energydesignresources

design brief

OPTIONS AND OPPORTUNITIES

Summary

When focus is placed on the largest energy uses in a particular type of building, incorporating pertinent enhancements in a standard design can readily improve energy efficiency. This Design Brief summarizes the energy-efficiency design strategies that offer the greatest potential benefit in 11 building types.

Although some of the measures discussed in this brief are frequently employed, others are seldom considered during the design process. This quick overview of energy-efficiency strategies appropriate to different types of buildings will allow designers to place a range of potentially useful options on the table early in the decision-making process.

Energy intensity is presented as an indicator of the potential for cost-effective, energy-efficient design strategies in a particular building type.

Not all energy-efficiency measures are appropriate for all building types, but some are especially useful for particular buildings. This Design Brief reminds designers and builders of opportunities they should consider in each of their projects.

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Introduction

Numerous reports and briefs are aimed at providing the building community with information to improve the energy efficiency of the buildings where we work, shop, live, and learn. Although much practical wisdom is contained in this vast literature, its very magnitude and breadth make it difficult for designers to judge which of many options may apply to a specific design job.

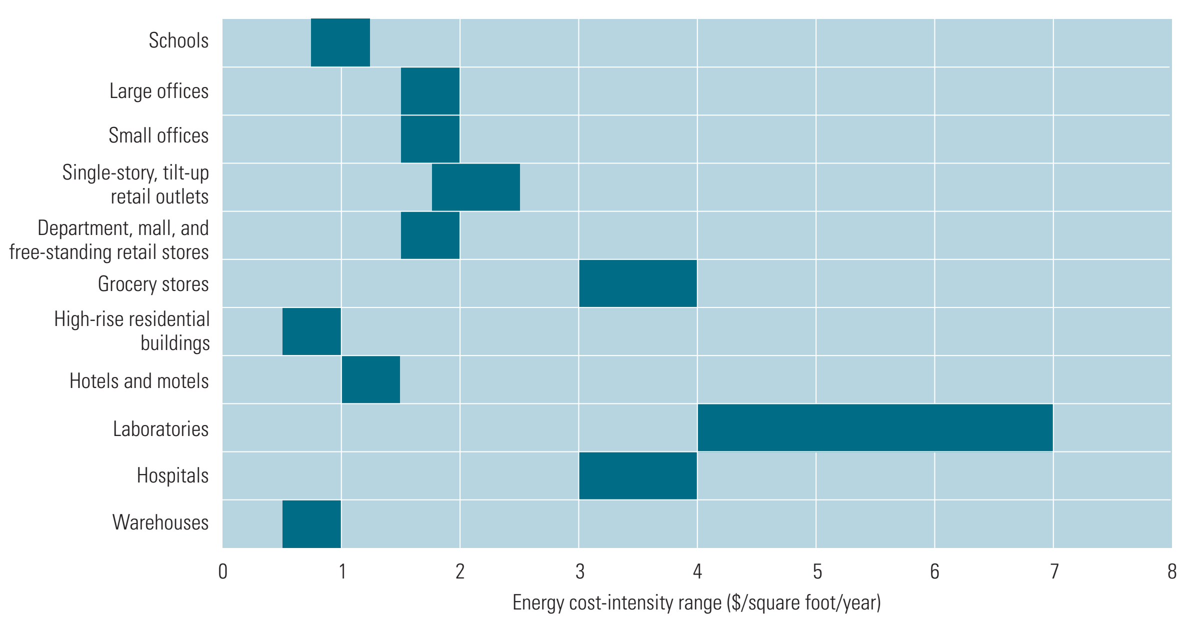
Opportunities to save energy in buildings are a function of how much energy they use in the first place. Consequently, before focusing on specific energy-saving measures, it is useful to understand how much energy various types of buildings typically consume.

Energy Cost Intensity and Energy Use Intensity

Energy cost intensity is the annual cost of energy used per square foot. (Energy cost intensities discussed in this Design Brief are derived from eQUEST, an Energy Design Resources energy modeling software program.) In general, as energy cost intensity increases, energy-efficient design strategies become more cost-effective. **Figure 1** shows the range of

Figure 1: Approximate cost-intensity ranges for different building types in California

Energy cost intensities for various building types are derived from eQUEST, an Energy Design Resources energy modeling software program. Actual cost intensities vary based on occupancy, usage, location, and building.



Source: Constructive Technologies Group (CTG) Energetics Inc.

energy cost per square foot in different building types. The figure shows that, in general, energy-efficient designs are especially cost-effective in laboratories, hospitals, and grocery stores.

Energy use intensity is the amount of energy per square foot a building uses annually from all metered sources. Energy use intensity is useful in comparing energy use in buildings of different sizes and occupancies. The pie charts presented with each building type show energy use intensity. The charts (which are discussed in the introduction to each section) can be used to compare energy use in different building types.

Table 1 summarizes many of the most cost-effective energy design strategies according to their energy use intensity. Cells in Table 1 that are completely filled in represent strategies that will target the most energy-intensive uses in a given building type. Implementing these strategies has the most potential for minimizing unnecessary energy use in the building type.

On the other hand, cells that are completely clear indicate that this strategy will probably not significantly affect overall energy use in the finished building.

Table 1: Energy-efficiency measures for specific building types

For each building type, energy-efficiency measures are categorized according to their ability to minimize energy use.

Measures	Schools	Large offices	Small offices	Single-story, tilt-up retail	Department, mall, and free-standing retail stores	High-rise residential buildings	Grocery stores	Hotels and motels	Laboratories	Hospitals	Warehouses
High-efficiency lighting	◐	●	◐	●	●	●	◐	◐	●	◐	●
Occupancy sensors	●	◐	●	◐	◐	◐	◐	●	◐	◐	◐
Efficient parking lot lighting	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Automatic lighting controls	◐	●	○	●	◐	○	●	○	◐	●	◐
Skylights and photocell controls	●	◐	◐	●	◐	◐	◐	◐	◐	◐	●
Exterior shading	●	◐	●	◐	●	●	◐	◐	◐	◐	◐
Cool roof	◐	◐	●	◐	●	◐	◐	◐	◐	◐	◐
High-efficiency HVAC	◐	●	●	◐	●	◐	◐	◐	●	●	○
Direct digital controls	◐	●	○	◐	◐	○	◐	○	◐	◐	○
Variable-speed drives	○	●	○	◐	◐	○	◐	○	◐	◐	○
Demand-controlled ventilation	◐	◐	◐	●	●	○	●	○	○	○	○
Direct/indirect evaporative cooling	◐	○	○	◐	○	○	○	○	○	○	◐
Water-heating heat recovery	○	○	○	○	○	○	○	●	●	●	○

● = Highest potential
◐ = Some potential
○ = Least potential

Source: CTG Energetics Inc.

Energy-Efficiency Design Strategies for New Construction

Table 1 lists many of the energy-efficient design strategies that are discussed throughout this Design Brief. The following sections give brief descriptions of these strategies. Specific applications of these strategies are discussed under the building types where they are most applicable.

Building envelope measures. The skin of a building should provide an appropriate barrier between interior and exterior environments. *Reflective surfaces*, especially on roofs and walls, will minimize the amount of solar heat that penetrates a building. In particular, Energy Star–compliant "cool roofs" reflect a large portion of the sun's heat energy back into the atmosphere. *Optimized thermal insulation* is essential to buffer the interior of the building from the fluctuating temperature outside. In general, Title 24 insulation requirements provide this optimization.

Exterior shading, such as horizontal overhangs and vertical fins, is a good way to decrease the amount of solar gain into a building and can also enhance the exterior design of the structure. In particular, shading fenestration from direct solar radiation has great potential to lower the cooling requirements of a building.

Two energy-efficiency strategies can be accomplished through glazing selection. *Lower solar heat gain coefficient* (SHGC) glazing reduces the amount of solar heat that is allowed into a building by reflecting or absorbing the heat that strikes it. Selecting glazing with low SHGC and high visible transmittance will allow light to enter the building and simultaneously reflect heat away from the interior. *Daylighting glazing* is a glazing specification strategy that allows the daylight entering the space to provide interior illumination without adding eyestrain or glare. Daylighting glazing is most often used in conjunction with the design of toplighting (that is, skylights and roof monitors) and sidelighting (windows and clerestories). This design strategy should be combined with *daylighting controls* to maximize energy efficiency.

Lighting measures. *High-efficiency lamps*, such as high-intensity T5 fluorescent lamps, T8 fluorescent lamps, and compact fluorescent lamps provide the same illumination as higher wattage counterparts. When these lamps are coupled with *electronic ballasts* and *efficient fixtures*, they form a lighting system that can provide superior lighting quality at higher operating efficiencies (**Figure 2**). *Efficient parking lot lighting fixtures* can reduce the energy use on the site without compromising safety or illumination. "Hockey puck" fixtures require fewer poles, cut down on light pollution, and use 70 percent less electricity than "cobra head" fixtures.

A task/ambient lighting design strategy that provides an appropriate level of general light and provides task-level light where it is needed reduces the overall electricity required for lighting. Good designs also enhance working environments.

HVAC measures. *High-efficiency packaged units* and *high-efficiency heat pumps* provide the same cooling and heating capabilities as their standard counterparts while consuming less energy by integrating high-efficiency components and controls within their systems. The higher-quality components and controls found in *premium-efficiency motors on fans and pumps* and *high-efficiency, water-cooled chillers* allow these components of a central plant to perform more efficiently than standard equipment.

Indirect/direct evaporative cooling uses the physics of water evaporation to cool with reduced levels of compressor cooling, which is an energy-intensive process.

Two-speed cooling tower fans and *variable-speed drives on fans and pumps* and *energy management systems* (or direct digital control systems) will modulate HVAC equipment so that it is not working at full output capacity at all times, but working only according to the requirements of the building spaces. *Demand-controlled ventilation* modulates ventilated air to keep CO_2 levels below a set point (for example, 800 parts per million), thereby matching ventilation rates to the number of people occupying the space. When occupancy is below peak design conditions, reducing building ventilation saves energy without compromising indoor air quality.

Figure 2: Compact fluorescent lamp ballast systems

Integral, modular, and dedicated are the three types of CFL lamp ballast systems.

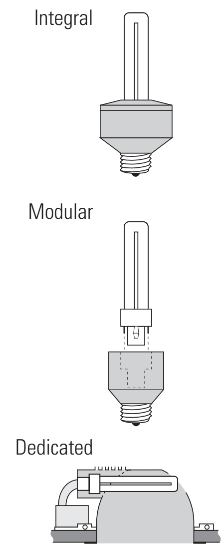
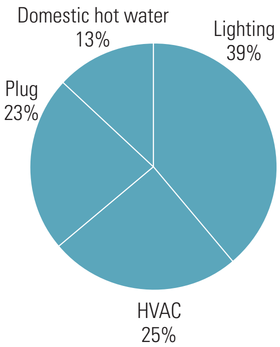


Figure 3: School energy use

Data is shown for climate zone 9 (the Los Angeles area) with nine months of occupancy. Energy use varies with usage, location, and building.



Source: CTG Energetics Inc.

Schools

Because school buildings are often occupied for 50 years or more, designing the facilities with respect to their life-cycle costs helps minimize operating expense and maximize energy efficiency. However, school budget processes can make life-cycle costing challenging. After reducing such internal loads as lighting, it may be possible to install smaller HVAC equipment.

Options and Opportunities

Incorporate daylight into the design. Consider using skylights in classrooms, gymnasiums, and media centers. Design supplemental electric lighting systems to optimize daylighting by specifying dimmable ballasts, photosensors, and daylighting controls. When installed, photocell daylighting controls should be carefully calibrated and tested. School building personnel should be trained in the use of this technology.

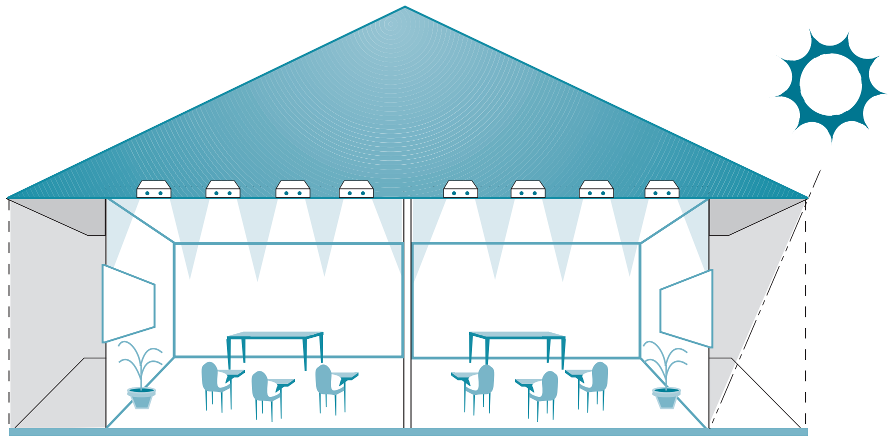
The ability to control the daylight entering a school is critical to the daylighting design's success. Although studies show that a classroom skylight design with manually operated internal louvers results in a dramatic increase in student performance, a skylight with no control is associated with a drop in math and reading scores. Daylight tends to penetrate from a window into an interior space about 1.5 times the head height of the window. Put the light fixtures in areas penetrable by sunlight on their own circuit and install daylighting controls.

Utilize occupancy sensors in intermittently used spaces. Occupancy sensors are recommended for intermittently used spaces such as conference rooms, restrooms, lounges, and storage areas. Lighting energy savings of 10 to 20 percent are often reported when schools are outfitted with these devices.

Shade classroom glass. The cooling load created by windows can be reduced or even eliminated by using overhangs to shade large windows in classrooms and other areas (**Figure 4**). Increasing the width of overhangs to create covered walkways can reduce or eliminate the need for internal hallways. First-cost savings can be realized by increasing the use of internal space; operational costs can be realized through lower HVAC energy use. These savings can more than offset the first cost of the overhang/walkway.

Figure 4: Shading classroom glass

Shading glass reduces the cooling load in classrooms and creates perimeter walkways. Reduced energy cost and the elimination of interior hallways can more than offset the cost of the overhangs.



Consider evaporative coolers in hot, dry climates. In hot, dry areas, specify small direct or indirect evaporative coolers instead of vapor-compression units. Evaporative coolers can save 60 to 80 percent of the cooling energy for spaces such as portable classrooms. In addition to saving energy, the direct evaporative coolers also add needed moisture to the conditioned air.

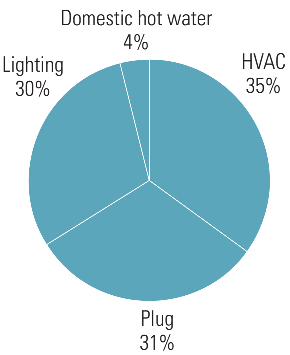
More School Options

In addition to those outlined, consider the following proven measures:

- Utilize compact fluorescent and other high-efficiency lighting.
- Include direct/indirect lighting in media centers.
- In hot climates, specify a cool roof (a light-colored roof that reflects large amounts of infrared light).
- Design efficient parking lot lighting.
- Specify high-efficiency HVAC systems.
- Use direct digital controls to link schools to one another.
- Consider demand-controlled ventilation in auditoriums and gymnasiums.

Figure 5: Large office energy use

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Large Offices

Air conditioning is the largest energy use in large office buildings. Specifying high-efficiency systems in the shell and core design can ensure energy savings over the typical building. However, tenant spaces are often responsible for the majority of the building's energy use. In order to capture maximum energy savings from an efficient shell and core design, consider incorporating energy-efficiency requirements into tenant improvement specifications. Requirements such as efficient ductwork, efficient lighting, and perimeter daylighting can reduce tenant energy use.

Options and Opportunities

Utilize a task/lighting and ambient lighting design strategy. In the office environment, the majority of the work is conducted at the desk level. Design using ambient lighting levels of approximately 30 footcandles and supplement this illumination with task lighting from high-efficiency fluorescent sources. Using a task/ambient lighting design can reduce overall lighting energy while reducing eyestrain due to glare on computer monitors.

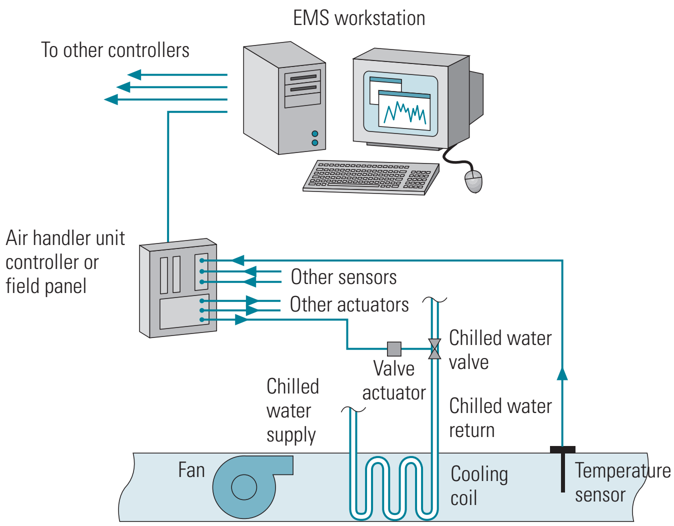
Include variable air volume (VAV) air-handling systems with variable-speed drives (VSDs). VAV systems can save considerable fan energy over constant volume systems. Although the energy-efficiency standards contained in California's Title 24 only require VAV in airside systems with more than 25 horsepower, VAV can also save energy in smaller systems. Incorporating a VSD on a VAV fan allows it to slow down as cooling load decreases. Because reducing fan speed by one-half will reduce power consumption to one-eighth, a VSD on a VAV fan system offers compound energy savings that can provide a payback of three to five years. Typical VSD installation costs are $200 to $250 per horsepower of the motor driven.

Specify high-efficiency, water-cooled chillers. For facilities with cooling loads of more than 200 tons, it is generally cost-effective to install a water-cooled chiller. A high-efficiency electric chiller can reduce energy consumption by 20 percent or more compared with a standard-efficiency chiller.

Incorporate direct digital controls (DDCs). The cost-effectiveness of installing DDCs on an HVAC system varies widely with the specific site and application. DDC systems save energy if they are used to turn building systems

Figure 6: Controlling HVAC with direct digital controls

An energy management system (EMS) consists of sensors, controllers, actuators, and software. An operator interfaces with the system via a central workstation.



Source: PECI

off when they are not needed. In office buildings, DDC systems can modulate HVAC and lighting equipment to achieve operational energy savings. A DDC system should permit programming changes to be easily accomplished in order to alter controls for tenant turnover, to respond to new utility rate structures, or to change control sequences (**Figure 6**).

Design optimized ventilation in parking structures. Consider installing demand control on enclosed parking garages using carbon monoxide sensors. Demand-controlled ventilation (DCV) turns on ventilation fans only when levels of carbon monoxide approach unacceptable levels. A DCV system reduces fan energy consumption during many hours of the day. Alternately, naturally ventilated parking structures eliminate the need for any mechanical ventilation. In naturally ventilated parking structures, take advantage of daylighting and install photocells and controls.

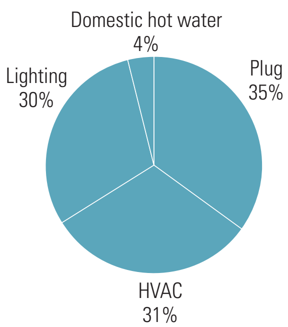
More Large Office Options

In addition to those outlined, consider the following proven measures:

- Utilize occupancy sensors in intermittently used spaces.
- Incorporate skylights and photocells for daylighting.
- Consider demand-controlled ventilation.

Figure 7: Small office energy use

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Small Offices

Small office buildings often have simple packaged HVAC units rather than central plants. In spec buildings, energy-efficient tenant improvements can be promoted both by specifying high-efficiency standards for the improvements and by passing the energy costs on to tenants.

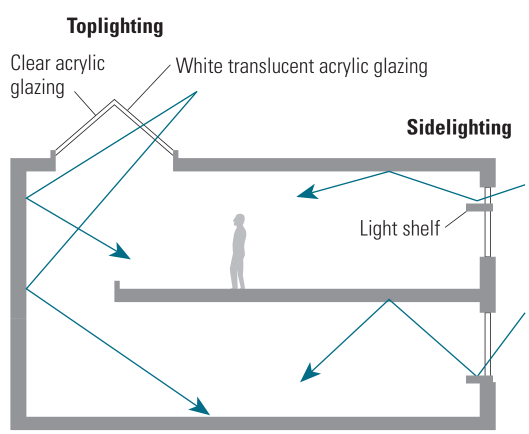
Options and Opportunities

Incorporate daylight into the design. Small office buildings should take advantage of the daylight available through sidelighting and skylights installed on upper floors (**Figure 8**). Specify continuously dimming ballasts in all spaces penetrable by daylight. Put these fixtures on their own circuit and control the electric lighting levels using a photosensor. Daylighting design is especially apt in single-story office buildings. Make sure that the photosensors are carefully calibrated after installation.

Shade office glass. The cooling load created by windows can be reduced or even eliminated by using overhangs and side fins to shade office windows, especially on south, east, and west facades. Increasing the width of overhangs to create covered walkways outdoors can reduce the need for hall-

Figure 8: Simple daylighting techniques

This schematic shows a mix of toplighting and sidelighting, light shelves, high-reflectance ceilings, and wall diffusion to provide fairly uniform deep-plan daylighting without the glare of direct sunlight. Selecting specularly selective glazing with an appropriate visual transmittance will reduce the contrast between indoor and outdoor lighting. If the glazing also has a relatively low solar heat gain coefficient, daylighting can be enjoyed while air-conditioning energy use is substantially decreased.



ways inside. First-cost savings from eliminated hallways can far outweigh the cost of increased shading devices.

Use high-efficiency HVAC units. A highly efficient, packaged air-conditioning unit can reduce cooling needs by 10 percent or more over a standard-efficiency, commercial packaged unit. Select equipment that has multiple levels of capacity (compressor stages) with good part-load efficiency, because equipment will usually run at less than maximum load. Consider specifying an airside economizer to take advantage of desirable outdoor air conditions. Specify durable components such as direct-drive actuators to avoid economizer failure.

Specify a cool roof in single-story offices. Because cooling energy is usually more than 20 percent of a small office building's energy use, a roof that reflects large amounts of infrared lighting can save energy. Consider specifying the conventional built-up roof with an Energy Star–compliant cool roof (see www.energystar.gov for more information and a list of products). The Energy Star program is an independent rating system supported by the Environmental Protection Agency and the Department of Energy.

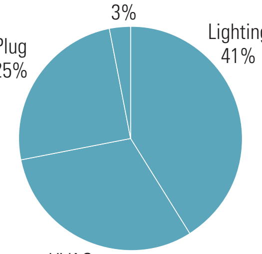
More Small Office Options

In addition to those outlined, consider the following proven measures:

- Use a task/ambient lighting strategy.
- Utilize occupancy sensors in intermittently occupied spaces.
- Specify efficient parking lot lights.

Figure 9: Single story, tilt-up retail energy use

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Single-Story, Tilt-Up Retail Outlets

Single-story, tilt-up retail stores are often occupied by large corporate chains using design specifications that might not take California's climates into full consideration. In order to optimize energy efficiency in these retail stores, the prototype design may need to be challenged. Lighting the sales floor is the most energy-intensive end use in these buildings. (For energy-efficiency strategies focused on storage areas, see the section on warehouses. For measures focused on administrative areas, see the small office section.)

Options and Opportunities

Incorporate skylights and photocell controls. In many retail designs, standard 4- by 8-foot bubble skylights are used. Usually, a skylight-to-floor area ratio of 3 to 5 percent balances daylight with space conditioning requirements. Daylighting controls may yield lighting energy savings of 10 to 50 percent. The costs of skylights and daylighting controls are typically offset by lighting and cooling energy savings in one to three years.

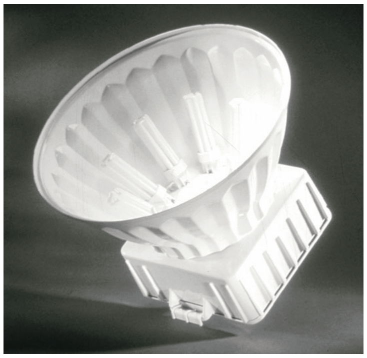
Specify high-efficiency lighting. In medium- and high-bay applications, high-intensity fluorescent lighting fixtures use less energy than conventional HID lighting. Although this lighting technology is relatively new to the marketplace, there are several manufacturers and fixture styles available (**Figure 10**). In addition to using less energy, high-intensity fluorescent fixtures have lower lumen depreciation rates, better dimming options, virtually instant start-up and restrike, better color rendition, and lower glare than conventional HID fixtures.

Where HID fixtures are more appropriate than high-intensity fluorescent technology, use pulse-start HID fixtures. Pulse-start fixtures need only 80 percent of the energy required by standard HID fixtures and have 50 percent longer lamp life. Other advantages include faster start and restrike times, reduced color shift, and improved lumen maintenance.

Install a demand-controlled ventilation system. When only a few people are in a store, energy can be saved by decreasing the amount of ventilation supplied by the HVAC system. A demand-controlled ventilation (DCV) system

Figure 10: Fluorescent fixtures

The conical fixture at the left, which uses eight 42-watt compact fluorescent lamps, is designed to resemble a typical HID fixture. Fluorescent lights can be mounted on two, four, or six arms of the fixture shown on the right.



Source: Sportlite (left); MetalOptics (right)

senses the level of carbon dioxide in the return air stream and uses it as an indicator of occupancy. DCV can save energy during peak cooling periods when many shoppers are at work and occupancy is low. In retail sales applications, DCV works best when a dedicated HVAC system serves the sales floor.

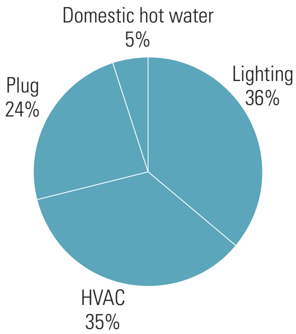
More Single-Story Tilt-Up Retail Options

In addition to those outlined, consider the following proven measures:

- Incorporate occupancy sensors in storage spaces and other intermittently used spaces.
- Design efficient parking lot lighting.
- In hot climates, specify a cool roof.
- Use high-efficiency HVAC systems.
- Control fans using variable-speed drives.
- Consider indirect evaporative cooling in hot climates.

Figure 11: Strip mall energy use

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Department, Mall, and Free-Standing Retail Stores

Retail stores have diverse loads, long operating hours, and high occupancy in the evenings. Retail stores can improve efficiency by reducing HVAC and lighting energy use during the day when electric rates are high and occupancy is generally low. Many retail chains impose very specific, corporate-level standards on their outlets, and tenant improvements are built out accordingly. Making a modification to those standards, even if it reduces utility bills, can be very challenging. (See the preceding section on single-story, tilt-up retail stores for energy-efficiency measures in large retail spaces.)

Options and Opportunities

Design high-efficiency lighting. Consider compact fluorescent or halogen fixtures for display lighting. These alternatives save significant amounts of energy by producing more illumination with less electricity and by avoiding the high cooling requirements generated by incandescent lighting.

Specify a cool roof. Because cooling energy is usually more than 20 percent of a retail building's energy use, a cool roof can reduce electricity bills without changing the appearance of the building. Specify an Energy Star–compliant cool roof (see www.energystar.gov for more information and a list of products). Energy Star cool roofs have industry-standard warranties in addition to proven performance in reflecting infrared and visible light.

Shade storefront glass in stand-alone buildings. The cooling load created by windows can be reduced or even eliminated by using large overhangs to shade storefront windows (**Figure 12**). To maximize energy savings, the size of the overhang should be calculated based on building location and facade orientation. Windows should be fully shaded while the building has the largest solar cooling requirement—usually during late summer afternoons.

Include a highly efficient HVAC system. Because retail stores have very diverse loads and occupancy often peaks during cool evening hours, HVAC energy use can be minimized with a carefully designed system. Because equipment will usually run at less than its maximum capacity, select HVAC equipment that has multiple levels of operation with good part-load efficiency. Consider specifying an airside economizer to take advantage of

Figure 12: Shading storefront windows with overhangs

The overhang should extend far enough to shade the entire window from direct late-afternoon summer sunshine.

Source: CTG Energetics Inc.

"free cooling" during the evening hours. Specify durable components such as direct-drive actuators. When one HVAC unit serves an entire sales area, consider including demand-controlled ventilation to save cooling energy when few customers are in the store.

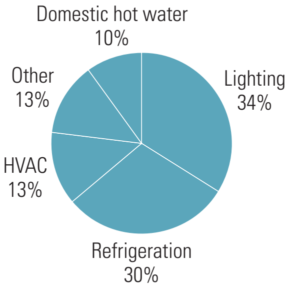
More Small Retail Options

In addition to those outlined, consider the following proven measures:

- Incorporate skylights and daylighting controls.
- Utilize occupancy sensors in intermittently used spaces.
- Design efficient parking lot lighting.
- Use distributed digital controls to connect stores.
- Control fans using variable-speed drives.

Figure 13: Grocery store energy use

Data is shown for a prototype grocery store chain. Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Grocery Stores

Grocery stores have long operating hours and diverse occupancy patterns. Their energy use is primarily for product refrigeration and interior lighting. Grocery stores can have high water-heating loads when they include cafeterias or food preparation areas. Like single-story, tilt-up retail, national grocery store chains often have rigid specifications from their headquarters that limit local decision-making.

Options and Opportunities

Design efficient refrigeration systems. Refrigeration systems in grocery stores should always include efficient, state-of-the-art technologies. Install highly efficient lighting in refrigerated cases to save energy on lighting and to reduce the cooling requirements; efficient lighting produces less heat. Include dewpoint controls for anti-condensate heaters on refrigerated cases. Incorporate efficient cooling system components such as high-efficiency compressors, water-cooled condensers, floating-head pressure controls, and multiple, unequally sized compressors feeding the same manifold.

To provide substantial savings, the floors of walk-in coolers should be insulated. Although the walls and ceilings of coolers are insulated, floors are generally the same slab that connects to the rest of the store. Specifying insulation over the slab (in the floor of the cooler) helps keep cold temperatures from being carried outside the cooler by the slab.

Incorporate automatic lighting controls. Automatic lighting controls that adjust lighting levels as a function of available daylight and operation needs are routinely very cost-effective. Consider reducing store light levels during stocking hours. Because grocery stores are often designed for very high illumination, full lighting is not required during stocking. Also consider adjusting lighting levels during the last hour of operation to signal that the store will be closing.

Rightsize HVAC. Sizing the HVAC equipment to take into account the cool air from the refrigerated cases is often referred to as taking "case credits." Because cool air leaks out of various cases and cabinets, the internal temperature of most grocery stores is lower than that of most single-story, tilt-up retail stores. Using the case credits as justification to downsize HVAC equipment can reduce the cost for HVAC systems, offsetting the higher first cost of higher-efficiency equipment.

Consider desiccant dehumidification in coastal regions. In California's coastal climate zones, dehumidifying air using conventional mechanical cooling can lead to unnecessarily high energy costs. Desiccant dehumidification (which uses thermal energy instead of electricity to drive the dehumidification process) is almost always less expensive. Desiccant technologies can lower operating costs by reducing refrigerator defrost time and reducing food damage, as well as providing more attractive-looking products for customers. Desiccant dehumidification can also help create a more comfortable climate in the freezer/refrigerator aisles, which are often overly cool, particularly in the summer.

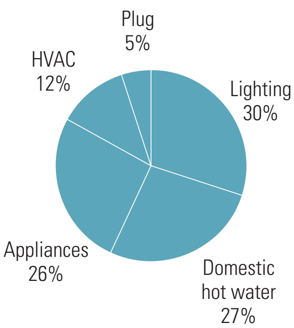
More Grocery Store Options

In addition to those outlined, consider the following proven measures:

- Use high-intensity fluorescent lighting.
- Utilize occupancy sensors in storage areas.
- Design efficient parking lot lighting.
- Incorporate skylights and photocell controls.
- Consider demand-controlled ventilation.
- Control fans and pumps using variable-speed drives.
- Specify an Energy Star cool roof.

Figure 14: High-rise residential energy use

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

High-Rise Residential Buildings

Unlike usage in most other commercial building types, high-rise residential energy use peaks in the evening and on weekends. Domestic hot water and appliances are the highest energy end uses. Because space is at a premium in residential buildings, space-efficient HVAC and domestic hot water systems such as fan coils or water-source heat pumps are usually specified.

Options and Opportunities

Utilize central domestic- and space-heating water systems. Water-source heat pumps can be an effective system choice in high-rise residential buildings. These units have energy-efficiency ratios between 15 and 20, which makes them about 50 percent more efficient than a typical split-system heat pump. Moving all of the individual heat rejection equipment to a central plant saves space for the building's tenants and optimizes energy use by combining all of the small, inefficient units into a large, more efficient central system. Consider specifying several sequenced small boilers instead of one large boiler.

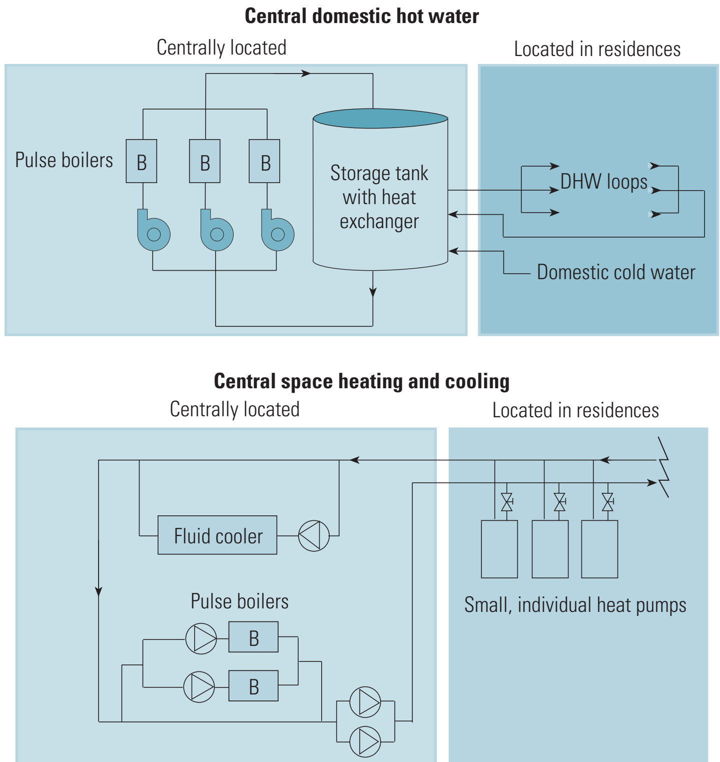
Sequenced central boilers can also meet domestic hot water needs much more efficiently than individual hot water heaters. Water is heated more efficiently and the collection of hot water storage in a central place reduces standby losses. Consider installing a recirculation system to recover the heat energy in the return water. Hot water piping should be insulated throughout the building (**Figure 15**).

Provide efficient appliances. Efficient appliances that carry an Energy Star designation can save tenants and homeowners significant amounts of energy. Newly manufactured refrigerators, washing machines, room air conditioners, and dishwashers are much more efficient than models made before 2001. Builders can often use efficient appliances as a selling point for the properties.

Specify efficient lighting systems in common areas. Install fluorescent lighting in hallways and compact fluorescent lighting in other common areas. This reduces both energy and operation and maintenance costs.

Figure 15: Central space heating and domestic hot water supply

Central space heating and domestic hot-water (DHW) supply systems free up floor space in residential units and offer a variety of energy-efficient options.



Shade fenestration. Provide tenants with balconies to not only build in exterior living areas, but also to shade apartment windows and glass doors. This reduces the need for heating and cooling and increases tenant comfort. Well-designed overhangs can also provide good shading when cost concerns preclude the use of balconies.

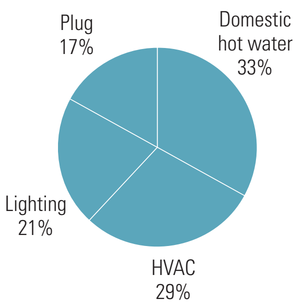
More High-Rise Residential Options

In addition to the others outlined, consider the following proven measures:

- Utilize occupancy sensors in intermittently used areas.
- Design efficient parking lot lighting.
- Incorporate skylights and photosensor controls in stairways and on top floors.
- Specify high-efficiency packaged HVAC units.
- Adopt energy-efficiency strategies in parking structures. (See the large office section.)

Figure 16: Hotel energy use

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Hotels and Motels

Hotels and motels have very diverse occupancy patterns, in terms of seasonal occupancy rates and in the schedules that individual guests keep. They have very high hot water heating loads because of laundries, showers, and food service. (For energy-efficiency measures focused on administrative areas, see the sections on large and small offices.)

Options and Opportunities

Specify high-efficiency water heating equipment. Small, mid-efficiency, atmospherically vented water-heating systems with energy factors of 0.62 to 0.70 are more cost-effective than standard, less-efficient equipment. Tankless, on-demand, gas-fired heaters with energy factors up to 0.81 offer huge energy savings over storage systems, with no loss in functionality. Direct-vent, sealed-combustion, and condensing boilers have even better energy factors—up to 0.86. Installing multiple boilers in hotels and motels provides a level of redundancy and can be staged in a way that more efficiently meets loads, compared with a single large machine. When specifying high-efficiency water heaters, designers should consider using Energy Star standards (see www.energystar.gov).

Use heat recovery for domestic water preheating. Installing gray water heat-recovery equipment on showers can save up to 60 percent of water-heating energy. Systems serving fixtures on upper floors need no pump and little or no maintenance. For below-grade applications, systems with demand-operated pumps are available. Where there is less simultaneous hot water drain and supply flow (as in laundries), gray water heat-recovery systems with heat storage can be installed. Heat storage systems require more space, as well as regular inspection and cleaning (**Figure 17**).

Utilize occupancy-based controls for lighting and HVAC in guest rooms. Energy consumption in unoccupied hotel and motel rooms is wasteful and represents a significant operating expense. Guest room occupancy sensors or central control systems can reduce energy requirements without inconveniencing guests. For example, a central switching system at the front desk can turn on heating or air conditioning as the guest checks in or manually adjust thermostat settings if the room is unoccupied. Heat sensing (infrared) detectors can activate HVAC and lighting systems based on human presence in the room. Preset turn-off time delays of 10 to 30 minutes accommodate the guest's departure from the room for short periods of time.

Consider heat-pump water heaters for swimming pools. Indoor swimming pools (natatoriums) require simultaneous heating and dehumidification. Heat-pump water heaters are a perfect solution for efficiently serving both of these needs: They heat water and simultaneously produce cool air, which can be used to decrease the natatorium temperature and humidity.

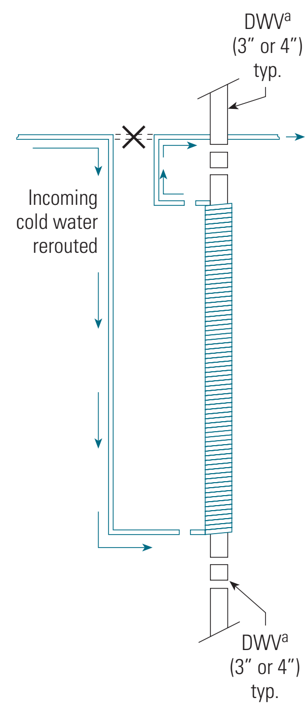
More Hotel and Motel Options

In addition to those outlined, consider the following proven measures:

- Include high-efficiency lighting.
- Utilize compact fluorescent lights in bathrooms.
- Shade fenestration to decrease cooling loads.
- Design efficient parking lot lighting.
- Incorporate skylights and photocell controls in common areas.
- Specify high-efficiency HVAC systems. Consider using a central plant.

Figure 17: Gray water heat recovery

Gray water heat-recovery systems capture thermal energy from drainwater and use it to preheat water going to fixtures. Depending on the end use and the installation, heat recovery efficiencies of up to 82 percent can be achieved.

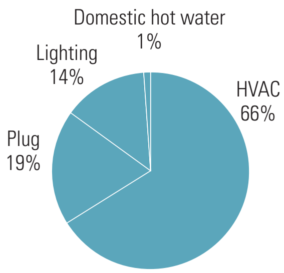


Note: a. DWV = drain waste and vent pipe.

Source: WaterFilm Energy Inc.

Figure 18: Laboratory energy use

Data is shown for climate zone 9 (the Los Angeles area). Energy use will vary with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Laboratories

Laboratory energy use is dominated by the need to condition air for proper laboratory temperature and humidity and to maintain safe working conditions by exhausting potentially hazardous air through fume hoods. Some laboratories also have large process heating loads. Laboratories have a high energy cost intensity that can be used to justify more efficient, energy-saving systems.

Options and Opportunities

The efficiency of laboratory exhaust systems is not governed by Title 24 even though they can be one of the largest energy users in laboratory and biotech facilities. Fume hoods are directly responsible for a large amount of fan energy use, and they are indirectly responsible for heating and cooling energy because of the large volume of conditioned air they exhaust.

Specify variable air volume (VAV) fume hood controls. To make fume hood exhaust systems more efficient without compromising safety, VAV fume hood controls can be installed (**Figure 19**). These systems provide a fast response when the sash is opened or closed, and some systems include an occupancy sensor.

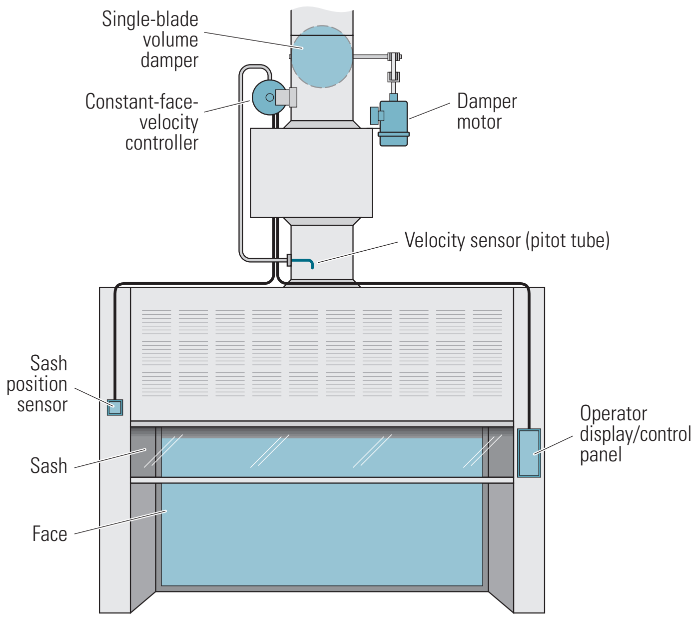
Include high-efficiency, in-line exhaust fans. General-purpose "utility" fans are typically used to exhaust contaminated effluent from laboratories. Reducing nozzles are usually added to provide the high exit velocity—typically 3,000 feet per minute—required to safely exhaust harmful fumes. The nozzles also cause the fan to work harder, which wastes energy. In-line exhaust fans are more efficient and eliminate the need for a reducing nozzle.

Serve labs and offices with separate HVAC units. Because laboratory air can rarely be recirculated, "once-through" HVAC systems are often installed throughout the building. To save heating and cooling energy, zone office and administrative spaces should be separated from laboratories so that recirculating systems can be specified in these spaces.

Incorporate heat recovery for large process loads. In laboratories where significant amounts of hot water are required for experiments, waste heat can be captured and reused. Preheating boiler makeup water with a heat recovery system from the boiler exhaust stacks can significantly decrease

Figure 19: Schematic of a variable-volume fume hood

The constant-face-velocity controller gathers information from a velocity sensor positioned inside the fume hood or from a sash position sensor. The sensor feeds information to the controller, which adjusts the damper position to obtain the necessary airflow.



boiler energy use. Sterilization systems, equipment cleaners, laundries, and dishwashers can also take advantage of heat-recovery systems.

Design high-efficiency lighting systems. Many laboratory procedures require high illumination of workbench areas. Providing task lighting to meet these needs allows designers to lower ambient lighting and save energy. Illumination at 30 footcandles provides plenty of light for all-purpose use.

Also consider integrating fenestration placement with interior laboratory layout to provide daylighting. Placing workbenches in line with windows can provide illumination with no additional energy use or first cost.

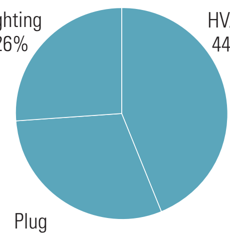
More Laboratory Options

In addition to those outlined, consider the following proven measures:

- Control fans and pumps using variable-speed drives.
- Utilize occupancy sensors.
- Design efficient parking lot lighting.
- Incorporate skylights and photocell controls.

Figure 20: Hospital energy use (not including process loads)

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Hospitals

Hospitals are a mixture of spaces, some open around the clock and others just during businesses hours. In general, much of the space consists of wards that are continuously operated. Because people are being treated for a variety of ailments, microbial contamination is a problem, and high ventilation rates with 100 percent fresh air are required. Although hospitals are dominated by HVAC energy use, they also consume a lot of electricity to light the 24-hour areas. Most also have significant process loads for sterilization, laundering, and cooking.

Options and Opportunities

Consider a waterside economizer for nighttime cooling. Hospital wards often need to be cooled throughout the nighttime hours, so including a waterside economizer can save a lot of energy. A waterside economizer is a system that uses cooling tower water directly or indirectly in the cooling coils, permitting the chiller to be deactivated when the outside wetbulb temperature is low enough to cool water without the chiller.

Specify chillers that work well with low condenser water temperatures. Most chillers are designed to use 85˚ Fahrenheit condenser water, but overall chiller plant efficiency can be increased by 1 to 1.5 percent for every degree of reduction in this temperature below 85. Design a chilled-water system that works efficiently with cold nighttime condenser water. Even with a waterside economizer installed, there will be times during the year when low-temperature condenser water is available but the economizer system is not sufficient to cool the space. Consult with the equipment manufacturer's representative about lowering the condenser water temperature to improve chiller efficiency.

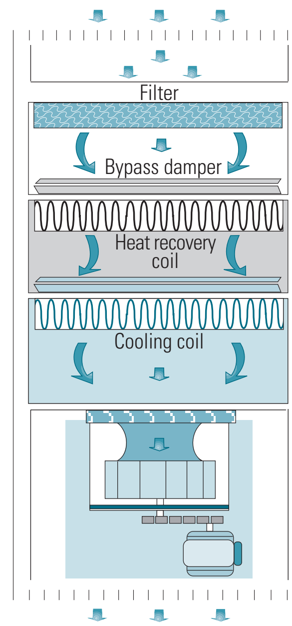
Include programmable controls to automatically shut off lighting and set back HVAC systems in daytime spaces. Lights and air conditioning in spaces occupied only during business hours often are left on all the time. To solve this problem, install automatic controls that shut lights off and set back temperatures after the business day. A combination of occupancy sensors and time switches can accommodate people who arrive early or stay after the end of the business day.

Recover heat from central plant equipment. Because many areas in hospitals must be zoned as "once-through" systems, the energy that heats and cools the hospital is only used once. However, much of this HVAC energy can be recovered before it exits the building by installing heat-recovery coils in the exhaust air handlers (**Figure 21**). This heat can then be used to preheat the outside air coming into the building.

Waste heat recovery can also be very effective when installed on boilers. A heat recovery system on the exhaust stacks of boilers can be used to preheat boiler makeup water. Sterilization equipment, laundries, dishwashers, and cleaning equipment can also benefit from hot water heat recovery.

Figure 21: A heat recovery system for once-through air handling

The warmth or coolness of the air exiting a once-through HVAC system can be recovered with heating and cooling recovery coils.



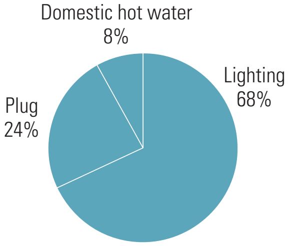
More Hospital Options

In addition to those outlined, consider the following proven measures:

- Consider distributed digital controls.
- Control fans and pumps using variable-speed drives.
- Use a task/ambient lighting strategy where appropriate.
- Utilize occupancy sensors in intermittently used spaces.
- Design efficient parking lot lighting.
- Incorporate skylights and photocell controls where appropriate.

Figure 22: Warehouse energy use (unconditioned)

Data is shown for climate zone 9 (the Los Angeles area). Energy use varies with occupancy, usage, location, and building.



Source: CTG Energetics Inc.

Warehouses

Warehouses have overall lower illumination requirements as well as lower cost intensity than other building types. The lower cost intensity is mainly because less space conditioning is needed than in most other buildings. Warehouses are often ventilated, only partially heated, and rarely cooled. The largest energy end use in warehouses is lighting. (For energy-efficiency strategies for administrative areas, see the small office section.)

Options and Opportunities

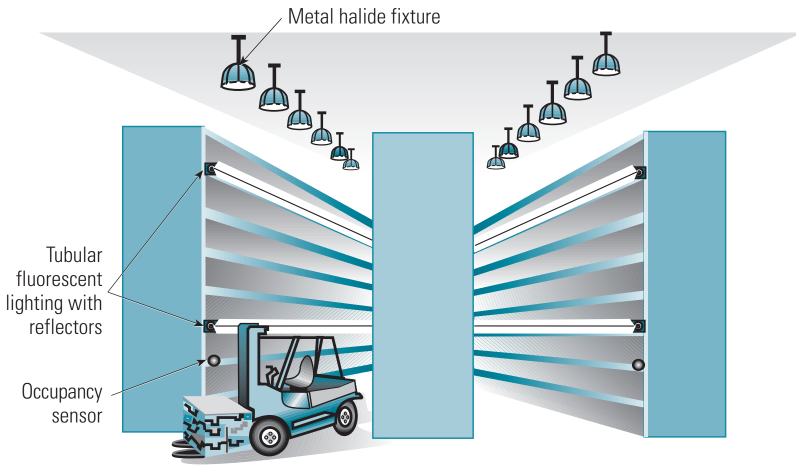
Incorporate skylights and photocell controls. Standard 4- by 8-foot bubble skylights are used in many warehouse applications. Usually, a skylight-to-floor area ratio of 3 to 5 percent allows plenty of solar radiation to enter and light the space without danger of overheating the interior. To maximize the daylighting design, integrate the skylight placement with the placement of the warehouse aisles. Install photosensors to control electric lighting, and make sure they are carefully calibrated.

Utilize task lighting in aisles with tall storage racks. Traditionally, high-bay warehouse areas with narrow, 30-foot storage racks are illuminated with HID fixtures, fluorescent fixtures, or skylights. Much of the available light is lost in the racks as it filters down to the floor. Provide task lighting in narrow aisles to more efficiently illuminate tall storage racks. Mount fluorescent fixtures on storage racks to facilitate access to the storage aisles and eliminate the need to install extra fixtures at the ceiling level. Consider controlling the task lighting with occupancy sensors installed at both ends of the racks. Occupancy sensors should be adjusted to keep the rack lighting on long enough for employees to complete their tasks (**Figure 23**).

Specify high/low HID fixtures controlled with occupancy sensors. In warehouses where occupancy will be irregular, installing an occupancy-controlled step dimming system on general HID illumination can attain major energy savings. Phosphor-coated metal halide fixtures work best for this application. The phosphor coating helps the lamp maintain its color while dimmed, and metal halide lamps are able to go from 50 percent dimmed to 100 percent output in only a few seconds. Controlling the dimming system with occupancy sensors allows the lighting to operate at reduced levels whenever occupants are not present.

Figure 23: Lighting a warehouse for intermittent occupancy

Secondary occupancy sensors actuate local task lights that illuminate shelving while material is being moved in or out. Note that the fixtures are configured to "wash" shelves with illumination while keeping direct light from the eyes of the occupants, thus minimizing glare.



Install infrared heaters. If forced-air convection heating is being considered, a more efficient alternative would be to install gas-fired radiant heating in warehouses. Instead of the entire volume of the warehouse, radiant heating uses infrared waves to directly heat objects that are in its line of sight. Because infrared heaters are about 80 percent efficient, they can have a simple payback as short as one year compared with a forced-air convection heating system.

More Warehouse Options

In addition those outlined, consider the following proven measures:

- Utilize automatic lighting controls.
- Consider evaporative cooling systems in hot, dry climates.
- Design efficient parking lot lighting.
- Specify an Energy Star cool roof.
- Incorporate demand-controlled ventilation in conditioned areas.

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