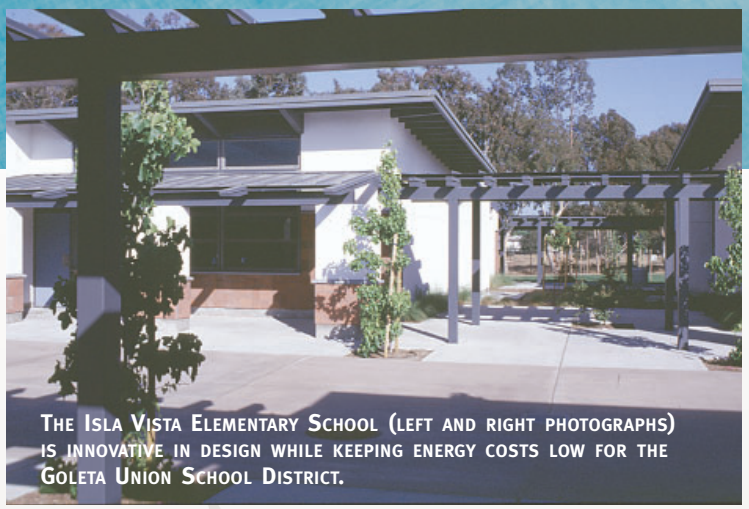


The Isla Vista Elementary School (left and right photographs) is innovative in design while keeping energy costs low for the Goleta Union School District.

More than ever before, school districts, utilities, and the state of California are working with design teams to build quality learning environments that are energy-efficient and cost-effective.

High Performance Learning

Choices made during the concept, design, and construction phases of new K-12 school projects in California impact students, teachers, parents, and the community for various reasons. For children and teachers, their daily comfort and performance is affected by the classrooms, hallways, gymnasiums, and auditoriums where they interact from five to eight hours each day. For school administrators, parents, and residential taxpayers, the decisions made by school boards and design teams create long-term financial obligations. Their decisions influence the construction dollars required, the operating and maintenance budgets needed, and the learning environment provided for each new school. Consequently, student performance and attendance, teacher and administrator satisfaction and retention, the overall health of students and school personnel, the checkbooks of parents, and the taxes paid by school district residents are affected. The impact may be felt for many years, since the useful life of a school campus is typically 30 to 50 years.

In a 2003 California Energy Commission report, *Recommended Best Design Practices for All New Public Schools*, it is estimated that the California school system spends more than $700 million on energy costs. The report also estimates that more than 100,000 new students enroll in the California school system each year. In many parts of the state, new schools are under design and construction to accommodate the increased enrollments and to address state-mandated reductions in class sizes. Also, aging school buildings in many districts need repair with approximately 30 percent of schools requiring major renovations. The Los Angeles Unified School District (LAUSD), the second largest in the nation, has embraced a massive construction program and is spending $19.2 billion on more than 150 new schools and approximately 18,000 repairs to existing schools. The expected completion for the LAUSD construction program is 2012.

The Bright Schools Program reports that some schools spend more on utility bills than school supplies. Yet, it has been shown that incorporating energy strategies into schools can save 20 to 40 percent of utility costs, freeing funds for teacher and student needs.

Energy Efficiency Strategies

Successful energy efficiency strategies for designing high performance schools include the following.

- Daylight should be harvested for use in classrooms, multipurpose rooms, and gymnasiums, by thoughtfully orienting the buildings and properly selecting the placement of windows. Clerestories (upper windows), skylights, and view windows should be carefully evaluated along with the proper selection of the glazing or type of glass. Light shelves should be considered to direct the daylight deeper into the teaching space, yet minimize undesirable glare.
- Natural ventilation may be appropriate for some classroom applications using operable windows, building orientation, and cross ventilation techniques to provide airflow. Though the mild climate of southern California supports the use of fresh air during most months of the school year, some type of mechanical heating and cooling still may be needed for extreme temperatures and to provide required ventilation. The California Title 24 Energy Efficiency Standards allows for outside air ventilation for classrooms or other school spaces either through natural or mechanical means.
- Electric lighting systems using direct/indirect fixtures combined with high-efficacy T-8 and T-5 fluorescent lamps and electronic ballasts provide quality light levels for classrooms. For other areas in the school such as libraries, gymnasiums, auditoriums, and corridors, the CHPS (see sidebar on page 3) Best Practices Manual provides suggested lighting technologies and design guidelines.
- Lighting controls are essential with some level of control mandated by Title 24 standards. Where electric lighting is designed to supplement daylight, it is important to evaluate and select effective control strategies. Stepped switching or fully automated dimming controls may be used to increase or decrease the electric light level as the daylight in the room changes throughout the day. Stepped switching are controls that turn off one row of lamps or fixtures at a time and are a cost-effective choice. Fully automated dimming controls gradually dim or increase electric light levels and are the most desirable, but may be cost prohibitive.

The Bright Schools Program, supported by the California Energy Commission, offers technical assistance for new construction and renovation projects.

www.energy.ca.gov/efficiency/brightschools

The Department of General Services offers information and resources on sustainable strategies including energy efficiency.

www.sustainableschools.dgs.ca.gov/SustainableSchools/

The Collaborative for High Performance Schools (CHPS) is an invaluable resource for case studies, specifications, and training. Also, the CHPS Best Practices Manual is a standard reference for high performance school design and features the CHPS Criteria rating system.

www.CHPS.net

The Southern California Edison's Classroom Lighting Guide booklet supplements CHPS Guidelines with lighting recommendations specific to Southern California's climate, with an emphasis on daylit classrooms.

www.sce.com/RebatesandSavings/DesignandEngineering/SCEClassroomLightingGuide

- Heating, ventilation, and air conditioning (HVAC) systems that are appropriate for schools vary widely. System types include gas/electric split systems, rooftop package units, evaporative cooling systems, baseboard heating, thermal displacement ventilation systems, ground source heat pumps, and chilled water plants. The choice and design of the system affects factors like thermal comfort, indoor air quality, noise levels, energy use, initial cost, and maintenance needs. Whichever system is selected, it should be designed in concert with the building envelope and glazing, the daylight harvesting and electric lighting system, and natural ventilation strategies. When integrated with other energy efficiency strategies, the heating and cooling loads may be reduced allowing for the HVAC system to be downsized. In turn, construction costs may be reduced or, at least, offset. Again, the CHPS Best Practices Manual provides an extensive discussion of HVAC technologies and design guidelines.
- Some level of HVAC controls are required by Title 24 standards. However, HVAC system designers can provide more flexibility by providing individual thermostats in the classrooms with a campus-wide control system for use during non-school hours.
- Commissioning is important. Ensuring the different building and energy systems are installed and operate as designed is the key to achieving the desired comfort, control, and energy savings that are expected. Also, systems start-up, short-term monitoring, training for facility staff, and O&M manuals are provided as part of standard commissioning services.
- Sustainable strategies for schools also are important to consider. Recommendations include selecting native vegetation for landscaped areas to reduce water use, using low volatile organic compound (VOC) materials (carpet, paint, etc.) to improve indoor air quality, specifying recycled products for building materials, and encouraging conservation efforts within the school to recycle cans, cardboard, and plastic.

Costs and Benefits

By evaluating energy efficiency and sustainable design strategies together rather than as individual components, construction costs may be offset or minimally impacted. Savings from the use of native vegetation and recycled material, or downsized HVAC systems may be used to counterbalance increased costs for additional glazing or building control systems. Additionally, technologies like direct/indirect electric lighting systems with high performance lamps and ballasts have become cost competitive when compared to conventional systems that use lay-in troffer fixtures.

It also is important to consider the long-term cost of selected strategies using either simple payback or life cycle costing analyses. For example, building a new school may cost approximately $100 per square foot. Upgrading the lighting system to include energy-efficient lamps and ballasts with automated dimming features may increase the cost from three dollars per square foot to five dollars per square foot, which is a 67 percent increase. However, it is only a two percent increase for the total project cost and may be more than offset by decreasing the cooling load and the size of the required HVAC system. The more efficient electric lighting system also may provide up to 10 percent savings on annual energy costs.

High performance schools offer enhanced learning environments. In fact, one study showed that natural light in classrooms increased learning and academic performance, which were directly reflected in higher test scores. The study, conducted in 1999, *Daylighting in Schools - An Investigation into the Relationship Between Daylighting and Human Performance*, found that students with the most daylighting in their classrooms progressed 20 percent faster on math tests and 26 percent faster on reading tests in one year, compared to students in classrooms with little or no daylight. A condensed version of the report is available on the Pacific Gas & Electric Company (www.pge.com) and the Coalition for Adequate School Housing (www.cashnet.org) web sites.

The benefits of integrating energy efficiency and sustainable design strategies into new schools are heightened student performance, reduced energy use translating into lower operating costs, and improved student and teacher satisfaction. Minimal or zero increases in construction costs also may be realized. Two example schools that were designed and built using some of the above-mentioned strategies are highlighted.

Isla Vista Elementary School

The Goleta Union School District decided it was time to renovate the Isla Vista Elementary School that was built in the 1950s. Working with Roesling Nakmura Terada (RNT) Architects, school district personnel wanted to create a "village-style" campus that would take advantage of prevailing breezes from the Pacific Ocean and the Southern California sunshine to bring fresh air and natural light to the students and teachers. This meant demolishing the old school and working with the community to re-orient the new campus on the existing site.

Located to the north and less than one mile from the ocean, the school site is surrounded on two sides by wetlands. Through a series of negotiations with the city and community of Goleta, the school district was allowed to extend soccer fields and a parking lot onto the wetlands. The change was significant because it provided the necessary space to shift the layout of the school buildings to take advantage of dominant wind patterns and daylight opportunities.

Public School Construction DGS

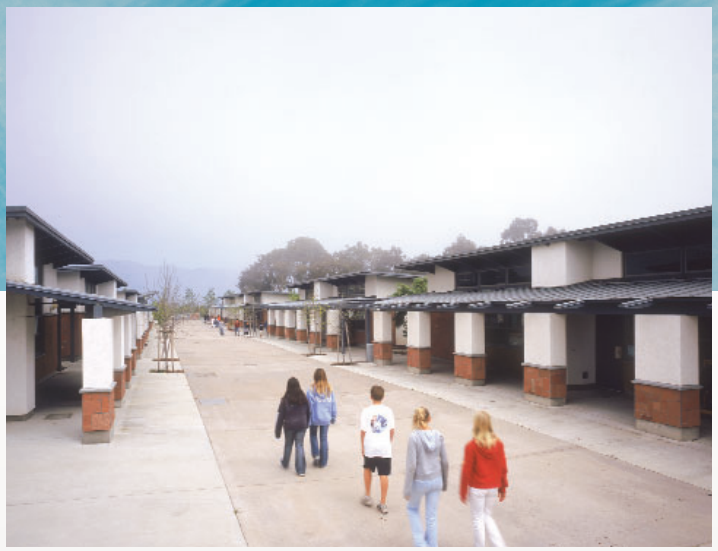
The Office of Public School construction (OPSC) implements and administers the School Facility Program that provides new construction and modernization grants to school districts.

The OPSC also has produced a Best Practices Report highlighting cost reduction guidelines, energy strategies, prototype plans, and information on specific school projects.

www.opsc.dgs.ca.gov

"We designed the Isla Vista School to meet the communities needs. The classroom and multi-purpose layouts are popular. The soccer fields are busy. The core design is interesting and innovative."

Jay Sullivan,
Director of Maintenance, Operations, and Transportation for the Goleta Union School District.



Daylighting and natural ventilation through operable windows are the key elements of the Isla Vista classrooms.

Photos courtesy of RNT Architects, Inc.

"When initial bids for the school were received, they exceeded the project budget. When cuts were made, the energy efficiency and sustainable items were retained for rebid because of their cost effectiveness."

Jay Sullivan, Director of Maintenance, Operations, and Transportation for the Goleta Union School District.

Completed in 2000, the new school encompasses 51,000 square feet and is designed with 31 classrooms built in clusters along a main walkway or "community street". The campus also has a multi-purpose room, library and computer lab, outdoor teaching areas, and administrative offices. It is home to more than 500 students speaking approximately 17 languages. The total cost of construction was approximately $8.56 million. "This project was a once in a lifetime opportunity to work with a very creative group of teachers and district staff with goals of creating a campus that embraces children of many diverse cultures and creative teaching programs," said Chikako Terada, Principal with RNT Architects.

From an energy perspective, the school buildings were designed to exceed the California Title 24 1998 standards by 30 percent. The design team integrated the following strategies to achieve their performance goals in the classrooms.

- Multiple operable side windows provide natural airflow and cross ventilation eliminating the need for mechanical cooling equipment.
- Clerestories direct natural light deeper into the teaching area to supplement the electric lighting.
- Pendant fixtures with high-efficient T-8 lamps and electronic ballasts provide the electric lighting. Teachers turn off lights in the classrooms when natural light is abundant.
- A metal arcade roof is used to reflect daylight into the clerestory windows while blocking direct sunlight into the lower windows.
- High-efficient heaters with individual thermostats provide heating in the classrooms during the winter months. Ventilation motors on each unit supplement air circulation throughout the year to ensure proper indoor air quality.

Teachers were trained to use the energy design strategies and regulate the ventilation, heating, and lighting systems in the classrooms based on their teaching style. "The classroom spaces have quite a bit of daylight now. Some teachers operate

Clerestory windows and shading are combined to provide proper amounts of daylight to the classrooms.

Photo courtesy of RNT Architects, Inc.

their lights and others do not at all. If we were to design Isla Vista today, we would include a larger daylighting component," said Jay Sullivan, Director of Maintenance, Operations, and Transportation for the school district.

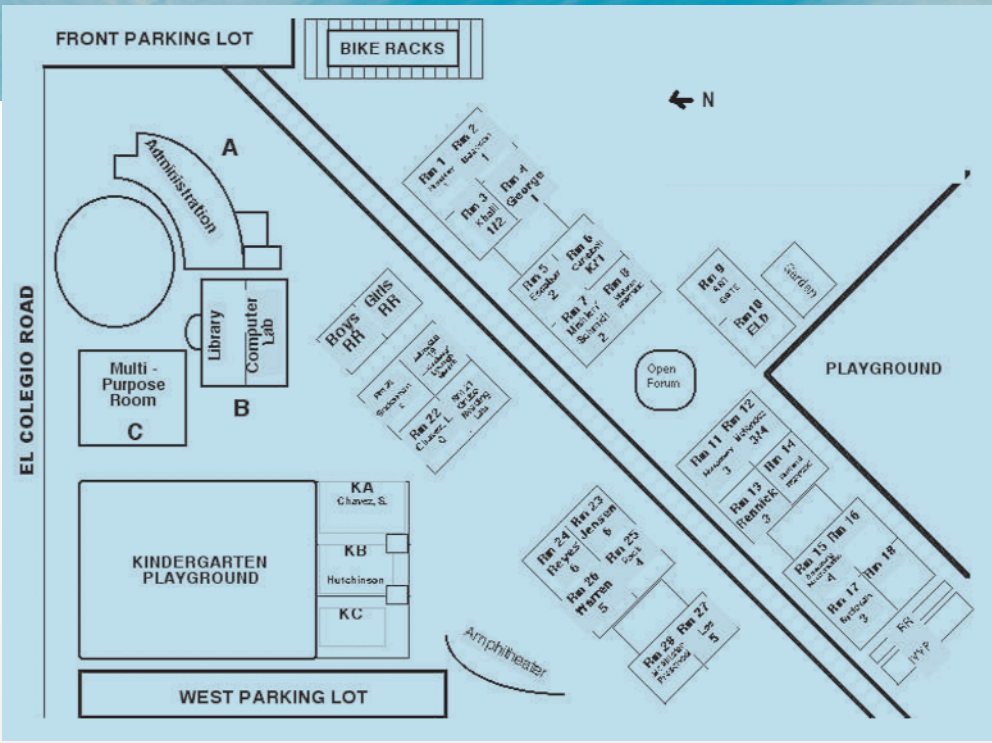
Classrooms are not the only spaces incorporating energy strategies. The design for the multi-purpose room is unique because the south wall features a roll-up door and the north wall has floor to ceiling glazing. Drapes are provided on the windows, if needed. The roof-mounted HVAC unit is highly efficient. Though facility personnel have used the HVAC unit sparingly, finding the room to be comfortable using the roll-up door for air circulation or letting the heat released by room occupants naturally warm the space.

A building automation system controls the HVAC and lighting systems for the front end of the school, which includes the administrative offices, library, and multi-purpose room. As mentioned, the classrooms have individual controls. The landscape areas around the campus are extensive and transition in some places from the

The multi-purpose room features a roll-up door and floor to ceiling windows.

Photos courtesy of RNT Architects, Inc.

Isla Vista is located only blocks away from the Pacific Ocean. The prevailing wind off the water provides fresh air through operable windows to students and teachers most days of the school year.



playground and soccer fields into the wetland environment. The design team used native vegetation, where appropriate, to preserve the original environment and minimize maintenance. Reclaimed water is used for all irrigation. Natural stone walls, used as an accent material, are strategically placed where there is a lot of student traffic to increase the durability of the surfaces and reduce maintenance costs. With the nearby wetlands and the energy design features, the students are continuing to learn about conservation in their school environment.

In 2004, actual electricity costs at the school were approximately $34,000 or 67 cents per square foot. Energy use was 252,000 kilowatt-hours (kWh) with a peak demand of 99 kW occurring in May. Performance and maintenance issues have been minor as expected with a new school that has minimal mechanical systems in the classrooms and common areas. With its innovative design and energy strategies, the project won two awards – the 2001 Savings By Design (SBD) Energy Efficiency Citation Award and the 2002 Honor Award from the Coalition of Adequate School Housing (CASH). Isla Vista's design also has influenced the design for other California schools.

Southeast Learning Center

Teaming up with WLC Architects, the LAUSD has built a three-story school for urban Maywood and Huntington Park that features numerous energy-efficient and sustainable design strategies. Completed in 2006, the Southeast Learning Center encompasses approximately 122,500 square feet using an optimized footprint. It includes 45 classrooms on nine acres and can accommodate from 1,100 to 1,500 students.

Described by the LAUSD and Southern California Edison as a showcase school, the $90 million project, which included $37 million in construction costs,

The design for Southeast Learning Center focused on an enhanced learning environment in an urban setting.

qualified as a CHPS high performance school and achieved LEED certification at the basic level. Energy performance is estimated to exceed Title 24 2001 standards by 30 percent. "Utilizing CHPS guarantees that all new LAUSD schools incorporate the best of today's design strategies and building technologies to provide better learning environments, reduce operating costs and protect the environment," said LAUSD Chief Facilities Executive Jim McConnell. "These improvements have been made at little or no additional cost. As the pioneer, LAUSD has learned lessons and established processes and strategies that are being utilized by other school districts around the country," added McConnell.

Specific energy efficiency and sustainable measures include the following:

- To optimize daylighting opportunities, most of the buildings are oriented east and west to take advantage of the south exposure.
- Use of light shelves, appropriate glazing, and a daylight dimming system capture and utilize natural light within the facility.
- Installation of a reflective white roofing membrane, or cool roof, minimizes roof temperatures.
- Carefully designed windows and doors provide natural ventilation, when appropriate, to students and teachers.
- An energy-efficient HVAC system provides cooling and heating when needed and is installed with interconnections to prevent simultaneous use of the mechanical system with open windows and doors.

energydesignresources

www.energydesignresources.com

The Energy Design Resources (EDR) web site provides a wealth of tools. Examples are:

- Design Briefs covering topics like daylighting, ventilation, integrated energy design, and commissioning.
- Case studies featuring schools, colleges, and other energy-efficient buildings.
- Software programs including the SPOT™ tool to assist designers on the integration of daylighting and electric lighting, and SkyCalc to help calculate the optimum skylighting strategy.
- Online and onsite Training covering a variety of technical subjects.

Daylighting and natural ventilation strategies provide natural light and fresh air to the Southeast Learning Center classrooms.

- To reduce water use and storm water runoff, the irrigation system is designed to connect to the city's reclaimed water system. Also, storm water is collected and retained on site, but not for reuse.
- Sustainable building material, many with recycled content, are used throughout the facility.

The design for the Southeast Learning Center features administrative offices, library, cafeteria, auditorium, and other support offices on the first floor with classrooms on the second and third floors. The campus also includes an inner courtyard, gymnasium, Olympic-size pool, and a variety of courts for sports activities. Vivid colors are used throughout the facility to brighten the learning environment and promote its educational functions. The campus includes five buildings, three are steel frame construction, and two are concrete masonry. It provides a neighborhood school where most students can walk to and from their homes.

Portable Considerations

For the state of California, the use of portable classrooms provides an additional challenge regarding indoor air quality and energy efficiency. In a November 2004 report to the California Legislature by the California Air Resources Board and the Department of Health Services, nearly one-third of all K-12 classrooms in the state were found to be portables. Using mail-in surveys from school personnel and field studies, information on both portable and conventional classrooms was gathered and compared.

One key finding in the report was the lack of proper ventilation in portables, due in part to teachers turning off HVAC units because the systems were too noisy. Additionally, 40 percent of the HVAC units in the portable classrooms were found to have dirty filters, which contributed to lower indoor air quality and increased energy use. Finally, light levels in the portables had lower light levels than traditional classrooms.

SAVINGS BY DESIGN

www.savingsbydesign.com

Savings By Design provides design assistance and financial incentives for building owners and design teams who improve building energy performance above Title 24 standards.

The report recommended the redesign of portable classrooms using a design approach that introduces more daylight into the space, specifies high performance electric lighting, addresses ventilation and noise issues with innovative HVAC systems, and provides improved control for lighting and HVAC systems. Several organizations including Southern California Edison, the California Energy Commission, and Lawrence Berkeley National Laboratories have been involved in improving the design and performance of portable classrooms.

It is estimated that one fifth of the California population spends their day inside a school building and it has been reported that learning environments affect student performance. With the tremendous amount of money spent on energy bills by school districts each year and the longevity of school campuses, it is important to design and build quality classrooms that are energy-efficient and cost-effective. Optimizing construction dollars, reducing operating costs through lower energy use, and creating high-performance learning environments should be at the top of everyone's school list.