Environmental Energy Technologies Division

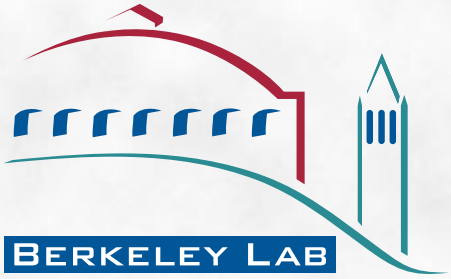
Lawrence Berkeley National Laboratory

Environmental Energy Technologies

Energy is vital to the health and security of the economy and the nation. Cost-effective, energy technologies can strengthen the economy, mitigate the effects of energy production on the environment, and protect human health. Development of such technologies requires a sustained, vigorous program of research on technology and market dynamics.

The mission of Berkeley Lab's Environmental Energy Technologies Division (EETD) is to perform research and development leading to better energy technologies and market mechanisms that reduce adverse energy-related environmental impacts. Our work increases the efficiency of energy use, reduces its environmental effects, provides the nation with economic benefits, and helps developing nations achieve similar goals through technical advice.

EETD carries out its work through the support of the U.S. Department of Energy (the Division's primary sponsor), other federal entities, state governments, and the private sector. Our staff of 300 represents a diverse cross-section of fields and skills, ranging from architecture, physics, and mechanical engineering to economics and public policy. Many staff members have joint appointments at the University of California, Berkeley, and the Division draws on students and recent graduates from UC and other academic institutions for research assistants and postdoctoral appointments.



Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) has been a leader in science and engineering technology for more than 65 years, serving as a powerful resource to meet national needs. As a multiprogram Department of Energy laboratory, Berkeley Lab is dedicated to performing leading edge research in the biological, physical, materials, chemical, energy, environmental, and computing sciences.

http://www.lbl.gov/

Major Areas of Research and Analysis in the Environmental Energy Technologies Division

Energy Efficiency in Buildings

- Energy-efficient windows and daylighting systems
- Energy-efficient lighting concepts and systems
- Simulation tools for energy use in buildings
- Information technology for energy efficiency in commercial buildings
- Application of advanced concepts to testbed buildings

Indoor Environment

- Advanced ventilation, infiltration, and thermal distribution systems
- Sources, emissions, and transport of indoor pollutants
- Air pollutant exposures and health risks
- Control strategies for indoor air quality

U.S. Energy Issues

- Appliance and equipment energy-efficiency standards
- Energy efficiency programs to promote market transformation
- Energy utility deregulation
- End-use energy demand forecasting and policy analysis

International Energy Issues

- Energy efficiency in developing countries (special emphasis: China and India)
- Energy efficiency and global climate change

Advanced Energy Technologies

- Electrochemical research on batteries
- Combustion and emissions
- Laser and other spectroscopic tools: development and application

Emerging Areas of R&D

Air pollution: from science to public policy

●

Electricity reliability: distributed energy systems, real-time control, and markets

●

Industrial energy efficiency: U.S. and international perspectives

Building Technologies

Division researchers work closely with industry to develop efficient technologies for buildings that reduce energy bills while improving the comfort, health, and safety of building occupants. Our technology efforts focus on windows, daylighting, lighting systems, building simulation research, and commercial building systems.

Division researchers develop advanced light sources, fixtures, and control systems...

...optical coatings and other materials for future windows...

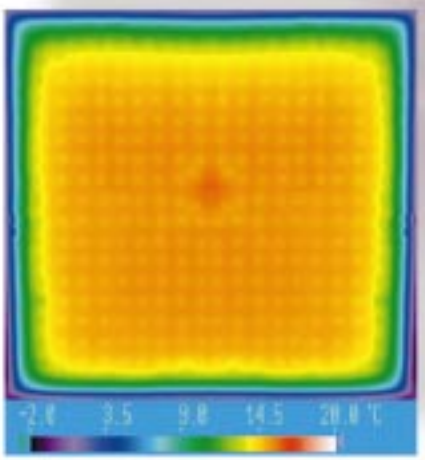
Windows and Daylighting

Every year, heat worth billions of dollars flows through windows in American homes and businesses. In hot climates, the heat radiates into homes, requiring expensive air conditioning. In cold climates, it leaks out, requiring more energy to keep the occupants warm. Thermally efficient windows save consumers and businesses energy and money.

The Division's researchers develop advanced optical coatings and materials for future windows; study the energy performance of windows and window systems (windows, glazings, and their frames, blinds, louvers, etc.); and create computer tools to improve window energy performance and aid product rating and labeling.

In the 1980s, EETD researchers worked with window manufacturers to develop special "low emissivity" window coatings to reduce heat loss through windows. These windows, which reduce energy loss by 20% to 50% depending on the design, now account for 35% of the market and have saved more than $1 billion in energy costs.

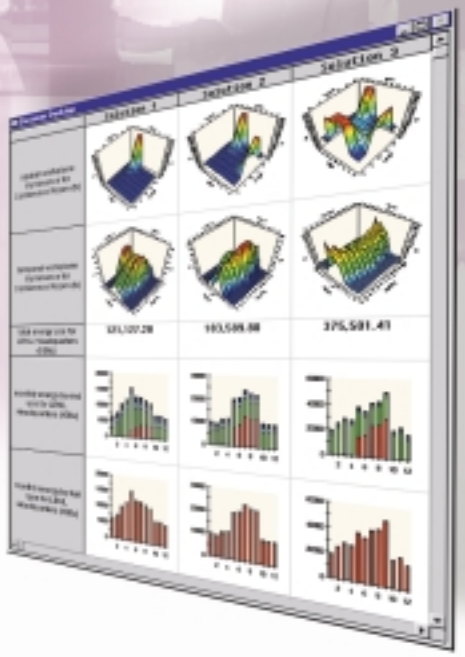
Current windows research includes developing new tools and measurement techniques to assess energy performance and comfort; advanced electrochromic coatings that automatically change the level of transparency depending on exterior lighting conditions; and technologies and design strategies for commercial buildings that maximize daylighting benefits. In addition, EETD works with industry partners in developing standards for rating windows.



By confirming that this window suffers its largest heat loss at its edges, the infrared thermograph provides manufacturers vital data for increasing window efficiency.

Data from this goniophotometer, developed by EETD researchers to measure the amount of light leaving a fixture at different angles, aid in developing more efficient lighting systems.

...and new simulation tools for building design professionals.



The Building Design Advisor's graphical interface allows users to compare alternative designs and their effects on a large variety of building parameters.

Lighting

Lighting accounts for 25% of all electricity consumed in the United States, at a cost of more than $35 billion per year.

Researchers here develop advanced light sources, optimize lighting fixtures and control systems for energy efficiency, design computer tools to quantify the energy performance of lighting systems, and test system performance in the field, including the impacts on human performance and health.

The Division's lighting team worked with manufacturers to develop electronic ballasts, a more efficient replacement for the magnetic ballasts used to control the current in fluorescent lamps. Electronic ballasts now account for 32% of the market, saving consumers hundreds of millions of dollars per year.

Working with industry, the group developed a torchiere floor fixture based on the compact fluorescent lamp—an energy-efficient, lower- temperature alternative to the hot 300-watt halogen torchieres that are blamed for starting hundreds of fires.

Building Simulation

Architecture and engineering firms use DOE-2—a computer program developed by Division researchers that analyzes the energy performance of buildings—to increase the energy efficiency of their designs. According to a DOE-2 user survey, buildings designed with DOE-2 save an average of 20% of building energy use. EnergyPlus, now under development, will replace DOE-2 and offer many new features.

Radiance—a computer program for lighting analyses, also developed by Division researchers—allows lighting and daylighting designers to assess the quantitative and qualitative performance of their designs. Desktop Radiance, now under development, will greatly facilitate the use of Radiance and increase its user base.

In addition to analytical tools, Division researchers are developing tools, like the Buildng Design Advisor, which change the way architects design buildings, by providing quick and easy access to multiple analysis tools linked to a single building database.

In the first-ever such use of the Internet, a program called Home Energy Saver is available to anyone with Web access (http://HES.lbl.gov). The user inputs information about a home, and HES (using DOE-2) calculates total energy use and cost, and suggests economic ways of reducing the energy bill.

Commercial Building Systems

The commercial building sector spends $80 billion per year on energy. Maximizing efficiency can cut billions from this cost. Researchers have launched a major effort to address this opportunity, developing tools to benchmark energy performance. Such tools let designers, owners, and operators access data throughout the building lifecycle and ensure that building operations meet performance targets.

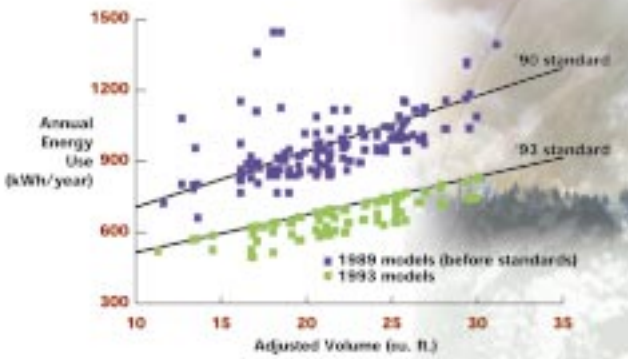
Energy Analysis

The Division's energy analysts gather and interpret information about energy, including supply and consumption, energy technologies, management practices, government policies, and economic and environmental impacts. These studies examine the performance of energy-efficient technology in the marketplace; the impact of various regulatory policies; the feasibility of different approaches to designing energy-efficient standards and building codes; and technology options for reducing the emissions of greenhouse gases. The work provides local, state, and national governments, as well as regulatory agencies and international institutions with information to help them formulate effective energy and environmental policies.

Refrigerator energy efficiency standards reduced average energy use substantially between 1989 and 1993—saving consumers billions of dollars every year.

Efficiency Gains with Standards

(for top-mount auto-defrost refrigeration)



Standards, Codes, and Policy Analysis

Appliance energy-efficiency standards and provisions in building codes in the United States save consumers billions of dollars a year. Often inspired by the U.S. experience, dozens of nations have adopted or are currently developing appliance standards and building codes. Division research provides impartial technical information on the energy use of appliance technologies to the Department of Energy's standards development process. In addition, studies of building codes help code officials formulate and fine-tune energy-efficiency measures.

Division researchers conduct studies of utility-related public policy issues, from transmission pricing and market power to the role of renewables and energy efficiency. As the electric utility industry undergoes restructuring in some states, Division studies provide useful information to the industry and the regulatory community charged with guiding this evolution.

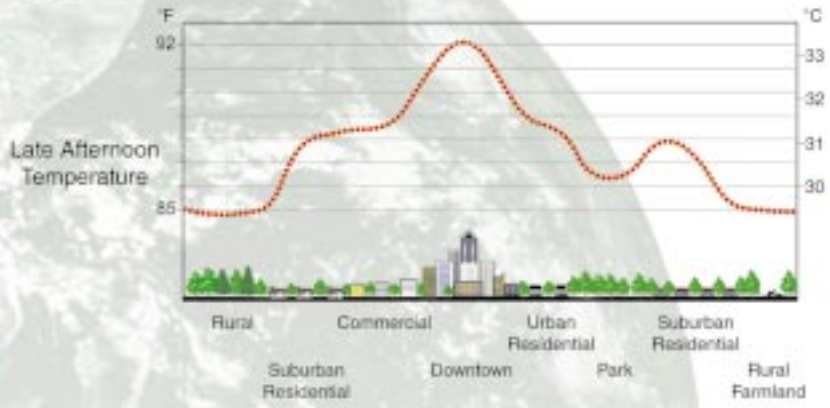
Energy-Efficient Procurement and Labeling

An important approach to improving energy efficiency is to provide large buyers with information about energy-efficient products. The President directed federal agencies—collectively the world's largest customer of most energy-using products—to buy products that are among the top 25% most energy-efficient options on the market. Researchers in Berkeley and the Division's Washington D.C. Office are involved in projects to help federal, state, and local agencies procure energy-efficient products. EETD researchers also provide analytical support for the voluntary ENERGY STAR programs in appliance labeling and new homes, administered jointly by the U.S. Environmental Protection Agency and its partner, the U.S. Department of Energy. The government harnesses market forces to promote energy efficiency and pollution prevention by inducing manufacturers to put ENERGY STAR labels on their products.

Urban Heat Islands

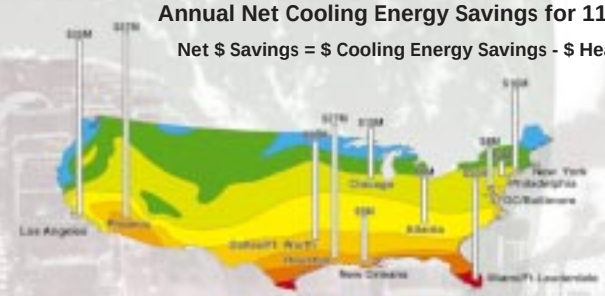
Cities are urban heat islands, zones of higher temperature relative to the surrounding countryside. The heat island effect intensifies the use of expensive air conditioning. Higher outdoor air temperatures also increase smog formation. Division researchers have pioneered an effective, simple approach to keeping cities cooler—the use of shade trees and solar reflective roofing and paving materials. EETD studies have found that the cooling effect from wide application of these measures could save billions of dollars and reduce smog in large cities nationwide.

Sketch of an Urban Heat-Island Profile



Annual Net Cooling Energy Savings for 11 Metropolitan Areas

Net $ Savings = $ Cooling Energy Savings - $ Heating Energy Penalties



Reducing Greenhouse Gas Emissions

EETD's studies of energy use and greenhouse gas (GHG) emissions have made the Division an important source of information on global climate change for policymakers. Researchers have analyzed the potential of energy-efficient technologies to reduce GHG emissions, and have evaluated the emissions of the world's buildings and industrial sectors. Our efforts include co-managing the policy study "Scenarios of U.S. Carbon Reductions," a cooperative effort of five U.S. Department of Energy national laboratories. Internationally, our contributions appear prominently in the United Nations-sponsored Intergovernmental Panel on Climate Change Scientific Assessments. Division researchers also provide technical support to developing nations creating programs, energy codes, and standards to reduce GHG emissions and encourage efficiency. A China energy group works extensively with the Chinese government to exchange information on energy use and energy-efficiency practices.

EETD is an important source of information on global climate change.

Indoor Environment

Approximately one-third of the energy consumed in the United States is used in buildings. Energy for ventilation and thermal distribution in buildings accounts for roughly one-sixth of this total (4 to 5 Quadrillion Btu/year) and is valued at about $40 to $50 billion annually. Reducing a building's infiltration and mechanical ventilation can save energy. However, this strategy may produce undesirable side effects, because building energy use, ventilation, indoor environmental quality, and occupant health, comfort, and productivity are interrelated.

Buildings can be designed and operated to protect human health and enhance productivity, while using energy as efficiently as possible. EETD researchers have estimated that improvements in U.S. building environments could decrease annual health care costs by $4 to $10 billion and increase worker productivity by $40 to $240 billion.

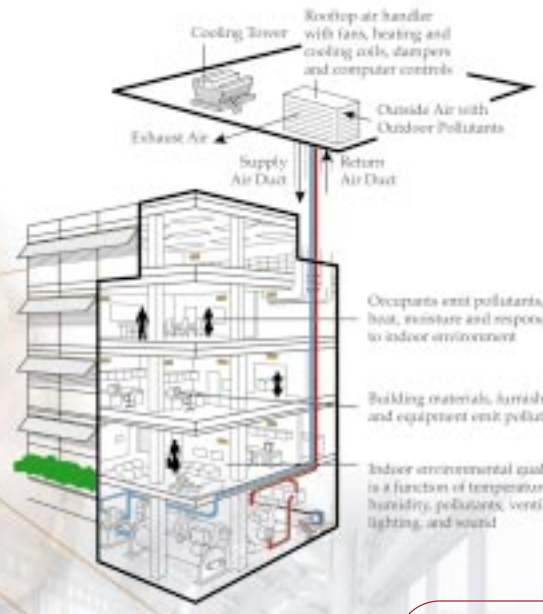
Developed by lab researchers, this device relies on aerosols to seal inaccessible leaks throughout ventilation duct systems, ensuring that the 20% to 40% of energy loss from air leaks is put to good use.

Ventilation Technologies

Division research on air infiltration and ventilation in commercial and residential buildings has led to significant advances in modeling and measuring ventilation and its energy requirements. The work has contributed to the development of many ASHRAE (Association of Heating, Refrigerating and Air-Conditioning Engineers) and state standards, as well as building codes governing ventilation and indoor air quality. EETD research includes developing new methods of measuring ventilation rates and their spatial distribution and evaluating new ventilation technologies with potential to improve indoor air quality and reduce energy use.

Sealing leaky, energy-wasting ducts is one way to reduce energy use substantially. An EETD study showed that a typical house with ducts located in the attic or crawlspace wastes approximately 20% to 40% of heating and cooling energy through duct leaks, and draws approximately 0.5 kilowatts more electricity during peak cooling periods. Sealing leaks could save close to 1 Quadrillion Btu of energy per year nationwide. Division research has led to the development of a major new duct sealant technology that uses aerosols to reach and seal areas of ducts inaccessible to humans. Its commercialization is underway.

Improvements in the indoor environment could decrease U.S. annual health care costs by $4 to $10 billion.



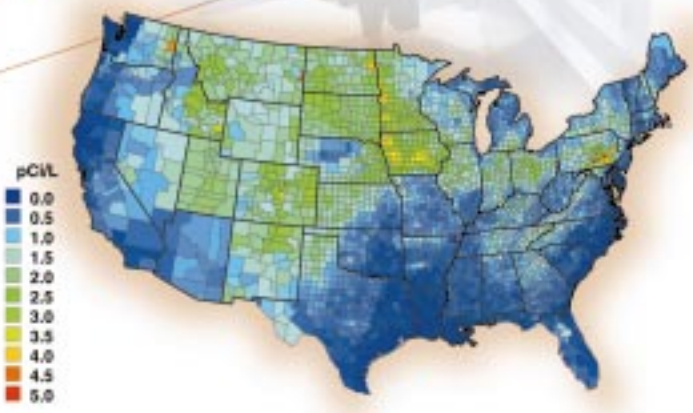
Indoor Chemistry and Exposure

Since most people in the United States spend about 90% of their time in buildings, exposures to many air pollutants occur indoors, whether from outdoor or indoor sources. EETD researchers have contributed to identifying indoor air pollution health risks. We have also enhanced understanding of the sources, behavior, exposures, and risks of a wide variety of indoor pollutants, including radon, volatile organic compounds, environmental tobacco smoke, carbon monoxide, polycyclic aromatic hydrocarbons, ozone, and airborne particles including bioaerosols. Energy-efficient technologies and strategies for reducing unacceptable exposures to air pollutants—increased ventilation, air filtration, radon-resistant construction of houses, and better cleaning practices—are developed and evaluated for effectiveness and cost.

EETD researchers are leaders in estimating distributions of population exposures to, and risks from, indoor air pollutants—such as radon, carbon monoxide, environmental tobacco smoke, and volatile organic compounds—through the development and application of new measurement methods, advanced statistical analysis methods, and models.

EETD researchers have made significant contributions to identifying major indoor air pollution health risks and sources.

Projected Long-term Mean Indoor Radon Concentrations



Division projections of long-term mean radon concentrations have helped identify regions where elevated radon concentrations can be found.

Air Flow and Air Quality Modeling

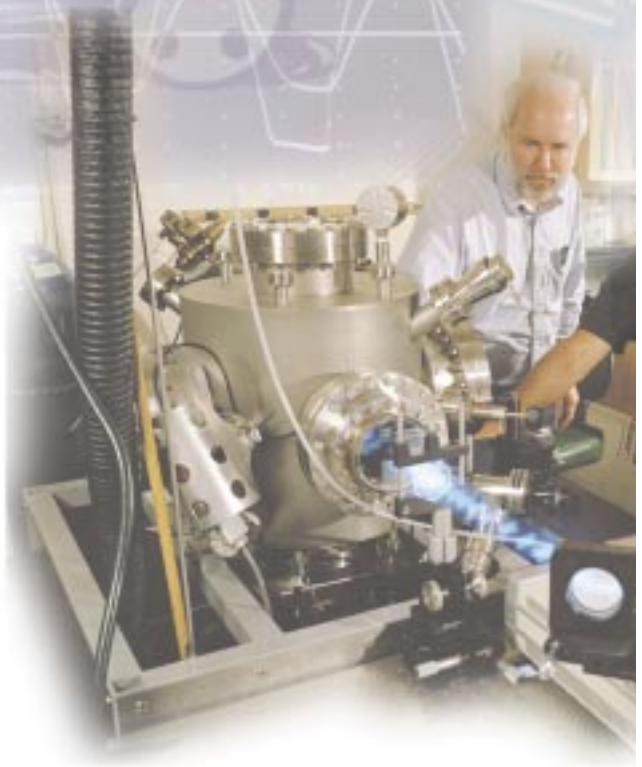
Models to predict air flow and pollutant behavior in complex buildings with many floors and rooms and multiple heating, ventilating, and air-conditioning systems are essential tools for designing and operating energy-efficient buildings with good indoor air quality. EETD researchers led the international effort to develop and evaluate the accuracy of the COMIS (Conjunction of Multizone Infiltration Specialists) air flow and pollutant transport model. We have also developed models to predict emission rates of many air pollutants from a wide range of indoor sources; the deposition of particles by size to indoor surfaces; sorption and desorption of organic vapors on indoor surfaces; and the transport of soil gases with radon and other pollutants into houses.

Advanced Energy Technologies

Research on advanced energy technologies aims to develop new processes and devices for more efficient, environmentally benign energy conversion and storage technologies, and to understand and mitigate the effects of anthropogenic substances from energy generation and other sources on the environment.

A thin wedge of Aerogel, a lightweight, highly efficient insulator created by Division researchers, blocks the heat from this intense flame. Ongoing work centers on making Aerogel an economic option for everyday application.

A goal of Division electrochemistry research is developing viable batteries for electric and hybrid vehicles.



Batteries and Fuel Cells

A major goal of the Division's electrochemistry research is to develop electrochemical power sources suitable for applications in electric and hybrid electric vehicles. Battery systems are expensive and don't hold enough electric charge to drive a vehicle the same distance as a comparable gasoline-powered automobile.

EETD is undertaking research that will lead to the development of low-cost, rechargeable, advanced electrochemical batteries with the high-performance potential to compete with the combustion engine. Current work focuses on lithium-polymer and lithium-ion batteries.

This low-swirl burner emits levels of nitrogen oxides far below stringent California state standards.

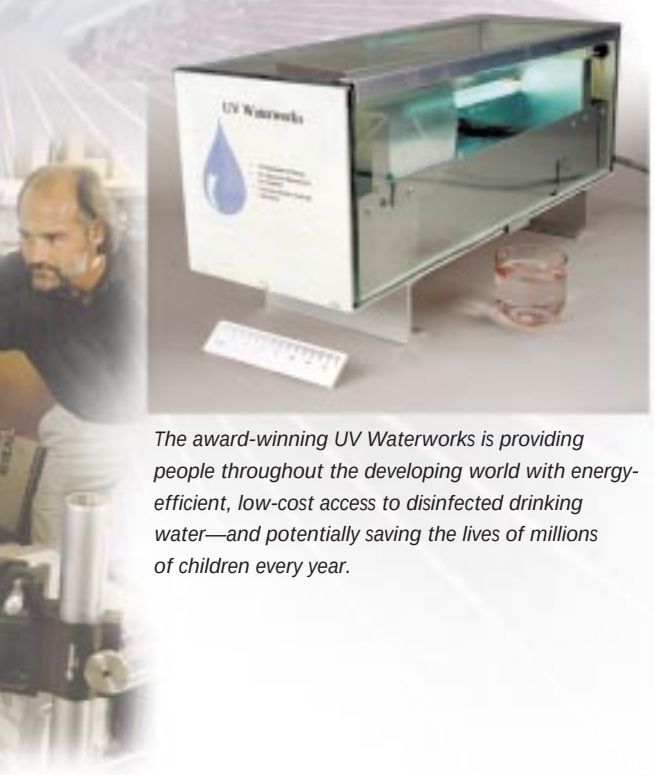
Cleaner Combustion

Combustion research generates the fundamental physical and chemical knowledge necessary to reduce emissions and increase efficiency. Experimental and modeling studies lead to the design of better combustion devices. EETD researchers work with Berkeley Lab's National Energy Research Scientific Computing Center (NERSC) to model combustion processes using high-performance supercomputers.

Turbulent combustion takes place in all heat and power generating systems, including combustion engines in automobiles and industrial boilers and furnaces. By studying the properties of turbulent fluid motion in combustion chambers, Division researchers have devised a low-swirl burner that emits 20 times less nitrogen oxide than current technology. (Nitrogen oxides are greenhouse gases, and when exposed to sunlight, also generate smog.) The burner could be used in the residential and commercial sectors in water heaters and boilers.

Safer Drinking Water

EETD's indoor environment researchers have created an inexpensive technology to solve a major health problem in developing nations. About one billion people do not have access to safe drinking water. UV Waterworks is an ultraviolet water disinfection device designed to provide safe drinking water to communities in the developing world. It disinfects water using the equivalent of a 40-watt light bulb at a cost of two cents per ton of water treated. The device renders harmless water's bacterial and viral content, improving the chance for infants to avoid the diarrheal diseases that, according to UNICEF studies, killed 3.8 million children under age five in 1993. A special version of the device has been designed for areas in developing or industrialized nations disrupted by natural disasters such as floods and earthquakes.



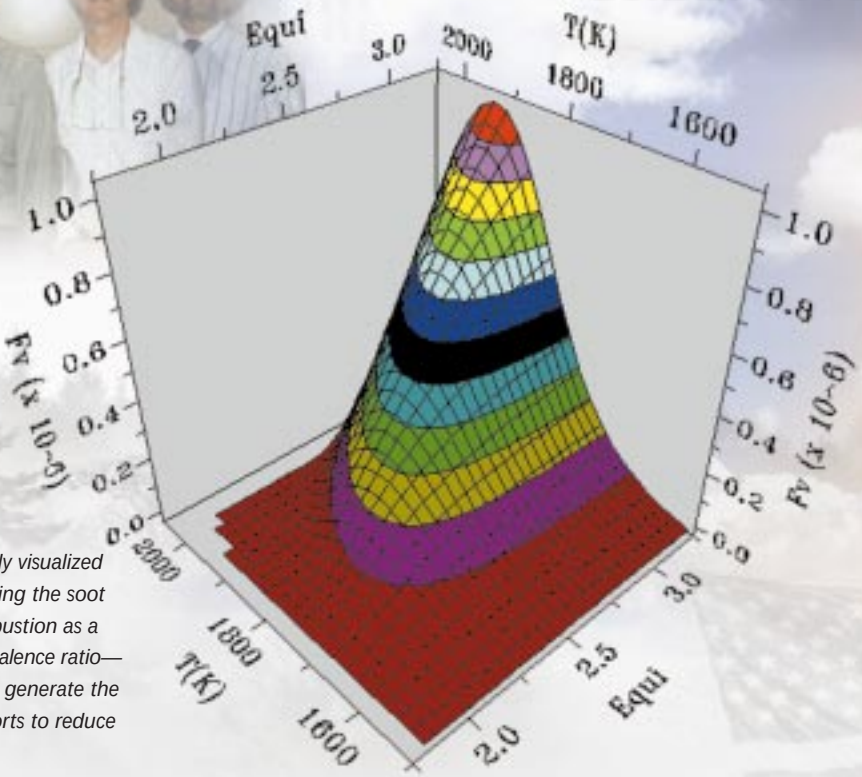
The award-winning UV Waterworks is providing people throughout the developing world with energy-efficient, low-cost access to disinfected drinking water—and potentially saving the lives of millions of children every year.

Advanced Instrumentation

EETD researchers apply advanced instrumentation such as laser spectroscopy, and basic knowledge of physics, chemistry, electrochemistry, and biology to develop other advanced energy technologies. These include sensors for the pulp and paper industry, electrotechnology for soil remediation, tools to characterize emissions from oil storage tanks, processes that simultaneously remove nitrogen and sulfur compounds from flue gases, and catalytic methods for improving industrial processes.

Cross-Cutting Activities

The "A" Team



Translating complex data into easily visualized formats—such as this graph showing the soot volume fraction for ethylene combustion as a function of temperature and equivalence ratio—combustion models are helping to generate the basic science needed to guide efforts to reduce air pollution.

The Applications Team

The Applications Team marshals the expertise and resources of energy-efficiency experts from EETD and Berkeley Lab's In-House Energy Management (IHEM) group, in the Facilities Department. Its purpose is to deploy advanced energy-efficient technology and indoor environmental quality concepts in buildings in the United States and abroad. Leading by example, the IHEM group has achieved 40% energy savings in the Lab's own buildings.

Atmospheric Processes, Effects, and Analysis Program

This research is an interdisciplinary effort to bring together researchers in the Division and the University of California, Berkeley, interested in atmospheric processes, technology, modeling, and climate change studies. Focus areas include atmospheric aerosols, atmospheric chemistry, modeling, emissions, advanced instrumentation, and global climate.

Federal Energy Management Program Technical Support

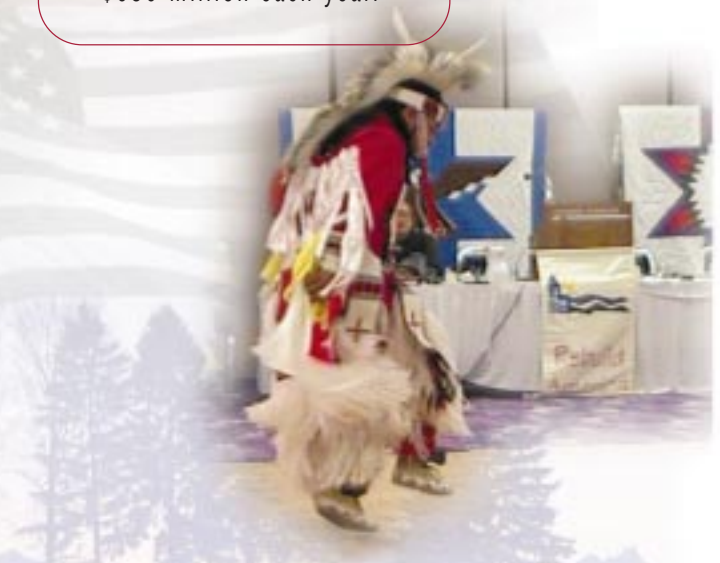
Executive Orders direct the federal government to become more energy-efficient, reducing its energy use 30% by the year 2005. Division staff work with the U.S. Department of Energy's Federal Energy Management Program to help the federal government achieve this goal through energy-efficient retrofits and other activities.

Replacing halogen torchiere fixtures (right) with high-efficiency compact fluorescent versions (left) significantly reduces fire risks.

Building partnerships are expected to save more than $650 million each year.

The Insurance Industry and Energy Efficiency

EETD staff works with the insurance and risk management communities to advance energy efficiency, renewable energy, and improved indoor air quality as an innovative strategy for reducing economic losses. For example, certain energy-efficient technologies can enhance fire safety and worker health, while reducing liability exposures of building professionals. Other measures enhance disaster-preparedness and recovery. The pollution-prevention attributes of new energy technologies also have potential value in curbing environmental liability and climate-related losses.



Rebuild America

This Department of Energy program helps community partnerships make profitable investments in building energy efficiency. By 2003, Rebuild America expects to have 250 projects underway that will save more than $650 million per year. EETD staff provide their advice and expertise on the best technologies and approaches for building partnerships throughout the United States. Rebuild America is partnering with the Native American Renewable Energy Education Project (NAREEP) to work with Native Americans to improve the energy efficiency and comfort of their homes and buildings.

FACILITIES

EETD's unique facilities and laboratories are available to research institutions and the private sector through collaboration with Division researchers on projects of mutual interest.

DUCT LAB

This lab has duct sections for studying the nature of duct leaks and methods used to seal them. It is also being used to develop new methods of measuring air losses through duct leaks.

ENERGY-EFFICIENT LIGHTING LAB

The lab has facilities for the development of efficient lamps, ballasts and fixture systems and devices to test the thermal and photometric performance of advanced lighting systems.

GEOGRAPHIC INFORMATION SYSTEMS LAB

The GIS Lab's Sun workstations run several types of software useful for studying regional patterns of data and combining geographically disparate data sets.

INFRARED THERMOGRAPHY LAB

The lab has a high-resolution infrared imaging camera for measuring surface temperatures and heat loss in windows, insulating panels, and other building components or equipment elements.

INTERIOR POLLUTANT DISPERSION EXPERIMENTAL FACILITY

This facility is used to conduct experiments on air pollution dispersion in large indoor spaces such as auditoriums and atriums. The results are used to evaluate and refine complex computational fluid dynamics models of dispersion processes. The facility is also used for experiments to develop new measurement techniques to detect and quantify pollutant concentrations in large enclosed spaces.

MOBILE WINDOW THERMAL TEST FACILITY

MoWITT contains two side-by-side calorimetric test chambers for testing the thermal performance of window and wall elements under actual outdoor conditions.

SINGLE AND MULTIPLE ROOM ENVIRONMENTAL CHAMBERS

The chambers are tools for studying sources and behavior of indoor air pollution. They can be conditioned to maintain specified temperature, humidity, and ventilation levels.

SKY SIMULATOR

A 24-foot diameter hemispherical facility, the simulator tests the daylighting performance of scale-model buildings. Light sources in the simulator can create luminous distributions typical of any type of sky condition at any location.

SOLAR HEAT GAIN SCANNER

The scanner is used to characterize the complex optical properties of window and shading systems.

THIN FILMS MATERIALS LAB

This facility houses equipment for depositing and analyzing thin-film coatings for more energy-efficient glazings and windows.

OTHER INSTRUMENTATION

Laser and other advanced optical spectroscopies are employed to study the chemical properties of materials, the electrode/electrolyte interface in advanced battery systems, turbulent combustion, and particulate emissions from diesel engines. X-rays from synchrotron light sources and NMR (nuclear magnetic resonance) are used in studies of components for advanced batteries and fuel cells. Chemical analysis instrumentation such as high-performance liquid chromatographs (HPLC) assist in analyzing catalytic reactions.

FOR MORE INFORMATION ON EETD FACILITIES, SEE:

http://eetd.lbl.gov/Facilities/

A Sampling of EETD Sponsors

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The Government of Ghana

The Government of the Philippines

The Joyce-Mertz Gilmore Foundation

The Republic of Venezuela

U.S. Advanced Battery Consortium

U.S. Advanced Research Projects Agency

U.S. Agency for International Development

U.S. Army Corps of Engineers

U.S. Consumer Product Safety Commission

U.S. Country Studies Management Team

U.S. Department of Defense

U.S. Department of Housing and Urban Development

U.S. Federal Aviation Administration

U.S. Food and Drug Administration

U.S. General Services Administration

U.S. National Aeronautics and Space Administration

U.S. National Oceanic and Atmospheric Administration

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ENVIRONMENTAL ENERGY TECHNOLOGIES DIVISION
(510) 486-5001
(510) 486-5454 FAX
HTTP://EETD.LBL.GOV/

Advanced Energy Technologies Department
(510) 486-6283, fax (510) 486-5454
http://eetd.lbl.gov/AET/

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Building Technologies Department
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Energy Analysis Department
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