Facilities: Behavior and Operations – and Beyond

The following Section is excerpted from ***School Operations and Maintenance: BEST PRACTICES FOR CONTROLLING ENERGY COSTS,*** **A Guidebook for K-12 School System Business Officers and Facility Managers.**

(The full publication is available for download at http://www.ase.org/uploaded_files/greenschools/School%20Energy%20Guidebook_9-04.pdf)

School energy costs are associated with the operation of a variety of equipment. Although lighting and space conditioning improvements typically represent the largest opportunities for savings, better management of other "end uses" will also produce sizable cost savings to your district.

Overview: Energy efficient operation and maintenance activities and procurements:

- Lighting Strategies
    - Schools can save anywhere from 8% to 20% of lighting energy by simply turning off lights in unoccupied rooms.
    - Periodic cleaning of lamps and light fixtures can save up to 15% of lighting energy.
- Computers and Office Equipment
    - Energy Star monitors have a low-power sleep mode that only uses between 2 to 10 watts.
    - Energy Star printers can save a school $25 per year.
    - Energy Star copiers can achieve savings of 40% compared to standard models.
- Building Envelope
    - All doors and windows should be inspected periodically for air leaks.
    - The building should be inspected periodically for water leaks.
- Heating, Ventilation, and Air Conditioning
    - Proper boiler maintenance can lead to energy savings of 10 to 20%.
    - Regular maintenance of the air conditioning system maintains optimal cooling performance and saves money and energy.
- Water Heating
    - Periodic maintenance on the hot water system can keep it operating efficiently and extend the life of the system.
    - Timers can be installed to shut off electric hot water tanks during periods when the building is unoccupied.
- Kitchen
    - Schools can reduce energy consumption by preheating ovens for no more than 15 minutes before use.
- Swimming Pools
    - Pool covers can save as much as 50 to 70% in energy, 30 to 50% in make-up water, and 35 to 60% in chemicals
- Vending Machines
    - An energy control device for vending machines can save as much as 47% with a payback of less than 2 years.

On average, space conditioning, i.e., heating and cooling, account for the majority of school energy end-use. Water heating and lighting are the next biggest energy consumers for schools. The figure below depicts the national average for school energy end-use.

National Average of School Energy End-Use					
Climate	**Heating**	**Cooling**	**Lighting**	**Hot Water**	**Misc.**
Cold and Humid	40	12	30	11	7
Cool and Humid	23	30	30	10	7
Cool and Dry	32	21	30	10	7
Temperate and Humid	14	41	30	8	7
Temperate and Mixed	30	23	30	10	7
Hot and Humid	18	35	30	10	7
Hot and Dry	16	38	29	10	7

Ref: Energy Design Guidelines for High Performance Schools, U.S. DOE, 2002.

These energy use numbers are very dependant on climate region. In fact, a Florida Solar Energy Center (FSEC) survey (FSEC-CR-951-97) showed that cooling accounted for 43% of total energy consumption in one school, whereas some northern schools have no air conditioning at all.

Energy saving strategies can be categorized as:

1) Equipment control. Limiting equipment operation exclusively to occupied hours and to building areas actually requiring heating, lighting, computers, etc. Adequate provisions and scheduling for weekend and vacation shutdown procedures.
2) Scheduled maintenance. Reinstate required maintenance procedures for filters, boiler feed-water, equipment lubrication, etc.
3) Simple repairs. Low-cost repairs that can be completed by in-house staff. Examples include steam pipe insulation, exterior weather-stripping, etc.
4) Equipment tune-ups and calibration. Periodic tune-ups and calibrations can extend the life of school facility equipment as well as ensure proper operation.

For some energy systems, all four strategies can be used.

Lighting

Lighting strategies present the easiest opportunities to modify energy consumption without any major expense. Simple and cheap strategies are switching off lights when not in use, delamping, and cleaning lamps, diffusers, and fixtures. A more expensive lighting strategy is periodic group replacement of lamps, or relamping. This strategy can keep the lighting system operating near peak output and efficiency. Schools can also install automatic controls such as occupancy sensors, time controls, photo-sensor controls, and dimmers.

Lighting Strategies

- Energy comprises approximately 80% to 90% of the annual cost, and between 65% and 85% of the life cycle cost of a lighting system.
- Lighting strategies present the easiest opportunities to modify energy consumption without any major expense.
- Simply turning off lights in unoccupied rooms can save schools anywhere from 8% to 20% of lighting energy.
- Carefully planned delamping of general overhead lighting can save schools 25–50% of lighting energy.
- Schools should consider replacing lamps once they reach 70% of their life expectancy.
- Lamps, diffusers, and light fixtures should be cleaned periodically to maintain proper lighting levels.
- Automatic lighting controls are retrofits that offer significant energy savings with short payback periods.

Electricity use comprises approximately 80% to 90% of the annual cost, and between 65% and 85% of the life cycle cost of a lighting system. The entire lighting system includes lamps, ballasts, fixtures, and controls that help provide the proper illumination levels throughout the building. Items such as windows, skylights, and interior building surfaces all interact with lighting systems.

1. Manual Light Switch (Turn Them Off)

Schools in your district can save a lot on their electricity bills by simply turning off lights in unoccupied rooms. Significant savings from turning off fluorescent lights can be achieved with minimal aggravation or inconvenience to the user. Pacific Gas and Electric estimates that 8 to 20% of lighting energy can be saved by simply turning off lights in unoccupied rooms. The entire school can participate in this effort. Organized student light patrols work very well with elementary students. Students can patrol the school and shut off lights in unoccupied rooms throughout the building. They can also leave post-it notes as reminders to students and staff to turn off the lights as they leave the room.

At night, most of the lights, excluding the security lights and exit signs, should be turned off. During the morning hours, building service staff should delay turning on the lights in vacant parts of the building until people arrive. This will allow your schools to reduce energy bills without causing any inconvenience.

2. Keep Them Clean

Even in a relatively clean environment such as a school, dirt and dust can reduce the amount of output from lamps by as much as 15 percent a year. You can increase lighting output levels by periodically cleaning the light bulbs and fixtures (tube and luminaire) with a dry cloth. Most normal maintenance procedures call for annual cleaning of light fixtures. However, depending on room conditions, more frequent cleanings may be required. Over time, diffusers will need to be replaced. Diffusers are the plastic covers over the lamps, and over time they can turn yellow/brown and significantly reduce the light output.

3. Window Blinds and Window Film

Window blinds and window films can be used to reduce the amount of solar heat loss or gain depending upon the season. Window blinds can be closed during the warmer months to prevent against excessive solar heating. Additionally, the blinds can be opened during the colder months to allow solar heating to

warm the classroom. This strategy can save on your heating and cooling bills. During the colder months, you can benefit from the lighting and heating of natural daylighting. However, there are tradeoffs between savings on your cooling bills and increasing costs on your lighting bills during the warmer months when the blinds are closed.

You can install window film to help reduce solar heat gain in the summer. The film will also cut down on annoying glare, but at the same time will reduce the amount of available daylight. Proper installation is critical for durability and aesthetics.

4. Exit Signs

Chances are your school has several exit signs, which must be on at all times. New exit signs that use light-emitting diodes (LED) have earned the Energy Star label. LED exit signs use about 5% of the energy used by incandescents and 20% of the energy used by compact fluorescents. An Energy Star LED exit sign can last 25 years without lamp replacement, compared to less than one year for an incandescent. The payback period for a new Energy Star LED exit sign is less than one year. Exit sign retrofits are inexpensive and easily implemented.

5. Delamping

Delamping is the process of removing fluorescent lamps from a light fixture. It is a quick and easy way to achieve significant savings on your utility bills, when current illumination levels are excessive. It is easy to do, and it does not cost you a thing. In some cases, installation of reflectors may also be combined with delamping. According to Pacific Gas and Electric, you could save 25-50% of lighting energy by delamping general overhead lighting.

How to properly delamp a light fixture depends on the technology implemented at your school. If your school has T-12 lighting (larger diameter bulbs, four per fixture), you must remove the lamps in pairs, either inboard or outboard. If your school has T-8 lighting (smaller diameter; two, three or four lamps per fixture), you can remove any lamp in order to reduce light output.

The best places to consider delamping are:

- near windows,
- doors and corners,
- over computers and televisions,
- near skylights, and
- corridors off the main hall.

There are several things to keep in mind when it comes to delamping. You should never compromise health, safety, and security to save on your energy bills. Follow the recommended light levels established by the Illuminating Engineering Society of North America. Their rule of thumb is that you should not delamp a fixture if in doing so there will be fewer than two 4-foot lamps for every 64 square feet. In addition, do not remove lamps from fixtures that are still under warranty. Delamping could void your warranty if something were to happen to the fixture.
For more information on the subject of delamping, visit http://www.iesna.org/.

6. Relamping

Typically, a fluorescent system will perform at 80% or less of its original useful light output after several years of operation, a drastic reduction in performance with no associated reduction in cost.

Maintenance in the form of periodic cleaning and relamping will keep the system operating near peak performance.

The initial equipment and installation costs of lamps and ballasts represent only 4% to 6% of the annual cost of operating a lighting system. Labor to clean and change lamps and ballasts represents 8 to 12%. The rest, 82 to 88%, is electricity cost to operate the system. A regular maintenance program can reduce lumen depreciation as much as 25 to 50%.

7. Automatic Lighting Controls

Occupancy Sensors

Occupancy sensors utilize motion detectors to turn off lights in unoccupied rooms or spaces. They are most effective in areas that are intermittently occupied such as the teachers lounge, staff restrooms, and storage areas. Occupancy sensors utilize two principal technologies, passive infrared and ultrasonic. Passive infrared sensors sense occupancy by detecting body heat, while ultrasonic sensors use volumetric detectors and react to broadcast sounds that are above the range of human hearing. To avoid false shutoffs, you may want to install a sensor that utilizes both of these technologies. These sensors feature two adjustments, delay and sensitivity. They must be properly adjusted to achieve the optimum compromise between energy savings and appropriate function.

A recent study conducted by the Florida Solar Energy Center, in two Florida elementary schools, produced mixed results. In one school, installing occupancy sensors achieved 11% savings with a payback of 3.6 years. The other school, however, did not see any savings. Savings were absent for the second school because an aggressive energy efficiency strategy was already in place. While occupancy sensors are relatively cheap and offer savings on your electric bill, a successful student light patrol program can achieve similar savings without any upfront costs. In order to be sustainable over a period of years, a faculty or staff member must champion student-involved activities.

Time Controls and Photo-sensor Controls

Time controls, via preprogrammed scheduling, allow you to save energy by reducing the amount of time the lights are operating. Time controls make good sense for areas of the building that have predictable occupancy hours. Some of the best locations for time controls are offices, libraries, auditoriums, certain classrooms, and exteriors. These automatic controls can be programmed, and you do not have to worry about physically turning lights off, for example, at the end of the day when the building is vacant. However, you must be vigilant and monitor lights to make sure that they are turned off when not needed.

Photo-sensor controls detect the daylight illumination levels in a room or area. A signal is sent to a control that either dims or switches the lights off in bright daylight conditions. Calibration of these controls is very important. If you are planning on changing the room in any way (paint, new carpet, additional desks, etc.), do so before you calibrate the photo-sensor.

Dimming Ballasts

Dimming ballasts are very effective in very well lit areas of the school. They can dramatically affect both the energy use of a lighting system and the usability of the lighting when the classroom is being utilized for audio/visual or computer presentations. Dimming ballasts permit both manual dimming as well as automatic dimming. Teachers can adjust the lighting to their

desired level and override the automatic dimming which responds to daylighting levels in the room. Although dimming ballasts are most appropriate to new school design, retrofits are applicable to certain situations.

Daylighting

Daylighting can be effective and energy-efficient in nearly all school areas, including classrooms, cafeterias, offices, shops, gyms, pools, corridors, locker rooms, and study halls. On days when the natural light is sufficient to illuminate a classroom, the overhead fluorescent lighting can be turned off. This practice could result in generous savings on your energy bill. Another benefit to daylighting is that by turning off the lights when they are not needed, the life of the electric lighting system is extended and maintenance costs are reduced.

8. Lighting Retrofits

Some schools still employ the older T-12 lighting technology. By switching from T-12 lighting to more efficient T-8 lighting with electronic ballasts, you can save as much as 20 to 30% of lighting energy. Super T-8 lamps, with reduced-power ballasts, save an additional 15 to 20%. High-intensity T-5 flourescents, with an electronic ballast, can save almost half of electricity consumption compared to metal halide with a magnetic ballast.

Note that lighting retrofits are a procurement issue and a major renovation. For example, the payback period for switching from T-12 to Super T-8 lighting with electronic ballasts may be 3 years or more, depending on electricity cost and home of operation.

Computers and Office Equipment

Similar to lighting retrofits, computers and office equipment are more of a procurement issue than operations and maintenance issues. Although instructional and office equipment is normally controlled by the staff using it, the O&M staff can play an important role in shutting off equipment at the end of the day, at agreed-to terms. Everyone needs to know what to do, and they must be given the authority to carry out the proper energy saving strategies. The majority of office equipment, including printers, copiers, and fax machines are all Energy Star compliant.

1. Personal computers

The average school computer is used for only a few hours per day, but is usually left on for a much longer time. Even if computers are turned off during nights and weekends, at least half the energy they consume could still be wasted due to continuous operation during the school day. A simple and effective way to reduce energy use and costs is to shut the computer off when it is not needed for an extensive period of time. Energy Star computers are equipped with power management features, but these must be set properly to minimize inconvenience while saving as much energy as possible. In some cases, the computer is left on continuously for network services or remote access, but even in these cases, the monitor can safely be shut off.

Computer and Office Equipment Strategies

- The computer monitor typically consumes 2/3 of the total energy used by the system.
- Energy Star printers can achieve a savings of $25 per year in electricity compared to standard models.
- Energy Star copiers can achieve a savings of 40% in electricity compared to standard models.

The monitor typically consumes 2/3 of the total energy used by the system. The Energy Star Monitor Power Management Program

provides free software to automatically place active monitors into a low-power sleep mode (2 to 10 watts) through local area network.

For more information on this subject, visit
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=LT

2. Printers

Individual printers should be turned off when the school is closed. Printers that need to be operating constantly because they are connected to a network can still profit from an Energy Star power-down feature, with savings in the range of $25 per year.

3. Copiers

Copiers should be turned off when they will not be used for extended periods of time, such as during long holiday breaks. In addition, make sure that the Energy Star power management features are activated on your copier. You should carefully follow the manufacturer's directions. There are tradeoffs between the energy savings, and having to wait for the copier to warm up from the Energy Star low-power mode. However, most of the new Energy Star copiers warm up much more quickly than previous models.

The electric power requirement of a photocopier when copying may range from under 100 watts for a small, low-speed unit to more than one kilowatt for a large, high-speed unit, although standby power is somewhat less. For a large photocopier that uses several thousand kilowatt-hours per year (costing several hundred dollars) when operating continuously, considerable savings can be realized simply by shutting it off when the school is closed.

Energy Star copiers can achieve energy savings of 40% in electricity compared to standard models. They are equipped with automatic controls to reduce their power consumption during periods of inactivity and to shut off the power after a further elapsed time interval. The time delays triggering these automatic controls should be set at the shortest time that balances the user convenience of quick machine response against the waiting time required for warm-up to occur.
For a medium speed copier, EPA estimates a savings of $25 per year when powered down to low power after 15 minutes of inactivity and to "auto-off" mode (actually still consuming 5–20 watts) after 90 minutes or less.
For more information, visit
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CX.

Building Envelope

The best way to have an efficient building is to design and construct it that way, but that is a rare opportunity. Unfortunately, retrofits can be complex and expensive, although always worth evaluating. Here we will consider only those options that are necessary for health and safety, or that are low in cost. The most obvious approach is to monitor doors and windows, which affect energy use as well as security. All doors and windows should be closed when the air conditioning or heating system is operating. An additional strategy is to maintain the integrity of the building envelope by finding and repairing leaks. You should make sure that doors and windows close tightly. It is also a good idea to check the caulking and weatherstripping for leaks. Caulking and weatherstripping help minimize air infiltration and can effectively reduce energy waste.

Building Envelope Strategies

- Close doors and windows when the air conditioning or heating system is operating.
- Make sure that doors and windows close tightly.
- Check the caulking and weatherstripping for leaks.
- Water damage to building envelope is second only to inadequate outdoor air ventilation as a frequently reported building-related indoor air quality problem.

Water leaks are a particular concern not just because of their resulting deterioration of building materials, but because of mold contamination and growth, a major health problem in schools today. In fact, water damage to building envelope is second only to inadequate outdoor air ventilation as a frequently reported building-related indoor air quality problem. Moisture could come from leaks in building roof, walls, or windows, from plumbing, or from condensation on cool surfaces such as pipes and air ducts.

Heating, Ventilating, and Air Conditioning (HVAC)

Space conditioning (heating, cooling, and ventilation) uses more than half the energy consumed in school buildings. It is a major target for significant energy savings, much of which can be achieved at little cost. Scheduled maintenance on HVAC units included cleaning burners and air conditioner coils, replacing and cleaning air filters and checking ducts and pipe insulation for damage. Detailed procedures for HVAC maintenance are not listed here but can be found in equipment manuals. By conducting general, periodic maintenance, you can extend the life of your HVAC equipment.

Two simple energy-saving strategies that O & M staff can do are:

1) Temperature control in the building – Make sure thermostats are set properly and controls are operating. During the heating season, a quick but effective check can be done just by walking around looking for open windows. (Or just make last sentence into a box or highlight?)
2) Unblocking air flow—Pacific Gas & Electric estimates that the simple step of clearing books and papers off the tops of unit ventilators could save 10% of heating and cooling energy.

1. Controls

Some successful school districts have established policies and procedures for maintaining temperature settings. ASBO International's *School District Energy Manual* states that many school districts use 68 degrees for heating and 78 for cooling in classrooms. Others may choose more moderate levels. Montgomery County, MD Public Schools sets temperatures at 70 degrees heating and 76 cooling. In addition, you should check proper operation of thermostats and calibrate temperature setpoints at least twice a year.

Programmable thermostats, with a cost premium of $50 to $200, are highly cost effective. Where an energy management system is not used for temperature control, a programmable thermostat installed in a room can increase energy savings as well as enhance comfort. However, they must be programmed and maintained properly, which requires training of the teachers or other staff who will be using them.

A central Energy Management System (EMS) can be a great benefit or a major problem for your district. The main point to remember is that it is

not a “set-it-and-forget-it” system. Building O&M personnel need to be trained in its use, and adequate communication must be maintained between central staff and building operators. System scheduling needs to be updated according to building use. The system should be recalibrated every 6-12 months.

2. Heating

In most climates, the boiler is usually the largest single piece of energy-using equipment in the school building. O&M personnel need to be continually reminded of that fact. It is always a best practice to keep detailed energy use and maintenance records. Although sophisticated software is available to analyze energy consumption, simple comparisons can also be useful, such as comparisons with similar school buildings and season-to-season comparisons, normalized for heating degree days.

Saving the invoices from service calls usually will not provide a detailed history on your boiler. For one thing, the carbon-copy invoices tend to fade over the years. In addition, the technician might have abbreviated certain information that won’t make sense in the future. Maintaining a notebook is a better strategy than sorting through old service invoices. Notes that are prepared when the information is fresh can be very useful for future service calls. For example, service records and fuel consumption records can show patterns that indicate problems or verify that the boiler is functioning smoothly.

Scheduled maintenance should be performed at least annually. Boiler inspection is essential for safe and efficient operation. Proper maintenance can lead to energy savings of 10 to 20%, reduced emissions, extended equipment life, and increased building occupant comfort.11 A qualified technician should perform boiler maintenance. However, certain things such as checking for leaks or looking for damaged or missing insulation, can be performed by your O&M staff.

Boilers should be inspected quarterly for safety as well as efficiency. The U.S. Department of Energy, Federal Energy Management Program (FEMP) on-line manual recommends that combustion efficiency be measured and recorded at least once a month during the heating season. Boilers also require other routine maintenance, such as checking feedwater, which will not be discussed here.

Steam heating systems are no longer common in new schools but are still common n older schools in cold climates. These systems have certain specific O&M needs, which will not be discussed here. Of these, steam trap maintenance is one of the most crucial, because just one malfunctioning steam trap can waste thousands of dollars a year.

3. Air Conditioning

Regular maintenance of air conditioning systems maintains optimal cooling performance and saves energy. The most common causes of degraded performance are:

- Dirty filters and fans;
- Improper belt alignment and adjustment;
- Air leaks in equipment cabinets and ducts;
- Improper air damper operation;
- Dirty condenser and evaporator coils;
- Improper refrigerant charge.

Most of the maintenance recommendations apply to all types of air conditioning systems found in schools, including package systems and classroom unit ventilators. Central chillers and cooling towers require additional maintenance not discussed here.

See the ASBO International, *School District Energy Manual*, pp. 13-14; and the U.S. Department of Energy, Federal Energy Management Program, *Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency*, December 2002.

Air Filters

Dirty air filters increase static pressure, and hence reduce fan motor power, and reduce airflow through the system. You should inspect and replace all filters on a regular calendar schedule, as recommended by the equipment manufacturer, typically between one to three months. The frequency should be increased under severe operating conditions or when the economizer cycle is being used. The filter's resistance to air flow increases as it gets dirtier. Measuring the pressure drop across the filter is a convenient way of determining when it should be changed, commonly when the static pressure increases by 0.5 inches of water.

For systems not manufactured with pressure taps, their installation is a simple job requiring a few dollars' worth of hardware. A complete air pressure testing kit with a dial gauge may cost about $70.00.

Fan

Fans typically operate trouble-free for several years with minimal maintenance required. This can allow O & M staff to develop a false sense of security, which usually results in maintenance neglect and eventual failure of the fan. Some of the steps that you can periodically take to prolong fan life are; 1) clean the fan blades, 2) inspect the bearings, 3) adjust/change belts, 4) check fan current.

Fan blades should be inspected at least once a year. Cleaning the fan blades is generally a time-consuming, but worthwhile and beneficial process. Small fans can take and hour or more to clean properly, while larger fans can take considerably longer. Although most newer fans have sealed self-lubricating bearings, older units may require periodic lubrication every three to six months. Bearings should be inspected for excessive noise, vibration, or heat, which are common signs of impending failure. Periodic cleaning and servicing enables fans to maintain a high efficiency and prevent excessive energy waste. For more information, please see the following resources:

Mike Rogers, "Top-Level HVAC Maintenance," FacilitiesNet Maintenance Solutions, October 2003. www.facilitiesnet.com/ms/oct03/oct03HVAC.shtml; *School District Energy Manual,* Association of School Business Officials International, 1997, p. 16.

Air Leaks

Leaks in the HVAC equipment cabinet and/or ductwork waste conditioned air, reducing system efficiency and occupant comfort. Annual checkups should include inspecting all access panels and gaskets, particularly on the supply-air side, where pressure is higher. Losing only 200 cfm from a 10-ton rooftop unit cuts cooling and air-flow capacity by about 5% and wastes more than $100 per year in energy costs.

Damper and Economizer

One of the most common problems with HVAC systems is improperly operating, or leaking, outside air dampers, which can affect not only energy efficiency but also indoor air quality throughout your facilities. If stuck open, they overload the cooling coil with hot outside air; if stuck closed, they lose the opportunity for free cooling. Cleaning and lubricating moveable surfaces and checking actuator movement and setpoint should be done every three to six

months. It takes only a few minutes of work, costing probably less than $10 if the technician is already there. If this maintenance causes a five-ton compressor to operate only 20 hours less, the energy savings (at $0.10 per kWh) repays the additional labor cost.

Heat Exchange Coils

Dirty condenser and evaporator coils reduce cooling capacity and make the compressor work harder and longer. Cleaning the condenser coil is one of the most cost-effective maintenance steps that can be done on the HVAC systems. A dirty coil that raises condensing temperature from 95° to 105°F cuts cooling capacity 7% and increases power consumption 10%, with a net compressor efficiency reduction of 16%. In a 10-ton unit operating 1000 hours per year this wastes about
$120 per year in electricity costs. You can clean the condenser coil in about an hour, for a cost of about $50, resulting in a payback of 2 to 3 months.

A dirty evaporator coil reduces air flow and degrades heat-transfer efficiency. Although the evaporator coil should stay fairly clean with good air filtration, it should be inspected at least once a year and cleaned as required.

Refrigerant Charge and Compressor Operation

Improper refrigerant charge reduces compressor efficiency. In an overcharged system the compressor works harder to overcome increased head pressure. In an undercharged system the evaporator does not have enough refrigerant and cooling capacity is lost. Either condition may be due to improper charging, but insufficient refrigerant is usually due to a leak, for which repair costs may range widely.

Compressors are checked by measuring the current draw and by analyzing the oil to see if moisture or acid are present. Inexpensive temperature indicator tapes may be used to measure case temperature, a frequent precursor of compressor failure.

4. Ventilation

Adequate ventilation is an essential part of maintaining a healthy and comfortable building environment. ASHRAE Standard 62 prescribes the amount of outdoor air required for various types of indoor air spaces. For classrooms, the current standard, 62-2001, requires 15 cubic feet per minute per occupant. Besides fan power, a considerable amount of energy can be required to bring this outside air to the proper temperature and to control humidity. Therefore, ventilation levels should be reduced as far as possible, consistent with code and health standards. During the heating season, unoccupied areas should not be ventilated (with the exception of special areas such as boiler and mechanical rooms, pools, or rooms with caustic chemicals).

In the cooling season, good ventilation strategy is essential for humidity control. Use of the air conditioning system to control mold is complex: It can lower humidity, but its effectiveness depends on many factors such as run-cycle duration. During low load periods, such as when the building is unoccupied, the latent heat performance of most air conditioning systems is poor, so they do not remove much moisture.

Water Heating Strategies

- The hot water system should be checked periodically for leaks.
- The burners of gas- or oil-fired water heaters should be tested annually.
- Fixtures should be flushed periodically to prevent bacteria growth.
- Storage-type hot water tanks should be flushed annually.

Water Heating

Periodic maintenance on your hot water systems can keep them operating efficiently. Keep in mind that a water leak is also an energy leak. It costs money not only to heat water but also to pump it throughout the facility. The burners of gas or oil-fired water heaters should be tested and adjusted on an annual basis. It is also a good idea to periodically flush the fixtures with very hot water to control bacteria growth.

Storage-type water heater tanks should be flushed out annually to remove sediments that reduce heat-transfer efficiency. The burners of gas-fired or oil-fired water heaters should be tuned up at least once a year. "Demand" (tankless/instantaneous) water heaters eliminate stand-by losses, but deliver a continuing flow of hot water once activated. These water heaters do not run out of hot water as a storage water heater can.

For more information on "demand water heaters," visit www.eere.energy.gov/ and type "demand water heaters" into the search box.

You should set the thermostat at the lowest acceptable temperature, because the hotter the water temperature the faster you lose energy through the pipes and storage tank. You should also locate water heaters near the point of main use. Installing a booster water heater for the kitchen, where higher water temperatures are required for dishwashing, is also a good idea. However, booster water heaters can rack up costs and should be monitored closely. Insulating the hot water pipes and storage tank will help to retain the heat. In addition, insulation on a cold water pipe will help prevent condensation from forming.

Your district may want to consider the possibility of adding a timer to shut off electric water heaters during periods when the building is unoccupied. These timers also control the hot water recirculation pump. Prices for recirculating system timers range from $40 to $50, and have a payback period of 2 to 5 years.

If a boiler is used for both space heating and domestic hot water, it is probably operating at low efficiency much of the year. From the fuel consumed when space heating is not required, you can estimate the annual energy cost of using the boiler for domestic water heating. Compare that to the energy cost to operating individual water heating alternatives.

Kitchen and Operations Strategies

- Use fan hood only when cooking.
- Pre-heat ovens no more than 15 minutes prior to use.
- Bleach clean with warm water.
- Keep refrigerator coils clean and free of obstructions.
- Only use lights that are needed, when they are needed.
- Shutdown equipment not utilized during vacation periods.

Kitchen Equipment and Operations

There are several opportunities for energy savings in school kitchens. You should keep refrigerator coils clean and free of obstructions. When possible, delay turning on appliances such as ovens, vent hoods, warmers, and mixers. You can reduce your energy consumption by as much as 60% by reducing the amount of operating time of the different appliances in your kitchen.

All ovens should reach their desired heating level within 15 minutes. There is no reason to preheat your oven for longer than fifteen minutes.

Only operate your hood fans when the stoves are in use. The hood fan draws large volumes of room air that has been air-conditioned or heated and exhausts it outside, which could send energy bills through the roof.

Swimming Pool Strategies

- The annual cost of maintaining an indoor pool can exceed $20,000.
- Water evaporation accounts for approximately 70% of energy lost for indoor and outdoor pools.
- Energy savings of 50-70% are possible with pool covers.
- Chesaning Union Middle School reduced pool energy costs by half in just 8 months with the implementation of a pool cover system.

Swimming Pools

The annual energy cost of maintaining an indoor pool can exceed $20,000. Daily use of a pool cover is probably the single greatest energy management technique for pools. Pool covers reduce the need to heat make-up water, and the reduced humidity means less energy for ventilating and conditioning the intake air. Energy savings of 50–70% are possible, along with 30–50% in make-up water and 35–60% in chemicals.

Maintenance staff say that no real effort is required as the covers glide easily across the pool surface, and are reeled in to remove. Maintenance personnel reel the covers in the morning, while lifeguards cover the pool at night. Other energy saving practices include maintaining correct water temperature control, nighttime setback, and proper filter cleaning to reduce the energy needed to heat make-up water.

Vending Machines

Vending machines, operating continuously, may use 2500 to 4000 kWh/yr, or $200 to $350 at average U.S. rates. Your district may consider installing energy control devices on vending machines. A commercially available energy control device for refrigerated vending machines consists of an infrared occupancy sensor combined with a controller that senses room temperature and powers up the machine when needed to keep the products cool. Savings average 47%, with a payback of less than 2 years. The device is now in use in hundreds of schools, some financed through local utilities.

Vending Machine Strategies

- Vending machines can cost a school from $200 to $350 (each) a year to operate continuously.
- Energy control devices for vending machines average a savings of 47% with a payback of less than 3 years.

For example, in the Moscow, Idaho School District each device saves about 1500 kWh/yr, averaging $75 per year for each vending machine. Some beverage wholesalers are willing to install these controllers in schools at no additional charge.

Vending machines are also equipped with fluorescent lamps that help advertise the name brand of the product being sold. A simple, no-cost strategy is to turn off the lights or delamp the vending machine during periods of no occupancy, or to permanently remove the lamps. Vending companies tend to believe that removing the lamps from the machines will reduce sales. Therefore, vending companies may not be willing to remove the lamps from their machines. Alternatively, schools could upgrade the vending machine lighting from T-12 to T-8. This could save about 1000 kWh per year.

Other Special Equipment (Laminators, Kilns, and Shop Machines)

Special Equipment Strategies

- Turn off laminators, kilns, and shop machines when not in use.
- Operate laminators, kilns, and shop machines during off-peak hours if possible.

Laminators, kilns, and shop machines should be turned off when not in use. You can also reduce the "demand charge" by scheduling the operation of these "heavy appliances" before or after the usual peak hours of 12 to 4 pm. In addition, automatic timers can be installed and programmed to turn equipment on and off at the beginning and end of desired periods throughout the school day.

Portable (Relocatable) Classrooms

Approximately one third, or 36 percent, of the schools participating in the 1999 National Center for Education Services, "Survey on the Condition of Public School Facilities," stated that they use portable classrooms to alleviate overcrowding.

Of those schools, 9% also utilize portable classrooms for other purposes, such as offices for administration and resource personnel. In addition, the Modular Building Institute estimates that more than 385,000 portable classrooms are in use in the U.S.

The operating cost must be part of the decision criteria when thinking about purchasing a portable classroom. Because their use is generally thought of as temporary, portable classrooms are often leased or purchased on the basis of lowest initial cost rather than operating cost. In actuality, portable classrooms are often used for years and experience escalating operating costs.
Portable classroom energy consumption varies across different regional climate conditions. Because they are usually all-electric, portable classrooms located in heating climates may have higher energy costs than conventional classrooms, typically by a factor of 2. On the other hand, a Florida Solar Energy Center study showed that, on average, portable classrooms used 10,840 kWh per year or 30 kWh per day, similar to conventional classrooms in Florida, which has a cooling dominant climate.

Florida Solar Energy Center simulations estimated that they could reduce the annual energy requirement of a conventional portable classroom by 44 to 48 % through a combination of improvements, such as:

- T-8 lighting with electronic ballasts;
- Occupancy-based controls for lighting and air-conditioning;
- High-efficiency heat pump with enthalpy recovery ventilation.

For hot, cooling-dominated climates, measures to reduce lighting and its heat generation showed greatest potential. In cold climates, insulation and duct air leakage control is most important. Heat pumps should be evaluated as an alternative to electric resistance heat.

You should replace the air filter at least every 3 to 6 months, ideally replacing the standard 1-inch thick filter with a 2-inch filter. Periodic (at least annual) maintenance on the HVAC system, including safety checks of the fusible links in the resistance heating system is strongly recommended.

Portable Equipment Strategies

- The Modular Building Institute reports that 385,000 portable classrooms are in operation in the U.S.
- School districts must include the operating cost as part of the decision criteria when thinking about purchasing a portable classroom.
- Measures to reduce lighting and its heat generation showed greatest potential for energy savings in cooling-dominated climates.
- Measures to reduce duct air leakage showed the greatest potential for energy savings in heating-dominated climates.

Programmable thermostats, with proper training and monitoring of use, can also reduce the annual energy requirement of portable classrooms.

The benefits of a lighting upgrade (T-8 lamps with electronic ballasts) are similar to those in conventional buildings. Because of the more remote location of portables, there might be a stronger argument for the use of lighting controls.