Bren Hall (left and right photos) combines a variety of energy-efficient strategies like natural ventilation and daylight harvesting.

Teaming Up with Nature

Two Southern California projects have taken advantage of climate-related and site-specific characteristics to design and construct high-performance, environmentally friendly buildings. Design teams and building owners have used the sun, wind, and moderate temperatures to provide air flow and natural light into building spaces. The majority of the artificial lighting, heating, and cooling systems are used to supplement nature's offering. Native vegetation and reclaimed water mitigate water use. The result is a comfortable, high-quality environment for the building occupants with lower energy and water requirements for the building owners.

"Energy efficiency is everything as far as buildings are concerned. We want all our campus buildings to be as efficient as Bren Hall."

Jim Dewey,
UCSB Energy Manager.

UCSB Bren Hall

The University of California, Santa Barbara (UCSB) campus, located 100 miles northwest of Los Angeles, is situated on approximately 1,000 acres with the Pacific Ocean as its immediate neighbor to the west. Nestled on the east side of campus is the Donald Bren School of Environmental Science and Management, also known as Bren Hall, which was designed and built as a high-performance building.

The 84,672 square foot facility, which opened its doors to students and faculty in early 2002, is the first laboratory building to achieve the Platinum level under the LEED (Leadership in Energy and Environmental Design) Green Building Rating System®. Bren Hall also was designed to exceed the California Title 24 1998 Energy Efficiency Standards by 32 percent. Working with Southern California Edison, several energy efficiency measures installed in the facility qualified for incentives worth $87,000 under the Savings By Design program.

The Pacific Ocean provides consistent air flow to the office wing of the concrete and stucco-clad building.

Bren Hall features a multi-story array of classrooms, offices, and conference rooms, totaling approximately 25,000 square feet. Another 21,000 square feet of the facility is designated for teaching and research laboratories. An open courtyard and numerous breezeways serve as informal study and meeting places for students, teachers, and researchers. The $26 million facility also includes a visitor's center, where building information is provided and tours are offered.

Key Strategies for Bren Hall

The essence of the design and resulting high performance of Bren Hall is focused on several key energy efficiency strategies:

- Natural ventilation – using operable windows and door transoms, the ocean breeze provides fresh air to the occupants of the office wing. Interlocks are used to ensure the heating system does not operate simultaneously with open windows.
- Daylight harvesting – natural light streams into offices and laboratories predominately through the use of view windows. Appropriate glazing characteristics were factored into the window selection. Roof monitors provide additional daylight to a fourth floor conference room space.
- High-performance electric lighting with associated controls – direct/indirect fluorescent fixtures with T-8 lamps, electronic ballasts, and occupancy sensors are used throughout the facility. Control strategies are designed according to room type with manual dimming for classrooms, automated dimming with occupancy sensors in offices, and multi-level switching in the laboratories. Without compromising light quality, designers used aggressive lighting power densities for the office areas, reducing the watts per square foot required by Title 24 1998 standards by more than 20 percent.

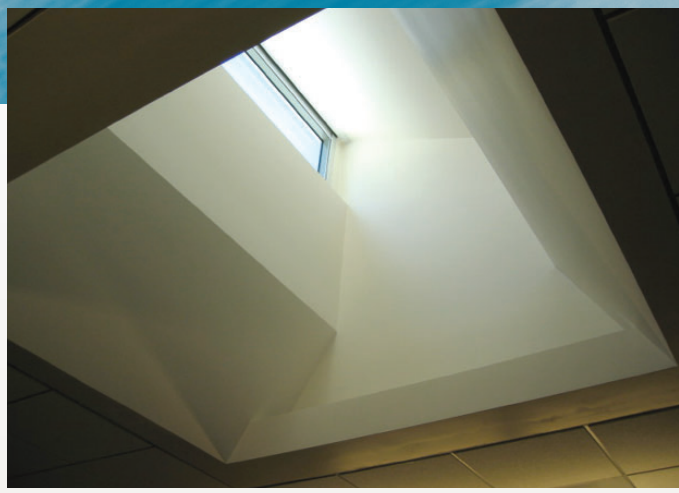
At Bren Hall, daylighting is integrated with electric lighting and associated controls.

- Variable volume exhaust system – Stringent ventilation control is required for the laboratory wing to maintain a negative pressure, yet minimize exhaust rates. The cooling load, ventilation rate, and sash positions of the fume hoods are closely monitored, and the exhaust rate is appropriately adjusted. Also, minimal requirements for air changes (six to eight per hour rather than 10) were used by designers.
- Integrated cooling – the chiller for Bren Hall is connected to the multi-building chilled water loop serving the entire campus. This strategy has significantly reduced the run time of the Bren Hall chiller.
- Efficient heating system – an 85-percent-efficient, low emission boiler unit is coupled with heat exchangers to supply heat for the facility.
- Integrated control system – the electronic monitoring control system at Bren Hall is integrated into the campus-wide control and energy information system. Control sequences have been programmed into the system, and performance data is stored and available for review via the Internet.

"People like to control their own environment and are happy when they can. The individuals in the office wing are very happy with the natural ventilation," said Jeff Kirby, Bren Hall Shop Manager. "It has been a challenge to effectively balance the cooling and ventilation systems in the labs. Since the lab wing requires a very controlled ventilation system, which means keeping the windows closed, we tend to have more comments about comfort issues from the individuals working in the labs."

Other energy efficiency measures include variable frequency drives on motors greater than five horsepower, outdoor air economizers for selected areas that are air-conditioned, and carbon dioxide sensors in high-density occupant areas like the auditorium and lobby to provide demand-controlled ventilation. A white reflective membrane is used on the roof to reflect the sunlight, thus lowering the building cooling

The Design Brief, Design for Your Climate, provides information to design teams and building owners about taking advantage of climate-specific conditions to lower energy use and improve comfort.
www.energydesignresources.com



Roof monitors bring natural light to a fourth floor conference room space. A white reflective membrane also is used on the roof.

load. The facility also was fully commissioned, which ensured the building systems operated as designed and the UCSB facility staff were trained.

Key sustainable design features focus on water conservation, recycled materials, and renewable technology. For water conservation, waterless urinals and toilets using reclaimed water are installed on the first floor. Low flow fixtures and automatic sink sensors are used throughout the building. Reclaimed water also is used for irrigation and combined with drought-tolerant landscape to save water. "Reclaimed water is not used throughout the building. We were concerned about future plumbing issues and did not want to have an extensive mix of reclaimed and fresh water piping. Having the first floor and the irrigation system use reclaimed water and the rest of the building use fresh water provided a good balance," said Kirby.

For recycled material, the list is extensive, ranging from structural steel that is recycled from cars and fireproofing material that includes recycled newsprint, to restroom stall partitions that have recycled plastics, and carpets, flooring, tiles, and furniture that all include recycled content of various types. Overall, the facility is composed of 40 percent recycled materials. Additionally, 100 percent of the demolition and 92 percent of the construction waste were recycled. "Most of the recycled material has worked great," Kirby said, "the only real issue has been the wheat board cabinets in the cold rooms, which were not a good choice and had to be replaced due to moisture issues."

For the renewable technology, a photovoltaic (PV) system is installed on the roof, and supplies up to 10 percent of the electricity, supplementing the utility grid system. Performance data from the system is displayed on the Internet. "The PV system has been virtually maintenance free. We did have a crow drop a clam on one panel and break it, but the manufacturer replaced it for free," said Kirby.

Additional resources are available about energy-efficient and sustainable design strategies.

Websites:

www.bren.ucsb.edu/

www.labs21century.gov

www.caddet.org

Bren Hall Resource Reports:

Building on Bren: Putting a Price on Green Lab Design, L. Matthiessen, T. See, P. Morris. 2003.

The Greening of Bren Hall, Donald Bren School of Environmental Science and Management, Sustainable Design Feasibility Study, Zimmer Gunsul Frasca Partnership, Eley and Associates, October 1999.

Bren Hall's PV system generates up to 10 percent of its electricity.

Savings, Costs, and Comfort

For evaluation purposes, energy simulation models were developed to predict the impact on electricity use from selected energy efficiency strategies. Comparing the predicted consumption with actual monitored data from 2002 through 2005 indicates that the building energy systems are operating as intended. Table 1 shows the total kilowatt-hours (kWh) from November through September for four comparison periods. Figure 1 shows the monthly kWh from November through September for each period.

Electricity use during the first year of operation showed to be higher than predicted values for two months – July and September. Conceivably, the increase could be due to move-in activities by occupants, weather events, control strategies that required adjustment, or further commissioning of energy systems. Electricity use in subsequent years has closely followed predicted values.

In a 2003 report by Davis Langdon Adamson (reference text box of Bren Hall Resource Reports), the premium cost was evaluated for adding the various strategies for Bren Hall to reach the LEED Platinum level. The cost was $1.5 million or an eight percent increase to the construction budget. Estimating the cost savings from lower water, gas, and electricity usage, a payback of 13 years or less is possible.

Most of the energy-efficient and sustainable strategies for this project were implemented during the construction phase. The report suggests that the premium cost would have been closer to 6 percent if the strategies were implemented earlier in the project during the design intent phase.

November - September	Total kWh	Difference	% Difference
Predicted	1,424,671	Base	0.00%
2002-2003	1,517,600	92,929	6.52%
2003-2004	1,382,390	-42,281	-2.97%
2004-2005	1,416,356	-8,315	-0.58%

Table 1: Total predicted electricity use for November through September is compared to total actual electricity use from 2002 through 2005.

"Energy efficiency is everything as far as buildings are concerned. We want all our campus buildings to be as efficient as Bren Hall," states Jim Dewey, UCSB Energy Manager. Dewey estimates that the power consumption at Bren Hall is less than half of comparable laboratory buildings on campus. However, he stresses that campus projects rely on funding mechanisms like bonds and donations and, with construction costs on the rise, energy efficiency measures sometimes suffer. "It is hard because of the focus on initial costs. Energy measures should be considered over the life of the building," said Dewey.

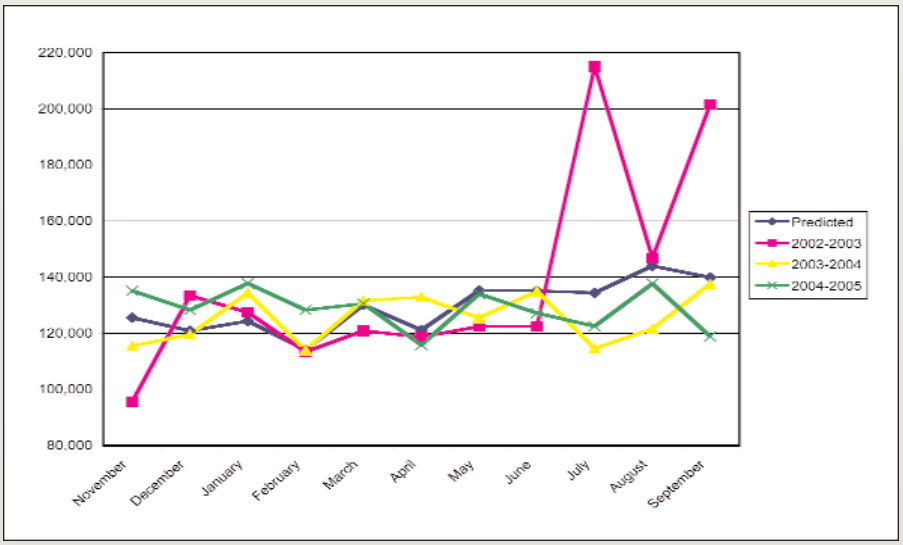


Figure 1: Monthly predicted electricity use for November through September is compared to monthly actual electricity use from 2002 through 2005.

Finally, Bren Hall occupants were surveyed about their satisfaction with the building environment. Of 120 distributed surveys, 64 individuals responded. The majority showed positive results with air quality and lighting scoring high marks. Acoustic quality and thermal comfort ranked slightly lower.

The Bren Hall project has received numerous honors since its completion, including:

- Flex Your Power Energy Efficiency Award (2004)
- International Interior Design Association Environmental Award (2003)
- Parade of Green Buildings Featured Site (2003)
- Goleta Valley Beautiful Award (2002)
- LEED Platinum Award, United States Green Buildings Council (2002)
- Commendation from former California Governor Gray Davis (2002)
- Commendation from the County of Santa Barbara (2002)

Demand Control Opportunities

In 2001, the UCSB facility staff started integrating and expanding the existing building controls system for the entire campus into a more centralized, Internet-based system that would provide analytical information. This enhanced energy management system, which includes Bren Hall, monitors performance, displays real-time data, provides trending and other critical analysis, and controls various energy systems.

The system has enabled the UCSB facility staff to participate in demand response initiatives. "We have participated in a couple of demand response programs, instantaneously curtailing up to one Mega Watt," said Dewey, "we are able to reduce fan speeds, and cooling and lighting loads in non-critical areas, almost with the flip of a switch." The cost impact for UCSB from participating in load curtailment programs has been nominal. "The key reason why we are involved in these programs is to contribute to the effort to avoid rolling blackouts," stated Dewey.

Key Considerations

Important considerations from the Bren Hall project are:

- Discuss and implement energy efficiency and sustainable design strategies from the project beginning to provide time for proper evaluation and to capitalize on cost savings.
- When using natural ventilation, consider including interlock sensors on all room openings including windows, transoms, and doors to maximize energy savings.
- Insist on commissioning of building systems with special attention to key areas like laboratories that may have multiple systems interacting. Also, ensure training is done and O&M manuals are provided.
- Research data about energy efficiency and sustainable design strategies and technologies. Many organizations, both public and private, provide information about demonstrated technologies, costs and savings, and qualified design teams and contractors. Also, the Internet provides a fast and easy-to-use access tool to much of this knowledge base.
- Take advantage of programs like LEED and Savings By Design, which advance energy efficiency and sustainable design strategies. For example, the LEED silver rating system has become the base criteria for new buildings on the UCSB campus. Incentives and design services from the Savings By Design program also mitigate initial costs.

Lakeview Terrace Library

For the city of Los Angeles, the Lakeview Terrace Library integrates the ideal education and community setting with an energy-efficient and environmentally friendly building. The facility qualified for the LEED Platinum rating and was designed to exceed Title 24 2001 standards by 40 percent. Incentives for the project were received from the California Integrated Waste Management Board and the Santa Monica Mountains Conservancy.

During the design process, several workshops were conducted to gain input and to educate the public and stakeholders about sustainable and energy-efficient ideas. Team meetings involving the architects and the engineers also were conducted on a regular basis. "Overall, we are happy with the results and it is a beautiful design. We balanced meeting our design requirements with the project budget. We were very selective of the energy efficiency and sustainable design measures with the cost consideration," said Charles Ngo, Project Manager with the City of Los Angeles Bureau of Engineering.

Key Strategies for Lakeview Terrace

Key energy efficiency features in the 10,700 square foot facility, which includes a community room, library, offices, display gallery, and exterior courtyard, are:

- Arched and elongated form matched with orientation – the building stretches east and west with both view and upper windows capturing natural light. The high-volume, arched ceiling promotes the use of natural ventilation by creating cross ventilation airflow.
- Focus on natural light supplemented with electric lighting – daylight is harvested and controlled, and provides proper light levels to 93 percent of the interior spaces throughout a typical day. View windows, upper windows, and skylights capture the natural light. Light shelves and fins combined with overhangs, awnings, and selective glazing direct the daylight, eliminating undesirable glare into the building.

"LEED was not well known at the start time of this project. If I had it to do over, I would have more meetings with the contractors to educate them about the documentation required for LEED. The architect was fully on board. The design was sufficient. Only the documentation from the contractors was lacking in the beginning stages."

Charles Ngo, Project Manager,
City of Los Angeles,
Bureau of Engineering

Capturing and controlling daylight is a key strategy for Lakeview Terrace Library

RMA Photography, Inc.

Operable windows and the high-volume, arched ceiling provide cross ventilation to interior spaces

RMA Photography, Inc.

Dimmable ballasts, photocells, and occupancy sensors are part of the electric lighting system, and integrate the electric lights with the daylight to ensure target light levels are provided throughout the day and night.

- Use of passive cooling strategies – 80 percent of the building is naturally ventilated. Operable windows, equipped with interlock controls, provide a continual supply of fresh air. To take advantage of the region's cooler nocturnal temperatures, night venting is employed. This strategy uses the building's walls, concrete masonry units with exterior insulation, to absorb and release the coolness well into the day. A cooling tower with evaporative coolers supplements the natural ventilation and provides cooling to the other 20 percent of the facility.

Other energy efficiency features include an ENERGY STAR® compliant roof that is insulated beyond Title 24 requirements, variable speed drives and pumps selected for the cooling and heating system, and a building integrated PV system that generates up to 15 percent of the facility's electricity. The building's energy systems also were fully commissioned.

Other Considerations

The $4.2 million project included numerous sustainable design strategies. On the north part of the site, bioswales, narrow channels with grassy vegetation that act as filters, mitigate stormwater runoff. Other parts of the site use a free-draining or

Honors received by the Lakeview Terrace Library include:

- Leadership in Engineering Award, Los Angeles Council of Engineers and Scientists (2005)
- Top Ten Green Projects Award, American Institute of Architects (2004)
- Savings By Design Energy Efficiency Integration Award (2004)
- LEED Platinum Award, United States Green Buildings Council (2003)

Natural light provides proper light levels to 93 percent of the interior during a typical day.

RMA Photography, Inc.

gabion wall, landscaped areas, and a dedicated filtration system to filter the runoff. Recyclable content has been used for several of the building's materials including flooring, tiles, walls, and panels. Water usage has been reduced through the use of native vegetation, highly efficient irrigation systems, and low flow water fixtures and controls inside the building.

Actual electricity use for the building has met expectations. "Utility costs have been low as expected. Comfort level is sufficient. People really have had no issues and we have had only the typical maintenance issues. Overall, people like what the city has done with the library and the surrounding site," commented Ngos. Completed in 2003, the energy efficiency and sustainable measures from the project have served as a model for other City of Los Angeles libraries and municipal buildings.