Energy Analysis
Building Technologies
Indoor Environment

# Center for building science News

LAWRENCE BERKELEY LABORATORY

ENERGY & ENVIRONMENT DIVISION • FALL 1994

## Subscriber Survey Inside!

# *Center for Building Science News* Reader Survey
# Fall 1994

Dear Reader,

A year has passed since the first *Center for Building Science News* was published, and we'd like to find out what you think, and how we can improve. Please fill out this survey and mail it back to us. You will continue to receive this newsletter unless you specify on this survey that you no longer want it.

*What is your occupation?*

- ❑ Consultant
- ❑ Contractor, energy or buildings
- ❑ Customer service
- ❑ Designer
- ❑ Energy auditor
- ❑ Engineer
- ❑ Information specialist
- ❑ Journalist
- ❑ Marketing
- ❑ Policy analyst
- ❑ Program manager
- ❑ Scientist
- ❑ Teacher (College level or below)
- ❑ Teacher (Continuing professional education, vocational training)
- ❑ Other______________

*What type of organization?*

- ❑ Architecture firm
- ❑ Contractor (energy or buildings)
- ❑ Education (College or university, Primary)
- ❑ Energy user
- ❑ Environmental group
- ❑ Equipment manufacturer
- ❑ ESCO
- ❑ Government (federal)
- ❑ Government (state or local)
- ❑ Library
- ❑ Media organization
- ❑ National laboratory
- ❑ Nonprofit organization
- ❑ Utility
- ❑ Other______________

Country______________

*How many people read your copy?*

❑ 1 to 3 ❑ 4 or more

*Have you ever saved issues of this newsletter or articles from it?*

❑ Yes ❑ No

*What types of stories were most useful to you? Check all that apply.*

- ❑ New building and appliance technologies for energy efficiency
- ❑ Energy policy analyses
- ❑ Indoor environment issues
- ❑ Building design software
- ❑ Internet and multimedia tools
- ❑ Center research facilities
- ❑ Education and public outreach efforts
- ❑ LBL-related news items
- ❑ International news
- ❑ Other______________

*What topics would you like to see covered more fully?*

*What topics do not belong in this newsletter?*

*How clear and understandable are the graphs, tables and charts?*

❑ Very clear ❑ Moderately clear ❑ Difficult to understand

*The technical level of the writing is:*

❑ Too technical ❑ Just right ❑ Not technical enough

*The length of the articles is:*

❑ Too long ❑ Just right ❑ Too short

*What would you change about the newsletter?*

*Have you missed any issues since subscribing?*

*Is there anyone you know who should receive this newsletter? If so, please list name and address:*

*Have you contacted anyone at the Center after reading about their work in the newsletter? If so, about how many times?*

❑ Yes ❑ No

Number of times___

*Do you use the internet?* ❑ Yes ❑ No

*Do you use the World Wide Web?* ❑ Yes ❑ No

Energy Analysis
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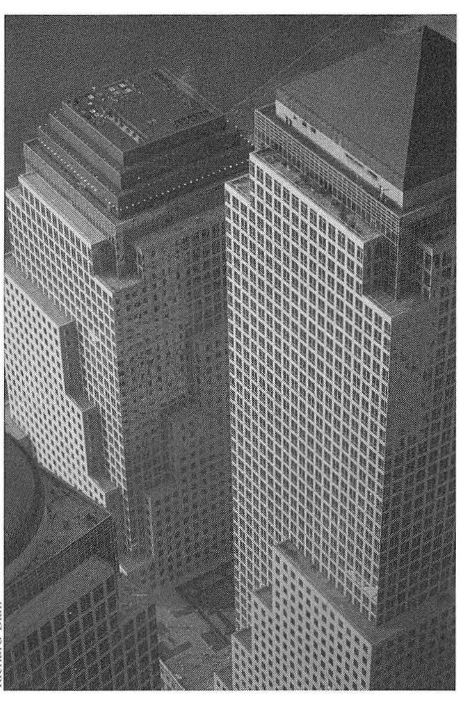
# The Applications Team is Here!

The Center's newly founded Applications Team (the A-Team) is ready to do business with the public and private sectors. It marshals LBL's unique capabilities and networks to conduct field projects aimed at deploying advanced energy efficiency and indoor environmental quality concepts in both the U.S. and overseas buildings sectors. Among the goals of the Team are:

- demonstrating proven and emerging building technologies to accelerate their adoption by consumers and building professionals
- elevating professional standards of practice
- transferring new energy management methods and tools to the private sector
- providing feedback to the Federal energy R&D planning process

The A-Team's philosophy calls for applying an integrated approach to retrofitting existing buildings or designing new ones. This approach encompasses the various stages of a building's life cycle as seen from the perspective of facilities management, addressing the areas of energy, illumination, comfort, and the indoor environment.

The A-Team assembles project teams drawn from the 250-person staff of the Center's three research programs, LBL's In-House Energy Management Program (IHEM), other research organizations and laboratories, and private firms. The IHEM program has managed a study and retrofit project slate of $18 million through 1994 for LBL's own facilities, including project planning, financial analysis, engineering, procurement, construction management, commissioning, monitoring, and evaluation. One of IHEM's recent notable achievements was its completion of the Department of Energy's first comprehensive performance contracting agreement with a private energy services company for retrofit of a laboratory building.


Richard Blair

To accomplish its goals, the A-Team also draws on a rich pool of relationships with other professionals in energy efficiency implementation from R&D centers across the country, government agencies, electric and gas utilities, state energy offices, manufacturers of energy-efficient technologies, and technical committees that define energy-related standards and guidelines.

*continued on page 2*

## About the Center

Addressing significant energy-related issues, the Center for Building Science has become an international leader in developing and commercializing energy-efficient technologies and analytical techniques, and documenting ways of improving the energy-efficient technology and indoor environment of residential, commercial and industrial buildings.

The Center is the home of three Energy & Environment Division programs—Building Technologies, Energy Analysis, and Indoor Environment. It serves as a national and international voice for energy efficiency, provides technical support to energy and environmental policymakers, supports and creates institutions and demonstration programs, provides a training ground for students in the energy field, and facilitates transfer of technology and information to the private sector.

Researchers at the Center recognize that despite significant, steady progress since the energy crises of the 1970s, a large potential for energy savings remains to be realized. The Center's inter-disciplinary staff studies a wide spectrum of environmental, economic, and technical aspects of energy-efficiency activities, recognizing that energy efficiency is a new and highly cost-effective energy resource.

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vacant

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**Technology Transfer**
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**Energy Analysis Program**
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This newsletter may also be found on the World Wide Web at URL: http://eande.lbl.gov/CBS/NEWSLETTER/CBSNEWS.html

# The A-Team

## Bridging R&D and Practice

The A-Team forges a new link between existing DOE building R&D activities and deployment initiatives. A-Team activities will benefit R&D program planners by providing improved feedback and recommendations for eliminating inefficiencies and missed opportunities during the implementation of new technologies and methods in the field. More specifically, the A-Team will:

(1) Develop, implement, and evaluate proven, cost-effective energy efficiency measures in existing buildings.

(2) Assemble confidence-building demonstrations of emerging technologies and energy management practices not commonly used by building professionals.

(3) Develop and disseminate state-of-the-art field guidelines and protocols, for example, for measurement and verification.

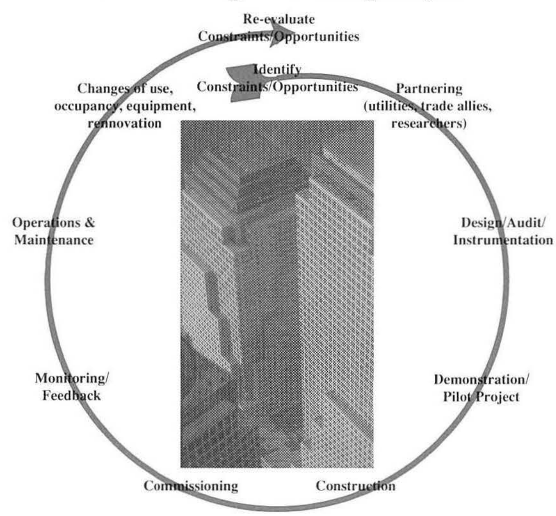
(4) Demonstrate the potential for achieving energy savings while maintaining or improving indoor environmental factors influencing human productivity and well-being, such as reduced indoor air pollution, better lighting quality, and thermal comfort.

(5) Transfer design and application methods and tools to private-sector practitioners such as architecture and engineering firms that collaborate with the A-team on projects.

(6) Support energy savings performance contracting on a national level.

## In the Field

Facilities Management Building Lifecycle




The A-Team benefits private-sector building professionals by raising the market's general awareness of the value of energy efficiency, for example, through high-profile demonstrations and independent verifications of performance and cost-effectiveness and by partnering with private-sector firms on specific projects. This kind of feedback will also prove valuable in product development and marketing.

Prospective clients for the Applications Team include federal agencies, utilities, states, regional or national efficiency program designers, and large public, private, or institutional building owners. To maximize their impact, the Team will choose projects very selectively, emphasizing high-visibility, replicability, and the specialized services and resources possessed by LBL and project collaborators. Current projects include creating the master plan for energy efficiency retrofits at the Presidio of San Francisco in cooperation with DOE and the National Park Service, and comprehensive audits of the Federal Aviation Administration's air traffic control towers and other facilities.

*—Evan Mills*

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# News from the D.C. Office

The federal government is the largest single purchaser in the world for many energy-related products. Federal buying power—along with that of state and local agencies—represents a largely untapped resource to increase the energy efficiency of consumer products and commercial equipment. LBL is helping the DOE Federal Energy Management Program (FEMP) develop and lead a government-wide initiative to capture this market-transforming opportunity. Jeff Harris and others in LBL's D.C. office are heading FEMP's efforts to identify how future federal purchases can be more energy-efficient.

The U.S. government spends more than $70 billion a year to purchase supplies and equipment, of which an estimated $10-20 billion are energy-related products. In the aggregate, state and local government buying power appears to be roughly three to four times greater than the entire federal market. For all levels of government, procurement of energy-efficient products would save both energy and money. By considering the life-cycle costs of efficient products, not just first costs, government is better serving the long-term interest of taxpayers and the public.

In addition, government purchasing can have a large effect on the overall market in two important ways. First, coordinated interagency and intergovernmental purchasing using the same energy-efficient criteria can help shift the mix of products manufactured and sold to *all* consumers, public and private—while bringing down costs through manufacturing volume and competition. Second, public sector purchasing can help create a "market-pull" for new technologies not yet commercially available. Adapting the "developmental procurement" methods used in weapons procurement, civilian agencies could issue credible offers to purchase advanced products, better than any now available, once they meet performance and cost specifications.

Federal initiatives to increase the purchase of energy-efficient products are authorized under the 1992 Energy Policy Act, recent Office of Management and Budget policy letters, and Executive Orders concerning federal energy management and environmentally preferred products. Coordinating federal purchasing with other levels of government, and with utility demand-side management programs, can further strengthen the market demand for energy-efficient new technologies and products. Finally, energy efficient procurement, including a new, government-wide "Procurement Challenge," exemplifies the type of voluntary, market-oriented actions favored in the Administration's Climate Change Action Plan.

Throughout the federal government, procedural reforms are needed to help redirect purchase decisions toward today's best energy-efficient practice, and to open up the federal market for tomorrow's more advanced technologies. To implement a recent Executive Order, DOE is cosponsoring an interagency "Procurement Challenge." This program encourages all agencies to change their own buying patterns, whether through direct purchases from commercial sources, acquisition through the supply agencies (Defense Logistics Agency and the General Services Agency), or "indirect" purchases made as part of larger construction and service contracts. Agencies participating in the Challenge make a voluntary pledge to lead the way in "best-practice" buying (products that are among the 25% most energy efficient) or in committing to purchase new, advanced technologies more efficient than any now on the market.

To exploit government purchasing as a market-pull resource will require a redefinition of procurement, and the associated attitudes and rules for thousands of practitioners. Instead of choosing among existing product offerings, government will take an active, explicit role in *market-shaping*: setting targets for more energy-efficient products and creating market incentives to expand the available options—not only for government itself but for all consumers.

*—Nancy Casey-McCabe*
*& Jeff Harris*

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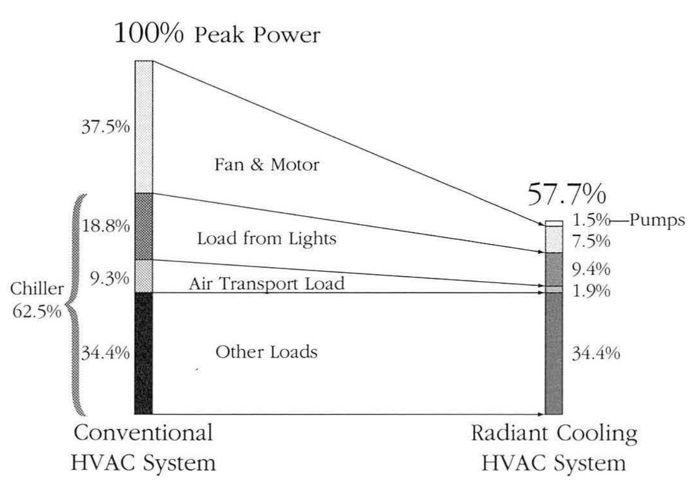
# Hydronic Radiant Cooling Systems

Cooling nonresidential buildings in the U.S. contributes significantly to electrical power consumption and peak power demand. Part of the electrical energy used to cool buildings is drawn by fans transporting cool air through the ducts. The typical thermal cooling peak load component for California office buildings can be divided as follows: 31% for lighting, 13% for people, 14% for air transport, and 6% for equipment (in the graph below, these account for 62.5% of the electrical peak load, labeled "chiller"). Approximately 37% of the electrical peak power is required for air transport, and the remainder is necessary to operate the compressor.

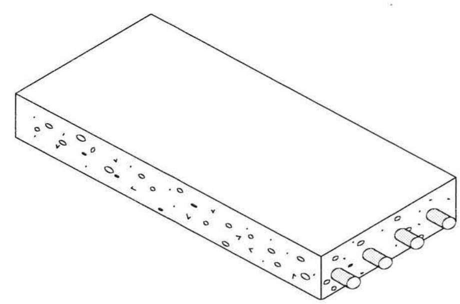
DOE-2 simulations for different California climates using the California Energy Commission base case office building show that, at peak load, only about 10% to 20% of the supply air is outside air. Only this fraction of the supply air is necessary to ventilate the buildings sufficiently to maintain a high level of indoor air quality. For conventional HVAC systems, the difference in volume between supply air and outside air is made up by recirculated air. The additional recirculated air, however, often causes drafts and indoor air quality problems by distributing pollutants throughout the building. This is the problem motivating our study of a building cooling technology called hydronic radiant systems which use less recirculated air, and in the process, could save energy.

Our efforts have taken the form of projects to characterize the technology and to develop a computer model. In order to be able to design radiant cooling systems and to simulate their thermal performance, we have developed a thermal building simulation model which operates in the SPARK environment, an easy-to-use graphical interface. The model is based on the finite differences method and covers both active and passive building elements. The aim is to integrate this model into PowerDOE, the successor of the DOE-2 thermal building simulation model (*CBS News*, summer 1994, p. 8).

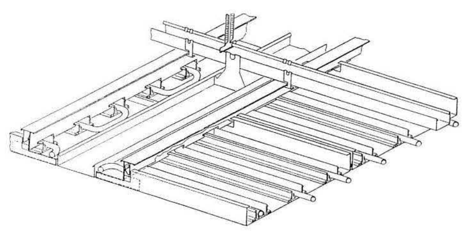



*Comparison of electrical peak power load for conventional systems and radiant cooling systems (percentages are relative to overall peak power for the conventional system).*

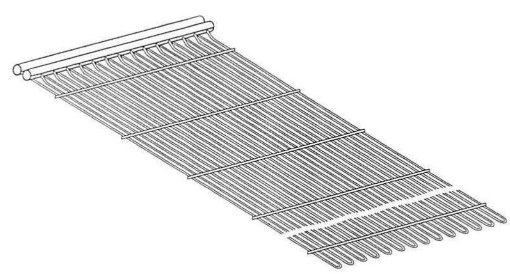
## Radiant Cooling Systems



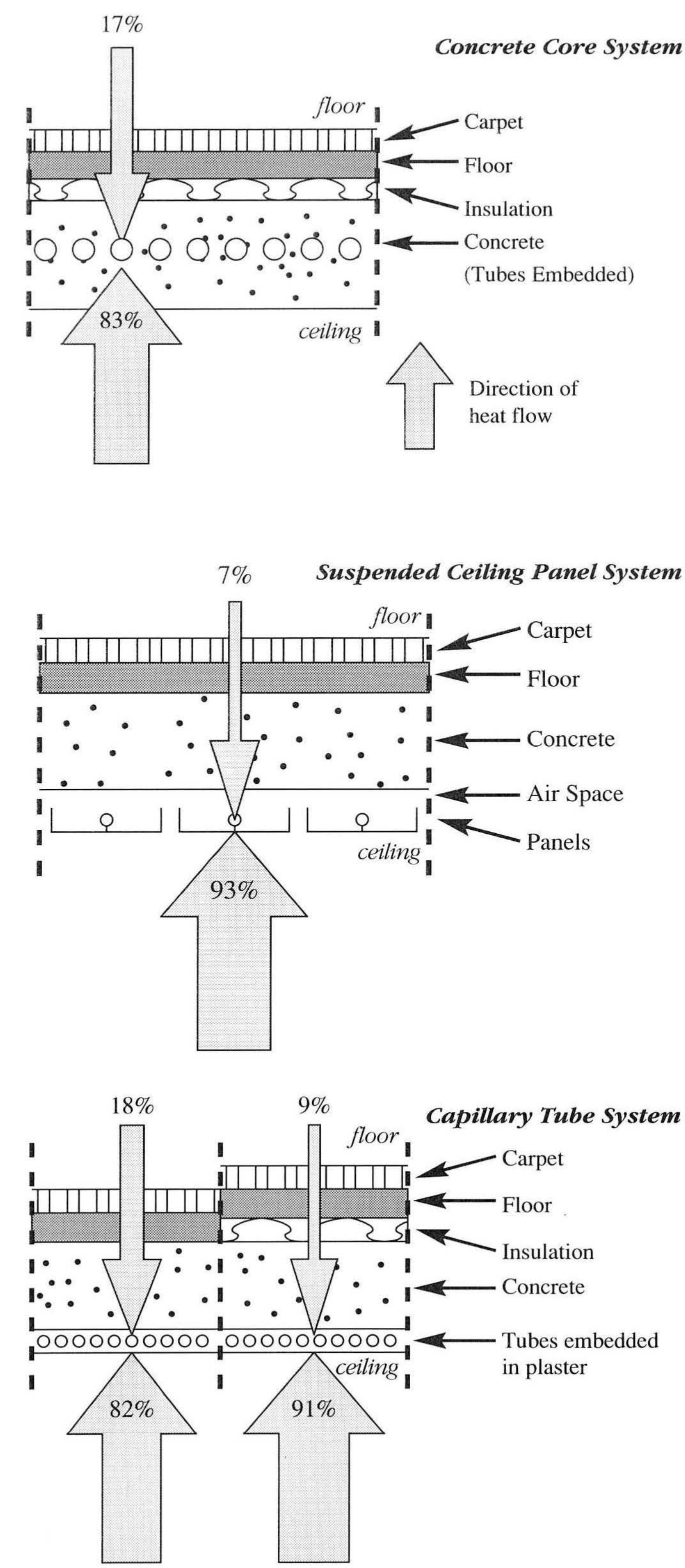
*A **core-cooled** ceiling is the cooling equivalent of a floor heating system. In this system, water is circulated through plastic tubes embedded in the core of a concrete ceiling. This layout allows the system to take advantage of the storage capacity of the concrete, and provides the opportunity to shift the building peak load away from the utility grid peak.*



*The most used system is the **panel system.** It is usually built from aluminum panels, with metal tubes connected to the rear of the panel. An alternative is to build a "sandwich system," in which the water flow paths are included between two aluminum panels. The use of a highly conductive material in the panel construction provides the basis for a fast response of the system to changes in room loads.*



*Cooling grids made of **capillary tubes** placed close to each other, can be imbedded in plaster, gypsum board, or mounted on ceiling panels. This system provides an even surface temperature distribution. Due to the flexibility of the plastic tubes, cooling grids might represent the best choice for retrofit applications.*




*As shown by the arrows most of the cooling effect occurs on the ceiling side of radiant panels.*

## Reduced Air Transport

Traditionally, HVAC systems are designed as all-air systems. Hydronic radiant systems are air-and-water systems that separate the tasks of ventilation and thermal space conditioning by using the primary air distribution to fulfill the ventilation requirements, and the secondary water distribution system to thermally condition the space. These systems reduce the amount of air transported through buildings significantly, because the ventilation is provided by outside air systems without affecting the recirculating air fraction.

Radiation provides most of the cooling, using water as the transport medium. Thanks to the physical properties of water, hydronic radiant cooling systems can remove a given amount of thermal energy using less than 5% of the fan energy that would otherwise be necessary. (Energy savings relative to conventional systems are shown in the chart on the facing page.) The separation of cooling and ventilation tasks not only improves comfort conditions, it also improves indoor air quality as well as the control and zoning of the system. Hydronic cooling systems combine mechanisms to control the temperature of room surfaces with central air handling systems.

Because large surfaces are available for heat exchange in hydronic radiant cooling systems (usually almost the whole ceiling or floor), the coolant temperature is only slightly lower than the room temperature. Since the coolant can be maintained at a high temperature level, the use of heat pumps with high coefficient-of-performance values, cooling towers, night cooling, or some combination of these can reduce electric power requirements further. At the same time, hydronic radiant cooling systems reduce problems caused by duct leakage, since they use significantly less ventilation air and since the air is conditioned only to meet room-temperature rather than cooling-supply air temperature conditions.

Another benefit is that the ventilation systems and their duct work need only about 20% of the space requirements of conventional HVAC systems, reducing cost. A hydronic radiant cooling system combined with the sprinkler system might reduce the initial cost even further. Because of the hydronic energy transport, this cooling system has a potential to interact with thermal energy storage systems and looped heat pump systems.

Hydronic radiant cooling has been applied in the U.S., but it never reached significant market penetration. In Europe too, hydronic cooling was more or less abandoned after some application in the late 1930s and the 50s. However, user complaints about all-air systems changed the designers' attitude towards the technology, which led to new hydronic system designs with better control. Together with efficient ventilation systems and humidity control, the hydronic radiant cooling system provides advantages over conventional HVAC systems that are worth considering during building design.

*—Helmut Feustel*

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# The U.S. Country Studies Greenhouse Gas Mitigation Assessment Workshop: A Report

On June 13-24, the Center's Energy Analysis Program hosted the U.S. Country Studies Greenhouse Gas (GHG) Mitigation Assessment Workshop. The workshop brought together more than 60 scientists and energy policy makers from 16 developing countries including Eastern Europe and the former Soviet Union, Asia, Africa, and Latin America. They came to LBL for hands-on training in techniques and models used for GHG mitigation analysis.

The workshop was part of a $1.4 million contract awarded to the Energy Analysis Program by the U.S. Country Studies Program through the Department of Energy. The Country Studies initiative grew out of the commitment made by the United States at the 1992 Earth Summit held in Rio de Janeiro. There, the U.S. pledged technical assistance for developing countries to help them comply with the Framework Convention on Climate Change established in Rio. The program is designed to help developing and transitional countries: 1) develop inventories of their anthropogenic emissions of greenhouse gases; 2) assess their vulnerability to climate change; 3) assess their ability to mitigate greenhouse gas emissions; and 4) help form and evaluate strategies for mitigating and adapting to climate change. The Country Studies Program selected the Center's Energy Analysis Program to provide technical support for the third task, because of its substantial knowledge of technologies, policies, and analytical methods for reducing greenhouse-gas emissions.

The White House organized an interagency team to oversee the implementation of technical assistance. Thirteen federal agencies underwrite the program, and six are participating in the program's management, including the Environmental Protection Agency, the Department of Energy, the Agency for International Development, the National Oceanic and Atmospheric Administration, the Department of Agriculture, and the Department of State. Steve Wiel, director of the Energy & Environment Division's Washington D.C. office and one of the project's two co-principal investigators along with Jayant Sathaye, says the interagency team is an impressive feat of cooperation. Rarely—if ever—have so many federal agencies worked so effectively together for such a large undertaking.

In winning a competition among national labs for this contract, the Center brought together a technical support team of 30 researchers from academic, private, and government institutions experienced in global climate change issues. The team includes six U.S. national laboratories: LBL, Oak Ridge, Pacific, Brookhaven, Argonne, and the National Renewable Energy Laboratory. Wiel noted that he is "especially proud of our association with the other national laboratories" because, he says, "I believe that cooperative efforts among the labs is an important way of life for the future of our program."

## Intensive Two-Week Training

Workshop participants received two full weeks of analytical training composed of lectures and computer demonstrations. They were divided according to their area of expertise—energy, non-energy, or macroeconomic analysis. More than 30 experts provided the detailed analytical instruction. In the energy group, instructors covered methods of, and issues in, mitigating emissions from the industrial, transportation, residential and commercial sectors, addressing both conventional and renewable energy supply. This group worked with sector-specific models, but instructors introduced another technique: the use of integrated energy sector models for mitigation assessment. The non-energy group examined mitigation methods in forestry, agriculture, rangeland, and waste management. The macroeconomic group listened to presentations on top-down models for the analysis of the economic impacts of greenhouse gas mitigation strategies.

In addition to the hands-on training for participants, the workshop was a forum for them to exchange their views about interrelated analytical topics. Jayant Sathaye said "This training is unique—nothing of this magnitude has ever been done, either in terms of the scope of the training program or the nature of the project itself. We are helping a large number of countries sharpen their decisionmaking skills in very important environmental areas."

## Next Steps

At the close of the workshop, participating countries developed and submitted workplans for greenhouse gas mitigation. To provide continuing support to these nations' GHG reduction efforts, the Energy Analysis Program is tailoring specific technical assistance plans for each country. The program's future support will be in the form of further training in the use of specific models, site visits to countries, and regional workshops where national representatives will discuss the results of their studies.

—*Lila Schwartz & Nathan Martin*

i
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*Jan Hrebec and Milos Tichy from the Czech Republic study the details of an energy model during a hands-on training session.*

US Country Studies Mitigation Assessment Workshop
Workshop Schedule, Overview, and Agenda, June 13-24, 1994

*All Tracks: Energy, Non-Energy, Macroeconomic Assessment*
Mitigation overview discussion of concepts, models, and assessment process
Computerized methodology demonstration, consultations and training
Key topics—presentation and discussion
Technical potentials, analysis methods and general discussion
Implementation strategies
Joint meetings with US project officers to develop work plan
Presentation of draft work plans

*Sectors:*
Transport, residential & commercial, industrial, agricultural, energy, forestry, conventional & renewable energy, waste management, and grasslands & rangelands

*Other Topics:*
Energy and macroeconomic models
Implementation strategies
Plenary session

LBL staff who presented at the workshop included: Steve Wiel, Jayant Sathaye, Mark Levine, Steve Meyers, Willy Makundi, Nathan Martin, Ashok Gadgil, Alan Sanstad, Jon Koomey, Lee Schipper, Puran Mongia, Nandita Mongia, Mollie Field, Charles Campbell, Diana Morris, and Karen Gee.

Academic institutions that participated in the workshop included the University of California at Berkeley, the University of California at Davis, the University of Michigan, Stanford University, and Oregon State University. Private participants included ICF, Inc., Future Resources Associates, and the Tellus Institute.


*Participants in the first GHG Mitigation Assessment Workshop.*

## Education

# The Advanced IRP Seminar

The Center has now run four seminars on advanced integrated resource planning (IRP) for state public utility commission staff members from around the country.

Technology transfer is a central aspect of the Energy Analysis Program's IRP project. Reviewing utility IRP filings by state utility regulatory commissions is a new challenge to commissioners because many IRP concepts, especially those dealing with demand-side management, are unfamiliar. At the request of the National Association of Regulatory Utility Commissioners, the EAP designed a seminar on leading IRP issues for state commission staff who must review these utility filings.

The fourth annual LBL Advanced IRP Seminar in early June hosted staff members from 22 utility regulatory commissions representing 21 state commissions, including staffers from three state commissions that had not participated previously. Nearly 90 regulatory staff members from 40 state commissions have attended at least one of the four seminars.

Two activities were on the agenda of the week-long seminar. Experts on core IRP issues delivered lectures on topics such as IRP plan guidelines, competitive considerations for IRP, the rationale for utility DSM programs, avoided costs, gas IRP, and transmission planning. In the afternoon, the participants had to roll up their sleeves, team up, and work through exercises including DSM program planning and rate impact mitigation using a commercially available DSM software tool. They estimated electricity avoided cost using a utility production cost model, and negotiated the level of utility DSM expenditures, the level of incentives paid to the utility, and the type of DSM program evaluation in a role-playing "game." They also took a tour and saw a demonstration of energy-efficient technologies at the Pacific Gas & Electric Energy Center, and attended an evening roundtable discussion of states' experiences with competition issues.

Among the many lectures was Joe Eto's discussion of disincentives for utilities to pursue DSM and his overview of revenue decoupling approaches, and a joint presentation on gas IRP by G. Alan Comnes and Charles Goldman. Participants also thought well of the negotiation simulation game, introduced for the first time this year.

—*Karen H. Olson*

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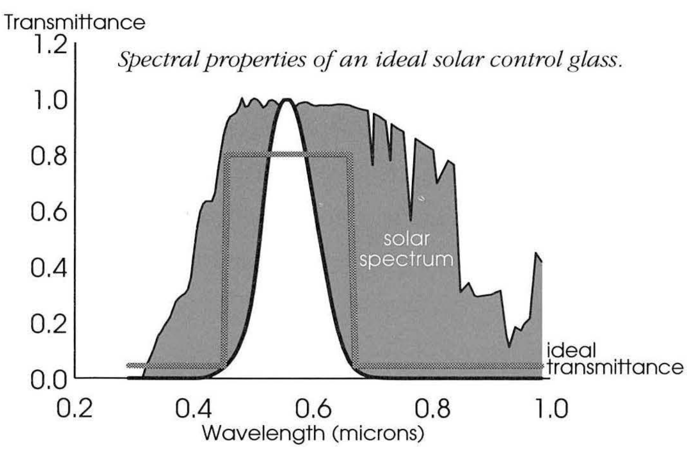
# Smar Thermal Skins or Vehicles

With a modest effort, many of the energy-efficient technologies developed for buildings can be transferred to the transportation sector. The goal of vehicle thermal management research at LBL is to save the energy equivalent of one to two billion gallons of gasoline per year, and improve the marketability of next-generation vehicles using advanced solar control glazings and insulating shell components to reduce accessory loads. Spectrally selective and electrochromic window glass and lightweight insulating materials improve the fuel efficiency of conventional and hybrid vehicles and extend the range of electric vehicles by reducing the need for air conditioning and heating, and by allowing the downsizing of equipment. At the same time, thermal comfort is greatly improved, safety is enhanced by reduced glare and heat, degradation of interior surfaces is slowed, and the weight and cost of the vehicle are reduced because of downsized heating and cooling equipment.

## The Problem

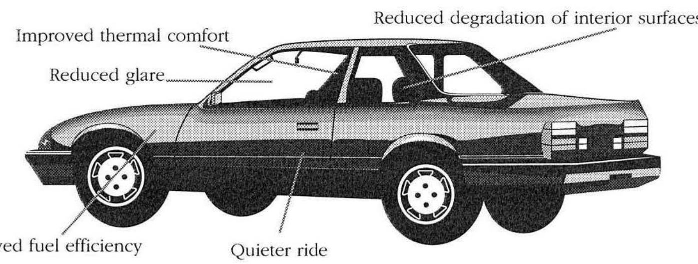
For several decades, the trend in automotive design has been toward larger and more steeply sloped windows. While these designs improve aerodynamics, they also increase the amount of solar heat gain through the glass. On a hot summer day the interior air temperature of a car parked in the sun will exceed 65°C (150°F). Interior surface temperatures will exceed 90°C (200°F). Automakers in Detroit have traditionally solved the cooling problem with the use of large inefficient air conditioners, typically of the same size that would be used to cool an average house. In terms of fuel penalty, manufacturers have no incentive to downsize equipment because air conditioning does not enter the fuel efficiency equation used to determine compliance with Corporate Average Fuel Economy standards. There has been no incentive to move towards more efficient air conditioners because they are more expensive. For fuel-efficient next-generation vehicles, minimizing the power drawn by heating and cooling equipment is imperative because it consumes a larger fraction of the fuel as the drive system becomes more efficient. It is also necessary to minimize loads in electric vehicles because heating and air-conditioning can reduce the effective range by as much as 40%. Although automotive air conditioning efficiency data are surprisingly difficult to come by, efficiency can almost certainly be improved.




*Spectral properties of an ideal solar control glass.*

## Advanced Technology Solutions

The problem of creating a comfortable thermal environment without adding excessive weight, space, or power requirements to the vehicle can be solved through aggressive thermal management using advanced window glazings, insulations, and fans. Photovoltaic powered ventilating fans are particularly well-suited to automotive applications and would substantially reduce interior temperatures for cars parked in the sun. Winter heat losses, a particularly serious problem for electric vehicles because they have no waste engine heat, can be reduced using body insulation, low-emissivity coatings on the glass, and thin double-glazed windows. Double-glazed windows are already being used in expensive European sedans to reduce the noise level in the passenger compartment. New insulation technologies, developed originally for appliances and buildings, are also promising for transportation applications. LBL recently patented one such advanced insulation, gas-filled panels (*CBS News*, Winter 1993, p. 9), that is particularly well suited to automobiles and aircraft because it is lightweight and inexpensive. Gas-filled panels are CFC/HCFC free and are up to four times more insulating than conventional fiberglass and twice as insulating as CFC foams.




*Benefits of Thermal Skins*

The single largest climate control problem in most vehicles is reducing the solar heat gain through the window glazing. Fortunately, several promising glazing technologies are available or under development, largely because of the work to improve windows in buildings. Solar radiation incident on a window is either transmitted, reflected, or absorbed. The bold line in the figure at left shows the spectral properties of an ideal spectrally selective glazing, which transmits most of the visible wavelengths of the solar spectrum while reflecting the invisible ultraviolet and infrared wavelengths.

Some green and blue tinted glasses can have a sharp spectral response as described above, although they absorb rather than reflect the solar infrared. The main advantages of tinted glasses are that they have the same high durability as clear glass, and cost only slightly more. However, the energy and visual performance of absorbing glazings is not as good as that of the best reflective products. Spectrally selective window glazings block solar infrared, but are nearly clear and have the high visible transmission required by law for windshields. Silver-based thin films most closely approach the ideal behavior illustrated in the figure. For the back side and rear windows, the transmission band can be lowered to reduce solar heat gain even further.

The ultimate solar control product will be a glazing whose properties can be controlled dynamically by applying a small control voltage. Electrochromic films work like a thin film battery, allowing active optical response to changing environmental conditions. Electrochromic devices change optical properties according to an applied current, so they can be linked directly to the vehicle HVAC system. They require very low power, and since they only require power to switch, they are stable in any given state, and won't suddenly go dark if there is a power failure. Although still in the developmental stage, electrochromic films show great promise if the cost and performance targets can be met.

To assess the effectiveness of solar control glazings and insulation in improving thermal comfort, field and laboratory tests are planned in collaboration with the Thermal Comfort Laboratory at the University of California, Berkeley. The laboratory has high quality, specialized instrumentation, including a segmented thermal mannequin that approximates a full-scale human sensor. It can make measurements of thermal stratification, radiant asymmetry, local jets of high-speed air flow, and the convective plume formed around the body by its own heat. The mannequin will be used in conjunction with infrared thermography, temperature measurements, and thermal analysis models.

—*Deborah Hopkins*

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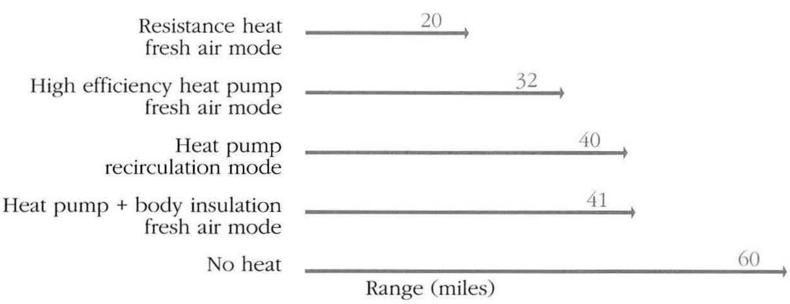
*EV range for different heating options*




*Instrumented thermal mannequin used to study human comfort.*

## Energy Currents

### LBL-Russia Collaboration on Lighting

In a newly minted collaboration, LBL and Russian researchers will explore a novel emerging technology for efficient lighting. Center researchers Michael Siminovitch, Evan Mills, and Francis Rubinstein will work with Dr. Julian Aizenberg of Russia's Lighting Research Institute to investigate "light pipes". These typically hollow tubes use highly reflective or light-conducting materials to transport and distribute light from a bright centralized source. Light pipes are a particularly promising technology for use with a new generation of small, highly efficient, high-output lamps now under development. A local Bay Area company, Peerless Lighting, will participate in the collaboration by helping to identify critical manufacturing and market-acceptance challenges.

The potential energy and non-energy advantages of light pipes include easier heat removal/recovery from lamps and ballasts, lower maintenance costs (fewer lamps and ballasts to replace), the ability to transmit daylight to non-perimeter offices, and greater safety when used in settings with an explosion hazard.

The project will begin with an assessment of the 30-year Russian research and deployment program on light pipes. Russia has much more experience with this technology than any other country. Researchers will then review the experience in eight other countries, and conclude with an examination of the technology's future directions and its applicability to the U.S. environment.

This collaboration comes at a time when hard economic conditions in Russia have placed the lighting research establishment in jeopardy. While not long ago 1,200 people worked in Aizenberg's institute, today only 400 remain and about two-thirds of the facility has been rented as office space to private enterprises. Many Russian lighting experts today work in banks.

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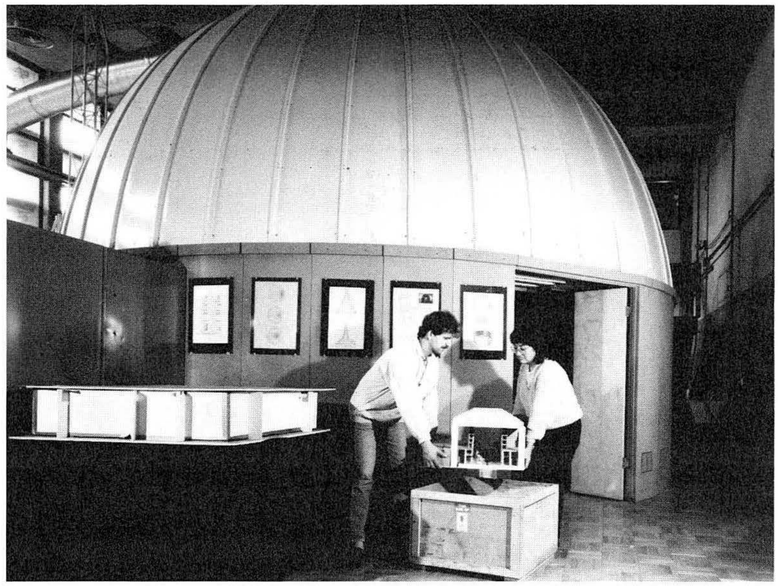
Center Research Facilities

# The Sky Simulator

Daylight reduces a building's dependency on electrical lighting and improves the beauty of its interior spaces. As architects apply well-established daylighting techniques such as windows and skylights to capture the natural light, scientists are developing innovative ways to bring in the light more efficiently. The sky simulator, operated by the Center's Building Technologies Program, is a 24-foot-diameter dome that researchers use to measure the illuminance levels in building models fitted with various daylighting systems. By testing these models, they can determine how well a building design or daylighting technology permits light to enter under conditions of varying time of day and season, building orientation, or geographic location.

Inside the dome, 108 fluorescent tubes shine onto the dome ceiling. Sky conditions can be varied by dimming the fluorescent tubes and thereby creating different sky luminance distributions. The fluorescent tubes are dimmable individually or in banks of up to 36 at a time. Models are mounted at the level of the dome's horizon on a raised platform in the center of the dome. The platform is actually a rotating, tilting drafting table mounted on a rigid framework. The sun is simulated with a 1,000-watt halogen lamp inside a parabolic mirror dish mounted on a track. It can assume any altitude angle from the horizon to the zenith. Azimuth angles are set by rotating the model platform. Photosensors connected to a data acquisition system are mounted inside the scale model to be evaluated to measure the illuminance in different parts of the proposed building. At least one reference sensor is usually placed on an unobstructed horizontal plane outside the model for daylight factor measurements. Daylight factor is the ratio of illuminance on a horizontal indoor surface to that of an unobstructed horizontal outdoor surface.



*Werner Osterhaus and Liliana Beltrán prepare a scale model for tests in the sky simulator.*

With the sky simulator, scientists in the Windows and Daylighting Group conduct different types of studies, including shading studies that reveal how a building's design blocks or permits light's passage to the interior; solar access studies, using city-scale models; and tests of the reflection and transmittance characteristics of new daylighting technologies. For scale model tests, the minimum suite of measurements of illuminances are taken at conditions simulating 9 a.m., noon and 3 p.m., measured at the solstices and the equinoxes. Crescent board, the construction material of most models, has known illuminances, and model makers can choose a board with the color and texture that would be closest to the proposed building's appearance.

Windows and Daylighting Group researchers have used the simulator to validate the results of computer models designed to predict the interior illuminance of buildings lit from outside, and from time to time, professional architects send their building models to be evaluated there. The sky simulator's ability to control and reproduce lighting conditions makes it a useful research tool. Located in the College of Environmental Design on the University of California, Berkeley campus, this LBL facility is also an important teaching tool for students.

*—Allan Chen*

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*In the facility's interior, Osterhaus and Beltrán conduct performance tests of a shading device for a hotel atrium using the sun simulator, upper right.*

**Energy Currents**

# Reducing Greenhouse Gas Emissions

As part of the Climate Change Action Plan effort to stabilize greenhouse gas emissions, researchers from the Center for Building Science's programs are working on five projects to improve energy efficiency in the residential sector. These multiyear projects are sponsored by the Environmental Protection Agency's Global Change Division, which is developing voluntary "market-pull" programs that reduce pollution, including greenhouse gas emissions, by accelerating the penetration of new or underused energy-efficient technologies. This work builds on and complements the research at LBL supported by DOE.

Four of the projects focus on specific technologies developed by LBL, while the fifth will conduct market assessments of these and many other residential technologies to identify the most effective means of increasing their market shares. A component of all the projects is to help EPA design and implement programs to promote these technologies in the marketplace, a relatively new application of the Center's energy-efficiency expertise. The projects are:

**Lighting**—Lighting consumes about 10% of the electricity consumed in homes. The goal of the lighting project is to develop dedicated compact fluorescent fixtures and high efficiency incandescent lamps to reduce lighting energy use. LBL will also work with fixture and lamp manufacturers to commercialize these technologies, help design deployment programs, and identify the residential lighting applications most suitable for government and utility programs.

**Windows**—While many new energy-efficient window technologies have been developed during the past decade, not all manufacturers offer optimally cost-effective products, and consumers often lack information or are confused about the options available to them. This project will explore marketing strategies to identify and better define energy-efficient window products for specific applications.

**Thermal Distribution Systems**—The goal of this project is to develop and commercialize an aerosol-based sealing technology to reduce energy losses through residential duct systems. Project scientists will also estimate the carbon reduction potential of aerosol-based seals and identify the regions and market segments where promoting the technology will most likely lead to widespread market adoption.

**Cool Communities**—To reduce air conditioning energy consumption caused by the urban heat island effect (*CBS News*, Spring, 1994, p. 6), this project will develop and commercialize high-albedo roofing and paving products. Cool communities researchers will meet their implementation goals by working with manufacturers, builders, utilities, and other interested parties to promote the use of cool building materials.

**Residential Market Analysis**—To help the EPA design effective energy-efficiency programs, researchers are using a detailed, geographic information system-based model to identify the regions and market segments where energy-efficient technologies are technically feasible, cost-effective, and acceptable to consumers. EPA will use this information to design programs targeted at the most attractive market segments. Candidate programs include utility incentive and loan programs, product labeling, and partnerships with manufacturers, builders, realtors, or lenders.

—*Rich Brown*

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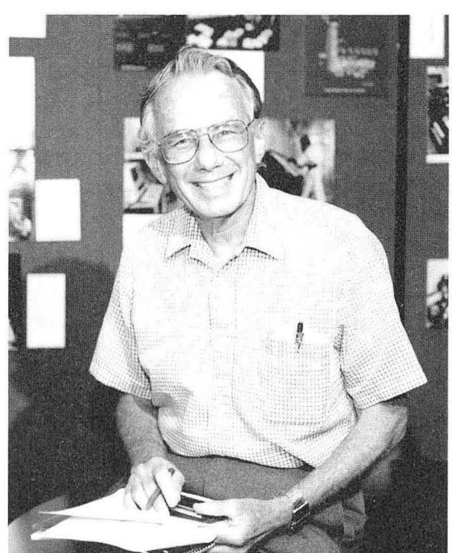
# LBL Scientist Joins Clinton Administration

Art Rosenfeld, former head of LBL's Center for Building Science, has been named a senior advisor in the U.S. Department of Energy, serving under Assistant Secretary for Energy Efficiency and Renewable Energy Christine Ervin. His appointment began July 1.

In Washington, Rosenfeld will sit on President Clinton's National Science and Technology Council. He will also serve as national spokesperson for the Administration's "Cool Communities" program and will help steer through the political process a proposed new "government-sponsored enterprise"—called EFFIE MAE for Energy Efficiency Mortgage and Loan Agency—that would guarantee loans for retrofitting energy-inefficient public buildings.

Rosenfeld spent the first twenty years of his professional life as a high-energy physicist before switching to the development of energy-efficient technologies for buildings in 1973 (after the OPEC oil embargo). For this work, he won DOE's 1993 Sadi Carnot Award in Energy Conservation. We look forward to his many contributions from "within" the government, and to having Art back at LBL after his stint in Washington.



*Art Rosenfeld*

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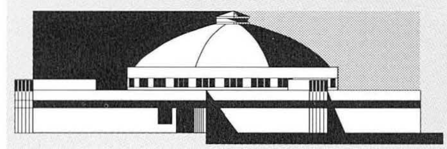
## About Lawrence Berkeley Laboratory

Lawrence Berkeley Laboratory is a multiprogram national laboratory managed by the University of California for the U.S. Department of Energy. The oldest of these nine laboratories, LBL is located in the hills above the campus of the University of California, Berkeley.

With more than 3,000 employees, LBL's total annual budget of about $250 million supports a wide range of unclassified research activities in the biological, physical, 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 of its success, LBL has had nine Nobel laureates, more than all of the other U.S. national laboratories combined. The Center for Building Science is one of 12 centers located at LBL.



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