



Energy Savings in Building Electrical, Mechanical and Plumbing Systems

An Online Continuing Education Course for Engineers

Course Number: BD-7001

Credit: 7 Hours / 7 PDH / 7 CPD

1. Energy and Conservation Issues

Technical Information

This course describes systems that provide key opportunities for energy savings in commercial buildings. The following areas will be explored in this course:

HVAC system improvements offer tremendous potential for energy savings in most facilities. Opportunities include replacing older equipment with more efficient products, improving controls, upgrading maintenance programs, and retrofitting existing equipment to operate more efficiently. Central plants contain many interrelated components, and upgrading them takes careful planning, professional design assistance, and careful implementation. This course covers chillers, boilers, air distribution systems, and other HVAC technologies.

Water heating is a major energy user in facilities with kitchens and laundries. Beyond reducing the use of hot water, various heat recovery and solar technologies can also help reduce operating costs.

Lighting. More than \$250 million could be saved annually if all facilities upgraded to energy-efficient lighting. Light energy savings of up to 40% can be achieved in interior applications by replacing lamps and ballasts. Savings of well over 50% are possible by designing and implementing an integrated approach to lighting that includes daylighting, task lighting, and sophisticated controls.

Office equipment is becoming an ever greater proportion of building loads. "Green" appliances that feature automatic power shutdown and more efficient electronics can help reduce energy consumption.

Energy Management and Control Systems (EMCSs) are critical in avoiding energy waste and monitoring energy consumption. Control technology should be applied intelligently for

each situation, and an optimized mix of local and central control should be used.

Electric motor systems that operate around the clock (or nearly so) consume many times their purchase price in electricity each year. This makes inefficient, large-horsepower motors excellent targets for replacement. If the driven load operates at reduced speed a majority of the time, installing electronic motor controls could reduce both energy consumption and operating costs.

Electrical power systems can be made more efficient through (1) maintenance practices focused on identifying potential trouble areas, such as loose electrical connections; and (2) selection of efficient electrical equipment, such as transformers. There may also be opportunities to use renewable power-generation equipment.

2. HVAC Systems

Heating, ventilating, and air-conditioning systems can be the largest energy consumers in buildings. HVAC systems provide heating, cooling, humidity control, filtration, fresh air makeup, building pressure control, and comfort control—all requiring minimal interaction between the occupants and the system. Properly designed, installed, and maintained HVAC systems are efficient, provide comfort to the occupants, and inhibit the growth of molds and fungi. Well-designed, energy-efficient HVAC systems are essential in buildings and contribute to employee productivity. Boilers, air distribution systems, chillers, absorption cooling systems, desiccant dehumidification, ground-source heat pumps, and new HVAC technologies are covered in the sections that follow.

Opportunities

Consider upgrading or replacing existing HVAC systems with more efficient ones if current equipment is old and inefficient; if loads have changed as a result of other conservation measures or changes in building occupancy; if control is poor; if implementing new ventilation standards has caused capacity problems; or if moisture or other indoor air quality problems exist. Be sure to have a plan in place for equipment change-out and failure. The phase-out of CFCs is another factor encouraging chiller replacement. In all these cases, an *integrated* approach should be utilized that looks at the entire cooling system and the entire building to take advantage of synergies that allow for *downsizing*, as well as boosting the efficiency of, a replacement chiller.

Technical Information

Strategies for reducing HVAC operating costs in large facilities include the following:

Reduce HVAC loads. By reducing building loads, less heating and cooling energy is expended. Load reduction measures include adding insulation; shading harsh wind and sun exposures with trees, shade screens, awnings, or window treatments and minimizing the use of heat-producing equipment, such as office equipment and computers; daylighting; controlling interior lighting; and capturing heat from exhaust air.

Incorporate building automation/control systems. These systems can be added or upgraded to improve the overall performance of the building, including the HVAC equipment. Perhaps the simplest measure and the first to be considered should be to ensure that HVAC systems are in "setback" mode during unoccupied periods. Existing control systems will often accommodate this very simple measure. Sections 6, 6.1, and 4.4 (for lighting) address energy controls in more detail.

Optimize for part-load conditions. Buildings usually operate under conditions in which the full heating or cooling capacity is not required. Therefore, significant improvements in annual efficiency will result from giving special consideration to part-load conditions. Staging multiple chillers or boilers to meet varying demand greatly improves efficiencies at low and moderate building loads. Pairing *different-sized* chillers and boilers in parallel offers greater flexibility in output while maintaining top performance. Units should be staged with microprocessor controls to optimize system performance.

Isolate off-line chillers and boilers. In parallel systems, off-line equipment should be isolated from cooling towers and distribution loops. With reduced pumping needs, circulation pumps can be shut off or modulated with variable-speed drives.

Use economizers. In climates with seasons having moderate temperatures and humidity, adding air- and water-side economizer capabilities can be cost-effective. When ambient conditions permit, outside air provides space conditioning without the use of the cooling plant. To prevent the inappropriate introduction of outside air, careful attention must be given to economizer logic, controls, and maintenance. With a water-side economizer, cooling is provided by the cooling tower without the use of the chiller.

Remember that ventilation systems have a tremendous impact on energy use because of the high costs associated with heating or cooling outside air. Buildings should be ventilated according to ASHRAE Standard 62. The outside air requirements—15 to 20 cfm (7.1-9.5 L/s) per person in most commercial buildings—of Standard 62's most recent version do not apply to buildings constructed before it was published, although for new additions of 25% or more, this "grandfathering" is not permitted by the major building codes. The indoor air quality benefits of complying with ASHRAE 62, such as higher productivity and decreased sick leave, may often make the added expense worthwhile, even when not required by law.

Upgrade cooling towers. Large savings are possible when cooling towers are retrofitted with new fill, efficient transmissions, high-efficiency motors, and variable-frequency drives. Good water chemistry is needed to minimize the use of environmentally hazardous chemical biocides. Ozone treatments also may be useful.



Chillers have changed dramatically in recent years. Today's models are far better for the environment than older products.

Photo: McQuay Air Conditioning

Interconnect mechanical rooms for greater modularity and redundancy. This increases effective capacity while improving part-load efficiency.

IMPORTANCE OF MAINTENANCE

Proper maintenance helps prevent loss of HVAC air balance (return, supply, and outdoor air); indoor air quality problems; improper refrigerant charge; fouling of evaporator coils by dust and debris; poor water quality in cooling towers; and water damage from condensate.

Provide a monitoring and diagnostic capability. An important part of maintaining the rated efficiency of equipment and optimal performance of HVAC systems is understanding how they are functioning. Incorporate systems to track performance and identify problems quickly when they occur.

Ensure that air handlers are maintained. To achieve better indoor air quality and reduce operating costs, steam-clean evaporator coils and air handlers at a minimum three-year rotation. Also service filters frequently.

Service the ventilation system. A good balance report is required. Airflows can then be periodically checked. Periodically lubricate dampers and check their operation by exercising the controls.

Prevent or repair air distribution system leakage. In residential and small commercial buildings, air duct leakage can be a huge energy waster. Leaks can also cause comfort and air quality problems. Check ventilation rates after duct repair to ensure that ASHRAE standards are met and that desired pressure relationships are maintained.

Eliminate or upgrade inefficient steam systems. Leaks are a common problem with older central steam distribution systems.

Regularly inspect for evidence of leaks; repair problems as they occur or upgrade the system.

Check for improper refrigerant charge. Refrigerant-based HVAC systems require precise levels of refrigerant to operate at peak capacity and efficiency, and to most effectively control interior humidity in moist climates. Loss of refrigerant charge not only wastes money but also damages the environment—most refrigerants deplete stratospheric ozone. Inspect for leaks and promptly fix problems. Consider replacing older equipment with new, more efficient, ozone-safe systems.

Provide or consider ease of maintenance when making any HVAC system modifications or equipment purchases. Make sure that access to filters (for cleaning or replacement), ducts (for inspection and cleaning), controls, and other system components remains easy. Label components that will need servicing, and post any necessary inspection and maintenance instructions clearly for maintenance personnel.

2.1 Boilers

Most medium-to-large facilities use boilers to generate hot water or steam for space heating, domestic water heating, food preparation, and industrial processes. For boilers to run at peak efficiency, operators must attend to boiler staging, water chemistry, pumping and boiler controls, boiler and pipe insulation, fuel-air mixtures, burn-to-load ratios, and stack temperatures.

Operational

Every boiler system has its own operating characteristics. When a new boiler is installed, the operator should

- Consider the boiler's operating range, including its ability to handle varying loads and its response to load changes.
- Consider the boiler's water chemistry requirements, including its tolerance for hardness and oxygen.
- Consider the boiler's fuel requirements, including its ability to handle varying fuel qualities and its response to fuel changes.

Technical

Note recent advances in boiler technology include decentralized control systems, digital control systems, and temperature control systems capable of

controlling steam header pressure. From combustion to steam generation, flue-gas temperatures are low enough to vent the exhaust through polyvinyl chloride (PVC) pipes; PVC resists the corrosive action of flue-gas condensate.

Replace inefficient boilers. In newer units, more fuel energy goes into creating heat, so

both stack temperatures and excess oxygen are lower. Estimate efficiencies of existing units by measuring excess air, flue and boiler room temperatures, and percent of flue-gas oxygen and carbon dioxide. Some utilities will provide this service free of charge. Boilers with efficiencies of 80% have efficiencies

of 70% or less. Larger units offer flexibility in scheduling, and heating losses by during no-load

Overall heating application of such as improved staged to large central doors to ease floorways.

Direct digital sensors, and some data efficiency.

to reset, op- continuous

combustion, feedwater and drum levels, and controlling steam header pressure.

Install an economizer. Install a heat exchanger in the flue to preheat the boiler feedwater. Efficiency increases about 1% for every 10°F (5.5°C) increase in feedwater temperature. If you are considering an economizer, ensure (1) that the stack temperature remains higher than the acid dew point in order to prevent flue damage, and (2) that

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