Implementation Tool for SEM measures at school level

ESMES Project

"Energy Smart Mediterranean Schools Network"

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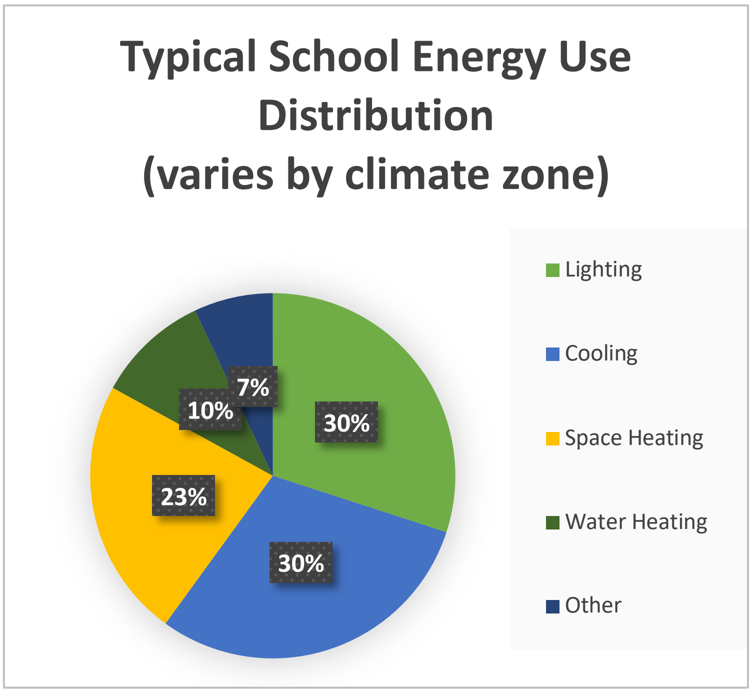
Preface and Index

PREFACE



In a typical school, energy distribution can be attributed to five main categories (fig.1) :

Of those energy uses, lighting and cooling systems draw the most energy, with space heating following closely. Although the numbers vary by climate zone, the results from this analysis provide a generalized summary of the systems with the largest opportunity for energy savings: lighting, HVAC, and water heating.

The following sections provide low cost or no cost energy management operations and maintenance practices for the major systems within school buildings.

When available, these sections also provide overview information on energy efficiency considerations for retrofits or major renovations. Refer to the Action Plan for each section for a detailed list of this information, which is ready to be incorporated into an existing O&M (operating and maintenance) or energy management plan.

1. LIGHTING

As illustrated in fig.1, lighting is one of the uses with the greatest impact, around 30% of the total, and also one of the objectives that can be more easily optimized by adopting good practices and cost-effective replacement interventions.

Refer to the Lighting Action Plan for a customizable checklist of O&M (Operational and Maintenance) measures, trainings, and communications.

1.1 Action Plan Template for Lighting

Action
Once
Establish voluntary teacher/student program to turn off lights to save energy
Install building automation system to monitor lighting energy use
Commission or re-commission timer controls, photosensors, and motion sensors
install timer controls, photosensors, and motion sensors where appropriate, especially in occasionally used: - Consult the manufacturer manual for setting calibrations - All timer and sensor settings should be adjusted for school activities and for changing sunset/sunrise times - All sensor settings should be adjusted to turn off lights after 15 minutes of inactivity - Place contact information near the control in case occupants need assistance
install dimming ballasts if appropriate and compatible with lighting system
Install LED lights on exit and emergency signs

Daily
Turn off lights in unoccupied rooms (work with teachers, students, and other building occupants to make this through "lighting patrols" or other programs), if lighting monitor and control systems are not installed or functional
Turn off all lights at night with the exception of security lights and exit signs, as safety considerations allow, if monitor and control systems are not installed or functional
Turn outdoor lights off selectively, as safely considerations allow, if lighting monitor and control systems are not installed or functional
Delay turning lights on in the morning until staff arrive, if lighting monitor and control systems are not installed or functional

Monthly
Check that all interior and select exterior lights are turned off during nights
Analyze lighting building automation system for opportunities to decrease lighting electricity use
Check for broken lamps and replace

Lighting efficiency is typically considered an energy efficiency "low-hanging fruit." Strategies such as switching off lights, de-lamping, cleaning, and daylighting are simple and inexpensive.

Re-lamping, or periodically replacing groups of lamps, requires slightly more investment. Similarly, schools can install dimmers, timers, and sensors to have more control over when lights are turned on. Not only is lighting O&M necessary for good visibility and security, it also saves money.

Simply de-lamping (a lighting strategy detailed in this section) can save 25 to 50 percent of lighting energy, which equals about one-third of schools' energy use.

The best practices and some low or no cost strategies aimed at minimizing the percentage of energy and consequently the costs of the lighting section are described below.

1.2 Lighting O&M Best Practices

- Maintain interior illumination levels in accordance with current building design standards.
- Establish scheduled cleaning routes for lamps and luminaires.
- Replace discolored plastic diffusers in fluorescent fixtures. Prismatic lenses are generally the most efficient type for the degree of glare control provided; fresnel-type lenses are the most efficient for recessed incandescent and high-intensity discharge fixtures.
- Use light-colored paints, carpets, tile, and upholstery.
- In areas with similar hours of operation, replace all lamps simultaneously to reduce labor costs. Consider replacing the lamps on a single switch at 70 to 80 percent of their average lamp life. If delayed much longer, lamps will start to burn out in a relatively short time, creating a maintenance problem, using additional energy, and providing insufficient illumination.
- Consider the installation of occupancy sensors and photosensors in classrooms and common areas.
- Teach staff and students about energy conserva- tion and how to use classroom lighting controls.
- Measure light levels in all areas. Use Illuminating Engineering Society of North America (IESNA) standards or your state recommendations to evaluate existing light levels and delamp or make other operational changes.

1.3 Low Cost and NO-Cost Lighting Strategies

- Turning off lights in unoccupied rooms can save from 8 to 10 percent of lighting energy annually.
- Automatic lighting controls can generate significant savings with short payback periods.
- Switching from T-12 to T-8 lighting with electronic ballasts can reduce lighting energy by 20 to 30 percent. When making this replacement, a four-tube T-12 fixture can be replaced with a three-tube T-8 lamp and achieve the same illumination. In some instances, four T-12 lamps can be replaced with two T-8 lamps. Lighting measurements are key in making this determination.

1.4 Monitor and Control

Turning off lights in unoccupied rooms can often save up to **10 percent of lighting energy** and can decrease cooling costs, too. All students, faculty, and staff can participate in this strategy through "lighting patrols," assuming that the school does not have an energy management system or other lighting controls.

At night, only security lights and exit signs should be left on. Outdoor lights can be selectively turned off as safety considerations allow. In the morning, turning on lights can be delayed to save energy use until people arrive. Cumulative energy use for lighting and space conditioning should be modeled with energy auditing software to accurately determine energy cost savings. Automated lighting monitoring and controls are critical to maintaining control of the system and should be calibrated to minimize energy use while preserving comfort.

1.5 Cleaning

Cleaning dirt and dust off lamps and their covers (also called luminaires) is a simple way to make sure light output stays at the maximum level. Without cleaning, light output decreases by as much as 15 percent every year. Most maintenance procedures prescribe annual cleaning of light fixtures and luminaires. However, O&M staff can more frequently keep this equipment clean if the job is incorporated into every lighting maintenance procedure, such as relampings and replacements. Diffusers, or the plastic coverings over lamps, tend to get darker with age and they should be replaced when they reduce light output.

For outdoor lights, trees and shrubs should be cleared from lights in addition to regular cleaning of fixtures and luminaires.

1.6 De-Lamping

De-lamping is the process of removing lamps from a light fixture for example, using only two fluorescent tubes in a three tube fixture wherever there is extra light. The best places for this no-cost strategy are where bright light is not a necessity: windows, doors, corners, computers, televisions, skylights, and corridors.

Confirm that removing lighting from these areas does not compromise the health, safety, or security of students, staff, or faculty. Lastly, installing spectral reflectors should be considered as a complement to delamping. The best time to delamp the lighting system is over weekends or holiday vacations, so the lighting change is less noticeable to building occupants.

1.7 Daylighting

Daylighting is the practice of using natural light, rather than electric lights, to illuminate a space. This strategy is effective in classrooms (with consideration for glare), cafeterias, offices, shops, gyms, pools, corridors, locker rooms, and study halls. By keeping lights off, users increase the lifetime of lamps and reduce maintenance costs.

Strategically opening or tilting window blinds can reduce heat loss in the winter or solar heat gain in the summer. Tilted window blinds can also help manage glare while still taking advantage of the natural light.

This strategy can save on heating and cooling bills. However, there are tradeoffs between savings on cooling bills and increased costs on lighting bills dur- ing the warmer months when the blinds are closed.

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

1.8 Light Emitting Diodes

Light-emitting diode (LED) exit signs use about 95 percent less energy than incandescent exit signs and 20 percent of the energy used by compact fluorescents. Combining these energy savings with the increased lifetime of the lamp, the payback period for LED exit signs is less than one year. LEDs can last 25 years, significantly reducing maintenance time to change bulbs. Because emergencies may require exit signs to operate when the power goes out, batteries for emergency power should be checked in groups in accordance with the lifetime specified by the manufacturer.

1.9 Renovation Recommendations

1.9.1 Relamping

Relamping is the replacement of lamps that are not performing at their peak performance. Lamps should be replaced at 75 to 80 percent of their rated life, and they should be disposed of according to local waste regulations because they may contain toxins such as PCBs (polychlorinated biphenyls) and mercury. Replacing all fluorescent lamps every five years or replacing one-third of all lamps biennially can maximize lamp life while reducing labor costs. This practice of group relamping is an excellent example of preventative maintenance and can be scheduled months or years in advance at cost-effective intervals. **The practice can improve lighting performance by as much as 25 to 50 percent.**

Installation and equipment costs of lamps can be up to 6 percent of annual operating costs. Scheduled group relamping can decrease these operating costs by minimizing storage requirements. Reusing individual lamp replacements can also decrease costs. After a group relamping, some lights will not be the original lights installed. These will have been used for less time and can be used as replacements for future burn- outs. This strategy requires careful record keeping of individual and group lamp replacements but can be used to save on the cost of new replacement lamps.

Large-scale lighting retrofits are significant investments that may be most appropriate during a major renovation. Although upgrading from T-12 to T-8 lamps can decrease the electric bill by as much as 6.6 percent, the payback period for this upgrade may be up to three years, depending on electricity rates. The T-8 lighting upgrade can save as much as 20 to 30 percent of lighting energy and T-5 fluorescents can save almost half of electricity consumption compared to metal halide lamps with magnetic ballasts.

For screw-in sockets, compact fluorescent lights (CFLs) have lower maintenance needs and reduce long-term costs. They use about 25 to 30 percent of the energy of incandescent lamps. Lastly, metal halide lamps are generally used to replace mercury lamps for lighting large spaces or for outdoor lighting. Over the lifetime of metal halide lamps, the light output from these lamps decreases and their color rendering changes markedly.

There are a number of lighting control mechanisms, such as timers, occupancy sensors, and photosensors, which are designed to minimize lighting system energy use.

1.9.2 Time Controls

Switch off lights at specified times and are a good solution for areas with predictable occupancy such as libraries, auditoriums, and exteriors. All timer settings should be adjusted for before- or after-school activities and for changing sunset and sunrise times. Key users for the controls should be trained and manufacturer's instructions should be accessible. If a control is accessible to room occupants, place a contact number near the control in case occupants need assistance. Users may damage or manually disarm timers, so regularly checking timer settings is critical to achieving energy savings.

1.9.3 Occupancy Sensors

Automatically turn off lights in unoccupied spaces when motion sensors detect inactivity. They should not be used with lights that require warm-up or re-strike times, like high-intensity discharge lamps. A study by *the Florida Solar Energy Center* reported 11 percent savings and a payback of less than four years by installing occupancy sensors.

Careful checking of sensors is necessary because they can be set off by irrelevant motion. For example, motion outside windows might cause the sensor to turn on lights at times when they are not needed. Such problems can be fixed by changing the sensor's placement or partially shading it. Maintenance contact information should be readily available to building occupants in case a sensor is malfunctioning. Annual commissioning is recommended as a preventative maintenance measure.

for occupancy sensors to assure they are operating correctly. Current sensors use infrared and ultrasonic technologies, which are a significant improvement from earlier generation sensors.

1.9.4 Photosensors

Dim or switch off lights when daylight reaches bright levels.

The sensors and the dimming ballast should work together to achieve a slow, smooth dimming response for indoor areas. Facility personnel should carefully calibrate these sensors; changes such as painting walls, new carpeting, and additional desks can change a sensor's setting. Photo-sensors should be located at an unobstructed location, such as the ceiling in the middle of a classroom. Care should be taken to make instructions and maintenance contact information accessible to building occupants. Initial commissioning is essential for these controls to achieve their potential energy savings.

1.9.5 Dimming ballasts

Are most commonly installed during new school design but may be appropriate as retrofits in some situations. Determining existing ballast quality is difficult, but they usually last seven to 10 years. This equipment allows for manual or automatic dimming and can dramatically decrease the energy used in lighting. To manually use the dimming ballasts, install dimming switches for occupants to adjust. If using fluorescent dimmable lights, make sure the lighting ballasts are dimmable. Otherwise, the bulb will burn out very quickly. For automatic control, the dimming system should be programmed into an existing or new energy management system. They are most effective in well-lit areas of a school.

2. HEATING, VENTILATING and AIR CONDITIONING

Refer to the HVAC Action Plan for a customizable checklist of O&M measures, trainings, and communication.

2.1 Action Plan Template for Heating Ventilating and Air Conditioning

Action
Once

Establish expected HVAC system efficiency.
- Write down the expected efficiency of HVAC systems to use as a baseline
- Add this information to maintenance plan documentation
- Some efficiency measures to collect are:
  - EER or kW/ton of cooling equipment
  - Thermal efficiency or HSPF for heating equipment
  - Bhp for fans and pump motors
  - Expected air and water flows

Determine type of economizer and proper operation both during benchmarking and at the installation of a new equipment economizer - Collect information on the type of economizer installed in each system and document the intended operational maintenance plan - Type of controls: fixed dry bulb temperature setpoint, fixed enthalpy setpoint or differential dry bulb or enthalpy control - Note whether the economizer is intended for integrated (together with compressor) or non-integrated operational
Commission, re-commission, or retro-commission HVAC system once for each season to identify baseline of HVAC system
Daily
Conduct overall visual inspection of all systems *
Turn off or sequence equipment when unnecessary *
Air Compressor
Look for and report any system leakages *
Check compressor lubricant level, color, and pressure. Compare with trended values *
Drain condensate from tank, legs, and traps *
Verify operating temperature is per manufacturer's specifications *
Air Conditioning
Chiller
Check all setpoints for proper setting and function *
Cooling Tower
Check for clogging by making sure water is flowing in tower *
Adjust all belts and pulleys *
Controls
Verify in control software that schedules and setpoints are accurate for season and occupancy *
Heating
Boilers

Follow manufacturer's recommended procedures in lubricating all components. Compare temperatures with performed after annual cleaning *

Regular maintenance of heating, ventilation, and air conditioning (HVAC) equipment has a number of benefits:

Energy savings

Extension of equipment life to avoid premature replacement and reduce life-cycle cost

Enhanced indoor air quality and ventilation

Elimination of contaminant sources

Increased occupant comfort

Improved reliability and reduction in emergency equipment issues

Avoidance of classroom disruptions with equipment operating at maximum efficiency

Integration into pest management through cleaning procedures

Empowerment of maintenance staff to take charge through demonstrated energy savings

Space conditioning uses more than half the energy consumed in school buildings. Accordingly, it is a primary target for energy savings, much of which can be achieved at little cost. Listed below is a summary of the low-cost or no-cost energy-saving maintenance actions that will be described in detail later in this section.

2.2 Low Cost and No-Cost Heating; Ventilation and Air Conditioning (HVAC) Strategies

- Clean burners and air conditioner coils
- Ensure systems run only during occupied periods
- Replace and clean air filters and keep economizer dampers clean
- Check ducts for leaks at joints and flexible connections
- Check hot and cold duct and pipe insulation and seals for inadequate insulation
- Fix faulty equipment
- Verify and adjust refrigerant charge on packaged air conditioning systems
- Check, adjust, calibrate, and repair all controls, such as thermostat controllers and valve and damper operators
- Monitor, calibrate, and repair enthalpy controls and mixed-air controls to maintain efficient operation

- Repair or replace all defective dampers
- Check, adjust, or replace fan belts
- Lubricate all bearings and other friction points, such as damper joints
- Inspect fan wheels and blades for dirt accumulation and clean them as required
- Adjust or repair packing glands and seals on valve stems and pumps
- Ensure that no oil or water enters the main air supply for the control systems

The first step to improving the energy efficiency of HVAC systems is to reduce its loads. Then, similar to benchmarking, it is necessary to establish the expected HVAC system baseline efficiency for evaluation before taking maintenance measures to reduce energy use. Write down the expected efficiency of the HVAC systems from manufacturers' literature or design documents. Key information to record includes:

- EER of cooling equipment
- kW/ton of cooling equipment
- Thermal efficiency or heating season performance factor (HSPF) of heating equipment
- Break Horsepower (BHP) of fans and pump motors
- Expected air and water flows18

Another good source for information on energy consumption is the sub-meter. For facilities that may have sub-meters on individual buildings or systems, such as chilled water plants, that are not read by the utility and are not on the utility bill, make the effort to collect that information monthly. Sub-meter information can help explain energy consumption and can contribute to the overall energy audit.

2.3 Heating

In most climates, the boiler is the largest single piece of energy-using equipment in a school building a good fact to keep in mind.

As a result, it is critical to keep detailed records of boiler energy use and maintenance. Although sophisticated software is available to analyze energy consumption, simple data analysis, such as comparing energy data with that of similar buildings, can also be useful. It is helpful if this comparison is done between buildings with similar equipment and if it is a season-to- season comparison, normalized for heating degree days. The boiler maintenance log may also be a good resource for this exercise.

2.3.1 Heating and Boiler Lessons Learned

- During unoccupied periods:
  - Turn off boilers, as recommended by equipment manufacturer. Some buildings shut down boilers when the outside air temperature is greater than 32°F and building temperature is greater than 50°F
  - Avoid shutting down boilers when temperatures are freezing or are close to freezing to prevent frozen coils
  - Program night setback temperatures on thermostats, though the settings will vary according to weather and season
  - Keep in mind system restart times to avoid negative consequences for normal building operations and delayed heating for building occupants
- In general:
  - Set boilers to operate automatically, using controls from the manufacturer.
  - Maintain tight control on make-up water to avoid using water treatment chemicals; maybe use alcohol or antifreeze to prevent equipment damage.
  - Institute a steam trap maintenance program

Maintaining a detailed service notebook is a better data management strategy than keeping old service invoices. Simply saving invoices from service calls does not provide a detailed history of your boiler. Service invoices deteriorate over time, contain quick notes or abbreviations, and are easy to lose. Notes that are prepared when the information is fresh are most 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 one to four times per year. Boiler inspection is essential for safe and efficient operation and may already be required by your state. A qualified technician should perform boiler maintenance. However, O&M staff have an important role as well: They need to check for leaks, look for damaged or missing insulation, and monitor energy efficiency.

The U.S. Department of Energy, Federal Energy Management Program (FEMP) online manual recommends combustion efficiency be measured and recorded at least once a month during the heating season. Combustion efficiency can be measured by the flue gas analysis. Typical combustion efficiencies for standard boilers range from 70 to 85 percent, depending on the firing rate of the boiler. Efficiency usually drops at lower firing rates. The efficiency for condensing boilers should be around 95 percent.

Boilers also require other routine maintenance, such as checking feedwater, which will not be discussed here. For more details, see the boiler manufacturer's operating manual, a standard reference text, or the local air quality management district regulations for required boiler tests.

Similar inspection guidelines apply to schools that heat spaces using furnaces:

- Inspect the furnaces for smooth ignition and proper flame color

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- Check the operation of limit devices or flame sensors
- Test gas connections for leaks
- Perform the American Gas Association furnace heat exchanger leakage test annually
- Inspect the flue for blockage
- Always see the manufacturer's guidelines for proper operation

If staff members identify any problems with the ignition or the flame, facilities personnel or a trained professional should clean the burners as needed and repair or replace the appropriate components.

Steam heating systems are not generally used in new schools but are still common in older schools in cold climates. These systems have specific O&M needs, which are overviewed in the list below. of these, steam trap maintenance is one of the most crucial, because just one malfunctioning steam trap can waste thousands of dollars a year.

2.4 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.

The general cooling efficiency of the air conditioning system should be checked every three to five years or following a change of the HVAC system. Cooling efficiency can be found based on measurements of airflow, temperatures, and electrical demand. There are commercially available measurement systems to help automate the process and help diagnose problems. Air flow and refrigerant charge measurements should be the first priorities, but efficiency estimation may not cost much more if an automated measurement and diagnostic system is used.

2.4.1 Air Filters

Dirty air filters increase static pressure, reduce fan motor power, and reduce airflow through the system. Inspect and replace all filters on a regular schedule, as recommended by the equipment manufacturer, typically every one to three months. This maintenance 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 will determine when it should be changed, commonly when the static pressure increases by 0.5 in. of water.19 For systems not manufactured with pressure taps, installation is a simple and inexpensive job. A complete air pressure testing kit with a dial gauge typically costs between $30 and $100.

Filters with increased area provide more friction to capture dust and other materials and, therefore, less energy is needed to move air across the filter. When replacing filters, minimize energy consumption by increasing the filters' cross-sectional area. Options include:

- Pleated filters
- Bag filters
- Angled filter banks

2.4.2 Fans

Fans typically operate trouble-free for several years with minimal required maintenance, but maintenance neglect can lead to premature failure of the fan.

Some steps that prolong fan life include: 1) clean the fan blades, 2) inspect the bearings, 3) adjust or change belts, and 4) check fan current. Generally, these systems should be inspected quarterly. Fan blades should be inspected for cracks and damages at least once a year.

Cleaning fan blades is time consuming but worth- while. Small fans can take an hour or two to clean properly, while larger fans can take considerably longer. Fan blades should also be checked for chips or cracks that may cause noise or vibration.

Although most new 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.

Fan belts should be checked for wear and to correct tension. If belts are too loose, they can compromise performance, increase noise, and increase wear.

Belts that are too tight can damage motors, bearings, and the belts themselves. The maintenance plan should include information on how to conduct the belt tightness test for each piece of equipment (based on the manufacturer's recommendations). Check belts and pulley alignment. Belts should be replaced annually or more frequently, as necessary.

2.5 Ventilation

Adequate ventilation is an essential part of maintaining a healthy and comfortable building environment.

ASHRAE 61-2001 requires 15 cubic feet per minute of outdoor air 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 much 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, a good ventilation strategy is essential for humidity and mold control.

Use of the air conditioning system to control mold is complex; while it can lower humidity, its effectiveness depends on many factors. 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.

Every three to five years, the air flow rates should be tested to ensure they meet requirements. Low air flow causes lower cooling efficiency and reduced total cooling capacity. The maintenance plan should list the appropriate air flow supply for each system. The plan should also describe the air flow measurement method. Refer to the Action Plan for specific test plan details.

2.5.1 Controls

Of all the O&M processes, verification of the control settings can have the biggest impact on energy consumption. It is important to ensure that the following control settings match the values in the facility maintenance plan. They may have been altered by users or may have become faulty.

- Setback and setup temperatures
- Start and stop times
- Fan operations
- Adequate dead band between cooling and heating operation (or manual changeover between heating and cooling mode)
- Heat pumps controlled to use electrical strip heaters, only when necessary
- Pressure
- Humidity
- Carbon monoxide
- Carbon dioxide

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°F for heating and 78°F for cooling in classrooms.Montgomery County, Maryland, Public Schools sets temperatures at 70°F heating and 76°F cooling.

In addition, check for proper operation of thermostats and calibrate temperature set points quarterly.

Determine if any control changes need to be made due to factors such as occupant discomfort and update the maintenance plan accordingly.

Programmable thermostats, which range from $50 to $200, are cost effective. Where an energy management system is not used for temperature control, a programmable thermostat installed in a room can increase energy savings and enhance comfort. Programmable thermostats must be set properly to achieve energy savings and increase occupant comfort. This step requires training of the teachers or other staff who will be using them.

A central Energy Management System (EMS) can be either a great benefit or a major time drain for a district.

The EMS needs constant monitoring by O&M personnel trained to use it. System scheduling needs to be updated according to building use. The system should be recalibrated once or twice a year25 to adjust for daylight-saving time changes, meet current building-use demands, and reduce energy use, where appropriate.

Inspections and fixes of other systems, such as piping and electrical connections, may also lead to better energy efficiency. Piping insulation should be checked annually as it tends to degrade over time, especially if exposed to sunlight. Loose electrical connections not only pose a danger but also may lead to overheating or improper equipment operation. Inspect electrical connections twice a year and tighten, if necessary. For safety reasons, shut off

all power to the unit before handling.

All of these O&M recommendations require attention to building systems and changes in behavior. The facilities staff needs to be aware of the value of preventative maintenance and inspections. Energy savings are achieved through continuous monitoring and improvement.

Students, teachers, and staff should monitor and maintain thermostats and windows. They should understand the importance of the following tasks:

- Keep thermostats set at the appropriate level
- Do not open windows and turn on the thermostat at the same time
- Turn off thermostats when rooms are unoccupied

2.5.2 Miscellaneous

Inspections and fixes of other systems, such as piping and electrical connections, may also lead to better energy efficiency. Piping insulation should be checked annually as it tends to degrade over time, especially if exposed to sunlight. Loose electrical connections not only pose a danger but also may lead to overheating or improper equipment operation. Inspect electrical connections twice a year and tighten, if necessary. For safety reasons, shut off all power to the unit before handling. All of these O&M recommendations require attention to building systems and changes in behavior. The facilities staff needs to be aware of the value of preventative maintenance and inspections. Energy savings are achieved through continuous monitoring and improvement.

Students, teachers, and staff should monitor and maintain thermostats and windows. They should understand the importance of the following tasks:

• Keep thermostats set at the appropriate level

• Do not open windows and turn on the thermostat at the same time

• Turn off thermostats when rooms are unoccupied

2.3 Design/Renovation Recommendations

Replacing older equipment with newer, more efficient units can save a significant amount of energy. Replacement will be most cost effective when energy prices are very high or the existing equipment is near the end of its useful life.

3. WATER HEATING

Refer to the HVAC Action Plan for a customizable checklist of O&M measures, trainings, and communications.

Action
Monthly
Walk-through check for leaks and pipe corrosion - Pipes - Valves - Fixtures
Track water usage and compare seasonally
Identify water usage disparities and adjust O&M
Maintain notes on service records and electricity consumption. Prepare the notes when the information is fresh
Compare water consumption with similar school buildings seasonally, normalized for heating degree days

Quarterly
Walk-through check: - Burners - Gauges - Pumps

Bi-Annually
Calibrate water temperature setpoints to between 120°F and 140°F

Annually
Establish and re-evaluate policies and procedures for maintaining temperature settings
Flush water heating system with hot water including storage tanks and pipes. Sediments reduce heat transfer efficiency
Inspect piping insulation annually, as it tends to degrade over time, especially if exposed to sunlight

Training
Train O&M personnel: - Setting water temperature - Identifying aging insulation - Identifying leaks
Train facilities staff to conduct water heating energy consumption comparisons with similar school buildings, a season-to-season comparison, normalized for heating degree days
Train facilities staff to maintain detailed notes on the equipment service records and energy use (fuel consumption) Prepare the notes when the information is fresh

On average, water heating is responsible for 8 to 11 percent of a school's energy demand.
Routine servicing addresses three possible sources of water heating inefficiency:

- Recovery efficiency, or how effectively heat is transferred from burner to water
- Standby loss, or the heat lost from the water stored in the tank
- Cycling loss, or the heat lost from water as it cycles through the heater, pipes, and valves

An effective water heater preventative maintenance plan addresses all of these areas and also increases the lifetime of the equipment. The typical hot water heater must be replaced every 10 to 15 years.
The first step for effective operations and maintenance of water heaters is routine inspection. Any leak from a valve, pipe, or fixture is a source of energy inefficiency because lost water translates into more water that must be heated. Pipe repairs typically have a payback of one to two years and leakage can be spotted by looking for corrosion on pipes and fixtures. Other routine maintenance includes checking burners, gauges, and pumps at least once a year. If a pump's motor is vibrating unnecessarily, the pump may not be functioning at the right pressure and needs to be replaced. Lastly, insulation should be properly maintained to minimize heat lost during storage and as water circulates through the entire system. This repair will typically pay for itself in less than six months.
Another important low-cost measure that improves energy efficiency is periodic flushing of the hot water system. This maintenance removes sediments from the system that reduce heat-transfer efficiency. Hot water storage and pipes should be flushed once or twice a year.
Shutting off water heating for extended periods when it is not needed, such as during the summer months, and lowering the temperature range of hot water decreases energy usage. It is helpful to set water heaters on timers, which are inexpensively priced at $40 to $50 per unit.
A mixing valve can be used to limit the temperature range of hot water faucets to 140°F; the Plumbing Manufacturing Institute recommends a range higher than 130°F for health reasons. The financial payback for this temperature setback strategy is less than six months.

3.1 Design/Renovation Recommendations

Replacing storage water heaters with tankless water heaters eliminates the need to store hot water and avoids standby losses. Tankless water heaters can be used in most applications and should be located as close as possible to their point of use. However, storage water heaters are generally necessary in areas that require large volumes of hot water, such as cafeterias, kitchens, and gymnasiums.

Another redesign option is to install booster water heaters for areas of a school that need water at a higher temperature. For example, kitchens often require temperatures above 140°F for dishwashing. Booster heater installation costs should be monitored closely and compared to energy use from centralized water heating alternatives.

Conclusion

In addition to the categories mentioned above and extensively covered, there are other topics such as the building envelope, distribution Transformers, Plug Loads, as well as Kitchen Equipment and Building Automation Systems which, in the context of integrated school efficiency, should be taken into account.

They are not highlighted in this report because ultimately their percentage weight in relation to effective energy efficiency and the consequent savings is decidedly lower

The optimization of the categories developed will in any case lead to a significant reduction in energy and water consumption of the school under consideration and if a consistent dissemination program is associated with this, the benefit in terms of knowledge will certainly be considerable.