energy design resources

More major store retailers are experimenting with energy-efficient designs to lower operating costs and enhance the shopping experience.

Bright shopping areas can be achieved using skylights, clerestories, light colors, and fluorescent lighting with pendant fixtures.

Thinking Outside the Box

Large retail or "big box" stores are looking toward energy efficiency and sustainable design strategies to provide a competitive edge and increased profitability across the nation and in California's hard-hitting marketplace. Small sales margins and an increased number of competitors are opening the door to cost savings from energy-efficient and environment friendly designs, which also provide marketing and community approval benefits.

Based on a 2002 report from the Center for Energy and Climate Solutions, major retail stores share many common characteristics—large, rectangle-shaped buildings located in high traffic areas focusing on shoppers in a time-crunched and cost-conscious society. The buildings appear as cookie-cutter designs, with immense parking lots, mostly windowless environments, and an array of aisles stocked with goods. Keeping costs low and sales volumes high drives the retailers. Additionally, traditional merchandise offerings by store type—grocery stores with groceries, clothing stores with clothes, appliance stores with gadgets—have shifted with many retailers offering a broad mix.

Surprisingly, large retail stores tend to not be excessive energy users, at least when considered on a square-foot basis. Most major retailers have implemented some level of energy conservation motivated in part by utility incentive programs and government-

mandated energy codes, or their own corporate leadership. The substantial energy consumption seen by major retailers is due to the large physical size of the stores, long run hours, and the quantity of stores within a geographic area.

Independent studies show that energy savings of 20 to 40 percent still are readily achievable for large retailers by using an integrated approach to the store design and installing high-efficient equipment and controls for major energy-consuming systems like lighting and cooling. Within the store, sustainable design strategies revolving around daylight harvesting and natural ventilation also offer significant reductions in energy loads while, outside the store, use of native landscaping and the capture of rainwater runoff present opportunities to decrease water use.

Energy and Sustainable Strategies Abound

Key areas to consider for energy and sustainable design strategies are those appropriate for inside the building or at the building level, site-related options, and multiple building considerations.

Building Level

1) Minimize envelope upgrades. For southern California, building envelope improvements have shown to be insignificant to internal loads. For example, tilt-up concrete wall construction versus masonry block walls showed one-half of a percent energy difference.
2) Optimize daylight harvesting. Skylights and celestories are suggested using maximum light transmission with minimal U-factor. Also, it is best to use translucent skylights to minimize glare. Photosensors integrating the harvested daylight with the electric light levels are recommended to realize the highest energy savings.

Resources for building owners and design teams include:

- DOE-2 energy modeling software, www.doe2.com/
- SPOT™ software for integrating daylighting and electric lighting, www.archenergy.com/SPOT
- USGBC LEED certification system, www.usgbc.com
- Flex Your Power website, www.flexyourpower.com
- Center for Energy and Climate Solutions website, www.cool-companies.org/homepage.cfm
- Skylighting and Retail Sales Study, www.pge.com/pec/daylight/daylight.shtml
- EPA Green Buildings, www.epa.gov/opptintr/greenbuilding/

Commercial retail buildings in California must comply with Title 24, the state's Energy Efficiency Building Standards for Residential and Nonresidential Buildings. According to the Flex Your Power organization, Title 24 has saved more than $20 billion in electricity and natural gas costs since 1978.

3) Invest in superior electric lighting technologies. Since lighting represents 30 to 50 percent of energy use in large retail stores, it is important to investigate the use of energy-efficient lighting systems, and properly specify the fixtures, the type and number of lamps, as well as the ballasts. Fluorescent lighting systems are recommended for store interiors, since metal halide and high-pressure sodium lighting tend to be less efficient and more expensive to operate and maintain. Also, designing multiple systems to provide ambient and task lighting for separate high-rack, low-rack, and display areas should be considered. For store exteriors, high intensity discharge (HID) lamps such as ceramic metal halide with electronic ballasts provide high-efficient choices for parking lots and walkways. Alternatively, solid state or LED lighting with its long life, low energy consumption, and unique optical properties may be appropriate for sign lighting, exterior walkways, and some indoor applications like refrigeration cases. Soliciting the help of a lighting designer to specify light levels, fixture layout, and system equipment by application is recommended.
4) Specify high efficiency HVAC (heating, ventilation, and air conditioning) equipment. For most California areas, designing adequate cooling capacity is the main concern since heating needs are minimal. Specifying energy-efficient electric lighting and using skylights to capture daylighting will help mitigate cooling loads. Multiple rooftop package units with the use of economizers to take advantage of free cooling are appropriate for many southern California areas. Inland and coastal areas of the state may require some pre-cooling and de-humidification of the outside air. Other HVAC alternatives such as evaporative cooling for arid regions and gas-absorption chillers may be worth evaluating.
5) Control major energy systems. Using an energy management system, HVAC systems can be easily sequenced to match building occupancy loads. Store operating hours also may be used to schedule both cooling and interior and exterior lighting systems. Controls for the interior lighting system should integrate the light levels from the electric lighting and the daylighting, and be organized by the different use areas of the store.

Other key considerations for energy-efficient strategies include using heat recovery from refrigeration equipment for domestic hot water, radiant floor systems for heating and cooling, and installing a cool roof with high solar reflectivity to lower cooling loads. Also, design teams may lower overall light levels by selecting interior colors with high reflectance to heighten visual perception of a bright shopping area.

Reducing the amount of paved area helps to reduce storm water runoff and allow for the opportunity to capture rainwater for reuse. Use of natural vegetation can mitigate water use.

Site-related Options

1) Optimize the building location and orientation. Site the building to take advantage of natural land or water features, the path of the sun, or natural wind patterns.
2) Minimize stormwater run-off. Parking lots contribute to stormwater runoff that is contaminated with oil, fuel, and trash. It is important to design sites that minimize the use of asphalt and impervious surfaces, and maintain as much natural vegetation as possible. Also, collecting rainwater from roof surfaces helps lower the quantity of runoff into the parking areas. Retention ponds are useful to collect stormwater and reuse for irrigation.
3) Harness power from the sun. Due to federal and state incentives, photovoltaic (PV) arrays are becoming more affordable for supplementing utility-supplied electricity and supplying power for both interior and exterior store applications.
4) Commissioning is key. Building and site-related systems need to be commissioned and the maintenance staff adequately trained before opening the store. Commissioning ensures that all major systems operate as intended and no critical errors have been made during the design, installation, and start-up phase of the project.

Multi-building Considerations

1) Optimize energy use through utility rate structures. Understanding the nuances like time of day, peak demand, load-shed, and seasonal variations for various utility rate structures is important for minimizing energy costs. For example, most utilities offer lower cost power for customers willing to shift load to off peak hours.

Some major retailers are exploring photovoltaic (PV) systems. Federal and state incentives are helping PV systems to become economically viable. Above left is a PV wall that converts the sun's energy into electricity and above right is a traffic sign that uses LED lights powered by a PV array.

2) Increase sales through daylighting. One study (see Resources reference on page 2) found skylights to be positively and significantly correlated to higher retail sales.
3) Consider LEED certification for projects. LEED (Leadership in Energy and Environmental Design Green Building Rating System®) provides a complete framework for assessing energy performance and meeting sustainability goals.
4) Contemplate carbon trading. As the issue of global warming grows, some countries are turning to allocations or penalties based on carbon dioxide emissions. The premise is simple: once emission allowances are set, companies exceeding the amount pay a penalty; those below the goal are given credits that can be sold on the open market. Lower energy use equals lower carbon emissions.

Benefits abound for retail businesses through lower energy costs, quality store environments for shoppers and employees, the potential for increased sales, and the societal benefit of reduced environmental impact.

Cases in Point

Three stores, designed and built in California using some of the above-mentioned strategies, illustrate the ways that different major retailers have reduced their energy use. Each store also qualified for incentives under the California Savings By Design (SBD) program.

Major Warehouse Retailer Estimated Savings

Electricity (kWh)	696,823
Electricity (kW)	189
Electricity ($)	$82,797
Gas (therms)	-2,941
Gas ($)	-$1,470
Cost Savings (%)	20%

Illustration #1

The prototype design for one major warehouse retailer consists of 145,500 conditioned square feet and approximately 3,100 non-conditioned square feet. The store design exceeds a baseline building designed to California Title 24 2001 energy standards by 18 percent. The projected Energy Use Index (EUI) for the prototype design is approximately 212 kBtu/sf/yr. When completed, the stores, which use refrigeration cases, typically qualify for incentives worth approximately $35,000 from

the SBD Program. Specific energy efficiency measures include the following:

- Daylighting through the use of skylights comprising approximately five percent of the roof area.
- Electric lighting using High Intensity Discharge (HID) lamps and fixtures with light levels designed to provide 55 footcandles (fc) for shoppers.
- Three-stage lighting controls integrating the skylights with the electric lighting system.
- High efficiency HVAC package units installed in the tire sales, main sales, bakery, and foodservice areas. The units' efficiency ranges from 10 to 11.5 energy efficiency ratio (EER).
- Partial subcooling and condenser control strategies for the HVAC units.
- Efficient fans on walk-in refrigeration units and refrigerated display cases.

With the enhanced equipment and design, the energy cost savings for the warehouse stores are projected to be $81,300 or 20 percent per year. The total package of measures provides 2.8-year simple payback.

Illustration #2

One major retailer enlisted Southern California Edison (SCE) Company to perform a whole building energy analysis on a 134,000 square foot prototype design. SCE evaluated energy measures for the prototype looking at 16 California climate zones. Results of the evaluation showed potential savings ranging from 5 to 30 percent by integrating daylighting, high efficiency electric lighting and HVAC, and energy management controls into the design.

A store using the prototype design was completed in 2004 and qualified for $66,000 in incentives under the SBD Program. The store design exceeded a baseline building designed to the California Title 24 2001 standards by almost 30 percent. The projected EUI is 99 kBtu/sf/yr. Specific measures included the following:

- Dual-glazed skylights, accounting for three percent of the total roof area and five

When appropriately integrated into the building design, skylights and high-efficient HVAC units can significantly lower energy use in retail stores.

MAJOR RETAILER ESTIMATED SAVINGS

Electricity (kWh)	834,893
Electricity (kW)	289
Electricity ($)	$120,629
Gas (therms)	-686
Gas ($)	-$490
Cost Savings (%)	23%

percent of total daylit area, are used to bring natural daylight to shoppers.

- Electric lighting comprised of T8 fluorescent lamps in suspended overhead fixtures provides light levels of 65 fc.
- Lighting controls are used to integrate the daylighting with the electric lighting. A two-step control strategy is employed that turns off 50 percent or 100 percent of the lights depending on available daylight.
- High efficiency HVAC package units ranging from 3 to 20 tons are installed with 11 EERs.

For the prototype store, cost savings were estimated to be approximately $120,000 or 23 percent per year. The simple payback for the measures is 1.6 years. Actual savings for the first year of operation are closer to $200,000 per year.

Illustration #3

One major clothing retailer uses a prototype design with a footprint of 87,450 square feet. The design typically qualifies for approximately $42,000 in incentives under the SBD Program and exceeds a baseline building designed to the California Title 24 2001 standards by 32 percent. The projected EUI is 91 kBtu/sf/yr, which is notably low for retail stores and due to the focus solely on clothing merchandise. Specific energy efficiency measures include the following:

- Electric lighting consisting of high performance T-8 lamps with low output ballast that provide energy savings, less lumen depreciation, improved color rendering, and longer lamp life.
- Upper stock room daylighting provides natural light and allows the ceiling-mounted recessed fluorescent fixtures to be shut off when daylighting provides adequate light levels.
- Continuous and stepped lighting controls are offered in alternate designs using an energy management system.
- Occupancy sensors installed in restrooms, fitting rooms, and stock rooms that turn off lights when the areas are not in use.
- High efficiency HVAC package units installed having greater than 11 EER.
- A reflective white membrane, or cool roof, is used that carries an ENERGY STAR® rating and has a six-year payback on energy cost savings.

MAJOR CLOTHING RETAILER ESTIMATED SAVINGS

Electricity (kWh)	533,640
Electricity (kW)	200
Electricity ($)	$81,800
Gas (therms)	-670
Gas ($)	-$470
Cost Savings (%)	40%

For the clothing store, total energy cost savings were estimated to be approximately $81,350 or forty percent per year with additional maintenance savings from the longer life T-8 lamps. The simple payback is estimated to be 1.6 years.

Opportunities and Challenges

Unique opportunities exist for major retailers. Due to the large quantity of stores that are built across California and other states, retail corporations are able to negotiate with equipment suppliers to reduce the initial cost of energy-efficient technologies. Also, costs associated with designing high-performance stores and purchasing, installing, and commissioning the equipment can be shared across a larger population of stores. Finally, retailers are able to experiment with prototype designs in one location that include various energy-efficient and sustainable measures, and verify the performance before approving the design for their stores.

As with any new construction project, challenges arise. The ability to vary building orientation to harvest daylight and limit site disturbances may be difficult due to land and access constraints. Adapting one standard building design to multiple climate zones may create thermal comfort issues. Asking operation and maintenance staff to be proficient with multiple building systems may not be practical. Also, the store operations manager and the merchandising manager may have conflicting interests in store designs, such as light levels for product displays. Challenges, like opportunities, should be thoroughly reviewed. Alternative prototype designs accounting for differences in building orientation or geographic locations are recommended; proper training of maintenance staff or retention of qualified contractors for commissioning of the building systems is a must; and including the personnel of various store business areas in the design process is key to success.

Conclusion

The main reason for integrating effective energy-efficient and sustainable strategies into new stores is to keep operating costs low by controlling electricity, gas, and water use. These strategies also provide a competitive edge by contributing to comfortable and distinctive store surroundings for shoppers, which may contribute to higher sales. Finally, retailers can strengthen their image within communities as corporations who care about their impact on the environment.

NOTE: Photographs in this case study show technologies that are used in two experimental Wal-Mart Stores and do not reflect an endorsement by EDR or Wal-Mart Stores.

SAVINGS BY DESIGN

The Savings By Design program offers services and incentives to architects and building owners to help them raise the bar regarding a building's energy performance. Benefits of participating include long-term savings on operating costs, monetary incentives to design teams and building owners, and assistance in evaluating various energy efficiency design strategies.

This program is funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison Company, and the Southern California Gas Company.

For more information, visit www.savingsbydesign.com.

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