and LBL expects to play a large role in helping FEMP meet its goals.

—William Carroll

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News From the D.C. Office

Expansion

With a growing amount of project support work and increasing contacts with our Washington-based clients, the Environmental Energy Technologies Division (EETD) Washington Project Office is preparing for an expansion this spring. Two years after the office opened, we are making plans to more than double our present space and add a second meeting room, as well as additional demonstrations of efficient lighting, daylighting, and office technologies. The expanded space will be located either on a different floor of our current building at 1250 Maryland Ave. SW or in another building equally close to DOE headquarters.

The Project office was established in Spring 1993 to enhance the Division's capabilities and performance by:

- Maintaining close contact with DOE and other Washington-based clients to help us better understand their needs and desires and transmit this information to E&E researchers and management.
- Working to help LBL staff design and manage projects that respond effectively to our clients-often in close cooperation with other labs.

- Participating directly, through LBL staff based in the Washington Project Office, in carrying out LBL projects that benefit from closer interactions with DOE Headquarters and with other agencies in Washington.
- Transmitting to existing and prospective clients information about LBL's technical capabilities and the results of recent and ongoing research.

The Project Office provides logistics support to LBL personnel who are in Washington either for short visits or on extended assignments. Located within walking distance from DOE and the Washington offices of five other national labs, the office also demonstrates some of the energy- efficient lighting and equipment technologies developed at LBL or supported by LBL analyses.

When it started in 1993, the Project Office was staffed with two LBL employees and an office manager. We expected to have room for three to four years' growth. Instead, our success in supporting Berkeley staff while in Washington, and in identifying projects that benefit from close proximity to DOE and other sponsors, has all but filled the available office space within two years. Recent project additions include international energy-efficiency projects in developing and industrial countries, analysis of energy-efficient federal and state purchasing, and measurement and verification of energy savings in federal buildings. Other LBL programs are also considering plans to conduct policy analysis and related activities through the Project Office.

Significantly, the LBL Director's Office, in consultation with other divisions, has decided to follow the lead of the Environmental Energy Technologies Division and participate in staffing and managing the expanded Project Office-with a broader mission of representing all LBL Divisions. As a result, we hope to see many more people from LBL-and their colleagues and guests-taking advantage of our expanded facilities beginning this summer.

—Jeff Harris

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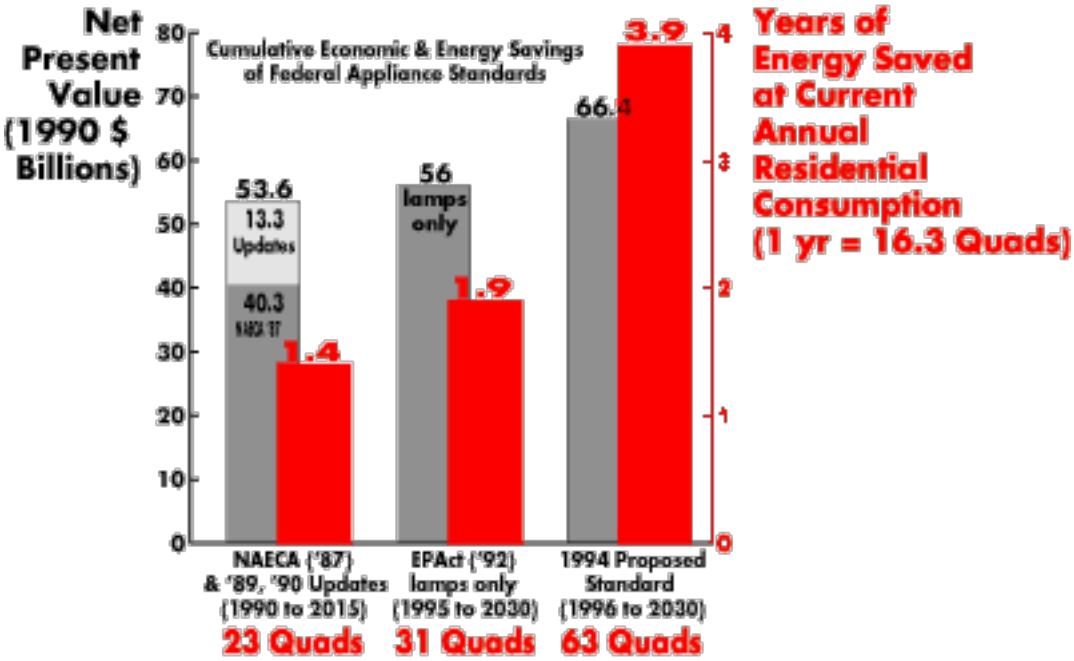
Appliance Efficiency Standards

Part 1 of 2

In the National Energy Policy Conservation Act (1978), Congress required DOE to set energy-efficiency standards for 13 residential appliances if technologically feasible and economically justified. In 1987, the National Appliance Energy Conservation Act (NAECA) established the first national standards for refrigerators and freezers, furnaces, air conditioners, and other appliances and established a schedule for possible updates. It was supported by manufacturers largely because it eliminated disparate state standards. The legislation was also supported by environmental and consumer groups, received broad bipartisan support in Congress, and was signed into law by President Reagan. Subsequent amendments added fluorescent lamp ballasts, and the Energy Policy Act of 1992 (EPAct) added lamps (incandescent and fluorescent), small electric motors, office equipment, and plumbing products.



LBL's Role

The Center's Energy Analysis Program has been a contractor to DOE since 1979 and the prime contractor for engineering and economic analysis of appliance standards since 1982. Currently about 25 people work on this project, including six scientists. LBL's role is to provide economic and technical analysis of alternative standard levels in support of the DOE, which selects the standard levels that ultimately become law.

The analysis of appliance standards includes:

- Engineering analysis: What design changes could save energy, and how much energy? The analysis includes using manufacturer and other researchers' data, developing or modifying simulation models (e.g., for thermal performance of a refrigerator, air conditioner, or water heater), calculating energy savings, and researching manufacturing costs.
- Economic analysis: What are the national impacts from the perspectives of consumers (net effects of increased equipment price and decreased energy expenditures), manufacturers (units sold and profitability), and utilities (lost revenues, but deferral of new capacity)? The analysis includes forecasting models for energy used in U.S. residential and commercial buildings through 2030, financial models of prototypical manufacturers in each industry, and estimates of reduced energy sales and of deferred requirements for new power plants.
- Environmental analysis: By how much will CO_2, SO_2, and NO_x emissions be reduced?

Analytical Results

Appliance standards have beneficial economic and environmental effects. The projected economic effects of standards to date (including original legislation and updates) include the following:

- The national economy benefits by about $1000 for every federal dollar expended on this program.
- Consumer benefits exceed costs by about 2.5 to 1. For residential appliances, the net present value (the benefits that result for consumers after subtracting the extra cost of more efficient appliances from the total energy savings) is $53 billion (1990$, discounted at 7% real) projected from 1990-2015 from the

NAECA standards and its updates on refrigerators and freezers, washers and sryers, and dishwashers.

- For lamps, the net present value of the standards in EPAct is $56 billion (1990$, discounted at 7% real, 1995-2030).
- Proposed rules, including those applying to ballasts and water heaters, if finalized, will save consumers an additional $66 billion (1990$ net present value at 7% real, 1996-2030). Public comments on these proposals are being analyzed, and new proposals for other appliances are expected in 1995.

The results from NAECA and updates that have already become law, and not counting EPAct or proposed rules will be:

- Cumulative energy savings (1990-2015) of 23 Quads, equivalent to 1.4 years of U.S. residential energy use.
- Deferred electricity generating capacity by 2015 equivalent to 21 GW, equivalent to 42 500-MW power plants. Proposed further standards could defer another 37 GW.
- Reduced environmental impacts (1990-2015) approach 400 million tons of carbon, 3.3 million tons of NO_x, and 5.0 million tons of SO_2, amounting to 2% of total U.S. emissions.

The second part of this article, to appear in the summer issue, will explore the policy context of appliance standards and describe the success of energy efficiency standards for refrigerators.

—Jim McMahon

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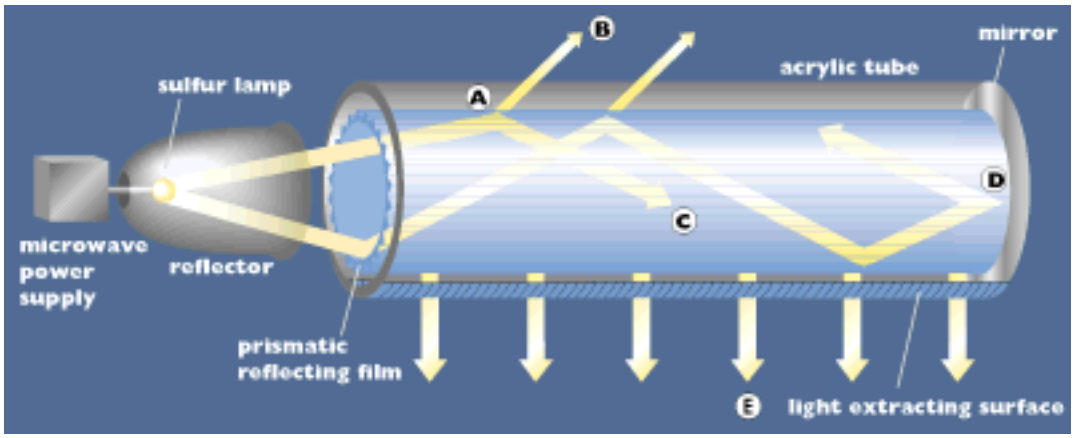
Sulfur Lamps-The Next Generation of Efficient Light?



The figure above is a schematic of the system installed at the National Air and Space Museum and the DOE headquarters in Washington, D.C., Light from the sulfur lamp is focused by a parabolic reflector so that it enters the light pipe within a small angular cone. Light travels down the pipe, reflecting off the prismatic film (A) that lines the outer acrylic tube. The prismatic film reflects the light through total internal reflection (C), an intrinsically efficient process. Some of the light striking the film (at A) is not reflected and "leaks out" of the pipe walls (B), giving the pipe a glowing appearance. A light ray that travels all the way down the pipe will strike the mirror at the end (D) and return back up the pipe. A special light-extracting surface (another type of reflecting film) is used to draw the light out of the pipe in a controlled manner to where it is most needed (E).

In 1994, DOE announced that a new, highly efficient lighting system was illuminating the exterior of the Forrestal Building in Washington, D.C., and the Space Hall of the Smithsonian's National Air and Space Museum. The new system is a technological breakthrough that couples high-power sulfur lamps to a light pipe system that distributes the light. The lighting of the two buildings is the first working U.S. example of the high-power version of the sulfur lamp. In these installations, a hollow pipe distributes focused light from the sulfur lamp evenly over large areas.

The sulfur lamp bulb consists of a spherical quartz envelope filled with a few milligrams of sulfur and an inert noble gas, such as argon, which is weakly ionized using microwaves. The argon heats the sulfur into a gaseous state, forming diatomic sulfur molecules, or dimers. The dimers emit a broad continuum of energy as they drop back to lower energy states-a process called molecular emission. Molecular sulfur emits almost entirely over the visible portion of the electromagnetic spectrum, producing a uniform visible spectrum similar to sunlight but with very little undesirable infrared or ultraviolet radiation. Conventional mercury lamps and most other high-intensity discharge (HID) sources are built around atomic emission and produce an artificial-looking light with many missing colors.

Unlike conventional sources whose outputs typically diminish 75% over time, sulfur lamps will maintain their efficiency and light output over their entire lifetimes. By eliminating the need to compensate for lamp lumen depreciation, fewer sulfur lamps can provide a required light level, possibly for long lives of up to 50,000 hours. In addition, sulfur lamps contain no mercury, an environmentally toxic substance used in all other conventional efficient sources.

The sulfur lamp was developed originally by scientists (now at Fusion Lighting in Rockville, Maryland) who discovered that sulfur excited by microwave energy could be used in place of mercury in ultraviolet industrial lamps to produce a high-quality white light. These lamps operated at power and light output levels (3.5 KW input and 450,000 lumens) too high for most commercial applications. The high wattage required air-cooling and spinning the lamps to operate them. Applying their expertise in electrodeless discharge lamps, LBL researchers developed lower-power lamps using radio frequencies instead of microwaves. In 1993, they demonstrated an RF-driven sulfur lamp that produced up to 15,000 lumens with an RF input of only 100 watts-a luminous efficacy of approximately 150 lumens per RF watt. While the lamps still needed to be rotated, lower-power operation allowed the air cooling to be eliminated.

Although they are prototypes, the first-generation lamps at the Forrestal Building and the National Air and Space Museum are nonetheless energy-efficient. The Forrestal Building's 280-foot light pipe and two sulfur lamps replaced about 280 mercury HID fixtures, resulting in a measured energy savings of more than 65% and saving DOE approximately $8000 annually in energy costs. Because the sulfur lamp system replaced an old mercury system at the end of its maintenance cycle, the new light levels were roughly four

times those of the old system. Maintenance costs are also lower, saving an additional $1500 per year.

DOE is funding Fusion Lighting through LBL to develop a microwave-operated, high-power sulfur lamp of 1000 watts, producing 125,000 lumens. It is best suited for applications like sports stadiums, convention centers, aircraft hangars, large maintenance facilities, highway and street lighting, and shopping mall and industrial lighting. Another DOE-funded project at Fusion Lighting is aimed at developing a commercial RF-driven sulfur lamp at lower power (50-100 watts)-small enough for use in homes and commercial buildings.

—Francis Rubinstein

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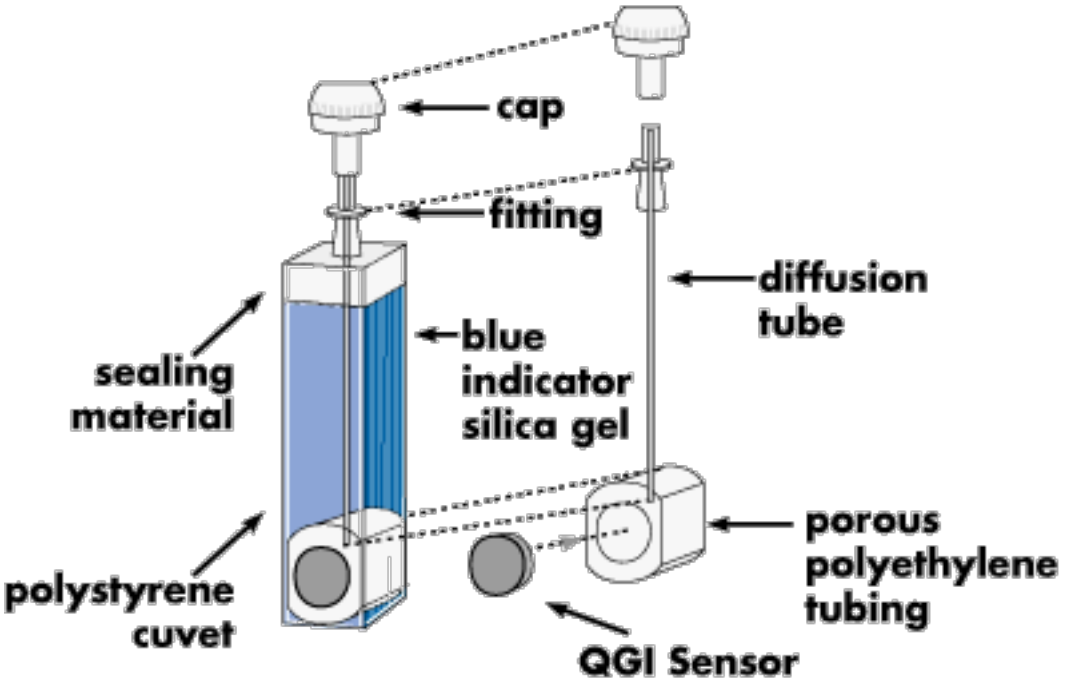
An Inexpensive CO Sensor



A schematic of the prototype CO passive sensor.

Carbon moNO$_x$ide is a colorless, odorless, toxic gas whose primary source indoor is the incomplete combustion of fossil fuels. This gas can be a potential problem in any house that uses combustion appliances for space or water heating, cooking, or idling an automobile in an attached garage. Although most appliances work correctly, a problem can exist in houses when the appliance is unventilated or its ventilation system does not properly eliminate exhaust gases from the house. Since Americans spend 90% of their time indoors and 65 to 70% in their residences, understanding how and when CO builds up indoors could save lives. We have very little systematic data on how CO hazards are distrubuted in the indoor environment, but mortality data from the Centers for Disease Control in Atlanta suggests that the lifetime risk of unintentional fatal CO poisoning indoors is about one in 3,000. This is 300 times greater than the risk at which the Environmental Protection Agency regulates toxic chemicals such as benzene.

Last year's death of tennis star Vitas Gerulaitis by CO poisoning from a faulty space heater focused public attention on the danger of carbon moNO$_x$ide poisoning. More than 12,000 carbon moNO$_x$ide poisonings were reported to the American Association of Poison Control Centers in 1993, but the Association believes this represents only a fraction of the actual number of events-often, nonfatal poisonings are misdiagnosed as flu or other afflictions.

Each year, about 1,500 deaths result from CO poisonings. Of these about 1000 are from CO emissions caused by malfunctioning, incorrectly installed, or misused combustion appliances such as furnaces and gas ranges, by the improper indoor use of outdoor appliances like barbecues, and by operating automobiles or generators in garages.

The possibility of hazardous CO exposure is greater in houses that have been sealed to improve their energy efficiency if precautions were not taken. CO from vented combustion appliances can enter a home through a cracked heat exchanger, a blocked vent, or by appliance "Backdrafting." Backdrafting is a reversal of the normal appliance ventilation flow; outside air is pulled through the appliance vent and hot combustion gases flow into the indoor environment. This potentially serious situation can occur when the vented gas appliance is located indoors and the house is severely depressurized through the operation of an unbalanced forced-air heating system, or if powerful exhaust fans such as range hoods or bathroom fans are used, or even when a large fire is built in a fireplace. Although not every house has a backdraft problem, it's best to call in a professional when one is suspected. The gas company or a heating contractor can test for CO and recommend such measures as changes to the ventilation system or appliance repairs to remove the hazard.

One reason for the lack of research on CO hazards in the United States is the absence of a simple, inexpensive way to measure its concentration in the field. Mike Apte and Greg Traynor, Indoor Environment Program researchers, are developing an inexpensive CO passive sampler designed for large-scale indoor surveys in cooperation with The Quantum Group of San Diego. The technology could also be adapted as an occupational hazard CO sampler or as a residential warning system that would turn off combustion appliances when CO reached dangerous indoor levels.

The prototype passive sampler consists of a flat disk with a chemical coating that darkens when exposed to CO. The disk is housed within a sealed vial filled with silica gel, a substance that removes moisture (which could interfere with accurate measurement) from the air. A narrow diffusion tube with known

dimensions brings external air to the sensor disk. The sampler is exposed to air for one week or less and is then analyzed using a spectrophotometer to measure a "time-averaged" CO concentration. Researchers have conducted preliminary tests at an outdoor location, a parking garage, a toll both, a residence with a gas range, and in an environmental chamber. They compared the passive sampler to a standard analytical measurement technique and found that the prototype sampler was accurate to nearly 1 ppm at low concentrations (5 ppm) and to within 20% at higher levels. The sampler can eliminate the need to test each site using expensive equipment and trained technicians. For example, a public health department or gas utility conducting a hazard study could mail the sampler to customers, who could use it in their homes for a week and then mail it back for analysis.

The team's plans include further refining and field-testing, making the sensor widely available through commercialization, and using it for large- scale field studies of residential and occupational environments. Eventually researchers hope to conduct regional field surveys to characterize the distribution and magnitudes of CO hazards in homes.

—Allan Chen

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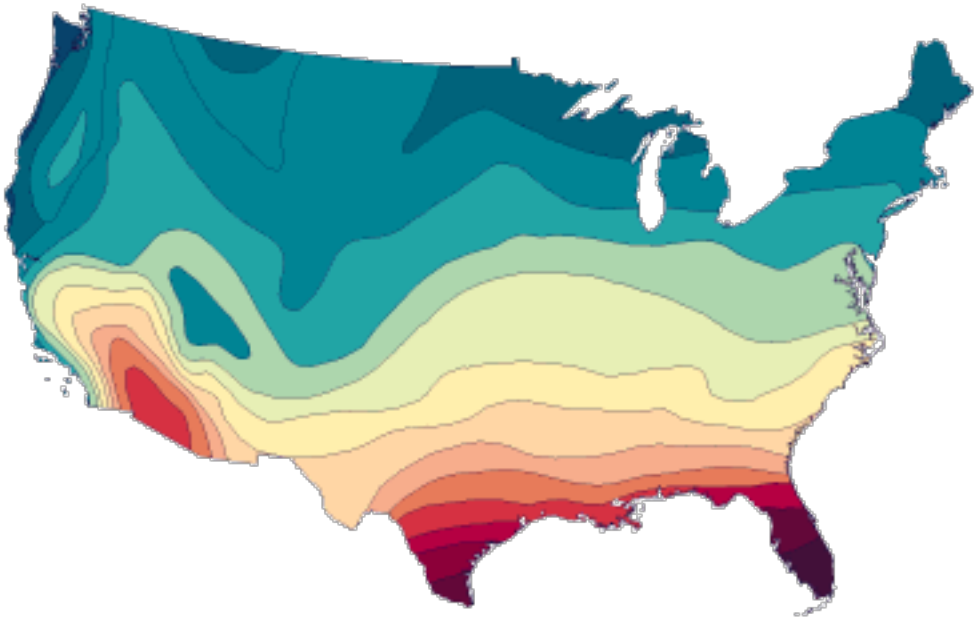
The Geographic Information Systems Laboratory

Visualization using geographic information systems (GIS) can be an indispensable tool of the energy analyst. Patterns that were once hidden in impenetrable numbers reveal themselves when they are plotted superimposed on such maps as terrain, climate, population density, and utility service area. Another important use of the GIS is combining data sets with dissimilar geographic boundaries. Now, an effort is underway in the Center to use the power of GIS to understand everything from regional patterns of appliance energy use to the effects of climate on energy-saving strategies.

Geographic information systems are not just maps, they are relational databases linked to geographic features that help users better query and visualize relationships among data and make those relationships easier to present. Researchers in the GIS Lab use SUN workstations-including a SPARC 20 and SPARC 1-Calcomp 9500 digitizer, a 486 PC, and several types of GIS software, primarily ARC/Info and Earth Resources Data Analysis System. ARC/Info is a vector-based GIS program produced by the Environmental Systems Research Institute; the ERDAS is a raster-based system. The vector-based GIS is better adapted for political boundaries and discontinuous data. However, ERDAS has superior image-processing capabilities.

The GIS's ability to manipulate, organize, and display detailed information about appliance type and ownership, demographic variables, and energy use has been invaluable to its users in the Energy Analysis Program's appliance standards group. The GIS is helping researchers fine-tune the appliance energy standards they are developing under a Congressional mandate, the National Appliance Energy Conservation Act. When completed, these standards will require 13 appliance types to meet uniform minimum energy-efficiency requirements in the U.S. Susan Mahler, Jim McMahon, and Xiaomin Liu are using the GIS to model the effects of proposed national appliance standards, examining the effects of different climates on energy consumption and studying the economics of efficient technologies in regions with differing energy prices.

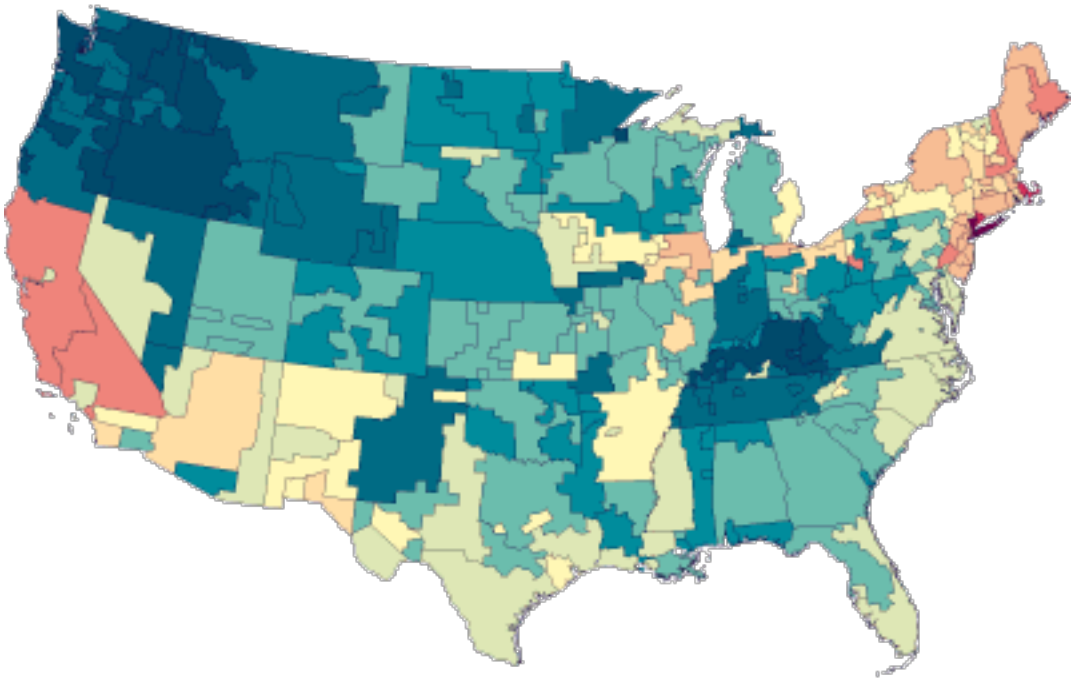
DOE Test Procedure Cooling Load Hours



Cooling Load Hours

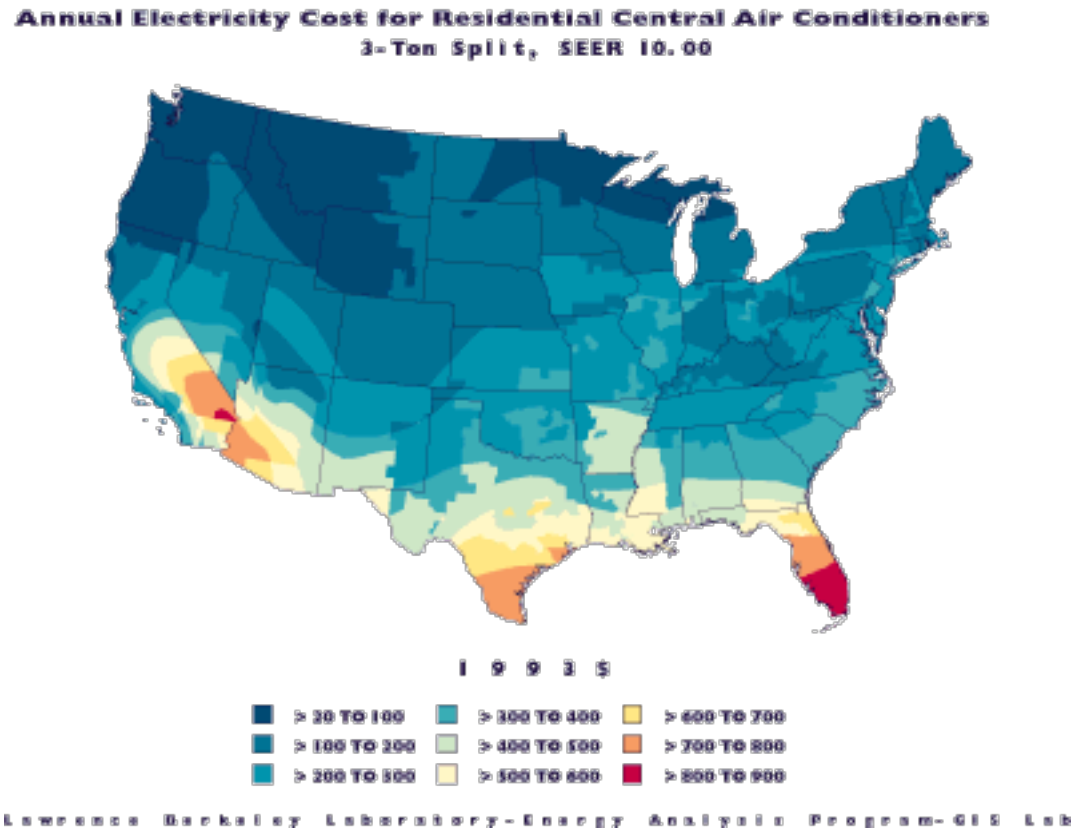
TO 200	> 600 TO 800	> 1200 TO 1400	> 1800 TO 2000	> 2400 TO 2600
> 200 TO 400	> 800 TO 1000	> 1400 TO 1600	> 2000 TO 2200	> 2600 TO 2800
> 400 TO 600	> 1000 TO 1200	> 1600 TO 1800	> 2200 TO 2400	> 2800

1993 Residential Electricity Prices



Electricity $/KWh

TO 0.05	> 0.07 TO 0.08	> 0.10 TO 0.11	> 0.13 TO 0.14
> 0.05 TO 0.06	> 0.08 TO 0.09	> 0.11 TO 0.12	> 0.14 TO 0.15
> 0.06 TO 0.07	> 0.09 TO 0.10	> 0.12 TO 0.13	> 0.15



GIS software can help combine data sets with dissimilar boundaries, as in this map of annual cost of electricity for residential air conditioners.

Rich Brown and Jonathan Koomey are using the GIS for targeted marketing of energy-efficient residential products as part of a project funded by the Environmental Protection Agency. This project is helping the EPA design effective energy efficiency programs. They are developing a detailed, GIS-based model to identify regions and market segments in which energy-efficient technologies are technically feasible, cost-effective, and acceptable to consumers. The EPA then applies this information to the design of programs targeted at the most attractive market segments. The GIS allows the researchers to compile and understand larger, more detailed data sets than they have worked with in the past. This is critical to defining the appropriate markets for energy efficiency program implementation. Xiaomin Liu used ERDAS to create a different type of GIS database for the Center's Heat Islands/Cool Communities Project . Liu and Haider Taha created a database of the albedo (surface reflectivity) of Southern California using images taken from the AVHRR satellite. They worked with the albedo data in a meteorological model to simulate the Los Angeles basin's climate, including its temperature field. With an urban airshed model, they produced a map of ozone concentrations for

the basin. The research will produce a better understanding of how air quality correlates with air temperature.

Others researchers are using the GIS Lab's capabilities to study indoor radon concentration in the U.S., and analyze thermal emissions in the Sacramento area. A project to analyze energy policy in China is in the formative stages.

—Allan Chen

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