Lawrence Berkeley National Laboratory

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Environmental Energy Technologies Division News

Air Quality Advanced Technologies Building Technologies Energy Analysis Indoor Environment

New Commercial Building Energy Efficiency Program Launched

A new three-year public-private research initiative, which will target substantial reductions in the $100 billion spent annually in energy costs for commercial buildings, has been launched under the leadership of Environmental Energy Technologies Division scientists. More than $13 million in research funding has been pledged by the California Energy Commission (CEC), the DOE, private sector partners, and Pacific Gas & Electric. EETD has assembled a team of 14 public and private sector partners to carry out the varied tasks within the High-Performance Commercial Buildings Systems Program.

The program will develop new information technologies to design, commission, and operate buildings, and integrated design techniques to generate substantial and sustained energy savings in commercial buildings—offices, schools, and other structures. Partnerships with the private sector will commercialize and deploy these technologies in the marketplace. Principal investigators include Stephen Selkowitz, Philip Haves, Mary Ann Piette, Frances Rubinstein, and Michael Apte of Berkeley Lab's EETD and David Claridge of Texas A&M.

"In California alone," says Selkowitz, "implementation of technologies and practices developed in this research program for both new and existing buildings could reduce overall commercial sector electricity consumption by 22 percent by 2015." And long before that, Selkowitz believes, the program's activities will help California businesses and utilities address more immediate needs such as responding to the load management and curtailment crises in California.

"Commercial building owners in the United States spend almost $100 billion per year on their energy bills," says Selkowitz. "New buildings today are often more efficient than existing building stock, thanks in part to CEC and DOE's building energy standards and the use of DOE-2, an energy-efficient building design program developed by EETD researchers."

"With new technologies and better systems integration, we cost-effectively could achieve savings of 50 percent or better in new buildings as compared with buildings that meet current codes, while improving the indoor environments in these workplaces," he adds. "But even when they are designed well, buildings are often not operated to achieve the expected energy savings. This program will address not just technologies and design practices, but building operation and maintenance practices to maximize energy efficiency, and the health and comfort of the occupants."

Studies conducted by EETD scientists suggest that in typical cases, commissioning and improved operations of buildings could save 20 percent of current energy use in existing buildings. (Commissioning is the process of checking and fine-tuning a new building's mechanical and electrical systems to meet operating specifications after completion but before it is occupied.)

The program will develop new technologies, and design and operations practices in five areas: (1) life-cycle tools—the information management systems for efficient building design and operations; (2) lighting, envelopes and daylighting—hardware

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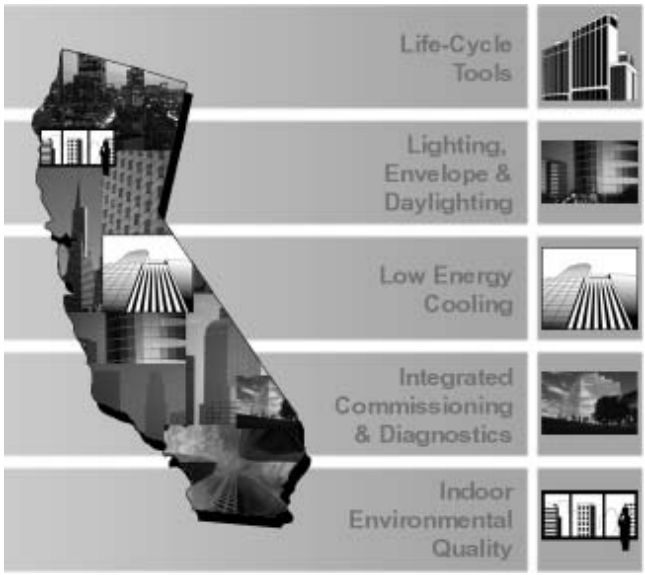

In this Issue

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

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and software to control lighting and ventilation systems, and dynamic window systems that modulate the amount of daylight and solar heat passing through them into the building; (3) low-energy cooling—novel design strategies and systems for minimizing peak and annual cooling needs in buildings; (4) integrated commissioning and diagnostics—procedures for cost-effectively commissioning buildings, monitoring ongoing performance, and identifying and diagnosing performance faults; and (5) indoor environmental quality—technologies to provide improved ventilation and minimize indoor pollutants in temporary (portable) classrooms. EETD will work with a team of 14 subcontractors and cost-sharing industrial partners to develop and deploy these technologies.

A unique feature of this initiative is the participation of northern California's utility, PG&E, in helping deploy the products of this research. Through its Pacific Energy Center training classes and outreach programs, as well as demonstration projects, PG&E will provide the resources and connections necessary to help move R&D results into the marketplace.

Primary program support of $6 million comes from CEC's Public Interest Energy Research (PIER) program. DOE matching funds over the life of the program are projected to be about $2.5 million, coming from several research areas within the Office of Building Technologies, State and Community Programs. In each area the new CEC projects are designed to extend important DOE-supported work.

The agreement marks a significant milestone for the DOE's Office of Building Technologies, State and Community Programs' efforts to cooperate with state governments to develop energy-efficient technologies and practices. This program is the first major agreement between DOE and the CEC to develop and implement technologies that save consumers money on their energy bills and reduce indoor air pollution.

The CEC's PIER program also made four two-year project awards in end-use energy efficiency directly to Berkeley Lab totaling $2.35 million. The research will cover (1) instrumented home energy rating and commissioning; (2) energy-efficient downlights for California kitchens; (3) heating, ventilation, and air conditioning (HVAC) distribution systems in commercial buildings; and (4) next-generation power management user interface for office equipment. Each of these projects builds on past DOE-funded work in Berkeley Lab's building R&D programs.

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Lawrence Berkeley National Laboratory

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 laboratories, Berkeley Lab is located in the hills above the campus of the University of California, Berkeley.

With more than 4,000 employees, LBNL's total annual budget of nearly $400 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, LBNL has had nine Nobel laureates. EETD is one of 13 scientific divisions at Berkeley Lab, with a staff of more than 300 and a budget of $36 million.

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Clean Energy Future Assesses Technology and Policy

A new report prepared by five Department of Energy National Laboratories assesses technologies and policies to meet the energy-related challenges of the United States as it enters the 21st century. It concludes that a number of policies and measures described in the report can lead to faster development and deployment of energy-efficient, low-carbon technologies, and that the successful implementation of these policies can reduce energy inefficiencies, oil dependence, air pollution, and greenhouse gas emissions at essentially no net cost to the U.S. The policies include increased R&D; voluntary agreements to promote energy efficiency in vehicles, buildings and equipment, and industrial processes; programs promoting cogeneration; electric sector restructuring; and a domestic carbon cap and trading system.

The study, *Scenarios for a Clean Energy Future*, led by Marilyn A. Brown of Oak Ridge National Laboratory, Mark D. Levine of Lawrence Berkeley National Laboratory, and Walter D. Short of the National Renewable Energy Laboratory, is the most comprehensive study of the role of energy technologies in reducing local and global environmental emissions that the U.S. Department of Energy has ever commissioned. Researchers at Berkeley Lab led two of the chapters: Jon Koomey, Carrie Webber, and Celina Atkinson (buildings) and Ernst Worrell and Lynn Price (industry). Jon Koomey and Etan Gumerman also led the integrated modeling to create the energy scenarios in the study.

Energy Issues Facing the U.S.

The report identifies a number of energy-related issues that will affect the U.S. in the next century: the potential for climate change from human-caused emissions of greenhouse gases; increases in acid rain from growth of energy generation; oil supply vulnerability and price volatility arising from the concentration of oil supplies in unstable parts of the world; and potential economic and physical disruptions during restructuring of the U.S. electricity sector. The study identifies and assesses public policies and programs to address these issues.

Figure 1. Carbon emission reductions by sector in the advanced scenario.

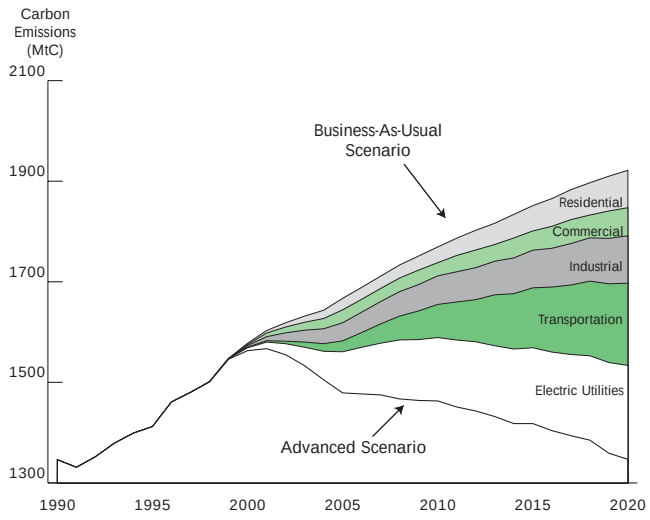
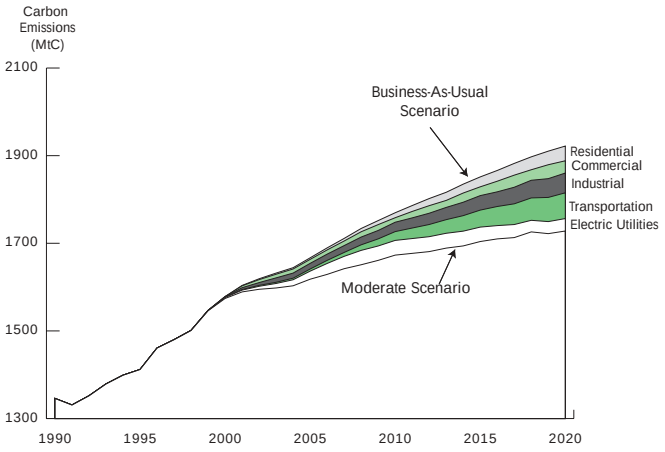


Figure 2. Carbon emission reductions by sector in the moderate scenario.



The Clean Energy Future (CEF) study created three scenarios of energy use: business-as-usual (BAU), moderate, and advanced. The BAU scenario is similar to the Department of Energy's Reference Case, published in the *Annual Energy Outlook 1999*. The moderate and advanced scenarios both assume a variety of policies and programs that are implemented to improve the energy efficiency of the buildings, industry, transportation, and electricity sectors.

Two significant differences from the moderate scenario are the advanced scenario's assumption that the U.S. adopts a cap on carbon emissions, and a carbon emission-trading system, and that the federal government doubles its appropriations for cost-shared R&D.

Three Scenarios and Their Results

As shown Table 1, the study finds that through the adoption of cost-effective technologies and policies, the U.S. can reduce its greenhouse gas emissions by 5% below the business-as-usual level in 2010 under the moderate scenario, and by either 13% or 17% in the advanced scenario, depending on whether the carbon permit-trading charge is assumed to be $25 or $50/ton. Primary energy use is 3% below BAU under the moderate scenario, and 8% to 10% below BAU in the advanced scenarios in 2010.

Some Conclusions

CEF concludes that the energy cost savings from more efficient use of energy throughout the economy can equal or exceed the direct cost of the policies and technologies deployed in the moderate and advanced scenarios. The growth of domestic "green" industries—wind, bioenergy and others—creates new employ-

continued on page 4

ment. However, in the advanced scenario certain sectors that might experience job loss, such as the coal industry, will need special additional attention to address the transition of workers to other jobs.

An important use of this report is to provide the technical and economic underpinnings for the policies that could be employed to reduce the growth of greenhouse gas emissions in the United States. By 2010, the moderate scenario brings CO_2 emissions 20% of the way back towards 1990 levels, the advanced scenario with a carbon permit value of $25/tC brings them 54% of the way down, and the advanced scenario at $50/tC closes 71% of the gap.

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To download the report and appendices in PDF format go to http://www.ornl.gov/ORNL/Energy_Eff/CEF.htm

To download the detailed result spreadsheets for all the combinations of scenario runs, go to http://enduse.lbl.gov/projects/CEF.html

The five national laboratories participating in the study are Argonne, Lawrence Berkeley, National Renewable Energy, Oak Ridge, and Pacific Northwest national laboratories.

Table 1. Selected Results for 2010 and 2020.

			2010 Scenarios			
	1990	1997	BAU	Moderate	Advanced ($25/tC)[a]	Advanced ($50/tC)[b]
U.S. Primary Energy Use (Quadrillion Btu)	84.2	94.0	110.3	106.5	101.3	99.5
Energy Use Reductions (Percent Change from BAU)	–	–	–	(-3.5%)	(-8%)	(-10%)
U. S. Energy Bill (Billion 1997$)	516	552	650	595	599[c]	634[c]
Energy Bill Reductions (Percent Change from BAU)	–	–	–	(-8%)	(-8%)	(-3%)
U.S. Carbon Emissions (Million Metric Tons)	1,346	1,480	1,769	1,684	1,540	1,467
Carbon Emissions Reductions (Percent Change from BAU)	–	–	–	(-5%)	(-13%)	(-17%)

			2020 Scenarios			
	1990	1997	BAU	Moderate	Advanced ($25/tC)[a]	Advanced ($50/tC)[b]
U.S. Primary Energy Use (Quadrillion Btu)	84.2	94.0	119.8	110.3	99.0	97.0
Energy Use Reductions (Percent Change from BAU)	–	–	–	(-8%)	(-17%)	(-19%)
U. S. Energy Bill (Billion 1997$)	516	552	694	594	542[c]	572[c]
Energy Bill Reductions (Percent Change from BAU)	–	–	–	(-14%)	(-22%)	(-18%)
U.S. Carbon Emissions (Million Metric Tons)	1,346	1,480	1,922	1,743	1,478	1,357
Carbon Emissions Reductions (Percent Change from BAU)	–	–	–	(-9%)	(-23%)	(-29%)

[a] This variation of the Advanced scenario has a domestic carbon trading system that equilibrates at a carbon permit charge of $25/tC.

[b] This "standard" Advanced scenario includes a domestic carbon trading system that equilibrates at a carbon permit charge of $50/tC.

[c] The energy prices used to calculate this energy bill include the cost of the carbon permit charge.

Managing the Health Impacts of Waste Incineration

Incineration destroys contaminated hospital wastes, reduces municipal waste volumes, and substantially cuts down on the amounts of hazardous chemical and biological wastes. But does this widespread practice threaten public health? This question was tackled in the September 2000 issue of the journal *Environmental Science & Technology* in an article penned by EETD's Thomas McKone and Katharine Hammond of UC Berkeley's School of Public Health. They write that in spite of continuing efforts to evaluate the health impacts of incinerated waste emissions, key data limitations still exist.

Hundreds of incinerators—industrial kilns, boilers, and furnaces—annually burn an estimated 3 million tons of municipal solid and other hazardous wastes. Emissions from incinerators are regulated through the 1990 Clean Air Act. As part of the Act, the Environmental Protection Agency has defined Maximum Achievable Control Technology (MACT) standards, which require incinerators to attain emission controls that reflect the average of the best-performing operations. However, a National Research Council (NRC) report released in November 1999 notes that MACT standards may not be sufficient to protect incinerator workers and regional populations. According to the NRC report, the low reliability of measured data and models, as well as imprecise data on intermedia transfer factors used to determine indirect exposure, are obstacles to regional-scale health assessments. Intermedia transfer refers to the exchange of pollutants between the air and soil, air and vegetation, air and water, soil and vegetation, and outdoor and indoor environments.

In the past, health concerns for waste incineration were focused on the communities living near the incinerator. The NRC report comprehensively identifies three potentially exposed populations: the local one, which inhales airborne emissions; workers, especially those who clean and maintain the pollution-control devices; and the larger regional population, who may be remote from any particular incinerator, but who consume food contaminated by one or more incinerators. Unfortunately, some of the MACT standards will not help people in all these categories. For example, workers who clean out air-pollution control equipment at municipal incineration plants have tested for elevated levels of dioxins and metals (arsenic, lead, cadmium, and aluminum) in both blood and urine. But the new standards will only require fewer emissions from a plant and not change the work conditions for people in the facility.

Uncertainties Characterizing Impacts

To characterize health impacts from incinerators, large amounts of data and models are required. But a lot of uncertainty is associated with these evaluations because the data and models must be used to characterize individual behaviors, engineered system performance, contaminant transport, human contact and uptake, and dose among large populations. The NRC report identified the issues of uncertainty and variability as having scientific and policy implications for attributing health impacts to incinerators. The committee noted that when the uncertainty and variability become large, interpreting or assigning relevance to the estimated magnitude of exposure and health risk become increasingly difficult.

One case in which uncertainty derives from exclusion is a health characterization based only on normal operating conditions. No data are available to evaluate actual emissions during start-up, which are normally higher than during routine operation. Consequently, evaluating exposure and potential health risks remains potentially erroneous because of this lack.

Emissions, Transport, and Exposure

The most difficult task for those who evaluate patterns of human exposures is tracking the concentration and movement of contaminants. Most pollutants are released as stack emissions to the atmosphere. As the pollutants spread, people who live close by can be exposed directly through inhalation, as well as by pollutant deposition to soil, vegetation, and surface water. People living at a distance from incinerators are also exposed through the same media. Unfortunately, multimedia, multipathway exposures remain poorly characterized and scientific studies, models, and direct measurements are lacking.

Exposures and health assessments are key steps in the analysis of a link between incinerator sources and human health risks. If properly conducted, these assessments can be useful in the development of an effective risk-management strategy. If efforts to characterize incinerator health impacts are to be useful, two essential research tools—models and measurements—must be better integrated. Models provide the means to integrate and interpret measurements, design hypothesis-driven experiments, and predict the effectiveness of risk-management strategies. Measurements, in turn, provide the tools needed for evaluating and improving models.

—Ted Gartner with Tom McKone

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"Managing the Health Impacts of Waste Incineration," *Environmental Science & Technology,* September 1, 2000/Volume 34, Issue 17/pp.380 A-387 A

This work was sponsored by the U.S. EPA, National Exposure Research Laboratory.

The Residential Ventilation Standard

Max Sherman is the Chair of ASHRAE's Standard Project Committee 62.2, which is reviewing public comments on the ventilation standard's first draft. This article describes the general outline of the draft's contents.

In August 2000, the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) released the first public review draft of its proposed residential ventilation standard entitled "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings." The Standard Project Committee (SPC 62.2P) responsible for developing this draft is now reviewing the results of that public review and will likely make changes to it, but the fundamental principles are unlikely to change.

The standard is an attempt by the Society to address concerns over indoor air quality in dwellings and to set minimum standards that would allow energy-efficiency measures to be evaluated. and source control. In addition to code-intended requirements, the standard also contains guidance information for the designer or user of the standard.

ASHRAE has long been in the business of ventilation, but most of the focus of that effort has been in the area of commercial and institutional buildings. Residential ventilation was traditionally not a major concern because it was felt that between operable windows and envelope leakage, people were getting enough air. In the quarter of a century since the first oil shock, houses have gotten much more energy-efficient. At the same time, the kinds of materials and functions in houses were changing in character in response to people's needs. People were also becoming more environmentally conscious not only about the resources they were consuming but about the environment in which they lived.

All of these factors contributed to an increasing level of public concern about residential indoor air quality and ventilation. Where once there was an easy feeling about the residential indoor environment, there is now a desire to define levels of acceptability and performance. Many institutions both public and private, have interests in indoor air quality, but ASHRAE, as the professional society that has had ventilation as part of its mission for over 100 years, was the logical place to develop a consensus standard. That standard has just finished its first public review.

ASHRAE Standard 62.2P defines the roles of and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality. It applies to spaces intended for human occupancy within single-family houses and low-rise multi-family structures and generally excludes institutional buildings.

The standard appears to be principally about ventilation, but the purpose of ventilation is to provide acceptable indoor air quality. The most effective strategy for keeping exposure to undesirable pollutants low is to keep them from being released to the general indoor environment in the first place. Such "source control" measures actually make up the bulk of the pages in the standard. Local ventilation is intended to exhaust pollutants from specific rooms before they enter the general environment. Whole-house ventilation is intended to bring fresh air into the general environment to dilute the pollutants that cannot be effectively controlled at the source.

Overview of the Standard

In developing this standard the committee recognized that there were many different kinds of houses, many different climates, and many different styles of constructions. To accommodate these difference, the major requirements were designed with several alternate paths to allow users flexibility. Some requirements are performance-based, with specific prescriptive alternatives. The standard recognizes that there are several different ways to achieve a specified ventilation rate and allows both mechanical and natural methods.

There are three primary sets of requirements in the standard and a host of secondary ones. The three primary sets involve whole-house ventilation, local exhaust, and source control. Whole-house ventilation is intended to dilute the unavoidable contaminant emissions from people, materials, and background processes. Local exhaust is intended to remove contaminants from those specific rooms (e.g., kitchens) in which sources are expected to be produced by design. Other source-control measures are included to handle those sources that can reasonably be anticipated.

The secondary requirements focus on properties of specific items that are needed to achieve the main objectives of the standard. Examples of this include sound and flow ratings for fans and labeling requirements. Some of the secondary requirements as well as the guidance in the appendices help keep the design of the building as a system from failing because ventilation systems were installed. For example, ventilation systems that push moist air into the building envelope can lead to material damage unless the envelope is moisture-tolerant.

Whole House Rates

The committee decided to make the target ventilation rate comprise a sum of the ventilation necessary to dilute background sources and sources attributable to occupancy. To find the total amount of outside air needed, one needs to add 2 cfm/100 sq. ft. (10 l/s/100 sq. m.) to the 15 cfm/person (7.5 l/s/person). Thus the air change rate requirement will vary by the size of the house and the occupancy. The figure shows the required air change per hour (ACH) for typical houses.

Ventilation System Requirements

The ventilation system, whether it be natural or mechanical, has to meet some basic requirements:

Capacity and Distribution. Because activities in the normal use of a house (cleaning, smoking, parties, painting, etc.) will produce pollutants in excess of what is handled by the basic rates, the standard requires that each room have either a window or a local exhaust system. The requirement would usually be met by the code-required amount of window area. There is no explicit requirement, however, for air distribution.

Filtration. Air handlers are required to have particulate filters having a minimum efficiency of 60% for 3-micron particles. Although this level of filtration has some direct benefit to the occupants, its main benefit is in keeping the HVAC and distribu-

tion system from becoming a contaminant source. In hot, humid climates dirt build-up combined with moisture can lead to microbiological growth.

Sound Ratings. In most cases noisy fans will not be used. Occupants are more likely to disable them than to run them. The standard requires that whole-house fans be very quiet (1 sone) and that bathroom and kitchen fans be reasonably quiet (1.5 sones) at their rated flows.

Flow Rating. To make sure that the fan actually delivers the amount of air intended, the standard requires either that the air flow rate be measured in the field or that certain prescriptive requirements be met. These prescriptive requirements are on the size and length of ducting as well as the manufacturer's ratings.

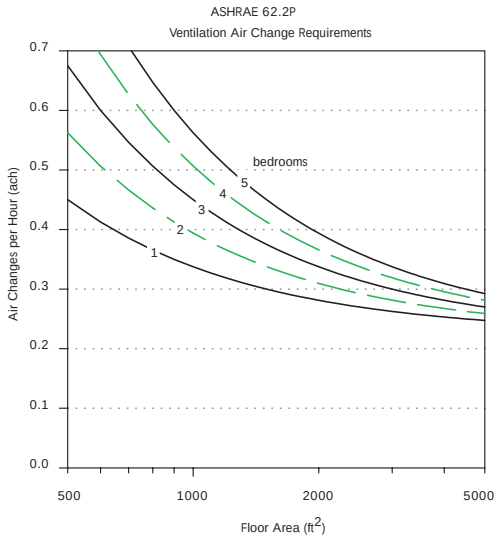
Source Control

While many of the potential sources of pollution are beyond the control of a standard such as 62.2P, various measures can reasonably be taken to reduce pollutant sources at the design stage and thus reduce the need for excessive ventilation. Indeed, for some sources, ventilation may make them worse and not better. This section summarizes some of the source control measures in the standard.

Outdoor Air. The outdoor air can be a source of pollution. The ventilation rates in the standard assume that the outdoor air is relatively clean and able, therefore, to improve indoor air quality by diluting indoor pollutants. When outdoor air quality excursions are foreseeable (e.g., excessive ozone) the standard requires that the occupants be able to reduce whole-house ventilation rates.

Ventilation Inlets. Even if the outdoor air is of good quality, pollution in the building's microclimate can make the air that enters in through windows or other intakes of low quality. The standard requires there be adequate separation between inlets and exhausts or other known sources of pollution.

Figure. Required ventilation for different size houses.



Garages. Attached workspaces or garages can be a source of significant pollution. Carbon monoxide is of particular importance when combustion (e.g., from cars) is taking place. The standard requires than any air-handling equipment placed in these spaces be sealed to prevent entrainment of these contaminants.

Clothes Dryers. 62.2P requires that clothes dryers be vented directly to the outdoors both to minimize moisture and laundry pollutions. Clothes dryers are treated as exhaust fans for the purposes of combustion safety and ventilation.

Moisture Migration. If moisture is forced into building cavities or the building envelope and allowed to condense, molds and other microbiological contamination can become a threat to indoor air quality and material serviceability. The standard forbids the use of ventilation methods (e.g., supply ventilation in very cold climates) that would contribute to that effect unless the building envelope has been designed to accept it.

Combustion Safety

Keeping combustion appliances from becoming indoor pollutant sources is a concern of the standard. Vented combustion appliances can become a problem if there is any significant backdrafting. 62.2P is not a standard about combustion safety, but indoor combustion sources can be a significant source of pollution and the requirements of 62.2P could have adverse impacts on those sources. The standard considers the impact that envelope tightness or ventilation systems could have on the operation of a combustion appliance.

To minimize the potential for backdrafting, the standard requires that naturally aspirated combustion appliances in the conditioned space pass a specific backdrafting test if the total of the largest two exhaust appliances exceed about 1 air change per hour of ventilation (not counting any summer cooling fans). Many new houses would be exempt from these considerations either because all their vented combustion appliances are outside the pressure boundary or are sealed combustion or because their two biggest exhaust appliances fall below the limit.

CO Alarm. The draft standard requires that a carbon monoxide alarm be installed. Ideally no carbon monoxide should be generated or allowed to come into the occupied space, but the requirements to assure this would be prohibitively costly (e.g., such control measures would include prohibiting air handlers in garages). Installing a CO alarm in the space provides more flexibility for builders.

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Download the draft ASHRAE residential standard at:
www.ashrae.org/standards/availdft.htm

Improving Air-Quality Modeling Results

Computer models of air quality provide local governments with the scientific information they use to regulate air pollution emissions, but these models are not always as accurate as regulators would like.

Environmental Energy Technologies Division researchers and colleagues at the University of California at Berkeley have been studying the photochemical characteristics of air pollution in southern California as part of an effort funded by the California Air Resources Board (CARB) to improve the reliability of air quality models. The team's work has yielded new insights into how variability in the solar flux and the concentration of aerosols in the atmosphere affect the formation of smog.

The Clean Air Act Amendments of 1990 require planners to use computer-based air quality models for evaluating emissions control alternatives in pursuit of regulatory standards. Reducing uncertainties in model results has been a focus of much research. "One of the uncertainties," says EETD's Laurent Vuilleumier, "is how well the models represent the optical properties of the atmosphere and their effect on the photochemical reactions that form smog." CARB designated variability in sunlight and its effect on photochemistry as one of the areas needing improvement in current air quality models.

Vuilleumier, an EETD scientist, UC Berkeley's Rob Harley, EETD's Nancy Brown, and colleagues have been using data from CARB's 1997 Southern California Ozone Study (SCOS97) to gain a better understanding of the relationship between the amount of light entering the atmosphere and the rates of photochemical reactions that form ozone, a significant component of smog that influences the concentrations of other air pollutants.

"Ozone concentration is extremely sensitive to reactions that are driven by sunlight," explains Vuilleumier. "These photolysis reactions initiate the decomposition of chemical species such as nitrogen dioxide and formaldehyde by sunlight. The photolysis rates are variable because the amount of light reaching the lower atmosphere—called the solar actinic flux—is variable. Aerosols, particles in the atmosphere, can extinguish light through scattering and absorption, reducing the rate of certain smog-forming reactions in the lowest layers of the troposphere, while sometimes enhancing their rates in the higher layers."

Vuilleumier, Harley, Brown, and colleagues used the SCOS 97 measurements of solar ultraviolet irradiance, taken at two stations in Riverside and Mount Wilson, to compute the atmosphere's total optical depth. As a measure of the transparency of the atmosphere to the penetration of sunlight, optical depth is very influential in determining solar flux. Using a mathematical method called principal component analysis, the researchers separated the factors affecting optical depth into components, and determined which components were most significant.

The largest component, which the researchers attribute to the concentration of aerosols in the atmosphere, accounted for 91 percent of the variability in the data. The second component, the concentration of ozone, accounted for another 8 percent of the observed variability.

"These results tell us that air quality models need to be modified to better account for the effects of aerosol and ozone concentration on smog formation," says Vuilleumier. "As a result of this work, we have prepared a report to CARB reviewing the mathematical methods used in the models to represent atmospheric optical properties and their effect on photochemical reactions, with suggestions on how to improve them. There are many other variables that affect the accuracy of these models, such as meteorological factors, chemistry, and emissions inventories, and we hope to continue our studies of some of these for CARB."

Air-quality models typically used by CARB today include the Urban Airshed Model and the SARMAP (San Joaquin Valley Air Quality Study Regional Model Adaptation Project) Air Quality Model.

"Variability in Ultraviolet Total Optical Depth during the Southern California Ozone Study (SCOS97)," by Vuilleumier, Robert Harley, Nancy Brown, James Slusser (Colorado State University), Donald Kolinski (University Corporation for Atmospheric Research), and David Bigelow (Colorado State) has been published in the February 2001 issue of *Atmospheric Environment.*

—Allan Chen

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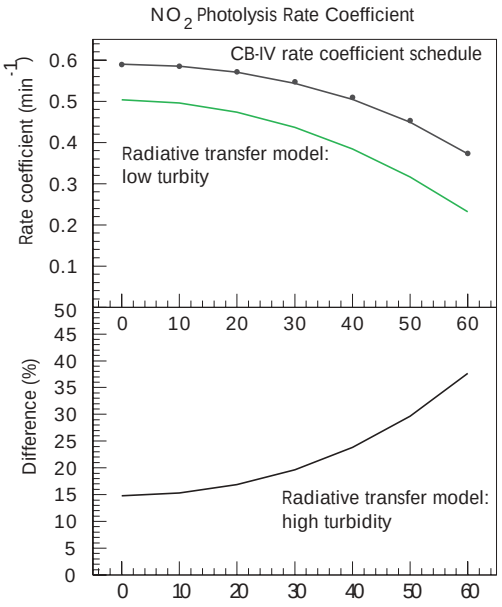
This research was funded by the California Air Resources Board.

Figue. Radiative Transfer Model prediction for nitrogen dioxide photolysis rate coefficient at Riverside (CA) assuming low aerosol concentration (low turbidity) and high aerosol concentration (high turbidity). This example illustrates the changes in photolysis rates that are expected to result from variations in aerosol optical depth that were observed during SCOS97.



Research Highlights

EETD Garners DOE Awards

Eight EETD research projects on energy-efficient technology were given a place on the DOE's "Energy 100" list of the department's best scientific and technological accomplishments since its origin in 1977. Also honored were four additional projects which garnered "Energy@23" awards by a "citizen judges" panel.

The technologies were chosen based on their impact on saving consumers money and improving quality of life. A number of these technologies have saved consumers billions of dollars in energy costs since 1977, and have the potential to save much more as their market penetration increases. Others improve workplace and home safety, and quality of life.

The Energy@23 awardees were chosen by the panel from the Energy 100 list. These 23 highest-ranked innovations "demonstrate benefits to the American public, contribute to U.S. competitiveness in the global marketplace, and have the potential for significant future growth," according to the DOE award criteria.

"These awards speak to the tremendous influence that Berkeley Lab researchers have had on our society in the area of energy and the environment," said Laboratory Director Charles V. Shank. "They also illustrate in tangible ways how our national laboratories make a difference in all of our lives."

"We are deeply honored that the judges have chosen to recognize our work in energy efficiency, environmental research, and air quality," said EETD Director Mark Levine. "We are continuing to conduct high-risk, high-payoff research in a number of new areas such as information technology, commercial building design, and electric grid reliability that will benefit American consumers with lower energy costs, a cleaner environment including reduced greenhouse gas emissions, more productive workplaces, and improved energy security."

The eight Berkeley Lab projects on the Energy 100 list are

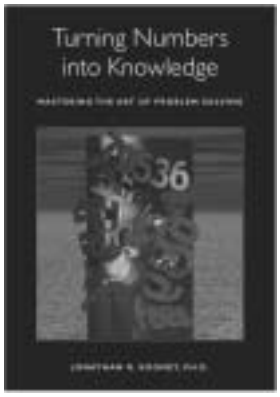
- DOE-2: Energy and Cost-Calculation Software—these programs provide an accurate estimate of a proposed building's energy consumption and environmental conditions.
- Residential Radon Entry and Mitigation—Berkeley Lab researchers led national efforts to study the infiltration of radioactive radon gas, a large risk factor in lung cancer, into homes from naturally occurring elements in certain soils, and to develop ways of removing this gas before it reaches living spaces.
- The Carbon Monoxide Dosimeter—this lightweight device worn on clothing provides an accurate, inexpensive, time-averaged measure of exposure to carbon monoxide.
- An Energy-Efficient Safe Torchiere Lighting Fixture—a safer, energy-efficient replacement for energy-guzzling halogen torchieres, this device uses compact fluorescent lamps. Halogens have been responsible for more than 200 fires and 30 deaths in the U.S.
- The Diesel Particle Scatterometer—this instrument to measure airborne particulates will enable state and federal agencies to precisely monitor diesel particulates and air quality and guide engine designers to minimize pollution in the environment.
- Efficient Low-Emissions Burner for Heating and Power—the simple, lightweight, low-emissions (far below the most stringent clean-air standards) technology can be scaled for small domestic water heaters or large industrial boilers and gas turbines.
- ` Methods for Reducing Urban Heat Islands to Save Electricity and Reduce Smog—Berkeley Lab researchers are working with the private sector and local governments to capture some of the billions of dollars in possible annual savings in cooling energy costs, and to reduce the incidence of severe smog episodes by reducing the "urban heat island effect" through cool roofs and shade trees.
- The Home Energy Saver: The First Web-Based Energy Tool for Consumers—empowers homeowners and renters by calculating their average energy bill, recommending energy efficiency improvements, and providing information on how to implement efficient retrofits.

The four Energy@23 honorees are

- The Electronic Ballast: Accelerating the Market for Efficient Lighting—this has replaced older magnetic ballasts as the power supply for fluorescent lamps.
- Energy-Efficient Windows—low-emissivity coatings and spectrally selective low-E coatings save U.S. consumers money by reducing heating and cooling energy lost through windows.
- Reducing Standby Power Losses—Berkeley Lab researchers are working with industry and governments to reduce standby power loss of appliances, the energy consumed when they are switched off or not performing their principle function, which may represent 5 percent of all electricity used in the U.S.
- The Aerosol Duct Sealer—a recently commercialized technology that blows aerosol adhesive particles through residential ducts to seal leaks. It can reduce the estimated 10 to 30 percent loss of heating and cooling energy in most homes.

The citizen judges panel consisted of individuals from private industry, academia, and the non-profit sector. Complete information can be found at www.ma.doe.gov/energy100.list.html.

EETD Researcher Teaches Readers to Use Numbers Effectively



EETD's Jonathan Koomey has just released his latest book, titled *Turning Numbers into Knowledge: Mastering the Art of Problem Solving.* The book grew out of his experience in training analysts for work within EETD in the past decade. It is written for beginning problem solvers in business, government, consulting, and research professions, and for students of business and public policy. It is also intended for supervisors of such analysts, professors, entrepreneurs, and journalists who

Research Highlights, *cont.*

focus on scientific or business topics.

The book includes many cartoons and other amusing graphics, as well as quotes and examples galore. The chapters are short and to the point, with plenty of further reading in the back for readers who want to explore further.

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Helping Builders and Homeowners Make Intelligent Window Choices

Berkeley Lab researchers with collaborators at the University of Minnesota have published the second edition of *Residential Windows: A Guide to New Technologies and Energy Performance*, with technical assistance from the Office of Building Technology, State and Community Programs. W.W. Norton & Company publishes the book. Based on the latest research, the book provides home owners, architects, designers, and builders with the information necessary to evaluate windows and make intelligent choices. This edition covers every aspect of window design and technology from the basic mechanisms of heat transfer to new products and energy efficiency ratings. And, it includes new tools for making home window purchasing decisions. The book is available in major bookstores or from the publisher at http://www.wwnorton.com/.

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VisualSPARK 1.0 Now Available

Simulation of a physical system requires development of a mathematical model, usually composed of differential and/or algebraic equations. These equations then must be solved at each point in time over some interval of interest. The Simulation Problem Analysis and Research Kernel (SPARK) is an object-oriented software system to perform such simulations. By "object-oriented" we mean that components and subsystems are modeled as objects that can be interconnected to specify the model of the entire system.

VisualSPARK 1.0 is now available from Berkeley Lab; some features are

- Ability to solve nonlinear dynamic systems of arbitrary complexity—from a few equations up to thousands of equations
- User-specified time step (variable time step is planned for Version 1.1)
- Robust solution methods
- HVAC component library
- Dynamic plotting allows results to be plotted while simulation is running
- Up to 20 times faster execution times than related programs (through use of graph-theoretic methods for problem size reduction)

The main elements of VisualSPARK are a user interface, a network specification language, a solver, and a results processor. With the network specification language you create calculation objects and link them into networks that represent a building's envelope or HVAC system. The solver solves this network for user-specified input parameters. The results processor graphically displays the results.

VisualSPARK runs under the Windows 95/98/NT/2000, SunOS, Solaris, Linux and HPUNIX operating systems. VisualSPARK costs $250. Please visit the Simulation Research Group web site, http://SimulationResearch.lbl.gov, for purchase information. VisualSPARK was developed by EETD's Simulation Research Group and Ayres Sowell Associates, with support from the U.S. Department of Energy.

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EETD Seminar Discusses Energy Crisis

What directions the city of Berkeley needs to take to survive the current California energy crisis was the subject of a noontime seminar recently held by the Environmental Energy Technologies Division. Leading the discussion were Jeff Siegel, graduate student in the Energy Performance of Buildings Group, Rick Diamond, staff scientist, also of EPOB, Bill Golove, staff research associate of EETD's Energy Analysis Department, and Neal De Snoo, city of Berkeley's Energy Manager. Siegel, who also is chair of Berkeley's Energy Commission, made a presentation similar to one he presented the previous evening to the Berkeley City Council.

Berkeley's Energy Commission was established to advise City leaders on steps Berkeley should take to maintain a healthy energy system. At an earlier brain-storming meeting of the Commission, such ideas as conservation, system efficiency, renewable sources, reliability, and social equity were suggested as possible strategies. Out of these, the Commission agreed that conservation should be the first method used by citizens to lower their utility bills. Other ideas posited for greater investigation include municipalization of the utilities, an opt-out aggregation program for Berkeley residences, and rates based on climate-based load profiles. Conservation tactics could include such simple actions as turning down thermostats or installing efficiency measures: attic insulation, water heater wraps, etc. Many believe that conservation efforts will result in less pollution and lower costs, and will protect ratepayers from future price spikes.

The Energy Commission will recommend that the City Council aggressively promote conservation measures and allocate City resources to these tasks. Other suggested measures will be more problematic. If Berkeley were to municipalize its utilities (buy the poles and wires), there would be no guarantees of cheaper rates

and the city would have to purchase and maintain an existing system. An opt-out aggregation would allow residential and small commercial ratepayers to form one large energy-purchasing block, making the city the default power provider, but such a measure would require a change in state law and still not guarantee any cheaper electricity rates.

The final picture of the crisis presents both good- and bad-news scenarios. The bad news is the problems will likely be exacerbated this summer when usage will be higher; but the good news is the crisis is a substantial opportunity for Berkeley to improve its environmental stances and commit itself to further reduction of greenhouse gases.

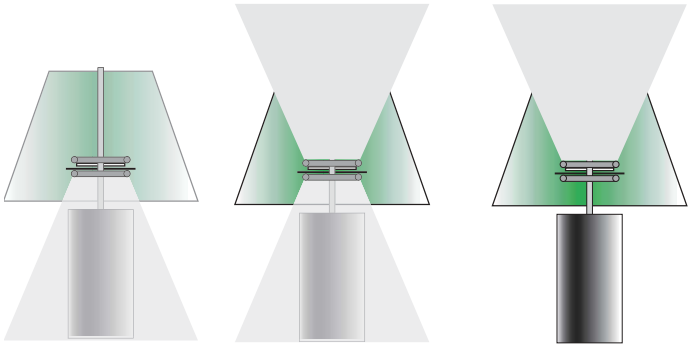
After the Commission presentation to the Berkeley City Council, the Council passed an encompassing resolution that listed nine different responses to the crisis. The text of the resolution can be found on the City of Berkeley's web site, http://www.ci.berkeley.ca.us.

EETD Develops Energy-Efficient Table Lamp

Researchers in EETD's Lighting Group have developed a new high-performance, energy-efficient table lamp that is designed to save energy in homes and offices while greatly increasing lighting quality and visibility. At full power, this two-lamp fluorescent system matches the combined luminous output of a 300-watt halogen lamp and a 150-watt, incandescent table lamp while using only a quarter of the energy. Berkeley Lab is working with the Sacramento Municipal Utility District (SMUD), Southern California Edison (SCE), and Pacific Gas and Electric (PG&E), to acquire and field-test the first production lamps based on the new high-performance design.

More details about the lamp will be published in the next issue of this newsletter. Information is also available at the following Web page: http://enews.lbl.gov/Science-Articles/Archive/cfl-tablelamp.html.

Figure. The new lamp combines efficient upward and downward lighting using dimmable fluorescents.



EnergySmart Schools Inventors Summit Takes Place at Berkeley Lab

Four creative elementary school students, winners of the EnergySmart Schools Contest, met on Jan. 12 with the nation's top energy scientists and engineers at Berkeley Lab, where their energy-saving ideas were built. The national invention contest for elementary school students was sponsored by Owens Corning and the U.S. Department of Energy.

Students drew an original, energy-saving device and submitted a description of how it works for a chance to be appointed an EnergySmart Schools Inventor and participate in the EnergySmart Schools Inventor Summit.

The winners were Annie Austin, sixth grade, Lewis Farrell Elementary School, Philadelphia, PA, Kate Flor-Stagnato, fourth grade, Coles School, Scotch Plains, NJ, Jonathan Ioviero, fifth grade, Oak Orchard Elementary School, Medina, NY, and Michael Torrey, fifth grade, Forest Park Elementary School, Fremont, CA.

At the EnergySmart Summit on January 12, the winners took a tour of Berkeley Lab and then convened at a workshop site in the afternoon to build their inventions with the help of scientists and engineers. Participating from EETD were Rick Diamond, Erik Page, and Michael Siminovitch. About 30 staff members from the Lab's Engineering Division helped build the invention prototypes.

Once the winners were announced in December, Berkeley Lab's Engineering Division worked to develop "kits" that the student inventors were able to assemble into their inventions when they arrived at the Lab. The inventions and the results can be viewed at EnergySmart Schools Inventors web site: http://eetd.lbl.gov/inventors/.

Correction

In the last edition of *EETD News*, incorrect contact information was given in the article entitled "Polymers Take Charge." To learn more about polymers, contact John Kerr, JBKerr@lbl.gov; telephone 510 486-6279; fax 510 486-4995.

Important Notice: *EETD News* Distribution Shifts to Web

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