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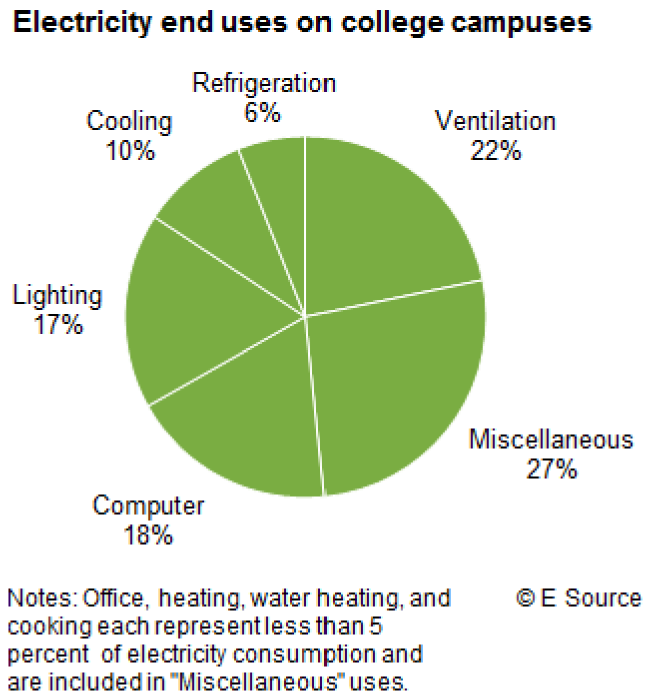
Managing Energy Costs in Colleges and Universities

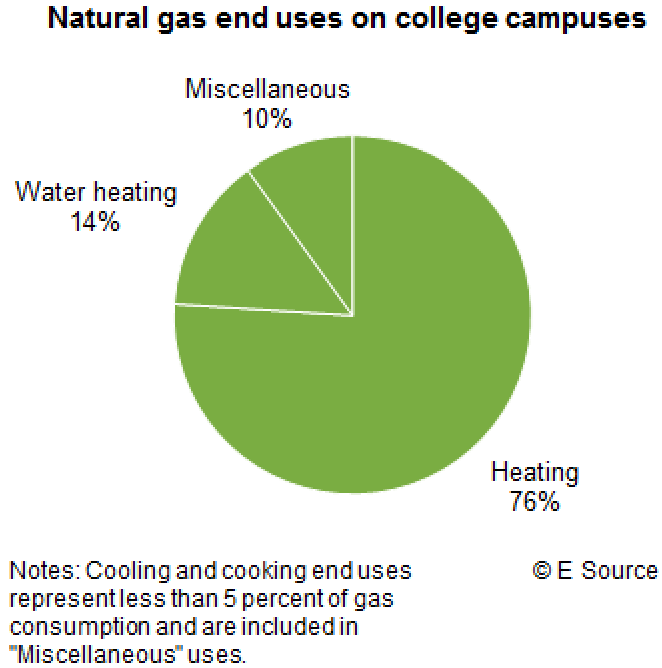
Colleges and universities in the US use an average of 18.9 kilowatt-hours (kWh) of electricity and 17 cubic feet of natural gas per square foot (ft^2) annually, and typical US higher-education buildings sized around 50,000 ft^2 consume more than $100,000 worth of energy each year. Lighting, ventilation, and cooling are the largest consumers of electricity, and space heating accounts for the vast majority of natural gas use (**Figure 1**). As a result, these areas are among the best targets for energy savings. By implementing cost-effective energy-efficiency measures, many colleges and universities have the potential to cut their energy bills by 30 percent or more.

Average energy use data

Figure 1: Energy consumption in US higher-education facilities by end use

Data from the US Energy Information Administration show that, in US higher-education facilities, ventilation, computer equipment, and lighting account for 57 percent of electric use and space heating dominates natural gas use at 76 percent.





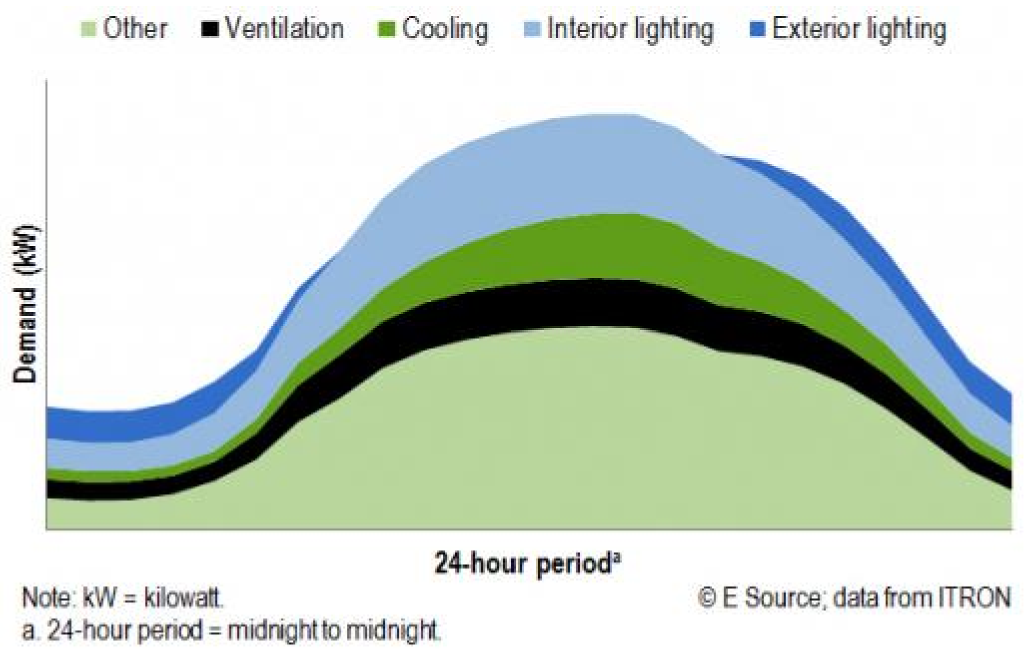
Top technology uses

- Heating
- Ventilation & air handling
- Lighting

Understanding your energy consumption can greatly help in the effort to control costs. Utilities can provide monthly data for your use and analysis, and some utilities will also assist with the analysis. In general, utilities typically charge commercial buildings for their natural gas based on the amount of energy delivered. Electricity, on the other hand, can be charged based on two measures: consumption and demand (**Figure 2**).

Figure 2: Load profile for a typical college building in California

Hourly energy consumption data show that lighting, cooling, and ventilation present some of the largest opportunities for reducing peak demand charges in college buildings.



The consumption component of the utility bill is based on the amount of electricity, in kWh, that the building consumes during a month. The demand component is the peak demand, in kilowatts (kW), that occurs within the month. Monthly demand charges can range from just a few dollars to upwards of $20 per kilowatt and can be based on the highest peak recorded in the previous 12 months. Since it can be a considerable percentage of your bill, care should be taken to reduce peak demand whenever possible. As you read the following energy cost management recommendations, keep in mind how each one will impact both your consumption and your demand.

All of the conservation measures discussed here will save money and enhance both the aesthetics and the learning environment of your campus. To help you implement these measures—and to identify additional strategies that may be well-suited to your particular campus—here are some additional resources to consider:

- Energy Star's list of resources for higher education
- The Association for the Advancement of Sustainability in Higher Education (AASHE)
- Labs21 Tool Kit

QUICK FIXES

this section

Many colleges and universities have tight operating budgets for their facilities, so it's especially important to find low- or no-cost ways to reduce energy expenditures. Engaging students and faculty in energy conservation can also save on campus energy bills—at many higher education institutions, students are the biggest advocates for energy efficiency and will respond enthusiastically to educational initiatives and conservation pledge campaigns.

Turning things off

Turning things off might seem too simple an action to make a significant difference, but remember that every 1,000 megawatt-hours saved by turning things off takes $100,000 off your institution's utility bill annually (assuming electricity costs of $0.10/kWh).

Computers and monitors. Computers and other electronic equipment are ubiquitous in campus buildings and can contribute considerably to overall energy consumption and cost per square foot. You can gain significant energy savings by verifying that computer power-management settings are enabled on individual campus computers and monitors, forcing them to enter sleep mode after a specified period of inactivity. Effective power management settings can cut a computer's electricity use roughly in half, saving up to $75 annually per computer. Although most computers are now shipped with some sort of power management settings enabled, they may be disabled or made less effective by users or internal IT, and can often be made more rigorous to maximize energy savings. For more information, the US Environmental Protection Agency (EPA) offers detailed instructions on an Energy Star page, The Business Case for Power Management . Some users may be concerned that automatic software updates will be inhibited if power management settings are enabled, but that's not the case; updates can automatically begin to download when the computer awakens from sleep mode.

Other plug loads. Like computers, devices such as printers and faxes have energy-reduction settings that can yield substantial energy savings. Additionally, consider using smart power strips to shut off plugged-in devices such as printers, monitors, miscellaneous computer peripherals, water coolers, and coffeemakers when not in use.

Lights. Lights should be turned off when not in use, but many people forget to take this step. To ensure that switches are off when desired, two effective options are to install occupancy sensors or recruit staff to serve as "energy monitors" in each campus building. Energy conservation–themed posters and stickers placed strategically around campus can be effective reminders, especially when designed as part of a larger energy-awareness campaign.

Laboratory vent hoods. Vent hoods are among the most energy-intensive equipment on college campuses and should be kept off unless they're needed for experiments or material-storage purposes.

Prewash sprayers in kitchens. Prewash sprayers are used to remove food from dishes, utensils, pots, and pans before they're placed in a dishwasher. Although all low-flow sprayers are currently required to limit flow rate to 1.6 gallons per minute (gpm), many sprayers currently use up to 5.0 gpm. Given the minimal initial cost of low-flow valves, the payback for this measure is typically less than two months when both water- and water heating–related energy savings are considered.

Chilled-water drinking fountains. Water fountains generally don't need to provide ice-cold water 24 hours a day unless it's required for health reasons. In most cases, you can turn off the cooling systems in drinking fountains.

Turning things down

Some equipment cannot be turned off entirely but can be turned down to save energy.

Building automation systems. Make sure temperature setbacks are coordinated with building occupancy on a quarter or semester basis. Facility engineers can coordinate with campus staff to align the HVAC schedules in the building automation system (BAS) with expected occupancy to optimize energy usage. Identify buildings that are not used at night, on weekends, or for long periods of time (such as during semester breaks), and adjust temperature settings in those locations. Also, check that HVAC systems are not set to overcool or overheat buildings. For facilities with regular occupancy schedules but without a BAS, programmable thermostats can make temperature setbacks a reliable option.

Water heaters. Consider reducing water heater setpoint temperatures (consistent with health requirements) in buildings that don't have laboratory or cooking facilities. You may also find that the water temperature is set higher than necessary for residential buildings (such as dorms); a temperature setpoint of 120° Fahrenheit (F) is usually sufficient.

Vending machines. Refrigerated vending machines typically operate 24/7, using 2,500 to 4,400 kWh/year and giving off heat and adding to cooling loads in the spaces they occupy. Timers or occupancy sensors can yield significant savings in this environment because they allow the machines to turn on only when a customer is present or when the compressor must run to maintain the product at the desired temperature. When it's time to replace or add vending machines in your facilities, consider specifying Energy Star–qualified models—each one can save over $150 annually on utility bills.

HVAC operations and maintenance

Regularly scheduled maintenance and periodic tune-ups save energy and extend the useful life of your HVAC equipment. It's best to create a preventive maintenance plan that includes regularly scheduled tasks such as cleaning, calibration, component replacement, and general inspections. It's also a good idea to ensure that information on setpoints and operating schedules is readily available for reference when equipment is checked or recalibrated.

Check the economizer. Many air-conditioning systems (other than those in hot and humid climates) use a dampered vent called an economizer to reduce the need for mechanically cooled air by drawing cool outside air into the building. But if the economizer isn't regularly checked, the linkage on the damper can seize up or break. An economizer that's stuck in the fully open position can add as much as 50 percent to a building's annual energy bill by allowing hot air in during the air-conditioning season and cold air in during the heating season. Have a licensed technician check, clean, and lubricate your economizer about once a year, and repair it if necessary. If the economizer is still operating, have the technician clean and lubricate the linkage and calibrate the controls.

Check air-conditioning temperatures. With a thermometer, check the temperature of the return air going to your air conditioner and then check the temperature of the air coming out of the register that is nearest the air-conditioning unit. If the temperature difference is less than 14°F or more than 22°F, have a licensed technician inspect your air-conditioning unit.

Optimize temperatures in peripheral rooms. Make sure that HVAC settings in stockrooms and other rarely used peripheral rooms are at minimum comfort settings.

Use window shades and blinds. During warm weather, blinds can block direct sunlight and reduce cooling needs; in the winter, opening the blinds on south-facing windows will let in sunlight to help heat the space.

Clean the condenser coils. Check the condenser coils quarterly because debris can collect in them. At the beginning and end of the cooling season, thoroughly wash the coils.

Change the filters. Filters should be changed periodically—every one to six months, depending on the level of pollutants and dust in the indoor and outdoor air. More frequent changes may be required when economizers are in use because outdoor air is usually dirtier than indoor air.

Check the cabinet panels. On a quarterly basis (or after filters are changed), make sure the panels to your packaged rooftop air-conditioning unit are fully attached, with all screws in place and all gaskets intact so that no air leaks out of the cabinet. Chilled air leaking out can cost $100 per rooftop unit per year in wasted energy.

Follow a steam trap inspection and maintenance plan. Steam traps remove water from the steam distribution system once it has cooled and condensed in radiators or other heat exchangers. Mechanical steam traps can become stuck open, which wastes heat. A single failed trap can waste more than $50 per month, and universities can have thousands of steam traps on a campus.

Sequence chillers on and off. Operators often run too many chillers for a given load. Because every chiller has a range of loading conditions in which it operates most efficiently, turn chillers off to keep the remaining units operating in their most efficient zones—typically, above the 30 to 50 percent load mark.

Operate multiple cooling towers to save fan power. Most chilled-water plants have excess capacity, and during low-load hours, at least one cooling tower won't be operating. To make the most of your existing cooling towers, simply run condenser water over as many towers as possible, at the lowest possible fan speed, and as often as possible.

Encourage energy-saving behavior

A number of colleges and universities are successfully using no-cost and low-cost public awareness campaigns to reduce energy use on campus. One popular—and effective—energy-awareness program is the “Dorm Energy Challenge,” in which residence halls compete against one another to make the largest energy reductions, or simply to improve their own energy performance. Other popular programs include “Green Crib Certified” awards for students with eco-friendly dorm rooms and “Eco Reps” programs to encourage peer-to-peer sustainable behavior in residence halls. For more information on these kinds of programs, see the online AASHE Resource Center .

LONGER-TERM SOLUTIONS

this section

Longer-term energy-saving solutions should also be considered. Although the conservation measures covered in this section require more extensive implementation and larger monetary expenditures, they represent good investments for colleges and universities. Most will not only save money, but will also enhance the learning environment and the comfort of your buildings. Ask your local utility representative for more information about initiating such projects.

Commissioning or recommissioning

Commissioning is the process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained according to the owner’s operational needs. By utilizing building inspection and systems testing, commissioning can provide quality assurance and systematically improve the efficiency and operation of building energy systems (particularly HVAC and air-distribution systems). For a typical 50,000-ft^2 university building, commissioning can often uncover around $17,000 or more in annual savings, yielding simple payback periods of just a year or two. In addition to providing energy savings, commissioning often increases comfort for occupants.

When the commissioning process is applied to an existing building that hasn’t been commissioned before, it's called retrocommissioning . When it's applied to a building that has been commissioned before, it's called recommissioning, which is good to do every three to five years to maintain top levels of building performance. In another type of commissioning—ongoing commissioning—monitoring equipment is left in place to allow for continuing diagnostics. For more information, see the Lawrence Berkeley National Laboratory (LBNL) report Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions .

Lighting upgrades

Fluorescent lamps. If your facility still uses T12 fluorescent lamps or commodity-grade T8 lamps, relamping with high-performance T8 lamps and electronic ballasts can reduce your lighting energy consumption by 35 percent or more. Adding specular reflectors, new lenses, and occupancy sensors or timers can double the savings. Paybacks of one to three years are common.

Daylighting. In classrooms and administration buildings, take advantage of daylighting where possible to reduce the need for electric light and improve the ambience of the space. Dimming ballasts and daylighting controls can reduce the amount of electric light used when daylight is present. Solar light tubes can also often be a cost-effective retrofit. However, be careful to employ proper design when implementing daylighting in order to avoid glare and overheating.

LEDs. LED lighting has rapidly improved in performance and decreased in cost to the point where there are very few applications for which LEDs don't at least merit consideration—they won't always be cost-effective, but they're worthy of consideration. But exercise caution in specifying LED products—they're not all equally effective. To keep abreast of developments in the field, visit the US Department of Energy's (DOE's) Solid State Lighting website .

Integral lamps, which feature an LED-and-driver package that can be installed as a single unit in a conventional socket, are available in the full range of lamp types, including A-lamps (the technical term for the commonly used lightbulb), PAR (parabolic aluminized reflector) lamps (which are used to direct light in flood or spot patterns), and others. Compared to the halogen and CFL alternatives, LEDs offer longer life and higher efficacy. LEDs are still more expensive than CFLs or halogen lamps, but prices are falling, making them worth consideration in areas like dorm rooms where integral lamps are prolific and frequently left on for extended periods of time.

For ambient lighting, LED troffers—more so than tubular LED lamps—have become an effective alternative to linear fluorescent fixtures. Found in many classrooms and other campus facilities, troffers are long, recessed lighting fixtures that are typically installed with the opening flush with the ceiling and with their inner surface serving as a reflector. The DOE's Exploratory Study: Recessed Troffer Lighting (PDF) reported on the results of the testing of LED troffers and LED tubular products installed in a mock office space. In addition to providing objective measurements, the study also shared the observations of a group of lighting designers, engineers, and facility managers. Researchers concluded that LED troffers can compete with fluorescent fixtures in lighting-quality factors such as glare, light distribution, visual appearance, and color quality. The only caveat: Some of the products flicker when dimmed, so it's important that LEDs be compatible with the dimming products they're paired with.

Finally, replacing fluorescent or incandescent task lamps with LED versions can save significant amounts of energy. The directional nature of LEDs allows task lamps to be oriented to illuminate only the working area without wasting energy by using a reflector or lighting unused areas. These savings can be further enhanced by delamping unnecessary overhead lighting and using occupancy sensors, which dim or turn off lamps at unoccupied desks.

Smart lighting design in parking lots. Parking lots are often overlit—an average of 1 foot-candle of light or less is usually sufficient. The most common lamps used for outdoor lighting are high-intensity discharge (HID) sources —metal halide (MH) and high-pressure sodium. In recent years, fluorescent lamps, CFLs, and induction lamps have also become viable sources for outdoor lighting, offering good color quality and better control options than HID sources. But LEDs are quickly becoming the go-to option because they can reduce light pollution while still offering high efficiency and long life. Dimming (for example, bi-level lighting) and occupancy-sensing controls can also add to energy savings in parking lots. For more information, including analysis tools and case studies, visit the Lighting Energy Efficiency in Parking Campaign website.

Stadium and arena lighting. Using LEDs to light stadiums and sports arenas can yield massive energy savings—roughly 75 percent over the commonly used MH lamps—while also reducing maintenance costs via the bulbs' longer lamp life and lower lumen depreciation rates. Unlike MH lamps, LEDs also offer instant-on and instant-restrike capabilities, which can be appealing to facilities operators. The latest LED fixtures also provide light of sufficient quality for high-definition broadcasts. Although prices vary, LED fixtures can currently cost up to four times as much as MH fixtures, but the dramatic energy and maintenance savings can make them an economical measure with potential simple payback periods of just two to three years.

LEDs can also be used at sports and entertainment venues for lighting façades, concourses, suites, bathrooms, locker rooms, and video boards. Examples of LEDs used in non-field lighting applications can be found in the Natural Resources Defense Council report Game Changer: How the Sports Industry Is Saving the Environment (PDF).

HVAC improvements

High-efficiency HVAC units. A high-efficiency packaged HVAC unit can reduce cooling energy consumption 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.

Demand-controlled ventilation. For spaces that have large swings in occupancy (such as auditoriums, gyms, classrooms, and cafeterias), energy can be saved by decreasing the amount of ventilation supplied by the HVAC system during low-occupancy hours. A demand-controlled ventilation system senses the level of carbon dioxide in the return air stream, uses it as an indicator of occupancy, and decreases supply air when carbon dioxide levels are low.

Reflective roof coatings. If facility roofs need recoating or painting, consider white or some other highly reflective color to minimize the amount of heat the building absorbs. Cool roofs can often reduce peak cooling demand by 10 to 15 percent. For a list of suitable reflective roof coating products, see the Energy Star Roof Products website .

Water use and heating systems

Low-flow faucets and shower heads as well as sink and shower controllers that automatically shut off can help conserve water and the energy used to heat water in recreational buildings. For dorms and recreation facilities, tankless water heaters can typically be used instead of traditional tank-type water heaters.

Gray-water heat-recovery systems can save 50 to 60 percent of water-heating energy when installed in shower drains, resulting in short payback times (especially in buildings with substantial hot water usage, such as recreational centers and dorms). Drainpipe heat exchangers also double or triple the first-hour capacity of water heaters. The equipment consists of a replacement section of pipe that diverts incoming cold water to a coil wrapped around the drain through which hot wastewater flows, heating the fresh intake water. These systems are only effective when hot water is needed at the same time that heated wastewater is generated—as is the case for showers, laundry machines, and dishwashers.

Boiler retrofits

Savings from boiler retrofit projects can be significant. Newer boilers feature a variety of efficiency improvements that can justify the replacement of older boilers before failure. Improvements include condensing heat exchangers, sealed combustion, electric ignition, and fan-assisted combustion. Smaller boilers are more efficient than large ones, and grouping multiple smaller boilers not only allows staged operation of each unit at its highest efficiency point, it also provides redundancy. If a larger boiler isn't ready to be retired, a smaller boiler can be added to serve the base heating load, reserving the larger boiler for additional heating as needed.

Laboratory air filtration

As filters accumulate dust, the airflow through them drops, causing drops in air pressure, which increases the energy required to push air through the filter. Choosing filters rated for the lowest possible pressure drop will cost more up front, but usually ensures lower energy costs because there's less resistance in the ventilation system. You can also save energy and lengthen the functional life of filters by "under-rating" your system. That is, if you force less air through the filter than the maximum amount it's rated to handle (over a specified unit of time), it will last longer and use less energy. For more information, see the filtration section of A Design Guide for Energy-Efficient Research Laboratories by LBNL.

Life-cycle costs for equipment procurement

Identify who is responsible for setting equipment procurement policies for your campus. Is it the Board of Regents or the state? Or is it individual schools and departments? Encourage those in charge to include consideration of energy costs and life-cycle costs in the procurement rules.

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