Northeast Energy Efficiency Partnerships

Regional Operations & Maintenance Guide for High Performance Schools and Public Buildings in the Northeast and Mid-Atlantic

Strategies for creating green, healthy & energy efficient existing buildings in your state or local government

August 2013

About NEEP

NEEP was founded in 1996 as a non-profit whose mission is to serve the Northeast and Mid-Atlantic to accelerate energy efficiency in the building sector through public policy, program strategies and education. Our vision is that the region will fully embrace energy efficiency as a cornerstone of sustainable energy policy to help achieve a cleaner environment and a more reliable and affordable energy system.

The High Performance Buildings Project was developed to promote operational energy savings in new and retrofitted buildings throughout the region. NEEP's vision is that the work done today on High Performance Buildings will pave the way for the development of zero net energy buildings, buildings that consume no more energy than they produce, on a broader scale throughout the region.

About Energy and Resource Solutions (ERS)

ERS is a progressive energy engineering and consulting firm based in North Andover, Massachusetts serving clients regionally, nationally, and internationally. ERS' areas of specialization include assessment and implementation of energy efficiency projects; utility program planning, management, and evaluation; renewable/sustainable building assessment; development of analytical tools and database software systems for project energy analysis; technology assessment; premium efficiency lighting design; and energy code compliance.

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CONTENTS

Using this Guide

This Regional Operations and Maintenance Guide is intended to provide guidance to state and local jurisdictions to ensure the continued performance of new buildings that are built to green building standards, as well as put existing buildings—regardless of age—on the pathway to becoming energy-saving high performance facilities.

The Guide contains O&M procedures that will help buildings reduce their operating costs, as well as lead to healthier indoor air, improved student and staff comfort, reduced water consumption, improved environmental stewardship, and overall improvements in the learning environment. O&M procedures targeted at energy efficiency can save 5 to 20 % on a building's energy bills. These savings can total up to hundreds of thousands dollars annually, and many can be achieved at no to little cost.

This Guide was developed with input from and at the request of local stakeholders, ranging from facilities managers to efficiency program administrators. NEEP will continue to update this guide periodically as new O&M strategies become available. We encourage continuous feedback from practitioners to ensure that the Guide is a useful and comprehensive tool for Northeast and Mid-Atlantic communities.

A Note on This Publication

This publication is designed to provide accurate and authoritative information with regard to the subject matters covered. Although great care has been taken in the compilation and publication of this manual, it is published with the understanding that (1) the publisher and authors make no guarantee that the manual meets all federal, state, and local statutory, regulatory, or other requirements, and (2) the publisher and authors are not engaged in rendering professional advice via this manual. The publisher and authors cannot be responsible for errors or omissions, or any agency's interpretations, applications, and changes of regulations or specifications described in this publication. Use of any provision contained herein is the sole responsibility of the specifier.

State, local, and federal governments maintain a collection of codes and regulations that apply to the construction and operation of public schools and other public buildings. Northeast-CHPS does not attempt to present or replace any regulations or code requirements. All relevant codes and regulations should be adhered to and the adoption of recommendations presented in this guide should be considered as enhancements that improve the educational environment and workplaces beyond what is required by the appropriate codes and regulations.

A note on the Collaborative for High Performance Schools (CHPS)

The Operations and Maintenance Guide is a companion piece to the Northeast-CHPS Protocol. The Protocol provides a set of guidelines for the construction and renovation of K-12 schools in a manner that provides for enhanced learning environments, energy efficiency, and low environmental impact. Northeast Energy Efficiency Partnerships (NEEP) has tailored Northeast-CHPS to the climate zones and school construction needs of the states in the Northeast, primarily Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. New York and Massachusetts each maintain a state specific version of CHPS (NY-

CHPS, MA-CHPS).

Above all, a high performance school provides an environment that enhances the primary mission of public schools: the education of future citizens. Northeast-CHPS provides guidelines for the construction of new schools, the renovation of existing schools, and the operations and maintenance of all schools.

CHPS Best Practices Manual

Portions of this O&M Guide were adapted from the CHPS Best Practices Manual by permission of the Collaborative for High Performance Schools, Inc. The CHPS Best Practices Manual is copyrighted by CHPS, Inc. Anyone may use or copy the content without further consent. However, prior permission from CHPS, Inc. must be granted in order to re-license, publish, or develop derivative works from CHPS-copyrighted materials.

The publication is based, in part, on materials from:

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www.chps.net

I. Establishing Operations and Maintenance Policies

Operating and maintaining public facilities to a high performance standard requires a coordinated, integrated process that provides guidance for the multitude of individual items that facility staff need to address. The establishment of an overall operations and maintenance policy is an important step in achieving high performance results.

Establishing an Operations and Maintenance Advisory Committee

Building administrators who institutionalize high performance policies and habits are not just operating better buildings; they are protecting the health, and improving performance of the occupants while lowering the building's operating expenses. It is recommended that policy makers such as school district leaders, public works directors, and facilities directors, collaborate to create a high performance operations and maintenance (O&M) advisory committee to oversee the implementation of an integrated O&M approach and that provides guidance for adhering to standards that promote a safe, healthy, and efficient environment.

The established committee should include representatives from the facilities, administrative, and staff in order to address all relevant concerns. For educational facilities, high school students should also be encouraged to participate in the committee, with the possibility of offering academic credit for constructive participation. A representative of the school board and/or a community sustainability committee may also prove valuable. The O&M advisory committee should be charged with guiding and executing the recommendations presented in this guide.

Developing Policies for Joint Use of Public Buildings

The most successful public facilities have a high level of community involvement. Public building managers should support the sharing of spaces for neighborhood meetings, recreational activities, adult education, and other community functions that can take place in a safe and secure environment. Municipalities should give careful thought to the types of programs, services, and facilities they currently offer, and look for opportunities to expand such offerings (e.g., library services, recreation services, meeting space, space for special events, etc.). At the same time, municipalities should establish policies to ensure that when outside groups utilize public spaces, they adhere to principles conducive to the safe and efficient operation of the space.

Joint use of recreational space is a growing trend across the country. Public facilities, schools in particular, are used by a number of community organizations for a variety of recreational purposes and other uses. For example, use of school playing fields by the local recreation department allows the community to optimize resources dedicated to community recreation and to share costs with other municipal departments.

Developing Policies for Leasing Public Buildings

Establishing Guidelines for the Leasing of Public Space for Private Use

When donating or leasing use of public building space, consideration should be given using a space appropriately sized for the task or activity. An example of this might be if a social group is interested in obtaining a space for a gathering, they should not be assigned a gymnasium or large hall if a conference room or cafeteria will do.

Municipalities should consider establishing green lease policies and energy efficient procedures when drafting joint use agreements. This will guide community users of public spaces towards the effective use of that space consistent with the adopted public policies. Included would be information on the efficient building practices outlined in this guide, information on local resources such as recycling programs, and energy efficiency protocols associated with the operation of building controls.

Establishing Guidelines for the Leasing of Private Space for Public Use

It is sometimes necessary, or desirable, to lease privately owned buildings for public use. In order to provide for the same level of comfort and environmental health that is offered to those occupying publicly owned buildings, and to reduce environmental impacts and associated energy costs, it is important to establish protocols for the leasing of such buildings. The protocols established will likely cover permanent attributes of the building, but also may include standards that are implementable before taking occupancy. Some of the issues to be addressed include:

- ❑ Insulated envelope cavities
- ❑ Air sealing of the envelope
- ❑ Minimum efficiency levels of heating systems
- ❑ Delivery of outside air
- ❑ Thermostatic and zone controls
- ❑ Lead testing
- ❑ Low VOC surfaces and materials
- ❑ Lighting power density and lighting quality
- ❑ Automatic lighting controls and/or bi-level switching
- ❑ Access to views and daylight

The State of Maine has established a set of protocols for the leasing of private space for government office use. It provides a good template for establishing a protocol for any public jurisdiction. Some examples of individual lease guidelines from the Maine document include:

- ❑ Automatic temperature setback during unoccupied times to no greater than 60 deg. F.
- ❑ Shutdown of outdoor air supply and interior exhaust fans during unoccupied times except for systems service areas and other areas required by code.
- ❑ Replacement of any continuously operated lights to energy efficient lighting such as incandescent lamps to CFL or LED lamps.

Municipalities should consider the possibility of leasing buildings that are ENERGY STAR certified, which will ensure the building occupied is energy efficient. In order to obtain the ENERGY STAR label, a building must be in the top 25 percent of buildings of a similar type for energy efficiency in the country. If utilities are the responsibility of the lessee, monthly operating costs will be lower compared to a typical building of the same type.

Resources

Green Lease Policies and Procedures, US General Services Administration:
http://www.gsa.gov/portal/content/103656

Green Lease Library: http://www.greenleaselibrary.com/

Maine Leased Building Energy Efficiency Requirements:
http://www.maine.gov/bgs/leased/lease_docs.htm

SEE Action, High-Performance Leasing for State and Local Governments:

http://www1.eere.energy.gov/seeaction/pdfs/commercialbuildings_factsheet_highperformanceleasing_statelocal.pdf

The ENERGY STAR for Buildings and Manufacturing Plants:
http://www.energystar.gov/index.cfm?c=business.bus_bldgs

Establishing an Indoor Environment Management Plan

Implementation of an Indoor Environment Management Plan provides valuable guidance for establishing and maintaining healthy indoor environments. The U.S. Environmental Protection Agency's (EPA) indoor air quality resources provide valuable guidance for establishing protocols. Notable is their Tools for Schools program which provides specific guidance for educational facilities. For proper implementation, a trained staff person should be designated as the point of contact for implementing the EPA tools or equivalent programs.

The EPA's indoor air quality resources and the Tools for Schools program are designed to identify, address, and prevent indoor air quality problems. The prevention and comprehensive planning for indoor air problems is more effective and far less costly than crisis-reaction approaches, especially when considering the worst-case-scenario of closed facilities while problems are mitigated. The EPA resources, including the Tools for Schools kit provide a basic set of operations and maintenance guidelines to this end. They establish responsibilities and clear communication channels so that indoor air problems can be prevented and problems can be quickly identified and solved. In addition, the Tools for Schools system can be used to address other environmental health and safety conditions that may arise in schools.

Additional resources for creating and maintaining a high level of indoor air quality can be found on the Building Technologies Program website listed below.

See it in Action:

Hartford, CT Tools for Schools Champion

Connecticut's Public Act 09-81, Chapter 170, Section 10-220(d) requires schools to adopt and implement an indoor air quality (IAQ) program. Hartford Public Schools district, responding to the state's legislation, utilized the *IAQ Tools for Schools* Action Kit to mobilize staff to address IAQ issues and establish procedures that would lead to sustained improvements. Each school established a School Health and Safety Team that was trained to use information in the *IAQ Tools for Schools* Action Kit to identify, organize and prioritize IAQ issues- in both existing and new construction. For more information and examples of "IAQ Champions," visit the EPA Tools for Schools website.
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Resources

EPA, Environmental Protection Agency, Region 1 New England office in Boston, Massachusetts, phone: (888) 372-7341: http://www.epa.gov/iaq/

EPA, Healthy School Environment Resources:
http://cfpub.epa.gov/schools/top_sub.cfm?r_id=1

EPA, Tools for Schools: http://www.epa.gov/iaq/schools/

The Building Technologies Program Indoor Air quality Resources:
http://apps1.eere.energy.gov/buildings/tools_directory/subjects.cfm/pagename=subjects/pagename_menu=other_applications/pagename_submenu=indoor_air

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Develop and Implement a Master Maintenance and Staff Training Plan

All public jurisdictions should have a master plan for the maintenance of all equipment and the training of staff as well as a process for assuring that future additions and renovations adhere to high performance standards. The plan should include an asset inventory of all equipment in the new or renovated buildings, its preventive maintenance needs, and projected operating costs of the new systems. The inventory should cover at least the following systems:

- ❑ HVAC
- ❑ Plumbing
- ❑ Non-HVAC mechanical systems
- ❑ Lighting
- ❑ Building control systems
- ❑ Life and safety systems
- ❑ Interior finishes
- ❑ Roof systems
- ❑ Switchgear
- ❑ High efficiency lighting transformers

The plan should address the preventive maintenance needed including: staff/vendor time and materials costs for each maintenance task, a schedule for these tasks, and a clear definition of who is responsible for performing the task, as well as the overall management of maintenance activities.

Ongoing staff training in the maintenance and operation of the inventoried equipment should be an integral part of the plan and must include provisions for expanding the plan to include

any school additions and/or renovations.

Regular maintenance and staff training are critically important to the operation and performance of public buildings. Every district has unique maintenance needs, but districts should invest sufficient staff and resources to ensure that the building systems continue to operate as designed. District should also ensure that equipment added during future additions and renovations is properly maintained.

High performance buildings are not maintenance intensive. However, all buildings and building systems require preventative – not deferred – maintenance if performance goals are to be met.

Master plans should include:

- ❑ Regularly scheduled preventative maintenance tasks over the lifetime of the building system or equipment. These tasks include cleanings, calibrations, component replacements, and general inspections. A commissioning plan and the required maintenance documentation are excellent starting points and references for developing the maintenance plan. The plan should include staff/vendor time and materials budgets for each maintenance task and clearly define who is responsible for performing the task, as well as the overall management of maintenance activities.

- ❑ An ongoing training plan for staff in the operation and regular maintenance of all building systems.

- ❑ Provisions to incorporate newly added equipment and systems that result from equipment replacement, renovations, and additions.

Resources

New York City: Energy Efficiency Operations and Maintenance Plan:
http://www.nyc.gov/html/dem/downloads/pdf/EEOM_Plan.pdf

LEED Existing Buildings, Operations & Maintenance: This guide is
http://www.usgbc.org/ShowFile.aspx?DocumentID=3617; See page 30

Energy Star: Operations and Maintenance Best Practices Guide for Energy Efficient Buildings:
http://www.energystar.gov/ia/business/15best.pdf

Energy Star: Guidelines for Energy Management Overview:
http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index

Facility Energy Management Program:
http://www1.eere.energy.gov/femp/program/sustainable_buildings.html

Facility Operating Plan Template from Vermont Superintendent's Association: This template facilitates the creation of an operating plan to properly manage buildings for efficiency and educational atmosphere for Vermont schools.

http://www.vtvsa.org/school-energy-management-program.php

Train and Certify Facilities Personnel Through a Comprehensive O&M Training Program

A good example of a comprehensive O&M training program is The Building Operator Certification (BOC™), a nationally recognized training and certification program that focuses on practical skills improvement for facility operators. This program was developed by the Northwest Energy Efficiency Council and the courses are taught nationwide at select locations by an experienced group of instructors with practical experience in their subject matter. Locations where courses are taught can be found on the BOC website in the resources below.

Independent evaluation research shows that BOC certified operators are saving money and energy in their facilities. BOC operators apply concepts learned in training and undertake measures such as large energy conservation projects and IAQ improvements. Average annual per participant energy savings are estimated by this research to be 172,000 kWh per year, equivalent to $12,000 annually at national average electricity rates.

BOC participants earn certification by attending training and completing project assignments in their facilities. Upon successful completion of the course, operators have learned techniques that will assist with operating facilities in a manner that promotes energy conservation, indoor air quality, and enhances the environmental health and safety of building occupants.

The BOC is not the only program that teaches energy efficiency building operation and management skills. Other organizations, such as the Building Owners and Managers Association (BOMA) and the Association of Physical Plant Administrators (APPA), offer programs targeted towards their respective audiences which are real estate owners and educational facility managers. BOMA is an international organization that developed its curriculum in partnership with the U.S. Environmental Protection Agency ENERGY STAR program, and APPA specializes in campus management.

ENERGY STAR also has its own online training program that is free and available to the public at any time. It consists of live web conferences, animated presentations and pre-recorded trainings accessible from the website located below. There are workshops geared towards specific sectors such as government and educational organizations, healthcare or entertainment.

Additionally, many state agencies and utility companies periodically offer training sessions that are relevant for building operators. These trainings are often an introduction to the BOC, or are termed "BOC Light." Please consult the resources listed below for upcoming training opportunities in any of the above programs.

Resources

BOC Web site: http://theboc.info/index.html

BOC Training Locations and Schedules: http://www.theboc.info/h-training-locations.html#register

BOMA: http://www.boma.org/sustainability/Pages/education-training.aspx

APPA: http://credentialing.appa.org/

State and Local Energy Efficiency Action Network: http://www1.eere.energy.gov/seeaction/

Energy Star Free Online Training:
http://www.energystar.gov/index.cfm?c=business.bus_internet_presentations

Public Service of New Hampshire Seminars:
https://www.psnh.com/NewsEvents/Seminars.aspx

Efficiency Maine Training Programs: http://www.efficiencymaine.com/professional-training/

State of Connecticut Training Programs: http://www.ctenergyinfo.com/index.htm

Massachusetts Facilities Administrators Association: http://www.massfacilities.org/

NSTAR Electric Training Programs:
http://www.nstar.com/business/energy_efficiency/seminars/default.asp

National Grid Training Programs:
http://www.nationalgridus.com/masselectric/business/energyeff/3_training.asp

PEPCO (Maryland Operations) and Maintenance Training:
https://cienergyefficiency.pepco.com/OMTraing.aspx

BOC Tuition & Funding Opportunities

BOC Level 1: $1,595 per participant

The registration fee includes 74 hours of classroom instruction, seven course handbooks, facility project assignments, and certification recognition materials.

BOC Level II: $1,595 per participant

The registration fee includes 61 hours of classroom instruction, seven course handbooks, facility project assignments, and certification recognition materials.

Course Discounts and Tuition Reimbursement

Many sponsoring utilities and energy efficiency programs offer financial assistance for completing the BOC programs. To find out if discounts are offered in your area, contact your local energy efficiency program, which can be located through the Database of State Incentives for Renewables & Efficiency (DSIRE) (http://www.dsireusa.org/), or look up your local registration page from the BOC website above.

Training Staff To Ensure Occupant Behavior Contributes To The Efficient Operation of the Building

While there are many technologies that eliminate the human component of energy-saving measures, such as the installation of sensors that turn off light fixtures or building automation systems that control HVAC systems based on a schedule, there are still many opportunities for building occupants to reduce the energy consumption of the space occupied. By educating staff about the specific actions they can take to reduce energy consumption, as well as the impact their actions can have, significant savings can be realized.

Examples of recommendations include:

- ❑ Turn off desk and office lighting, and any other lighting not controlled by automatic controls, when a space is vacated
- ❑ Close windows and doors securely when HVAC system is operating, and conversely, shut-off or adjust thermostat settings when windows are opened for ventilation
- ❑ Turn off all computer peripherals and office equipment at the end of the workday
- ❑ Ensure faucets are fully off after use to prevent the waste of water

Teaming up with coworkers to develop a "Green Team" can be an effective way to encourage energy-efficient behavior through-out the workplace. The key to having a successful Green Team is to develop a list goals, and then work together to accomplish these goals. ENERGY STAR has a developed a check-list for Green Teams to use as a reference that can result in a more energy-efficient and a more engaged workplace:

http://www.energystar.gov/ia/business/challenge/bygtw/Green_team_checklist_FINAL_4.pdf

Implementing a system that provides real-time feedback regarding energy consumption is a helpful tool to encourage sustainable occupant behavior. Simply by making occupants aware of the effects of their actions can result in a change in behavior that leads to a reduction in total building energy consumption.

Outside of encouraging actions beneficial to the operation of the building, staff should also be encouraged to pursue actions beneficial to society. Such an example can include encouraging staff to bike, carpool, or take public transportation to work, which can also reduce employee's commuting costs.

See it in Action:

Energy Behavior Program in the Workplace: An Energy and Cost Savings Initiative from New Hampshire State Government

According to ACEEE 2012 report, "*Greening Work Styles: An Analysis of Energy Behavior Programs in the Workplaces*," government and institutional buildings are the best candidates to take the lead in promoting and set an example for energy behavior programs. An analysis of the reviewed case studies reports energy savings between 4% and 75% from standalone behavior program to comprehensive project with behavior component. Notable shared strategy among successful behavior programs is the use of community-based social marketing techniques and effective communication tools to engage building occupants.

As part of the interagency effort to encourage energy-savings behavior among state employees both at work and at home, New Hampshire recently launched an initiative that uses personal pledge forms asking employees to commit to various energy-saving actions, such as shutting off lights or unplugging appliances when not in use. The initiative accompanied with the use of prompt signs as action cue throughout state agency further increases the visibility of the program. The ACEEE 2012 study notes that personal pledge forms made in public often lead to a higher rate of actual action.

See it in Action:

UNH Unplugged Energy Challenge

The University of New Hampshire's (UNH) annual Unplugged Campus Energy Challenge began in 2006 to address and reduce the energy usage of on-campus residence halls and apartments. According to the UNH Unplugged website, UNH dorms emit 19,000 metric tons of greenhouse gas emissions every year. The Campus Energy Challenge focuses on educating and advocating for energy conservation behavior by encouraging students to turn off lights and unplug unused appliances. On-campus residence halls and apartments compete with one another and prizes are awarded to those who reduce their energy use the most.

Winners of the competition from previous years, such as Hubbard Hall, saved over 3,000 kilowatt hours of electricity in a 3-week period, a 15.9% reduction when compared to a baseline value. With comprehensive advocacy and education efforts on college campuses, occupant behavior holds serious potential for energy savings. Additional resources available to students from UNH Unplugged Campus Energy Challenge include virtual tour of an energy efficiency dorm, Energy IQ quiz, on-campus building energy use data, as well as useful energy saving tips.

Resources

US DOE Building Technologies Program – Manage Organization Energy Use in a Commercial Building: https://www1.eere.energy.gov/buildings/commercial/manage_energy.html

US DOE Building Technologies Program - "Achieving Energy Efficiency Through Real-Time Feedback": http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20930.pdf

The Center For The Built Environment – Analyzing Building Operators' Behavior to Reduce Energy Use in Commercial Buildings: http://www.cbe.berkeley.edu/research/operations.htm

Centerline (CBE Newsletter), Summer 2010 – "Behavior and Buildings – Leveraging Occupants to Improve Energy and Comfort": http://www.cbe.berkeley.edu/centerline/summer2010.pdf

Teamcore Research Group – "Human-Building Interaction for Energy Conservation in Office Buildings", 2012: http://teamcore.usc.edu/papers/2012/CRC_Final_Paper.pdf

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Strategies for Reducing Plug Loads: Behavior, ENERGY STAR Equipment and Advanced Power Strips

Behavior

The energy use of a facility is not only associated with the building systems (HVAC, lighting, etc.), but also with the supplementary equipment associated with typical operations. So-called "plug loads" are a rapidly growing portion of operating budgets because of the reliance on computer systems and other related equipment. Choosing efficient equipment has a large impact on energy consumption and costs and as buildings become more efficient, plug loads become a larger portion of the building's total energy consumption. Office, instructional, vocational, and cleaning equipment, as well as personal appliances brought from home, are all examples of plug loads. Most of this equipment is left on all day and can account for up to 25% of the electricity consumed annually. To conserve energy from these loads, O&M procedures should include plug load management approaches.

The National Renewable Energy Laboratory has published a guide outlining nine steps that a facility can undertake to reduce plug loads: http://www.nrel.gov/docs/fy11osti/51199.pdf. In general terms these steps cover the following actions:

1. Designate a "Champion" - a person or team to undertake the plug load reduction project
2. Establish a business case for the proposed actions
3. Benchmark current equipment with an audit and possible metering
4. Identify occupant's true needs
5. Eliminate unneeded equipment and select efficient equipment
6. Turn it off - during non-business hours equipment should be powered down
7. Institutionalize plug load reduction measures
8. Address unique plug loads such as vending machines
9. Promote building occupant awareness

The school environment provides a rich learning laboratory for students to learn about energy consumption in a way that is in line with Science, Technology, Engineering and Math (STEM) curriculum and to get involved in hands-on plug load reduction activities. A pilot program launched by the Green Schools Committee of the Massachusetts Chapter of the United states Green Building Council (USGBC) provides an example of how to bring plug load learning to life

in your schools. For more information: http://www.usgbcma.org/PlugLoad

Purchasing Policies: ENERGY STAR Equipment

Establishing a written policy that all newly purchased equipment and appliances to be used in the facility be ENERGY STAR compliant (in any product categories where there are applicable ENERGY STAR categories) will ensure that plug loads are kept to reasonable levels. Additionally, the policy should prohibit the purchase of low efficiency products, including incandescent task lights, halogen torchieres, and portable electrical resistance heaters.

The ENERGY STAR program was established to provide accuracy and consistency in energy usage ratings and to encourage the purchase of efficient equipment. The program maintains a database of compliant manufacturers and products, including computers, monitors, copy machines, water coolers, printers, scanners, refrigerators, ceiling fans, and washing machines. In many cases, equipment that exceeds ENERGY STAR's efficiency requirements is available and should be considered.

Advanced Power Strips

An additional option for reducing plug loads is the use of advanced power strips (APS). Two basic types are available. The first type of APS are essentially occupancy sensors for plug loads. These devices turn off some of their outlets when vacancy is detected, returning power to those outlets when the space is re-occupied. The second type of APS turns off peripheral devices when the power consumption at the "control outlet" drops to an off or hibernating level, such as when a computer goes into sleep mode. This second type of device is gaining better market acceptance as they are both less expensive and more consistent in operation than are occupancy based controls. Investing in devices such as these can reduce energy consumption and increase awareness of plug loads.

Another intuitive way to decrease plug loads is by data collection and feedback for behavior change. There are companies that offer energy monitoring devices that provide feedback on energy consumption. Users who are more aware of their consumption habits are more likely to reduce them through conscious adjustment of habits.

Resources

NREL Assessing and Reducing Plug and Process Loads in Office Buildings:
http://www.nrel.gov/docs/fy11osti/51199.pdf

ENERGY STAR: http://www.energystar.gov/

ACEEE: Plug Load Reduction – Rumsey Engineers:
http://www.institutebe.com/InstituteBE/media/Library/Resources/Green%20Buildings/Plug-Load-Reduction,-ACEEE.pdf

EPA: Managing Plug Loads:
http://www.epa.gov/climateleadership/documents/events/11feb_plugloads.pdf

Plug Load Action Plan Template (EnergySmart Schools):
http://apps1.eere.energy.gov/buildings/publications/pdfs/energysmartschools/ess_plug-loads-template.pdf

Guide to Operating and Maintaining EnergySmart Schools:
http://apps1.eere.energy.gov/buildings/publications/pdfs/energysmartschools/ess_o-and-m-guide.pdf

National Energy Education Development Project (NEED) – Plug Load Curriculum:
http://www.need.org/needpdf/PlugLoads.pdf

Steps for Energy Conservation & Efficiency

There are many opportunities for energy conservation and efficiency in our schools and public buildings. You might be wondering where to start. Although it can be overwhelming to determine your starting point, the first step is always to build a relationship with your custodial and facilities staff to find out what has already been done and what activities you can work together on moving forward.

"Low Hanging Fruit" Measures

Lighting

- Turn off lights when not in use and utilize daylight
- Post turn-off reminder sign near light switches
- Replace all incandescent bulbs with high efficiency CFL or LED lights

HVAC

- Keep large items away from air vent to avoid the obstruction of heat or AC flow into rooms
- Let your facility staff know if a room is uncomfortably hot or cold. Avoid opening of windows when the heat is on to minimize energy loss or plugging in space heater when it is cold.
- If possible, reduce the demand for heating or air conditioning in unoccupied areas in the building through shades and thermostat setting.

Electronics and Appliances (Plug Load)

- Turn off computers, printers, and other electronics when not in use.
- Use power strips to shut off multiple appliances and electronics at the end of the day
- Post signs about vampire or phantom loads to educate occupants about the amount of energy consumed when electronic devices are off or in standby mode

Occupant Behaviors and Education

- Hold public or intra-organizational training to educate staff and occupants on building energy/ resource uses and conservation tips. Publicize energy costs and savings.

Further Conservation & Efficiency Measures

Weatherization

- Utilize weather-stripping and caulk to seal leaks and drafts near windows, doors, and any other area where outside air may infiltrate the building

Lighting

- Install occupancy sensors

HVAC

- Keep regular maintenance of air filter in the ventilation systems and replace them based on manufacturer's recommendation.
- Identify ducts and pipes that are lacking insulation.

Appliances

- Decommission refrigerators for the summer in unoccupied buildings
- Set a policy that requires that all new appliances or electronics be ENERGY STAR rated or very energy efficient.
- Specify in procurement documents that an energy-consuming devices will be selected based upon the lowest lifecycle-cost, not the lowest first-cost

Water

- Install low-flow showerheads and sink aerators and worn washers to reduce water use
- Identify and repair leaky faucets

Anti-Idling Policies for School Buses and Other Vehicles

According to the Environmental Protection Agency (EPA), exposure to diesel exhaust, even at low levels, is a serious health hazard and can cause respiratory problems such as asthma and bronchitis. Diesel emissions are well-documented asthma triggers and may increase the severity of asthma attacks. Asthma is currently the number one cause of missed school days for American children, and asthma affects more than one in nine children in the Northeast. (Source: Asthma Regional Council Web site – see Resources below)

All school systems should adopt a no idling policy that applies to all school buses used to transport the students of the school. The policy should include the following minimum provisions:

- ❑ School bus drivers will shut off bus engines upon reaching destination, and buses will not idle for more than five minutes while waiting for passengers. This rule applies to all bus use, including daily route travel, field trips, and transportation to and from athletic events. School buses will not be restarted until they are ready to depart and there is a clear path to exit the pick-up area.

- ❑ Prohibit idling of all vehicles for more than five minutes (including all passenger vehicles and delivery trucks) in the school zone AND post appropriate signage.

- ❑ School bus companies and drivers will limit idling time during early morning warm-up to manufacturers' recommendations – generally five minutes in all but the coldest weather and for pre-trip safety inspections.

- ❑ Establish provisions for an indoor waiting space for drivers.

- ❑ Evaluate and shorten bus routes whenever possible, particularly for older buses with the least effective emissions control.

- ❑ All bus drivers will receive a copy of the school district's No Idling Policy or equivalent educational materials at the beginning of every school year.

- ❑ Establish a program to enable school children to enforce the anti-idling rules

Exceptions are appropriate only to meet state regulations or when running an engine is necessary to operate required safety equipment or perform other functions that require engine-assisted power, e.g., waste-hauling vehicles, handicap accessible vehicles, etc.

Resources

New Hampshire Department of Environmental Services, School Bus Anti-Idling Initiative: http://des.nh.gov/organization/divisions/air/tsb/tps/msp/irc/school-bus/index.htm

Asthma Regional Council of New England – School Bus No Idling Policy: http://asthmaregionalcouncil.org/uploads/IAQ/ModelNoIdlingPolicy.pdf

Anti-Idling Policies for Municipal Vehicles

Idling of both diesel and gasoline-powered vehicles should be avoided to protect health and to minimize the amount of fuel and money wasted. Municipal fleets present a unique challenge in anti-idling campaigns due to their various functions: police cruisers needing emergency radios and road/construction equipment needing auxiliary power, for example. Municipalities should consider adopting a no idling policy for their municipal fleets and should explore anti-idling retrofit technologies that are commercially available.

Establishing an Alternative Fueled Vehicle and Equipment Program

Beyond reducing the impact of diesel fueled buses and equipment, municipalities may want to consider adopting/promoting clean alternatives to diesel fuel for their school bus and public works fleets. The municipality should carefully consider the pros and cons of each type of alternative fuel.

- B-20 bio-diesel is a mixture of 20 percent agriculturally derived oils and fossil fuel. It burns cleaner than 100 percent diesel fuel, but is known to exhaust elevated levels of nitrogen oxides. B-50 and B-100 (50 percent and 100 percent agriculturally derived oils respectively) are also available in many areas. The oil is typically soybean derived and has been successfully used by the United States Military for years.

- Compressed natural gas (CNG) is an efficient and clean fuel. However, CNG refueling stations can be quite expensive to construct, so this option would be more attractive to communities with existing CNG fuel stations.

- Diesel hybrid buses employ a mixture of battery power and diesel fuel power. The technology is available for city transit buses and is currently being studied for its applicability to school buses. Early results indicate that "plug-in" hybrid electric-diesel vehicles, which charge at night, exhaust few emissions, and can reduce fuel costs over the life cycle of the vehicle.

- Recently, Kings Canyon Unified School District in California received the first all-electric school bus made by Trans Tech Bus and called the eTrans. It has a range of 45 to 120 miles based on a lithium-ion battery and should be competitively priced against other hybrid buses.

- In December 2008 the U.S. D.O.E. released a report to congress entitled "Fuel Cell School Buses", which documents the development of demonstration programs utilizing hydrogen fuel cells. To date, there have been several demonstrations of fuel cell or hybrid fuel cell battery buses for use in public transportation. However, fuel cell

See it in Action:

New York City Greens its Municipal Fleet

New York City's efforts to improve air quality as outlined in PlaNYC include reducing emissions from the transportation sector by reducing, replacing, retrofitting, and refueling vehicles. New York City's municipal fleet consists of more than 26,000 vehicles and motorized equipment, of which 25% are hybrid or alternative-fuel vehicles, making it the largest clean-fuel municipal fleet in the country. The City's Clean Fleet Transition plan seeks to convert the City's fleet to hybrid and electric vehicles. The City also works with the New York State Energy Research Development Authority (NYSERDA) to encourage private and non-profit entities to retrofit their vehicles with the assistance of the federal Congestion Mitigation and Air Quality initiative, as well as other funding sources. The City works with NYSERDA to encourage and support alternative-fuel vehicles, anti-idling technologies, and the installation of charging stations.

powered vehicles are very expensive to purchase and operate, and remain in an experimental phase.

Resources

EPA's Clean School Bus USA: http://www.epa.gov/cleanschoolbus/

DOE's Clean Cities: http://www1.eere.energy.gov/cleancities/

ICLEI's Clean School Bus Initiative Biodiesel Toolkit: http://www.icleiusa.org/action-center/learn-from-others/clean-school-bus-initiative-biodiesel-toolkit

Fuel Cell School Buses: http://hydrogen.energy.gov/pdfs/epact_743_fuel_cell_school_bus.pdf

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Maintaining Bicycle and Walking Access to the Facility

Proper maintenance of walking and bicycle paths and providing proper bicycle storage areas will help to encourage occupants to arrive at their location under their own power. Paths should be kept clear of dirt, stones, and especially broken glass. Warning signs where paths cross roads should be clearly visible and warning lines should be repainted annually. If the paths are part of a town or regional bike path system, it should be clearly understood what portions of the path are the responsibility of the building personnel to maintain.

Active methods of traveling to work also promote a healthier lifestyle. The 2012 Bicycling and Walking in the United States Benchmarking Report establishes that in areas where bicycling and walking rates are higher, obesity, high blood pressure and diabetes are lower.

In order to encourage active methods of transportation to work, and in addition to maintenance of paths, a shower area or changing room should be provided for the convenience of those participating. A bike rack in a secure enclosed space should be provided and kept free of other objects and debris. Providing storage for bike shoes and helmets will help keep the storage room tidy. Additional encouragement can be offered in the form of incentive or challenge programs that log how many miles have been commuted by the participant and how much fuel has been saved.

For the overall promotion of safe walking and biking to school, it is recommended that districts participate in the National Safe Routes to Schools Program: http://www.saferoutesinfo.org/

Resources

Employer's Commuting Guide: http://www.sfbike.org/?employers

Implementing a Successful Bicycle and Active Commuting Program: http://www.fedcenter.gov/_kd/Items/actions.cfm?action=Show&item_id=15046&destination=ShowItem

2012 Bicycling and Walking in the United States Benchmarking Report: http://www.peoplepoweredmovement.org/site/index.php/site/memberservices/2012_benchmarking_report/#findings

International Walk to School provides information on encouraging safe walking and biking to school: http://www.walktoschool-usa.org/

Phasing-out the use of CFC and HCFC-based Refrigerants

CFC and HCFC based refrigerants both contain chlorine, a chemical proven to be a significant contributor to ozone depletion. The production and sale of CFC refrigerant-based equipment was banned in the United States in 1995. However, many CFC based air conditioning systems are still in operation. "Virgin" HCFCs can no longer be produced or sold after December 31, 2009, and all HCFC refrigerants are scheduled to be phased out by 2030. Further, the U.S. Environmental Protection Agency is considering accelerating the phase-out of HCFCs.

Facility projects should not include the installation of CFC or HCFC-based refrigerants in building Heating, Ventilating, Air Conditioning, & Refrigeration (HVAC&R) systems when renovating or adding systems. Consider replacing any equipment that uses CFC or HCFC-based refrigerants and is over ten years old. It is economically beneficial to install newer, more efficient equipment and take advantage of efficiency program incentives. Implementing a plan to phase-out the use of such refrigerants in all existing equipment within five years will also return efficiency and environmental benefits.

In replacing such equipment no refrigerants should be released into the atmosphere. Licensed and trained contractors should remove the used equipment, complete with all refrigerants, for proper disposal/recycling.

Resources

Greening your Refrigerants; USGBC: http://www.fmlink.com/ProfResources/Sustainability/Articles/article.cgi?USGBC:200607-25.html

U.S. EPA Refrigerant Guidelines and Regulations: http://www.epa.gov/Ozone/title6/608/index.html

Utilizing Facilities as Teaching Tools

A high performance building offers an excellent opportunity to serve as a teaching tool for staff and the public. A plan to utilize schools and other facilities as teaching tools for environmental quality, energy efficiency, and renewable energy should include annual training of all relevant facility characteristics, as well as an informational kiosk or other display that presents these same benefits.

In particular, high performance schools should take advantage of the educational opportunity their buildings offer by providing information about the facilities to the students.

A successful plan will include at least the following elements:

- ❑ At least one annual workshop for staff that covers the educational and environmental benefits of the facility
- ❑ A plan to incorporate education regarding the high performance aspects of the school in science and vocational curricula, as appropriate depending on grade level taught
- ❑ An informational kiosk, or other display, in a public area of the building that presents the educational and environmental benefits of any energy efficiency project

See it in Action:

Blackstone Valley Regional Vocational Technical HS (Upton, MA)

Completed in 2006, the renovation and expansion project at **Blackstone Valley Vocational Technical High School** remodeled and upgraded its more than 40 year-old facility and added 80,000 sq. feet of additional classroom and showcase space. With eco-friendly design and construction, as well as numerous energy conservation measures, the high performance buildings achieves more than 40 percent in energy savings compared to other buildings meeting the state energy code. Some of the Blackstone Valley Technical's high-performance features include 43.4 kW peak capacity solar photovoltaic systems, daylight tubes and high-efficient lighting, efficient boilers, and displacement ventilation that help school officials save more than $160,000 per year in energy cost, according to a NREL's case study.

The school has sought the opportunity to incorporate the high performance features of the newly renovated features as a learning opportunity for its students; (i.e. the Energy Management System helps the students understand the building energy use.) In addition, the school district also generates curriculum that gears toward training in energy efficiency building construction and renewable energy education.

Figure: Exterior view of Merrimack Valley Regional High School (Pennacook, NH) Wood Chip Heating Plant. The smaller building near the entrance of the plant serves as the observation learning space for students and visitors.

Credit: The Jordan Institute

Resources for Schools

The Apeiron Institute's Schools Programs offer resources and curriculum for Rhode Island teachers and students: http://www.apeiron.org/new/education/index.php

Cape Light Compact's Energy Education Program provides materials, workshops, and support at no cost to Barnstable and Dukes Counties in Cape Cod: http://www.capelightcompact.org/ee/energy-education-program/

The Maine Energy Education Program (MEEP) provides experiential energy education programs for Maine students and teachers: http://www.meepnews.org/.

The National Energy Education Development Project (NEED) is a non-profit organization that works with students, educators, businesses, government, and community leaders to design and deliver energy education programs http://www.need.org. Their catalog of materials may be downloaded at http://www.need.org/needpdf/Catalog.pdf

The U.S. Department of Energy offers educational materials for K-12 including lessons plans: http://www1.eere.energy.gov/education.

The Vermont Energy Education Program (VEEP) VEEP provides training and curriculum materials for Vermont teachers on the topics of energy efficiency, renewable energy, and conventional energy sources: http://www.veep.org/.

Utilizing Computerized Maintenance Systems

Computerized maintenance management systems offer the opportunity to enhance maintenance practices through the automatic scheduling and tracking of maintenance procedures. Web-based services and stand-alone products are available. If a computerized maintenance system does not incorporate automated maintenance scheduling, the system can typically be upgraded to allow such capability.

See it in Action:

Computerized Maintenance Management Systems (CMMS) Applications in Newton, MA

Before its transition to using CMMS, the city of Newton, MA faced a long-standing problem with overdue maintenance work orders for its public buildings. The lag time caused by the use of the paper-based system often caused a lag time and a delay in the process. The lack of tracking and accountability further the exacerbated the prolonged deficit in the municipal operation and maintenance budget. Since 2007, the use of CMMS has enabled a faster process of work order and repairs. The ability to track and report budget, as well as the easy access by school administrators and other stakeholders, has resulted in higher accountability and budget stability. With the use of CMMS, the city of Newton processes over 7,500 work orders each year among its schools and public buildings.

Resources

Maintenance World is focused on facility maintenance and maintains a series of articles concerning software tools at this link: http://www.maintenanceworld.com/CMMS-software.htm

SchoolDude's suite of school scheduling programs: http://www.schooldude.com/

MicroMain™ software for preventive maintenance scheduling and automated work orders: http://www.micromain.com/industries-we-serve/education/

NetFacilities maintenance management software: http://www.netfacilities.com/

CMMS offers several different maintenance management tools: http://www.cmmssoftware.org/

National Institute of Building Sciences: Computerized Maintenance Management Systems: http://www.wbdg.org/om/cmms.php

*These are a sampling of available programs and tools; NEEP does not endorse any specific products.

II. Indoor Environmental Quality

A quality indoor environment is crucial to the health and performance of building occupants. Indoor air quality is the most obvious component of indoor environmental quality, but lighting and views of the outdoors also play a role. Proper indoor environmental quality reduces the potential for long and short-term health problems, which helps limit staff sick leave and student absenteeism. Excellent indoor environmental quality is maintained through careful long-term planning and proper maintenance procedures.

Maintaining Access to Views

Access to views has proven to be extremely beneficial in all work environments. A human connection to the natural rhythms of the outdoor environment is important to both mental and physical health.

In order to maintain access to views, the facilities staff should consider the following procedures:

- ❑ Make sure that all window blinds and shades are in good operating condition
- ❑ For schools, avoid displaying student projects on windows
- ❑ Establish a cleaning schedule for glazing and shades
- ❑ Control the growth of vegetation with potential to block view

Facilitating and Maintaining Daylighting Performance

Employees and students typically thrive in daylit spaces, but as with access to views, direct sunlight glare restricts the full use of daylighting in most facilities. Properly designed daylighting is the best way to illuminate building interiors. Several recent studies have shown that employee and student performance improves dramatically under daylit conditions. However, poorly designed daylighting doesn't provide the same benefits, and performance may actually deteriorate to levels below that of the performance under artificially illuminated spaces. There is also growing evidence that daylighting positively affects circadian rhythms, playing an important role in regulating sleep patterns.

In order to enhance and/or maintain the utilization of daylight, the following should be considered:

- ❑ Replace simple shades and blinds with window shade systems that allow incoming sunlight to be directed to ceiling and wall surfaces to facilitate glare-free daylighting. And, make sure that all window blinds and shades are in good operating condition
- ❑ Utilize blinds and shades to control excess daylighting to avoid glare and overheating of spaces. East and West exposures can be problematic year-round, while South exposures present special problems during the winter months
- ❑ When repainting walls and ceilings select paints with high reflectivity values (85 percent or higher) to allow these surfaces to be used to bounce indirect sunlight into the space.
- ❑ Avoid displaying school projects on windows

- ❑ Limit the display of school projects on walls that have indirect daylighting potential
- ❑ Establish a cleaning schedule for glazing and shades
- ❑ Control the growth of vegetation immediately adjacent to vision glazing
- ❑ Consider the installation of interior or exterior light shelves to reflect sunlight to ceilings to evenly illuminate the space
- ❑ Conduct a daylighting workshop for staff, discussing the advantages and demonstrating proper use of shades and blinds for daylighting performance
- ❑ Install automatic daylighting controls (refer to the Daylighting & Lighting Controls Sections of the Northeast CHPS Protocol for information regarding the installation and commissioning of Automatic Lighting Controls)

Resources

CHPS Best Practices Manual, vol. 2, "Daylighting and Fenestration Design" chapter: www.chps.net

LEED Existing Buildings, Operations & Maintenance: http://www.usgbc.org/ShowFile.aspx?DocumentID=3617; See page 73

Lighting Research Center: http://www.lrc.rpi.edu/researchAreas/daylighting.asp

Pacific Gas and Electric Daylight Initiative: http://www.pge.com/pec/daylight/daylight.shtml

HESCHONG MAHONE GROUP, INC., Daylighting Studies:

http://www.h-m-g.com/projects/daylighting/projects-PIER.htm

U.S DOE Building Technologies Solid-State Lighting: http://www1.eere.energy.gov/buildings/ssl/

Maintaining the Ventilation System with a Goal of Meeting ASHRAE Standard 62.1-2007 for Indoor Air Quality

Modern public buildings are designed and constructed to meet ASHRAE Standard 62.1 (2007 or 2010 depending on current codes) for ventilation rates and performance. Achieving good indoor air quality is critical to occupant health, maintained performance and regular attendance. Supplying fresh air to occupied areas is vital to the protection of good indoor air quality. Facility staff should ensure that the ability of the ventilation system to introduce outdoor air has not been compromised and that Standard 62.1 is met.

As ventilation systems age, controls drift out of specification and mechanical components fail. A common response to comfort complaints is to block-off or otherwise disable the introduction of outside air. Facility staff should strive to understand how the system is designed to introduce outside air, and provide ongoing maintenance and repair to ensure that outside air is delivered to the occupied spaces.

See it in Action:

Healthy Students

As an example of how a proactive approach to indoor air quality can help occupants, the Hartford public schools in Connecticut decreased asthma visits to their health rooms by implementing a proactive indoor air quality maintenance program.

This case study is available on the US Environmental Protection Agency website: http://www.epa.gov/iaq/schools/casestudies.html

If outside air has not previously been introduced to the facility, an overall HVAC system assessment will help to ensure that introducing outside air is accomplished cost-effectively and does not adversely affect control strategies and occupant comfort.

Resources

The American Society of Heating, Refrigerating and Air-Conditioning Engineers: http://www.ashrae.org/

LEED Existing Buildings, Operations & Maintenance: http://www.usgbc.org/ShowFile.aspx?DocumentID=3617; See page 63

Revised Standard 62.1 2007: http://www.techstreet.com/standards/ashrae/62_1_2007?product_id=1409997

U.S. EPA Creating Healthy Indoor Environments In Schools: http://www.epa.gov/iaq/schools/

Provide and Maintain Walk-Off Systems

Particles tracked into buildings are one of the chief sources of contamination of carpets and floors. Research on carpeting in particular shows that it can be a reservoir of pesticides,

heavy metals, and dust tracked in on occupants' shoes.

The best way to keep facilities free of dust, dirt, and contaminants is to prevent these unwanted items from entering the building in the first place. In school environments, it is especially important to protect young children since they are more likely to sit and play on classroom floors and therefore be more exposed to contaminants.

All buildings should have a walk-off system at any active entryway. At a minimum, for existing buildings, a 15 foot walk-off mat should be provided and frequently cleaned. When renovating, or when otherwise possible, a two or three-part walk-off system that also incorporates grills or grates in addition to a mat will provide enhanced protection.

Walk off system at New Hampshire school

Resources

American School & University article focusing on walk-off mats: http://asumag.com/mag/university_keeping_clean/

Environmental Design and Construction Magazine: CleanZone Matting System: http://www.edcmag.com/articles/the-cleanzone-matting-system

Cleanlink: http://www.cleanlink.com/sm/article/Matting-Leaving-Dirt-At-The-Door--9209

A Google™ search on the terms "school walk-off mats" generates dozens of suppliers. Specify mats with no PVC or other chemicals.

Reference article on money savings associated with this type of walk-off system: http://www.mcmorrowreport.com/sfm/articles/mats.asp

National Floor Safety Institute: http://www.nfsi.org/splash.php

See it in Action:

"Stomp Day" at Lamprey Elementary School (Raymond, NH)

Being one of the very first schools in the state to receive the Healthy Schools grant by New Hampshire Partners for Healthy Schools, Lamprey River Elementary School aims to implement strategies to improve indoor air quality (IAQ) in its school environment. One of the approaches that school officials have taken is the purchase of additional walk-off mats for building areas with higher foot traffic. Particular on "Stomp Days" the students are asked to stomp their feet from the buses until the end of the walk-off mats.

The practice helps to reduce the cleaning time and cost of hallway and school entrance and significantly reduces the amount of dust, dirt, and other pollutants coming off the shoes of 600-plus people entering the building each day. According to an industry report, it costs about $500 per pound to remove dirt tracked into a building; thus, capturing more dirt and contaminants by walk-off mats further reduces facility cleaning costs.

Preventing Irrigation Systems from Spraying Water on Buildings

Irrigation systems that spray water on buildings often cause structural damage and mold growth. Irrigation systems should be redesigned, relocated, and or adjusted to eliminate water spray on buildings.

Replace HVAC Filters on a Schedule

HVAC filters perform an important function, trapping airborne contaminants that would otherwise be re-circulated throughout the facility. But they are often neglected and left in place long after they have become clogged and ineffective. Air circulation becomes hampered, fan motors work too hard, and containments are often forced around filters and get reintroduced to the indoor environment. A log of filter replacement should be kept and dates should be written on filter frames or on filter doors when replacement is made. If filter doors are not readily accessible, modifying the configuration may be in order. Keeping to the recommended schedule for the filter and equipment type installed will enhance indoor air quality and avoid costly repairs.

Generally speaking, the higher the "Minimum Efficiency Reporting Value" (MERV) rating for filters, the more often they will need to be replaced in order to maintain airflow rates.

Resources

Furnace Filter Care is an independent website with extensive information on filters:
http://www.furnacefiltercare.com

Engineers' Edge article on filter types and performance:
http://www.engineersedge.com/filtration/air_filter_types.htm

Selecting and Upgrading HVAC Filters

The filtering efficiency of HVAC filters is measured on a scale termed the "Minimum Efficiency Reporting Value" (MERV). MERV ratings range from 1 – 16. The higher the MERV value the greater the ability of the filter to extract particulates from the airstream. Some of the common particles related to MERV ratings are dust, spores, bacteria, pollen, insecticide dust, and viruses. Minimizing exposure to viruses and common allergens are important goals for indoor air quality and related health issues. Higher MERV filters are somewhat more costly, and can restrict airflows making fans work harder, but the improvements in air quality outweigh the added expense when properly maintained. Following manufactures' recommendations, new high efficiency equipment must have comply with higher filtration requirement or warranty maybe voided.

Common filters found in residential use only have a MERV rating of 1 to 4. The unit ventilators commonly found in schools also often have filters that perform in that range while older unit ventilators typically utilize filters with a rating of MERV 2, and many had their filters removed or disabled over the years. Filters found in commercial equipment applications commonly rated at MERV 5 to 8. These filters will collect particles as small as 3 microns.

Filters with a MERV rating of 9 to 12 are used in commercial and industrial applications and will stop particles in the 1 to 3 micron range. The most efficient filters are rated at 13 to 16 and will capture particles as small as .3 microns. These filters are used in hospitals and other super clean environments. When using filters with MERV ratings above 8 it becomes critical to clean or replace them on the recommended schedule. If not maintained, filters will severely restrict air flow when they become clogged with dust, leading to performance problems and decreased operating efficiency.

See it in Action:

Keefe Regional Technical School (Framingham, MA) – HVAC filter upgrade

Looking to improve indoor air quality (IAQ) for its students, teachers, and staff, Keefe Technical School worked with National Air Filtration Association (NAFA) to upgrade its HVAC filter. The school also wanted to upgrade the filtration efficiency to meet or exceed the filter efficiency required by ASHRAE Standard 62.1. The decision to upgrade the filter to 4-inch MERV 11 pleated filter from the 8-inch cartridge type MERV 6 helps school officials to realize the cost savings associated with reduced and labor and disposal costs. The higher efficiency filters also keep the ductwork clean and optimize HVAC system operating efficiency and ultimately improve IAQ.

For most commercial air handling equipment found in schools and other public buildings, MERV 10 filters can be selected without major performance concerns. However, equipment manufacturer specifications and recommendations should be consulted. UVs can typically tolerate filters with MERV ratings no higher than 7.

Resources

Maintenance World article on selecting filters:
http://www.maintenanceworld.com/Articles/plantengineering/hvac-attack.htm

Furnace Filter Care is an independent website with extensive information on filters:
http://www.furnacefiltercare.com/merv-ratings.php

Engineers' Edge article on filter types and performance:
http://www.engineersedge.com/filtration/air_filter_types.htm

Maintaining Energy Recovery Ventilation Systems

Most schools and many other public buildings built in the last several years incorporate energy recovery ventilation (ERV) or heat recovery ventilation (HRV) for at least some of the high occupancy rate spaces. For simplicity we will refer to both system types as ERVs in this document. Maintaining proper operation of these units is critical for both indoor air quality and energy efficiency. The two most common types of ERV units are cross-flow plate units with heat exchange cores and units that utilize heat recovery rotating wheels. For any type of

ERV system to perform properly facility personnel must understand how the system functions and the intended control strategy, as well as perform scheduled maintenance.

Commissioning/retro-commissioning of ERV systems – Because they are an integral part of maintaining indoor air quality, ERVs should be properly commissioned (Visit Section VI for more on commissioning) upon installation. If the installed system was never commissioned, or is not functioning properly, retro-commissioning is called for. Commissioning should include calibration of the sensors and controls, measurement and balancing of airflows, training of facility personnel, and the delivery of a complete O&M manual.

Regular Maintenance – Although following the system supplier recommendations for scheduled maintenance is the recommended procedure, depending on system type, some of the maintenance duties may include:

- ❑ Replacing air filters
- ❑ Checking that outdoor air hoods are free of debris and snow/ice
- ❑ Making sure that any condensate drains are clear
- ❑ Check the operation of any frost protection cycle
- ❑ Clean and service the fans
- ❑ Following the manufacturer's recommendations, cleaning of the heat exchange core or wheel
- ❑ Cleaning of ductwork
- ❑ Checking the operation of automatic dampers
- ❑ Checking for the proper operation of system controls (CO_2 sensing, occupancy sensing, timer operation, and parallel control with standard ventilation system are all possible control schemes)
- ❑ Monitoring of CO_2 levels in occupied rooms and other regularly used areas will help ascertain if the system is delivery adequate outside air

Resources

ACEEE research paper on commercial ERV systems: http://aceee.org/research-report/a092

Sustainable Sources website article on ERVs:
http://energyrecoveryvent.sustainablesources.com/

Contracting Business website ERV maintenance article:
http://contractingbusiness.com/service/cb_imp_6051/

Replacing Pilot Lights with Electric Ignitions

Under certain conditions, the accumulation of carbon monoxide from pilot lights can cause dangerous air quality conditions for building occupants. Therefore, electric ignitions should be specified for all newly installed gas-fired equipment, including water heaters, cooking stoves/ovens, air handling units, and boilers.

Whenever possible, it is advisable to modify any existing gas-fired equipment of the above types with electronic ignitions. Installed equipment that retains pilot lights should be identified and included in scheduled maintenance checks.

Eliminating the Use of Fossil Fuel Powered Maintenance Machinery within the Building

If your facility still includes mobile equipment inside the building that burn gasoline, propane, or other fossils fuels, now is the time to retire them. Exhaust from equipment such as polishers, burnishers, fork-lifts, etc. pose a serious threat to indoor air quality. Electric powered alternatives are available for all such equipment, and have the added benefit of being significantly quieter.

Minimizing Mercury Exposure

Fluorescent lamps, high intensity discharge lamps, batteries, and many thermostats contain mercury. It is not possible to completely eliminate mercury from public buildings, but exposure risks can be minimized by eliminating mercury containing thermostats and other equipment, installing only low-mercury lamps, and labeling other products containing significant levels of mercury. In addition, the recycling of all fluorescent lamps and batteries should be included in a comprehensive recycling program.

According to the United States Environmental Protection Agency, mercury exposure is a serious health and environmental issue that should be addressed in all public buildings.

From the United States Environmental Protection Agency:

> "Health effects of mercury. Mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages. Research shows that most people's fish consumption does not cause a health concern. However, it has been demonstrated that high levels of methylmercury in the bloodstream of unborn babies and young children may harm the developing nervous system, making the child less able to think and learn.
>
> In addition, mercury poses a significant threat to the environment and wildlife. Birds and mammals that eat fish are more exposed to mercury than other animals in water ecosystems. Similarly, predators that eat fish-eating animals may be highly exposed. At high levels of exposure, methylmercury's harmful effects on these animals include death, reduced reproduction, slower growth and development, and abnormal behavior."

See Section X for more information on mercury recycling.

Resources

United States EPA:

- http://www.epa.gov/mercury/about.htm
- http://www.epa.gov/mercury/mgmt_options.html
- http://www.epa.gov/epawaste/hazard/wastetypes/universal/lamps/index.htm
- http://www.epa.gov/epawaste/hazard/wastetypes/universal/lamps/recycle.htm

Other Resources:

http://www.pprc.org/
http://www.newmoa.org/prevention/mercury/imerc/FactSheets/lighting.cfm
http://www.lamprecycle.org/

III. Integrated Pest Management

Integrated pest management (IPM) includes a set of techniques that are used to exclude pests from buildings and to destroy the habitat of pests by limiting their access to food, water, and free movement without dependence upon chemicals that are harmful to human health. Regular monitoring and record keeping is used to determine when treatments are needed to keep pest numbers low enough to prevent damage. Chemical controls are used only when necessary and in the least toxic formulations that are effective.

Insect and rodent allergens are known triggers for asthma, and pest infestation affects a range of other human health issues. In addition, pest infestation can be damaging to building structure and systems.

Research demonstrates that the use of insecticides and rodenticides helps to limit infestations, but does not eliminate them. Over time, repeated application of pesticides may lead to resistance among targeted species, requiring greater amounts, or the use of more toxic materials to achieve the same effect.

An IPM program should include, at a minimum, the following measures:

- ❑ For all exterior walls, foundations, attics, roofs, utility chases, and interior partitions and ceilings in food storage, preparation and disposal areas, and penetrations:
  - Block all openings in the enclosure larger than 1/4 inch by 1/4 inch with concrete or mesh-reinforced caulk or copper or stainless mesh or screen over openings that must allow air flow.
  - Caulk all cracks larger than 1/16th inch, including all plumbing and electrical penetrations.
- ❑ Keep all shrubbery a minimum of 10 feet from the building structure.
- ❑ Utilize dumpsters and other rubbish containers that seal tightly and locate them as far away from the building as practicably possible.
- ❑ Do not allow debris to collect near doors and other building openings.
- ❑ Protect building facades so that pigeons cannot roost.
- ❑ Maintain a schedule for the cleaning and degreasing of stoves, refrigerators, cabinets, floors, and walls in kitchens, bathrooms, lounges, etc.
- ❑ Minimize the use of hazardous pesticides.
- ❑ Maintain a schedule and record of treatment.
- ❑ The adoption of the IPM methods detailed in the EPA's *IPM for Schools: A How-to Manual* is recommended. Appendix B of the manual provides a guide for the

development of an IPM program. The manual may be downloaded free of charge from the following link: http://www.epa.gov/pesticides/ipm/schoolipm/index.html

Resources

EPA: *IPM for Schools: A How-to Manual:* http://www.epa.gov/pesticides/ipm/

State and Regional IPM Coordinators:
http://www.epa.gov/pesticides/ipm/ipmcontacts.htm#region1

Safer Schools IPM Guide including several case studies:
http://www.beyondpesticides.org/schools/publications/IPMSuccessStories.pdf

IV. Energy Efficiency

High performance buildings incorporate design features and systems that operate with minimal energy usage while providing superior performance. The buildings are well-insulated and resist uncontrolled infiltration/exfiltration. In addition, heating, ventilation, and lighting systems provide premium efficiency and improved comfort levels.

Commissioning, maintenance, and training are critical to the performance of the building and its systems and are key to maintaining energy efficiency. Commissioning involves a rigorous quality assurance program that ensures the building and its systems are built and operated optimally and that the facilities manager receives the proper training and documentation needed to operate and maintain the building. Chapter VI of this guide specifically addresses commissioning and retro-commissioning. No building can perform optimally without adequate maintenance. Training is critically important for maintenance staff to thoroughly understand how to maintain and operate the building systems, and when staff turnover occurs, documentation must be on hand for the training of new team members.

Understanding and Quantifying Energy Usage

The first step in operating a facility more efficiently is to understand energy usage by recording energy consumption by fuel type, identifying energy using equipment and energy associated building components, and identifying O&M energy efficiency opportunities.

Energy Surveys and Audits

Energy surveys and audits represent the systematic gathering of information that provides a path for determining the energy performance status of a facility at the time of the survey. It should provide a blueprint for identifying opportunities for energy efficiency improvements. Surveys and audits offer a critical starting point for identifying information about energy usage and the O&M procedures that will reduce operating costs for any facility.

CHPS Operational Report Card

The CHPS Operations Report Card (ORC) is an online benchmarking tool available to school building owners and operators. The ORC software generates a report card of results and provides recommended steps for improving maintenance and operations. The report card assesses participating schools according to seven categories: energy efficiency, thermal comfort, visual comfort, indoor air quality, acoustics, water efficiency and waste. To learn more about the ORC, visit the CHPS website.

There are several different types of audits, often available through state and local utility efficiency program that can be useful for identifying energy efficiency opportunities. Setting audit goals and budgets will help in selecting the most suitable type of audit for the facility. The most common types for school and public facilities are:

Walkthrough Audits – This type of audit can provide insight into building operations, equipment, and the associated energy usage. Metering and logging is not performed, but a comprehensive list of energy related factors can be developed that will prove useful in developing action plans. Some of the issues typically covered are:

- ❑ Building occupancy schedules

- ❑ Energy consumption from utility billing data
- ❑ Survey of plug loads such as computers, copiers, vending machines, etc., and their control strategies
- ❑ Lighting and lighting controls, including the illumination of unoccupied areas
- ❑ Type and age of heating and cooling equipment
- ❑ General condition of building envelope including windows and doors
- ❑ Renewable energy opportunities

Walkthrough audits completed at schools can include the participation of students, which can act as a valuable learning experience. Student surveys should always include an action plan that is acted upon by facility personnel and utilized as a starting point for further energy efficiency investigation.

Facilities Personnel Conducted Audits – The next step up are audits conducted by the facilities operations staff at the facility. The scope of these audits is only limited by the training and experience of the staff and the amount of staff time available. Training in the facilitation ofself-audits is often available through efficiency programs. These audits typically include all of the above elements plus:

- ❑ The control strategies, and their operational status for HVAC systems, such as temperature control and setbacks based on time and occupancy
- ❑ An evaluation of the physical condition of HVAC components
- ❑ A review of HVAC maintenance procedures

See it in Action:

"Greenprint" Report (Springfield, MA)

The City of Springfield's Department of Parks, Buildings and Recreation Management partnered with the 9th grade Environmental Science classroom from the Springfield Renaissance School for an educational project aimed at reducing energy consumption and saving money for the city. Students from the school conducted hands-on energy audits at four elementary schools, which they synthesized into a final report entitled, *Greenprint*.

Participating students outlined the energy conservation measures recognized for each school, along with payback periods, available incentives, and potential energy savings, and presented their findings to the Mayor. Involving students throughout the process brought a refreshing and persuasive perspective while attracting community support and media involvement.

- ❑ Nameplate information gathering of heating and cooling system model numbers, sizes and rated efficiencies
- ❑ A comprehensive survey of lighting equipment and controls
- ❑ A review of staff resources available for energy system maintenance and oversight

Third-party Comprehensive Audits – The most valuable energy surveys are third-party comprehensive audits. Conducted properly, they provide a comprehensive analysis of the status of the energy performance of the facility as well as specific recommendations for

improvement. Third party audits are relatively expensive, but funding is often available through government or utility managed efficiency programs.

The audit analysis should include at a minimum:

- ❑ All of the elements listed in the walkthrough and facility personnel audits
- ❑ A full breakdown of energy usage by system type (lighting, heating, air conditioning, plug loads, etc.)
- ❑ An analysis of energy usage trends over at least a full year's time period
- ❑ Low cost/no cost recommendations for improving the operational efficiency of installed equipment
- ❑ Recommendations for the retrofit and/or replacement of energy using equipment
- ❑ Referrals to appropriate energy efficiency programs for the funding of projects

Time-of-Use and Streamlined Building Modeling Assessments

Assessments using alternate methods to the methods described above are beginning to be offered. These methods incorporate new data sources, such as energy consumption data associated with time-of-use (TOU) meters, and/or new analytic tools, including streamlined building energy modeling protocols, that have not yet been integrated into the standard ASHRAE approach. The main advantage to these newer evaluation methods is a much quicker and less expensive energy assessment.

Assessments that use time-of-use meter data are limited to facilities with time-of-use electric meters (also called interval meters). Reviewing these data provides insight into a building's operations that a traditional analysis, which relies on monthly consumption reports, would often miss, such as whether a building's electric demand remains high overnight when it would commonly decrease. Conversely, if an on-sight visit is not conducted, a time-of-use assessment may miss equipment-based energy savings opportunities.

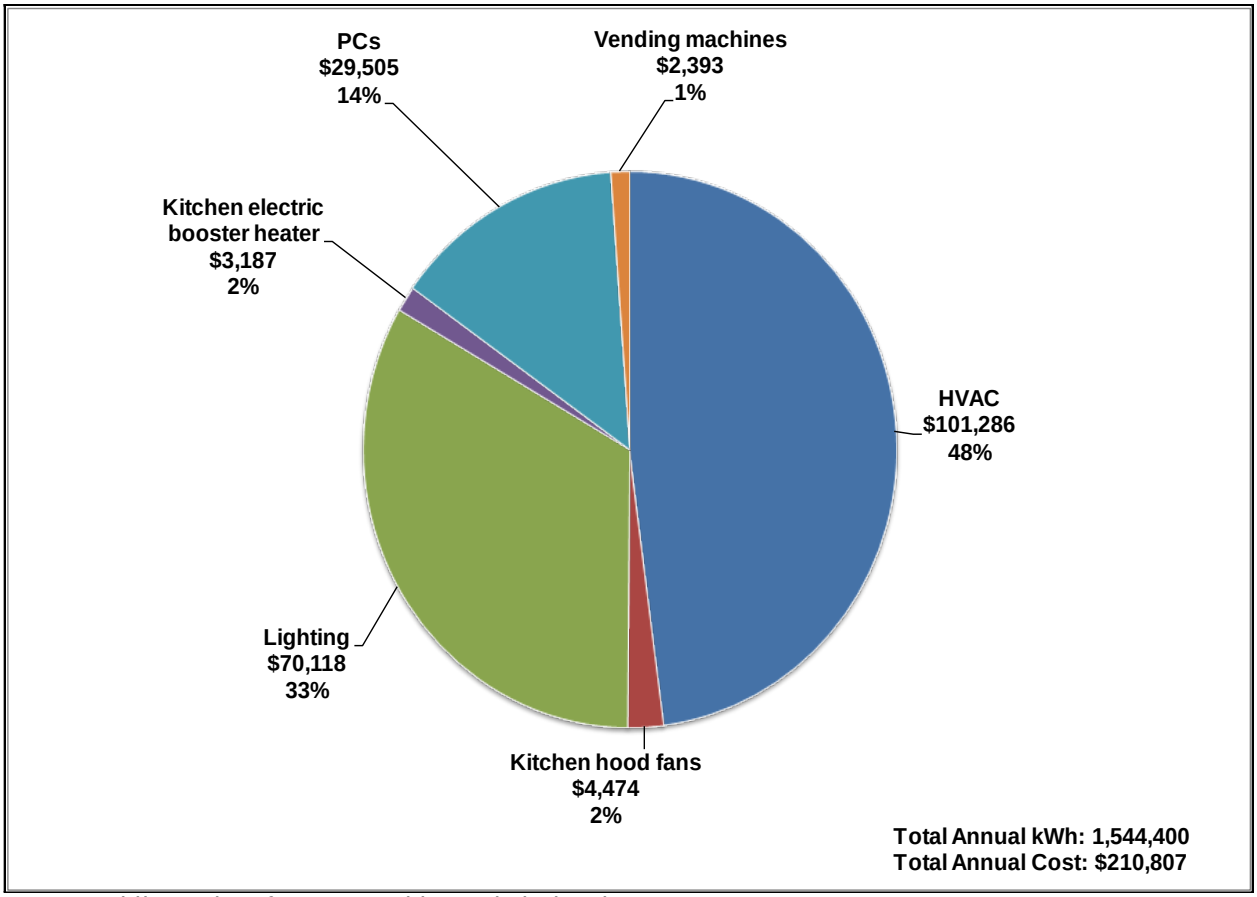
Resources

How to Choose an Energy Assessment for Municipal Buildings in Massachusetts:
http://www.mass.gov/eea/docs/doer/green-communities/eap/audit-recommendations-for-municipalities.pdf

Field Guide to New Hampshire's Municipal Buildings & Energy Audit Guidelines
http://www.nhsea.org/download/Audit_Guidelines_Nov2011.pdf

SEE Action, Energy Audits and Retro-Commissioning: State and Local Policy Design Guide and Sample Policy Language:
http://www1.eere.energy.gov/seeaction/pdfs/commercialbuildings_audits_rcx_policy_guide.pdf

Figure 1
Energy Usage Breakdown from Actual New Hampshire Middle School Audit



Source: Public Service of New Hampshire Technical Assistance Program

Figure 2
Energy Efficiency Recommendations from the Same NH Audit

No.	Energy Efficiency Measures	Energy Savings (kWh)	Demand Reduction (kW/mo)	Gas Savings (therms/yr)	Total Cost Savings ($/yr)	Installed Cost	Simple Payback (Years)
1	EMS Optimization - Demand contr ventilation	-	-	10,633	$12,015	$7,000 - $8,000	0.6 - 0.7
2	Replace electric booster heater with gas-fired equivalent	30,799	31.5	(1,917)	$3,473	$2,500 - $4,000	0.7 - 1.2
3	Vending miser	8,974	-	-	$908	$1,200 - $1,300	1.3 - 1.4
4	Building envelope improvements	-	-	4,078	$4,608	$6,300 - $6,900	1.4 - 1.5
5	Motor Replacement and VFD Installation	167,440	-	-	$16,938	$27,000 - $30,000	1.6 -1.8
6	Lighting controls	23,865	-	-	$2,414	$5,000 - $6,000	2.1 - 2.5
7	Lighting Retrofit	146,930	45.7	(2,951)	$15,188	$65,000 - $75,000	4.3 - 4.9
8	Install Daylight Controls	800 - 900			$80 - $90	$700 - $800	8.8 - 8.9
9	Kitchen hood control	1,275	-	671	$888	$11,000 - $12,000	12.4 - 13.5
Totals		**379,283**	**77**	**10,514**	**$56,432**	**$125,700 - $144,000**	**2.2 - 2.6**

Source: Public Service of New Hampshire Technical Assistance Program

Benchmarking Facility Energy Usage

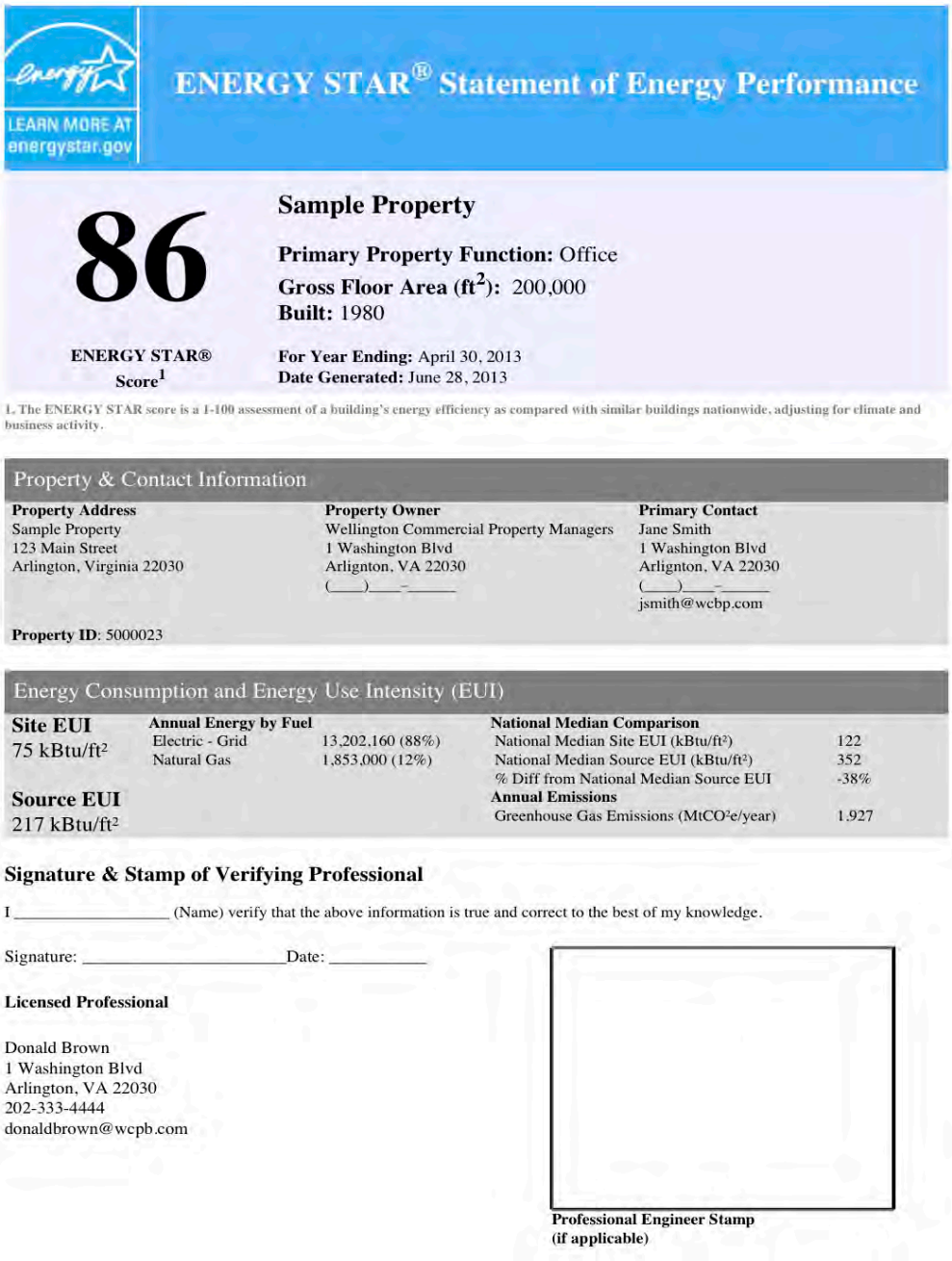
Benchmarking is a process by which municipalities can tabulate and compare their buildings' energy use with similar buildings around the region, or nation. The information obtained through benchmarking is useful for identifying potential problems and to provide the impetus for municipalities to pursue energy upgrades.

As with comprehensive auditing, one of the primary steps is to develop a report of a building's energy usage through current and historical consumption and from utility bills and/or energy management systems. Many utilities will provide online access to account information, easing the administrative burden.

The online benchmarking tool, ENERGY STAR Portfolio Manager, provides a relatively simple method for assessing a building's energy performance and water consumption in relation to other similar buildings. Users input building specific construction and usage information, as well as energy billing information. An energy consumption score ranging from 1 to 100 is calculated for comparing the energy performance with the performance of similar buildings. The tool is also useful for benchmarking ongoing performance compared with historical performance for the same facility. A "Benchmarking Starter Kit" is available at; www.energystar.gov/benchmark. When seeking a Portfolio Manager Statement of Energy Performance, discussions with a Registered Professional Engineer should start early in the process to ensure that the process and expectations are understood by all parties. A sample Statement of Energy Performance is illustrated in Figure 3. It should also be noted that an in-house trained energy professional or facility manager can use Portfolio Manager to benchmark their building's energy performance. A sample Statement of Energy performance is illustrated in Figure 3.

Figure 3
Example Portfolio Manager *Statement of Energy Performance*

http://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/verify-and-document/sample



LEARN MORE AT energystar.gov

ENERGY STAR® Statement of Energy Performance

86

ENERGY STAR® Score[1]

Sample Property

Primary Property Function: Office
Gross Floor Area (ft²): 200,000
Built: 1980

For Year Ending: April 30, 2013
Date Generated: June 28, 2013

1. The ENERGY STAR score is a 1-100 assessment of a building's energy efficiency as compared with similar buildings nationwide, adjusting for climate and business activity.

Property & Contact Information

Property Address	Property Owner	Primary Contact
Sample Property 123 Main Street Arlington, Virginia 22030	Wellington Commercial Property Managers 1 Washington Blvd Arlignton, VA 22030 (____)____-_____	Jane Smith 1 Washington Blvd Arlignton, VA 22030 (____)____-_____ jsmith@wcbp.com

Property ID: 5000023

Energy Consumption and Energy Use Intensity (EUI)

Site EUI
75 kBtu/ft²

Source EUI
217 kBtu/ft²

Annual Energy by Fuel	
Electric - Grid	13,202,160 (88%)
Natural Gas	1,853,000 (12%)

National Median Comparison	
National Median Site EUI (kBtu/ft²)	122
National Median Source EUI (kBtu/ft²)	352
% Diff from National Median Source EUI	-38%
Annual Emissions	
Greenhouse Gas Emissions (MtCO²e/year)	1,927

Signature & Stamp of Verifying Professional

I _____ (Name) verify that the above information is true and correct to the best of my knowledge.

Signature: _____Date: _____

Licensed Professional

Donald Brown
1 Washington Blvd
Arlington, VA 22030
202-333-4444
donaldbrown@wcpb.com

Professional Engineer Stamp
(if applicable)

Resources

Department of Energy – Schools
http://www1.eere.energy.gov/education/school_buildings.html

Department of Energy – Asset Rating
http://apps1.eere.energy.gov/buildings/commercial/resource_database/detail.cfm?p=562

ENERGY STAR Portfolio Manager: www.energystar.gov/benchmark

National Association of State Facilities Managers provides information of facility assessment: including energy usage: http://www.nasfa.net/

MassEnergyInsight - MassEnergyInsight is a web-based tool to help Massachusetts cities and towns manage energy use of municipally owned buildings, streetlights, and vehicles. http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/massenergyinsight.html

ESTABLISH A POLICY TO DISCLOSE AND RATE THE ENERGY USE OF ALL PUBLIC BUILDINGS

As states ramp up their energy and carbon savings goals, one innovative policy energy is mandatory building energy ratings. Policies requiring that buildings be rated for energy use, with that rating publicly disclosed, can help transform the market by requiring that meaningful information about building energy performance be disclosed to potential buyers, renters and the public. This also encourages compliance with the code, facilitates code enforcement and increases the likelihood of cost-effective energy efficiency upgrades in buildings.

A building energy rating policy, ensures that public building administrators measure their buildings' performance annually, institute continuous improvement practices, benchmark against other buildings (within or outside of their own fleet), and establish performance targets in their annual plans and objectives.

See it in Action:

Boston, MA: Building Energy Reporting and Disclosure Ordinance (BERDO)

On May 8, 2013, Boston became the first city in New England and the eighth nationwide to enact a building energy disclosure ordinance for all large buildings. Leading by example, the City will annually disclose energy and water use in all its facilities starting in 2013. Over the next five years using a phased in approach, all non-residential buildings sized 35,000 square feet, or greater, will be required to annually report their energy and water usage data and benchmark their buildings through ENERGY STAR Portfolio Manager, or an equivalent mechanism approved by the City's Air Pollution Control Commission.

Buildings that are unable to demonstrate high energy performance or continual improvements over time will be required to conduct energy assessments every 5 years to identify opportunities for energy efficiency retrofits and building upgrades.

Other major cities such as New York City, Philadelphia, Washington, D.C., Seattle, and San Francisco have also passed similar energy reporting and disclosure requirements as an effective policy measure to reduce energy and greenhouse gas emissions in their jurisdictions.

For more, visit: http://www.cityofboston.gov/environmentalandenergy/conservation/berdo.asp

See it in Action:

Arlington County, VA: Fresh AIRE Program and Building Energy Report Cards

Through its Fresh AIRE program and innovative Building Energy Report Cards idea, the County has dramatically reduced energy consumption in its buildings, and since 2007 is saving $400,000 annually in avoided energy costs.

For more visit: http://www.arlingtonva.us/portals/topics/aire/BuildingEnergy.aspx

Resources

Benchmarking and Disclosure: State and Local Policy Design Guide and Sample Policy Language
http://www1.eere.energy.gov/seeaction/pdfs/commercialbuildings_benchmarking_policy.pdf

Benchmarking Fact Sheet
http://www1.eere.energy.gov/seeaction/pdfs/commercialbuildings_factsheet_benchmarking_localgovt.pdf

BuildingRating.Org
http://www.buildingrating.org/content/us-policy-briefs

Valuing Building Energy Efficiency through Disclosure and Upgrade Policies: A Roadmap for the Northeast U.S. Update and Lessons From the Field
http://www.neep.org/Assets/uploads/files/public-policy/building-energy-rating/NEEP_BER_Report_12.14.09.pdf

Department of Energy Buildings Performance Database
http://www1.eere.energy.gov/buildings/commercial/bpd.html

Implementing a Master Energy Efficiency Plan

Armed with the information garnered from audits and/or benchmarking, it is valuable to develop and implement a master plan for energy efficiency improvements. In developing this plan it is best to set energy usage reduction goals for the facility. Benchmarking the building against other similar buildings can be very useful in setting these goals. In most cases, improving the energy efficiency of existing buildings by at least 15 percent is very reachable without major renovations. Lighting retrofits, HVAC tune-ups and maintenance, installation or the commissioning of existing automatic controls, and the tightening of building envelope often will achieve this level of savings.

Items that should be considered in a Master Plan include:

- ❑ Management and reduction of plug loads
- ❑ Lighting controls
- ❑ Light power density (lighting power per ft² of floor space)
- ❑ Mechanical equipment efficiency
- ❑ Domestic water heating efficiency
- ❑ Fundamental economizer performance if air conditioning is installed
- ❑ Fenestration performance

It is important to educate and inform buildings occupants including, staff, teachers, and students of the plan and the benefits of the various energy efficiency improvements taking place throughout the facility.

Municipalities should work with local and state-wide energy efficiency programs to identify and address all cost-effective energy efficiency opportunities. Additionally, the DOE Building Technologies Program provides useful guides and data to assist with making these decisions: https://www1.eere.energy.gov/buildings/index.html

Resources

Core Performance Guide by New Buildings Institute, Inc. 2007 edition: http://www.newbuildings.org.

ANSI/ASHRAE/IESNA Standard 90.1 – *Energy Standard for Buildings Except Low-Rise Residential Buildings*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA, 2004, 2007, 2010: http://www.ashrae.org.

ENERGY STAR – A federal-government-sponsored program helping businesses and individuals protect the environment through superior energy efficiency: http://www.energystar.gov/

DOE – Energy Smart Schools program: http://doe.cefpi.org/

The Database of State Incentives for Renewables & Efficiency (DSIRE) provides a comprehensive list of energy efficiency programs by state, which may be able to provide

technical assistance and financial incentives for energy-efficiency projects: http://www.dsireusa.org/

Efficiency Vermont: http://www.efficiencyvermont.com /

Long Island Power Authority (LIPA): http://www.lipower.org

Mass Save: http://www.masssave.com/

National Grid: https://www1.nationalgridus.com/CorporateHub

SEE Action, Strategic Energy Management: http://www1.eere.energy.gov/seeaction/pdfs/commercialbuildings_factsheet_strategicenergymanagement_stateandlocal.pdf

US DOE Building Technologies Program: https://www1.eere.energy.gov/buildings/commercial/index.html

Maintaining the Building Envelope for Energy Efficiency and Occupant Health

Controlling air and water leakage are critical to controlling energy usage in any facility. Even if best practices were followed during construction, continual attention to the building envelope is necessary if energy costs are to be controlled. Inspection and repair of envelope penetrations, roof and wall transitions, and fenestrations should be a part of the regularly scheduled building maintenance.

The regularly scheduled maintenance of the building envelope should include:

- ❑ The inspection of exterior walls and roofs for the deterioration of materials and the growth of molds or algae.
- ❑ For masonry construction, mortar should be checked or cracking and re-pointed as needed. Efflorescence, the deposit of salts on exterior masonry surfaces is an indicator of air and vapor leakage through the structure.
- ❑ The removal or trimming of tress or shrubbery growing close to buildings that might contribute to mold and fungus damage, or block access for regular maintenance.
- ❑ The inspection of all windows and doors for signs of failing caulking and weather stripping. If caulking is cracked, it is often best to remove and recaulk, rather than to attempt a surface patch. Be sure to select caulks formulated for the particular building materials to be sealed.
- ❑ The inspection and sealing/resealing of all envelope penetrations (pipes, vents, ducts, conduit, etc.)
- ❑ The inspection of all transitions from one envelope element to another (foundation to walls, walls to roof, wall assembly to wall assembly, etc.). These areas are all prone

to air and water leakage and often are never properly sealed at the time of construction.

- ❑ As much as is practicable, the inspection of insulation for signs of water absorption from leakage or from vapor diffusion. Wet insulation has very little insulating value and is a prime candidate for mold growth.
- ❑ The cleaning of all rain gutters and downspouts to ensure that water is transported away from the building.
- ❑ Consider periodically hiring a firm or individual to perform infrared photographic thermal imaging/scanning of the building envelope to identify areas of excessive air leakage, insulation gaps, and wet or deteriorated insulation.
- ❑ For smaller areas that can be isolated, consider hiring a firm to conduct blower door testing to evaluate the air-tightness of the area.

Resources

U.S. Environmental Protection Agency, Tools for Schools, Inspection Guidelines: http://www.epa.gov/iaq/schools/actionkit.html

The Air Barrier Association of America provides a wealth of information concerning the techniques and materials involved in properly installing air barriers, and air sealing techniques: http://www.airbarrier.org

National Inspection Services, "Tips for Inspecting and Maintaining a Commercial Property": http://www.nationalinspection.net/inspection_articles/commercial-inspection-articles/maintaining_a_commercial_property/

For information on blower door testing, visit the following DOE Web site: http://energy.gov/energysaver/articles/blower-door-tests

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Energy Management Systems (EMS)

With the installation of an EMS, proper training of maintenance staff is absolutely critical. The district must be prepared to budget for training both existing staff and new staff hired when those knowledgeable about the EMS leave employment. Too often system automation is overridden due to failed components, lack of proper documentation, and/or lack of operator training in the system.

The monitoring capabilities of EMS allows for the comparison between various types of building loads throughout all spaces of the building. This information can be used to manage and optimize energy use.

When installing or upgrading an EMS, the system should be capable of the following:

- ❑ The monitoring and trending (create trend logs) of controlled variables at the operator interface. Control variables may include air and/or water flow, temperature, pressure, CO_2, and pump or fan speed.
- ❑ The trending of outdoor air temperature.
- ❑ Monitoring and trending of the status for all equipment with motors greater than 1 hp.
- ❑ Indication and trending of damper and valve commanded position.
- ❑ Monitoring of building electrical, natural gas, and heating oil demand and consumption.
- ❑ Monitoring indoor and outdoor CO_2.
- ❑ Data storage – A data storage system with adequate capacity to record trend data for use by building operators. Data export requirements should facilitate user-friendly data access and manipulation.
- ❑ Operator interface – An operator interface designed for remote/Web access, monitoring requirements, trend-log reporting, and diagnosing building problems through a user-friendly interface. This includes providing a visual (non-text based) operations and reporting interface to facilitate rapid system assessment that utilizes color coding, diagrams of floor plans, and graphing capabilities.

Maintaining and Retrofitting Lighting Systems

Quality lighting is crucial for work and educational environments. Good lighting design and the use of appropriate lighting technologies are important, but proper maintenance is equally important to preserve performance. Proper maintenance will keep lighting systems operating efficiently, keeping lighting levels up and energy costs under control.

Lighting Maintenance

Even the best designed lighting systems will lose significant lighting output if not properly maintained. Lamps and fixture surfaces collect dust rapidly and lenses and painted surfaces are attacked by ultraviolet radiation, losing their abilities to transmit or reflect light. Proper maintenance will keep lighting levels up to specified levels and forestall lighting replacement and redesign.

A lighting maintenance plan should be developed that includes:

- ❑ The periodic cleaning of lamps, lenses, and fixture surfaces (annually or more often)
- ❑ Visual inspection for faded or flickering lamps
- ❑ The measuring of light levels with a simple foot-candle meter to address low-light level complaints
- ❑ Inspection of manual and automatic controls for proper function and to make sure controls have not been disabled
- ❑ The cataloging and stocking of proper replacement lamps and ballasts

- ❑ The replacement of all incandescent lamps with the appropriate compact fluorescent lamp or a complete linear fluorescent fixture

- ❑ A lamp recycling policy and a proper storage place for lamps awaiting recycling (See Section X for more information on mercury recycling)

Re-lamping Fluorescent Fixtures

Depending on the lamp selected, fluorescent lamps have an average life of 10,000 to 30,000 operating hours. The way lamps are rated, the average life is the number of operating hours at which half of the installed lamps are expected to fail, based on testing of that lamp type. The average life will vary somewhat based on operating temperature and the number of on/off cycles.

Heads Up – PCBs in Lighting Ballasts:

PCBs are suspected carcinogens and may still be in older schools

Congress banned the manufacture of a potentially harmful chemical, polychlorinated biphenyl (PCBs) in the United States in 1977. However, recent EPA inspections in New York City public schools found that many light ballasts in these schools contained PCBs and had also failed, causing the PCBs to leak.

The EPA presents a detailed explanation for PCBs in schools, as well as inspection results from NYC schools on its website. According to the EPA, any building built before 1979 likely has PCB-containing ballasts that should be removed in order to avoid potential degradation and exposure to PCBs from these older fixtures. Guidance from the EPA, along with several frequently asked questions concerning retrofitting PCB containing ballasts, can be found here. By taking advantage of these resources, school districts may overcome the lack of awareness concerning the associated risks and mishandling of PCB materials, ensuring responsible action is being taken to avoid exposing students and staff to a potentially hazardous pollutant.

Group re-lamping is often promoted as a maintenance cost-savings strategy. Group re-lamping refers to replacing all of the lamps in a room or area at one time whether they have failed or not. It is sometimes recommended by lamp manufacturers that group re-lamping be performed when the first lamps in an area fail. This is a costly mistake, as a small percentage of lamps fail long before average life is reached. A much better group re-lamping strategy is to replace all lamps in an area when they have operated for approximately 75 percent of their rated life. This will mean that operating hours will need to be estimated for space types, and spot re-lamping will need to be performed for early burnouts. Any easier way to obtain similar results is to spot re-lamp until a particular area becomes problematic with lamp failures and then replace all lamps. Date-marking lamps with a Sharpie™ will allow the prevention of replacing a new lamp that was a spot replacement. Cleaning fixtures during re-lamping saves a separate effort.

Spot re-lamping involves replacing individual lamps as they fail. This can often be effectively done as part of a room cleaning routine. A workable approach can be to replace all lamps in a fixture when one of them fails. Badly flickering lamps should be replaced immediately as the flickering is a distraction for students and teachers and usually signals a lamp that is near failure or has a failing ballast.

Fluorescent Ballast Replacement

Note: In many jurisdictions, lighting ballasts may only be replaced by licensed electricians.

Fluorescent lighting ballasts fall under two general categories: electronic and magnetic. Most general use lighting ballasts manufactured today are electronic. But magnetic ballasts represent the vast majority of ballasts installed prior to the 1990s. When magnetic ballasts are near failure, they often become noisy (buzzing sounds) and often cause excessive lamp flicker. Rather than replace them with ballasts of the same specification, a better approach is to retrofit the fixture with electronic ballast, or ballasts, and T8 lamps (see the Lighting Retrofit guidance in Section IV).

Older magnetic ballasts may contain PCBs and should be considered hazardous waste. Regardless, all ballasts removed should be disposed of with a certified recycling service. Most services will provide bags and barrels for the storage of ballasts to be recycled.

HID Lighting Maintenance Issues

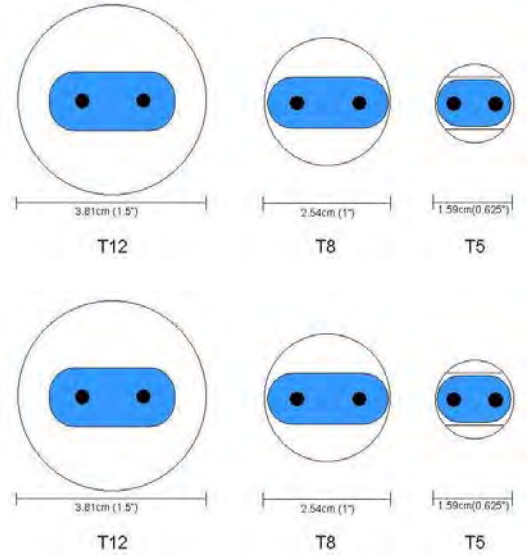
High intensity discharge (HID) lighting includes metal halide, high-pressure sodium, and mercury vapor lighting. Mercury vapor lighting is now rarely seen, but metal halide is often used for gymnasium lighting, and both metal halide and high-pressure sodium are found in exterior lighting fixtures. Although HID lamps are long lived, they do not maintain their initial light output as well as fluorescent lamps. For this reason, lamps should be observed for significant output reductions and replaced at that time. HID lamps may also start to cycle on and off when nearing end-of-life. HID ballast often become very noisy when near failure and should be replaced when loud buzzing is heard. HID ballasts represent most of the cost of an HID fixture, so ballast failure is a good time to replace the fixture with a more efficient option such as fluorescent high-bays.

Lighting Retrofits

Public buildings require high-quality electric lighting when daylighting is not available or is insufficient. High-quality electric lighting provides adequate light for the task, improves the rendering of colors, reduces glare, and saves energy. Retrofitting lighting fixtures offers an excellent opportunity to improve facility performance and appearance. With the incentive programs available throughout the region, lighting retrofits pay for themselves very quickly.

Most lighting fixtures installed in schools prior to the 1990s utilize T12 (Tubular 1½" diameter) fluorescent lamps. Modern T8 lamps (Tubular 1" diameter) and their associated electronic ballasts are more efficient, produce higher quality light, maintain their output better (lumen maintenance), and last longer. Nearly all T12 lighting fixtures can be retrofitted with T8 lamps and electronic ballasts. In addition, retrofit kits are available which replace ballasts, lamps, and reflective fixture surfaces as a unit.

Figure 4
T = Tubular, Followed by the Diameter in 1/8" Increments



T8 Lamps & Ballasts – Modern T8 lamps paired with electronic ballasts, provide high-quality lighting combined with excellent energy efficiency. Additionally these systems maintain their light output better over time than do the standard T12 lamps they have replaced. High Performance T8 (HPT8, as defined by CEE, the Consortium for Energy Efficiency) lamp and ballast systems provide enhanced efficiency when compared with other T8 systems. Their costs are only slightly higher than standard T8 systems, and are readily available through normal distribution chains. High Performance systems are listed on the Consortium for Energy Efficiency's (CEE) Web site: http://www.cee1.org./. Most energy efficiency incentive programs throughout the region also use the CEE list for incentive qualification.

T5 Lamps & Ballasts – T5 (5/8" diameter) lamps are also excellent choices for classroom lighting when the fixture is being replaced. They will not fit in standard T12 or T8 fixtures without modification of the fixture. It is often assumed that because T8 lamps are more efficient than T12 lamps, that T5 lamps are more efficient than T8 lamps. This is not accurate, as many T8 lamps produce more light per watt (efficacy) than do T5 lamps. However, the thin profile of T5 lamps makes them ideal for use in fixtures where optical control is important. For this reason, many high performance lighting fixtures incorporate T5 lamps. Because they produce a lot of light for their size, T5 lamps produce a significant amount of glare and should only be used in fixtures that hide the lamp from direct view and optically control glare.

LED Lamps and Fixtures – Light-emitting diode (LEDs) are an excellent high-efficiency option for certain lighting applications. Although still a young technology, a lot of progress has been made over the last several years in their construction and performance. LEDs have the potential to generate substantial energy savings while also producing quality light and having a much longer life compared to an incumbent technology, leading to reduced maintenance costs. Special care must be taken to select the right product, though. Due to the current popularity of this technology, the market is flooded with products, many of which are of poor quality. Additionally, LEDs are not appropriate for all installations. LEDs are inherently directional and are therefore excellent options as, for example, flood and spot lights, parking lot fixtures, and wallpacks, but are not necessarily a good choice as an omnidirectional light

source such as a linear fluorescent lamp replacement. ENERGY STAR® and the DesignLights Consortium® (DLC) are two excellent resources for high-quality products in applications appropriate for this technology.

What is called "lifetime" for LEDs is actually an estimation of how many burn hours the LED has until it reaches 70% light output. When it gets to this point, it is considered to be at its end of life. There will be some small percentage of early failures, but these will generally happen at installation or at the very beginning of life (first 100 or 1000 hours) – largely due to manufacturing defects or damage during shipping. The main thing is that LEDs don't fail "off" – they just reduce to 70% output.

Fixture Types for Lighting Redesigns – Fixture styles that are used to provide high-quality interior general lighting include:

- Pendant mounted indirect or direct-indirect T8 or T5 fixtures – Fixtures should be selected that have a tested overall efficiency of at least 75percent and the ceiling should be painted white for good light reflection.
- Recessed or surface mounted indirect or direct-indirect T8 or T5 fixtures – Fixtures should have a tested overall efficiency of at least 65 percent and shield lamps from direct view.
- Recessed advanced optics T8 or T5 fixtures – This class of fixture is relatively new to the marketplace. Advanced optical features are used to distribute the light evenly and control glare. Tested overall efficiency should be at least 75 percent. Examples of this fixture style are the Lithonia RT5, Metalux Accord, and LedaLite Pure FX. Retrofit kits that are based on this fixture style have recently reached the marketplace and are a popular option for classroom and office lighting.
- High Intensity Fluorescent T5 and T5 High Output (HO) fixtures – These fixtures are an excellent choice for gymnasiums, field houses, and vocational shop areas. They work best with ceiling heights of 16' or greater. They are often used as 1 for 1 replacements for HID (typically metal halide) fixtures, and offer not only reduced wattage, but also the ability to turn the lights on and off without warm-up times, allowing automatic controls to be put to full use.

See it in Action:

Allentown, PA City Hall Exterior Walkway Lighting Upgrade

The City of Allentown, with the aid of a grant from the PPL Sustainable Energy Fund of Central Eastern Pennsylvania, installed LED fixtures to the City Hall building at no cost to the city. The new LED lights replaced metal halide lights, improving light levels, and saving about 25,000 kilowatt hours and $5,000 in combined electric and maintenance costs. For more project details, visit the Atlantic Energy Concepts website.

Resources

Consortium for Energy Efficiency (CEE): http://www.cee1.org/

Illuminating Engineering Society of North America: http://www.iesna.org/

Advanced Lighting Guidelines, New Buildings Institute: http://www.newbuildings.org/lighting

ENERGY STAR: http://www.energystar.gov/index.cfm?c=ssl.pr_commercial

DesignLights Consortium: http://www.designlights.org

Reducing or Eliminating Night-time Security Lighting

Several recent studies (see Resources below) have concluded that after hours interior and exterior site lighting do little, if anything, to prevent vandalism. While it is very important to provide security lighting during and immediately following the work day and sanctioned events, significant savings can be realized by reducing or eliminating night time security lighting. In addition, interface lighting with enabled security systems can provide a set time window for the last person to leave and get to their car safely before alarm activated reduced lighting mode comes one.

The International Dark-Sky Association's Dark Campus Initiative provides guidelines for establishing a policy that keeps all interior and exterior lighting off after daily activities. They also maintain a list of recommended exterior fixtures for reducing light pollution.

See it in Action:

East Lansdowne Borough, PA

East Lansdowne Borough, Pennsylvania underwent both interior and exterior lighting retrofits for its two main municipal buildings, Main Building and Community Hall.

Interior Lighting: LED lighting and OptaLume fixtures replaced existing and inefficient T-12 fixtures (F40T12- 4, F40T12 – 2 U, F40T12 – 1). The more efficient interior lighting will save the community more than $15,600 in energy costs and $10,600 in maintenance costs over a ten year period. This will also be a 64 percent reduction in energy usage. The old interior fixtures consumed more than 18,000 kWh/year.

Exterior Lighting: LED wall packs and PAR 38 lamps were also used to replace existing exterior lights. There will be a 65 percent reduction in energy usage, while saving 15,064 kWh per year.

Did you know?

According to the International Dark-Sky Association, wasted nightlight security lighting is estimated 17,400 gigawatt-hours a year. At an average of $.10 per kilo watt-hour the cost of that wasted energy is $1.74 billion a year. That equates 9.1 million tons of coal or 32.2 million barrels of oil. Reducing or eliminating exterior nightlight lighting is not an operational cost saving opportunity for school campuses and public facilities, but also a mechanism to reduced crime and vandalism, as cited in previous case studies by IDA.

Resources

International Dark-Sky Association: www.darksky.org/

IESNA Model Lighting Ordinance (MLO):
http://www.ies.org/PDF/MLO/MLO_FINAL_June2011.pdf

Britain's Royal Commission on the Environment has published a report titled, *Artificial Light in the Environment – see issue from September 3, 2009*: http://www.rcep.org.

The National Institute of Justice Report to Congress: *Preventing Crime: What Works, What Doesn't, What's Promising*: http://www.ncjrs.gov/works/

Maine Legislature Dark Skies Report:
http://www.maine.gov/doc/commissioner/landuse/docs/final_dark_skies_report_with_appendices.pdf

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Improving Efficiency in Municipal Street and Public Lighting

Street and public lighting can account for a quarter of a municipality's electricity bill. By upgrading their older and inefficient lighting in the streets and public spaces with more energy-efficient light emitting diode (LED) lighting, cities and towns can reduce energy use resulting in lower energy costs, reduced maintenance costs, and improved nighttime environment in their communities. State and utility incentives are available to municipalities to upgrade their street lightings (i.e. PSNH Municipal Smart Start Program, Efficiency Vermont's Municipal Street Lighting program).

See in Action:

New Hampshire Communities Taking Advantage of PSNH Municipal Smart Start Program to Upgrade Streetlights

The Smart Start Program offered by Public Service of New Hampshire (PSNH), an electric utility, assists municipalities installing energy-saving measures with no up-front costs. Payments can be made over time through an added cost, which is calculated to be less than the monthly savings to a municipal facility's monthly electric bill. Municipalities benefit from both the payment plan and savings obtained from lower energy costs.

Thanks to the PSNH's Smart Start program, several New Hampshire communities have been able to make important energy saving upgrades to their streetlights by replacing inefficient fixtures with more energy-efficiency ones. For example, towns of Bristol, Chesterfield, Jaffrey, and Marlow converted a total of 479 inefficient streetlights, with an estimated conversion cost per town ranging from $10,904 to $91,038. Savings are estimated to range between 15 to 30 percent of an annual municipal street lighting bill.

Resources

Department of Energy Municipal Solid-State Street Lighting Consortium:
http://www1.eere.energy.gov/buildings/ssl/consortium.html

Efficiency Vermont's Efficiency Street Lighting Program:
http://www.efficiencyvermont.com/for_my_business/solutions_for_me/municipal_and_state_government/general_info/municipal_street_lighting.aspx

Energy-Efficient Street Lighting in New York State: http://www.rpi.edu/dept/lrc/nystreet/

PSNH Municipal Smart Start Program: http://www.psnh.com/SaveEnergyMoney/For-Business/Municipal-Smart-Start-Program.aspx

Massachusetts Department of Energy Resources Efficient Streetlights: http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/energy-audit-program-eap.html

HVAC - Maintenance

Boilers

In the Northeastern United States the gas or oil-fired boiler, or multi-boiler system, is typically the largest single piece of energy using equipment in a commercial or institutional building. It is critical to adopt a proper maintenance plan and stick to it. It is also useful to keep detailed records of boiler fuel usage to signal performance deterioration and to assist in troubleshooting. Although sophisticated software is available to analyze energy consumption, simple data analysis, such as comparing energy data with that of similar buildings (benchmarking) can also be useful if it compares buildings with similar equipment and if it is a season to season comparison, normalized for heating degree days.

Maintaining a detailed service notebook should be done in addition to keeping old service invoices. Records prepared immediately upon completing maintenance items are most useful for future service calls. Service records and fuel consumption records can show patterns that indicate problems that should be investigated.

Scheduled maintenance should be performed more frequently than once a year, and up to four times per year for older or trouble-prone systems. The maintenance plan should include before and after the heating season start-up/shut-down procedures. 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 has an important role as well, and should be responsible for:

- ❑ Checking for leaks
- ❑ Looking for damaged or missing insulation
- ❑ Monitoring energy efficiency
- ❑ Checking feedwater
- ❑ Steam trap maintenance in steam systems

Steam Traps

Steam traps are automatic valves that release condensed steam (condensate) from a steam space while preventing the loss of live steam. They also remove non-condensable gases from the steam space. Steam traps are designed to maintain steam energy efficiency for performing specific tasks such as heating a building or maintaining heat for process use. Once steam has transferred heat through a process and becomes hot water, it is removed by the trap from the steam side as condensate and either returned to the boiler via condensate return lines or discharged to the atmosphere, which is a wasteful practice.

Steam Trap Maintenance (Adapted from the Federal Energy Management Program)

Excluding design problems, two of the most common causes of trap failure are oversizing and dirt:

Oversizing causes traps to work too hard. In some cases, this can result in blowing of live steam. As an example, an inverted bucket trap can lose its prime due to an abrupt change in pressure. This will cause the bucket to sink, forcing the valve open.

Dirt is always being created in a steam system. Excessive build-up can cause plugging or prevent a valve from closing. Dirt is generally produced from pipe scale or from over-treating of chemicals in a boiler.

Characteristics of Steam Trap Failure:

Mechanical or Inverted Bucket Steam Traps - These types of steam traps have a "bucket" that rises or falls as steam and/or condensate enters the trap body. When steam is in the body, the bucket rises closing a valve. As condensate enters, the bucket sinks down, opening a valve and allowing the condensate to drain. Inverted bucket traps are ideally suited for water hammer conditions but may be subject to freezing in low temperature climates if not insulated. Usually, when this trap fails, it fails open. Either the bucket loses its prime and sinks or impurities in the system may prevent the valve from closing.

Thermostatic Bimetallic and Bellows Steam Traps - These steam traps have, as the main operating element, a metallic corrugated bellows that is filled with an alcohol mixture with a boiling point lower than that of water. The bellows will contract when in contact with condensate and expand when steam is present. Should a heavy condensate load occur, such as in start-up, the bellows will remain in a contracted state, allowing condensate to flow continuously. As steam builds up, the bellows will close. Therefore, there will be moments when this trap will act as a "continuous flow" type.

At other times, it will act intermittently as it opens and closes to condensate and steam, or it may remain totally closed. These traps adjust automatically to variations of steam pressure but may be damaged in the presence of water hammer. They can fail open should the bellows become damaged or when there are particulates in the valve hole, preventing adequate closing. There can be times when the tray becomes plugged and will fail closed.

Thermodynamic "Disc" Steam Traps - Thermodynamic traps have a disc that rises and falls depending on the variations in pressure between steam and condensate. Steam will tend to keep the disc down or closed. As condensate builds up, it reduces the pressure in the upper chamber and allows the disc to move up for condensate discharge. This trap is a good general type trap where steam pressures remain constant. It can handle superheat and water hammer but is not recommended for process, since it has a tendency to air-bind and does not handle pressure fluctuations well. A thermodynamic trap usually fails open. There are other conditions that may indicate steam wastage, such as "motor boating," in which the disc begins to wear and fluctuates rapidly, allowing steam to leak through.

Thermostatic and Float Steam Traps - Float and thermostatic traps consist of a ball float and a thermostatic bellows element. As condensate flows through the body, the float rises or falls, opening the valve according to the flow rate. The thermostatic element discharges air from the steam lines. They are good in heavy and light loads and on high and low pressure, but are not recommended where water hammer is a possibility. When these traps fail, they usually fail closed. However, the ball float may become damaged and sink down, failing in the open position. The thermostatic element may also fail and cause a "fail open" condition.

Orifice Steam Traps—In the case of fixed orifice traps, there is the possibility that on light loads these traps will pass live steam. There is also a tendency to waterlog under wide load variations. They can become clogged due to particulate buildup in the orifice and at times impurities can cause erosion and damage the orifice size, causing a blow-by of steam.

General Indications of Possible Steam Trap Failure

- ❑ Abnormally warm boiler room.
- ❑ Condensate received venting steam.
- ❑ Condensate pump water seal failing prematurely.
- ❑ Overheating or underheating in conditioned space.
- ❑ Boiler operating pressure difficult to maintain.
- ❑ Vacuum in return lines difficult to maintain.
- ❑ Water hammer in steam lines.
- ❑ Steam in condensate return lines.
- ❑ Higher than normal energy bill.
- ❑ Inlet and outlet lines to trap nearly the same temperature

The U.S. Department of Energy's 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 a flue gas analysis procedure. Typical combustion efficiency ratings for standard boilers range from 70 to 85 %, with the efficiency ratings for condensing boilers reaching as high as 95 %.

Domestic Hot Water (DHW) - If the facility service hot water is heated by the main boiler(s), consider installing a dedicated DHW system to avoid operating large boilers inefficiently.

Boiler Maintenance/Cleaning Checklist

Description	Comment	Maintenance Frequency			
		Daily	Weekly	Monthly	Annually
Boiler use and sequencing	Turn off or sequence unnecessary boilers, and sequence efficient boilers to operate first.	X			
Overall visual inspection	Complete overall visual inspection to be sure all equipment is operating and that safety systems are in place.	X			
Follow manufacturer's recommended procedures in lubricating all components	Compare temperatures with tests performed after annual cleaning.	X			
Check steam pressure	Is the variation in steam pressure as expected under different loads? Wet steam may be produced if the pressure drops too fast.	X			
Check unstable water level	Unstable levels can be a sign of contaminates in feedwater, overloading of boiler, or equipment malfunction.	X			
Check burner	Check for proper control and cleanliness.	X			

Check motor condition temperatures	Check for proper function.	X			
Check air temperatures in boiler room.	Temperatures should not exceed or drop below design limits.	X			
Boiler blowdown	Verify the bottom, surface and water column blow downs are occurring and are effective.	X			
Boiler logs	Keep daily logs on: • Type and amount of fuel used • Flue gas temperature • Makeup water volume • Steam pressure, temperature, and amount generated • Return water temperature Look for variations as a method of fault detection.	X			
Check oil filter assemblies	Check and clean/replace oil filters and strainers.	X			
Inspect oil heaters	Check to ensure that oil is at the proper temperature prior to burning.	X			
Check flue gas temperatures and composition	Measure flue gas composition and temperatures at selected firing positions — recommended O2% and CO2%. **Fuel** **O2%** **CO2%** Natural gas 1.5 10 No. 2 fuel oil 2.0 11.5 No. 6 fuel oil 2.5 12.5 Note: %ages may vary due to fuel composition variations		X		
Check all relief valves	Check for leaks.		X		
Check water level control	Stop feedwater pump and allow control to stop fuel flow to burner. Do not allow water level to drop below recommended level.		X		
Check pilot and burner assemblies	Clean pilot and burner following manufacturer's guidelines. Examine for mineral or corrosion buildup.		X		
Check boiler operating characteristics	Stop fuel flow and observe flame failure. Start boiler and observe characteristics of flame.		X		
Inspect system for water or steam leaks and leakage opportunities	Look for: leaks, defective valves and traps, corroded piping, and condition of insulation.		X		

Inspect all linkages on combustion air dampers and fuel valves	Check for proper setting and tightness.		X		
Inspect boiler for air leaks	Check damper seals.		X		
Check blowdown and water treatment procedures	Determine if blowdown is adequate to prevent solids buildup.			X	
Flue gases	Measure and compare last month's readings for flue gas composition over entire firing range.			X	
Combustion air supply	Check combustion air inlet to boiler room and boiler to make sure openings are adequate and clean.			X	
Check fuel system	Check pressure gauge, pumps, filters and transfer lines. Clean filters as required.			X	
Check belts and packing glands	Check belts for proper tension. Check packing glands for compression leakage.			X	
Check for air leaks	Check for air leaks around access openings and flame scanner assembly.			X	
Check all blower belts	Check for tightness and minimum slippage.			X	
Check all gaskets	Check gaskets for tight sealing. Replace if they do not provide a tight seal.			X	
Inspect boiler insulation	Inspect all boiler insulation and casings for hot spots.			X	
Steam control valves	Calibrate steam control valves as specified by manufacturer.			X	
Pressure reducing or regulating valves	Check for proper operation.			X	
Perform water quality test	Check water quality for proper chemical balance.			X	
Clean waterside surfaces	Follow manufacturer's recommendation on cleaning and preparing waterside surfaces.				X
Clean fireside	Follow manufacturer's recommendation on cleaning and preparing fireside surfaces.				X
Inspect and repair refractories on fireside	Use recommended material and procedures.				X
Relief valve	Remove and recondition or replace relief valves.				X
Feedwater system	Clean and recondition feedwater pumps. Clean condensate receivers and deaeration system.				X

Fuel system	Clean and recondition system pumps, filters, pilot, oil preheaters, oil storage tanks, and other system components.				X
Electrical systems	Clean all electrical terminals. Check electronic controls and replace any defective parts.				X
Hydraulic and pneumatic valves	Check operation and repair as necessary.				X
Flue gases	Make adjustments to ensure optimal flue gas composition. Record composition, firing position, and temperature.				X
Eddy current test	As required, conduct eddy current test to assess tube wall thickness.				X

Source: US DOE Federal Energy Management Program (FEMP), Operations & Maintenance Best Practices, Release 3.0, August 2010, pg 9.26: http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf

Furnaces

Few public buildings in the region heat with warm-air furnaces, but similar procedures apply:

- ❑ Inspect the burners for smooth ignition and proper flame color
- ❑ 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.

Unit Ventilators - Best Practices

Herman Nelson invented the unit ventilator (UV) in 1917, and they are still in common use in offices and classrooms today. The first UVs provided heat and ventilation, while many current UVs are also designed to provide air conditioning.

There are many indoor environmental quality issues associated with UVs, including:

- ❑ **Fresh Air Delivery** – Theoretically, an advantage of UVs is the delivery of outside air. However, UVs often have design and maintainability issues that cause fresh air delivery to become inconsistent. In addition, staff often blocks off fresh air delivery in older UVs in response to cold air complaints.
- ❑ **Short Circuiting of Supply Air and/or Poor Air Distribution** – The short-circuiting of conditioned air between the discharge and the return is a common complaint, made worse when books or other items are placed over the louvers.

- **Noise** – UVs typically generate unwanted noise during operation, but the proper use of acoustical materials such as carpeting, curtains, and acoustical ceilings will help alleviate this problem. Additionally the ability of the unit to operate at lower fan speeds will help reduce noise levels for part of the time.

  ANSI Standard S12.60 recommends that classroom equipment noise levels be kept below 35 dB in order to not interfere with student hearing. This level is likely impossible to achieve with UVs.

- **Inefficient Air Filtration** – ASHRAE Standard 52.2 recommends a minimum filtration of MERV 6, and this requirement calls for MERV 7 filtration. Older UVs typically utilize filters with a rating of MERV 2. The added static pressure drop associated with a higher filter rating may significantly affect airflow, especially in older UVs.

- **Difficult Maintenance** – Maintenance of UVs is often neglected, partly because they are difficult to work on. The interior components are crowded into a small case and access usually means lying on the floor.

The following steps should be taken to optimize UV performance:

- All UVs in the facility should be assessed for air delivery, noise, and air filtration.
- All poorly or non-functioning fans, dampers, controls, should be replaced; or the entire UV should be replaced.
- Air filters with a minimum MERV rating of 7 should be installed in each UV. This may require the upgrade of UV fans in some older systems. (Note: higher MERV rating will increase your energy costs, so facility needs to plan and budget accordingly)
- Consider a control strategy that combines occupancy sensing with thermostatic control to avoid bringing excess fresh air into unoccupied areas.
- The facility maintenance plan should include annual maintenance of the UVs.

Bio Alternatives to No. 2 Fuel Oil

Bio-fuels and woody biomass can both be attractive alternatives to standard fossil fuels. Many municipalities across the country are beginning to incorporate bio systems for the heating of both school and municipal buildings. In the Northeast and Mid-Atlantic states, the abundance of waste-wood from the forest products industry has made wood fired systems particularly attractive.

Bio-fuels are technically and economically viable alternatives to No. 2 fuel oil and are less hazardous than petroleum fuels. The addition of bio-fuel combustion capability is simple and inexpensive, as it is not necessary to replace or compromise the operation of existing fossil fuel systems, provided normal material compatibility recommendations for the particular fuel blend are followed.

Just as there are now alternatives to diesel fuel for vehicles, bio alternatives to fuel oil are now reaching the marketplace. A product now available in Massachusetts that will be expanding throughout the region is a blend of standard No. 2 heating oil and biodiesel, which is oil refined from vegetable oil, recycled cooking grease, or animals fats. The currently available blend is 20percent biodiesel blended with 80percent heating oil. The goal is to increase the biodiesel content as new blended products are introduced.

In order to ensure the quality of the blended fuel, the American Society of Testing and Materials (ASTM) has approved specifications for the biodiesel (D-6751) utilized in formulating the blended product. This standard ensures that the product will be constant and not subject to any harmful contaminants that might come from a non-industrial production method. Most of the biodiesel made today in the United States comes from soy oil. Soy oil is a commodity product extracted in the soy processing system.

Biodiesel Case Study – University of Georgia

As a portion of ongoing research into bio-fuel alternatives, The University of Georgia (UGA) Engineering Outreach Service used fats and grease (chicken fat, yellow grease, choice white grease, and beef tallow) as industrial boiler fuels in the 100,000 lb./hr. No. 2 boiler at the UGA steam plant in 2002-2003.

A summary of the results include:

- ❑ Laboratory analyses showed that the fats and greases tested have high heating value, low ash, negligible sulfur, low moisture, and other physical and chemical properties conducive to their use as boiler fuel. Heating values for the biofuel blends tested are within 95% of the heating value of No. 2 fuel oil.
- ❑ The tests demonstrated that the biofuels burn cleanly, readily, without odor and without damage to boiler equipment.
- ❑ During this test program, biofuels produced steam within 3.8percent to 5.3percent of the efficiency of No. 2 fuel oil. Biofuels blended with No. 2 fuel oil were more efficient than unblended biofuels, and can actually produce steam with more efficiency than No. 2 fuel oil alone. Throughout the tests part load efficiency was greater than maximum load efficiency, and steam production with flue gas recirculation (FGR) was more efficient than without FGR.
- ❑ Biofuels are clean burning. They produce fewer combustion emissions than No. 2 fuel oil.
- ❑ FGR is an effective way to reduce nitrogen oxide (NOx) emissions for both fossil and biofuels.

Participating in Utility and Governmental Energy Efficiency Incentive and Technical Assistance Programs

Utility-Sponsored Program

Virtually every utility customer in the region is eligible to participate in at least one, and typically several, energy efficiency programs. The programs offer either technical assistance or incentives for efficient equipment and practices. Many programs offer both technical assistance and financial incentives for the installation of efficient equipment and the incorporation of efficient design practices.

See it in Action:

LIPA Offers Rebates to Long Island's School Districts

Since 2000, Long Island Power Authority (LIPA) has partnered with over 100 of Long Island's school districts through their commercial efficiency and renewable rebate programs. In 2012 alone, 171 energy efficiency projects were completed in over 150 schools, totally nearly $5 million rebates providing energy savings of 9.6 million kWh per year.

Sag Harbor School District recently receives a rebate of $101,355 from LIPA for its lighting upgrades in three school buildings. The school district replaced and retrofitted approximately 1,810 fixtures with energy efficient and high performance lighting equipment that will save up to 179,000 kWh per year and $32,000 annually in energy costs.

In addition, last year the district installed a 1,480 watt solar generator at Sag Harbor Elementary School which qualified for a $4,070 rebate through LIPA's Solar Entrepreneur Program.

Incentives from the Federal Government

In addition to utility and state government operated programs, the Federal Government offers a tax credit program (Section 179D) that will allow the designers of energy efficient buildings to apply for a tax credit to help offset the costs of the design and construction of efficient buildings.

Participation in these programs not only leads to possible financial incentives, but often provides valuable information regarding best practices in the local area and local expert design and consultation services. Facility personnel should contact their electric and gas utility companies as well as their state energy office for specific program information.

What is Section 179D?

Section 179D of the Federal Tax Code provides up to $1.80 per square foot federal tax reduction for energy efficiency improvements and building designs, including installation of efficient lighting, HVAC, and building envelope systems.

Are government entities eligible for the tax deduction?

According to the IRS, governments may allocate their 179D deduction to ESCOs, architects, and engineers who designed energy efficient elements of their buildings, such as municipal buildings and schools. The government entities, therefore, can use the tax benefit in exchange for a negotiated payment with ESCOs or the lead designers of their buildings as a way to finance the costs of energy efficiency upgrades.

Resources

The Database of State Incentives for Renewables & Efficiency (DSIRE) provides a comprehensive list of energy efficiency programs by state: http://www.dsireusa.org/

Department of Energy, State and Local Solution Center,
http://www1.eere.energy.gov/wip/solutioncenter/

Department of Energy, 179D DOE Calculator,
http://apps1.eere.energy.gov/buildings/commercial/179d/

Electrical Demand Reduction and Response Opportunities

Demand reduction can help municipalities to save substantially on their utility bills. Demand reduction and/or response strategies are supported by utility companies with incentives offered for reducing total demand during peak hours, or periods of time when electric grids experience the greatest amount of power draw. This peak demand period typically occurs during the summer in the early afternoon when cooling loads are high, though this can differ across regions. Demand reduction benefits the utility as it eliminates the need for them to buy additional capacity during peak periods to then sell to their customers, which is very costly. Providing financial incentives to customers to reduce their demand during these periods is a less costly alternative.

While the details of such arrangements can vary greatly from customer to customer and across utilities, the principle is the same: during peak demand periods, the utility will contact the customer (such as a building owner) and request they reduce their electric demand. This can include turning off electric chillers or other equipment that draws large amount of electricity. If a building owner is capable of delivering this reduction, they receive a payment according to the total kW reduction. Similarly, contracts can be arranged where a customer is provided with a reduced electric rate, with the agreement that during peak demand periods they will reduce their demand.

Not all utility companies offer demand reduction programs, and the incentive approach varies widely with either reduced rates, or cash incentives being offered. Both permanent demand reduction and demand response (customers decrease their electrical demand upon request) may be available.

Some utilities also provide incentives for the installation of controls that result in overall demand reduction through-out the facility. More information on an example of this type program can be found here: http://www.cl-p.com/business/saveenergy/loadmanagement/demandreduction.aspx

While demand response strategies are typically adopted for manufacturing facilities that have large electrical loads that can typically be shifted to different times of the day, it may be appropriate for certain public buildings as well. Determining whether demand response is appropriate will depend on the equipment found within the building, the building's typical operating schedule and the requirements of the occupants.

In additional to formal demand response programs in which a customer enrolls and is paid to reduce their demand upon request, many municipalities may be able to lower their electric demand charges by reducing their use on peak days and hours. This is particularly true of high-demand public buildings such as wastewater treatment facilities, water treatment facilities and high schools.

Resources

US Energy & Information Administration – Today In Energy: Demand Response Can Lower Electric Load When Needed, Feb 15, 2011:
http://www.eia.gov/todayinenergy/detail.cfm?id=130Internation Energy Agency Demand Side Management – includes some useful information on demand reduction, including case studies: http://www.ieadsm.org/

The Database of State Incentives for Renewables & Efficiency (DSIRE):
http://www.dsireusa.org/

Combined Heat and Power (CHP) or Cogeneration

Combined heat and power (CHP) or cogeneration is an integrated system that simultaneously generates electricity and useful thermal energy from a single fuel. CHP is a more efficient way of generating useful energy by recovering the thermal energy in the form of heat or steam that normally would be wasted in the process of generating electricity, and also save the fuel that would otherwise be used to produce the thermal energy in a separate boiler or furnace.

Currently, there are 82 GW of installed CHP generation capacity with over 4,000 sites across the U.S. Although most of the current capacity is used in manufacturing, there is increasing number of CHP applications at large commercial and institutional sector. Evidently, many higher education and public facilities (i.e. multifamily affordable housings, wastewater treatment plants, correctional facilities) are taking the advantage of using CHP to generate its own electricity while supplying its thermal load. CHP systems offer tremendous

opportunities for significant economic savings and reduction in fuel consumption and they also lower a facility's carbon footprint and greenhouse gas emissions.

See it in Action:

Central Connecticut State University (New Britain, CT) – CHP system

CCSU's 2.5 MW combined heat and power (CHP) system began its operation in 2004 replacing an outdated and inefficient steam heating system. The new 3,600 square foot energy center provides all heating and cooling need, as well as some electricity, for the campus. The center uses electric generators in a CHP system which utilizes recovered exhaust from electricity production to supplement the boilers in generating steam for campus-wide heating and cooling.

CHP application on CCSU's campus provides increased power reliability on campus and supplements power plants in meeting the region's peak demand. The construction of the newer energy center also helps to replace asbestos-encased steam lines that were previously used as part of the older steam heating systems.

Resources

EPA's Combined Heat and Power Partnership Program makes resources and tools available to CHP project developers and policymakers at http://www.epa.gov/chp/

V. Alternative and Renewable Energy Systems

Biomass Systems – Woody Biomass (Wood Pellet and Chip) Boilers

Wood-fired boiler systems have become readily accepted for the heating of school facilities and other public buildings. According to the Biomass Energy Resource Center's Vermont Fuels For Schools Initiative, more than 30 percent of public school students in Vermont currently attend a wood-heated school.

Wood pellet and chip boilers are relatively simple biomass heating systems. Wood pellets and chips are generally uniform in size, shape, moisture and energy content, so fuel handling is not burdensome. Nevertheless, there are some ongoing maintenance requirements for these systems.

A wood fired boiler will take more time to maintain and operate than a traditional gas, oil, or electric heating system. At the institutional or commercial scale, however, many of the maintenance activities can be cost-effectively automated by installing off-the-shelf equipment such as soot blowers or automatic ash removal systems.

See it in Action:

Bennington, VT saves money by switching to biomass

According to the Property and Environmental Research Center (PERC), Vermont is home to 60 biomass heating facilities, which is nearly half of the facilities in the United States. A piece by the Forest Business Network described Bennington's Mount Anthony Union (MAU) Middle School and MAU High School, which saved taxpayers more than $1 million thanks to their biomass boilers. To learn more about Vermont's leadership in biomass upgrades, visit the state's Fuels for Schools Program brochure and PERC's case study.

The manufacturer of the installed system should supply a schedule for required maintenance. When considered on a daily basis, the total time required for maintaining wood fired boiler systems equates to roughly 15-30 minutes per day over the entire heating season.

Some of the typical maintenance activities required for wood fired boilers include:

- ❑ Ash removal from grates and/or collection containers
- ❑ Monitoring control devices to check combustion temperature, stack temperature, fuel consumption, and boiler operation
- ❑ Checking and adjustment of fuel feed rates and combustion air
- ❑ Checking boiler settings and alarms, such as those that alert to a problem with soot buildup
- ❑ Boiler tube cleaning
- ❑ Cleaning of firebox and heat exchange surfaces
- ❑ Greasing augers, gear boxes, and other moving parts
- ❑ Checking for wear on conveyors, augers, motors, or gear boxes

See it in Action:

Craftsbury Academy's Biomass Boiler

In 2010, the Town of Craftsbury, Vermont installed a 1 million BTU Advanced Climate Technologies Biomass Boiler that replaced three separated oil-fired heating systems servicing four buildings totaling 45,000 square feet. With the goal of greening its schools and moving toward carbon neutral while supporting Vermont's local economy, the town officials intend to take advantage of Vermont's abundant biomass resource and use wood pellet produced by a local factory as the main feedstock.

The biomass boiler installed is capable of accepting both pellets and wood chips that gives the school the flexibility in choosing the fuel source depending upon prices and availability. Annual savings are estimated to exceed $20,000 with an operational cost savings estimated at $280,653 over a 15-year period. (See *Communities Tackling Vermont's Energy Challenges* – page 26).

Off Season

- ❑ Perform complete inspections of all conveyance system parts that can't be observed due to fuel storage. Parts showing any measurable signs of wear should be replaced at this time since they are generally inaccessible during the heating season
- ❑ Remove all woodchips from storage area to avoid the proliferation of flies

Resources

ASHRAE Standard 55: http://www.ashrae.org

US DOE: "Guide To Operating and Maintaining Energy Smart Schools": http://doe.cefpi.org/

FEMP boiler maintenance recommendations:
https://www1.eere.energy.gov/femp/technologies/eep_boilers.html

FEMP Operations & Maintenance Best Practices, Release 3.0, August 2010, pg. 9.2:
http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf

FEMP steam trap information: http://www1.eere.energy.gov/femp/pdfs/FTA_SteamTrap.pdf

FEMP Operations & Maintenance Best Practices, Release 3.0, August 2010, pg. 9.3:
http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf

New England Fuel Institute: http://www.nefi.com/

National Biodiesel Board: http://www.biodiesel.org/

Northeast Biodiesel: http://www.northeastbiodiesel.com/

University of Georgia Engineering Outreach Service: "A Demonstration of Fat and Grease as Industrial Boiler Fuel": http://www.biorefinery.uga.edu/docs/biofuel_oil_report.pdf

The Biomass Energy Resource Center (BERC) in Montpelier, Vermont is an independent, national nonprofit organization that offers information and assistance regarding biomass systems: http://www.biomasscenter.org/

Renewable Energy Vermont – Biomass:
http://www.revermont.org/main/technology/bioenergy/biomass/

Wood Chip Heating Systems and *Vermont Fuels for Schools* are both useful guides to wood-fired systems and are downloadable at this address:
http://www.biomasscenter.org/resources/publications.html

Massachusetts Division of Energy Resources: *Wood Pellet Heating: A Reference on Wood Pellet Fuels & Technology for Small Commercial & Institutional Systems:*
http://www.biomasscenter.org/pdfs/DOER_Pellet_Guidebook.pdf

Manual boiler tube cleaning at Calais Elementary School, Calais, Vermont (from the Biomass Energy Resource Center's Wood Chip Heating Systems)

Maintaining Solar Thermal and Photovoltaic (PV) Systems

As with all energy producing equipment, proper maintenance of site-installed solar systems is essential to long-term performance and the avoidance of costly repairs. The tasks involved are not onerous, but are often not well communicated to facility personnel and/or neglected in favor of tending to other immediate needs.

O&M Manual - All solar system installations at school facilities should include an O&M manual that describes exactly how the system works and the recommended scheduled maintenance

to be performed by both the owner and the contractor. The O&M manual should not be merely a compilation of component manufacturers' literature, but should include instructions specific to the installed system.

Solar Thermal Systems

Solar thermal systems for service water heating and supplemental space heating are making a strong comeback in the United States. During the late 1970s and early 1980s, thousands of solar thermal systems were installed on residences, schools, and businesses with the support of federal and state incentive programs. Much was learned about the maintenance of solar systems, and that knowledge should be applied today to ensure that investments in solar technology contribute to reduced energy consumption for the next decades.

Solar panels at Providence Career and Technical Academy in Providence, RI

Monitoring Performance – Nearly all systems are installed with at least some temperature probes, and many include flow meters and digital temperature monitoring at several points in the system. Monitoring and recording system performance over time will assist in identifying problems early. Some operators keep daily logs, but weekly recorded information is sufficient. At a minimum, a log should be kept of the following:

- ❑ Time of day and weather conditions at time of reading
- ❑ Temperature at the collectors
- ❑ Temperature of fluid entering the heat exchanger or storage tank
- ❑ Temperature of fluid exiting the heat exchanger or storage tank
- ❑ Temperatures at the bottom and top of the storage tank
- ❑ Transfer fluid flow rate (if a flow meter is installed)
- ❑ Transfer fluid pressure (closed loop systems only)

If degraded performance is observed, a troubleshooting exercise should be performed by staff with the assistance of the solar contractor. Likely component failures include:

- ❑ Leaking transfer fluid
- ❑ Shorted or out of specification thermisters (temperature sensors)
- ❑ Faulty differential thermostat control
- ❑ Failed circulator pump
- ❑ Inoperable automatic valves such as check valves, vacuum relief valves, mixing valves
- ❑ Failed expansion tank
- ❑ Other

Regular Maintenance – Some of the following maintenance items would typically be performed by the installing, or other, solar contractor. A thorough visual inspection of the system should be done every six months looking for any signs of corrosion of mounting hardware, exposed control wiring, leaking roof penetrations, broken glazing seals, plumbing leaks, loose pipe insulation, etc. The collector glazing rarely will need cleaning unless there is a nearby pollution source. If needed, the glass should be cleaned with plain water only.

For closed loop systems utilizing propylene-glycol as a heat transfer fluid, maintaining the fluid is extremely important. Although solar system rated glycol solutions contain corrosion inhibitors, if the fluid becomes acidic it will start to corrode the inside of the plumbing loop. Glycol solutions breakdown with extended overheating which can occur if circulation stops during sunny weather causing the fluid in the collectors to overheat. The fluid should be tested once a year for pH and some technicians also test for reserve alkalinity. Use only propylene glycol with corrosion inhibitors rated for solar thermal systems when adding or replacing glycol.

Pressurized water storage vessels should be maintained as any pressurized water heater.

Solar Photovoltaic (PV) Systems

PV systems require less routine maintenance than do solar thermal systems. However, simple maintenance procedures will protect the investment and keep the system operating at peak output. As with solar thermal, monitoring of system performance will signal most significant issues.

Note: The information presented here assumes that the PV system is grid connected and not a standalone system with storage batteries. If the system includes storage batteries, it is extremely important that facility personnel follow the manufacturer's safety and maintenance recommendations.

Monitoring System Performance – Any PV system installed on a school should include a meter that records the amount of energy generated and/or the energy being exported to the grid. If the metered information is downloadable to a computer, the performance of the system can easily be tracked over time. If the meter simply displays the output, a log should be kept that includes time of day, date, weather conditions, and system output in order to record performance over time.

PV system owners should not expect the system to operate at the full rated output. The energy industry uses the term "Performance Ratio" to identify the actual system output. According to the National Renewable Energy Laboratory (NREL), the standard performance ratio for a new PV system averages 77 percent, and over time the performance of the system is expected to degrade at the rate of about 1 percent per year.

Periodic System Inspection – The system should receive a thorough visual inspection on a schedule, as recommended by the manufacturer or installation company. The following items should be included:

- ❑ Safety first – PV systems are electrical systems with all the dangers inherent in any electrical devices.
- ❑ Inspect the modules for any cracks or discoloration.

- ❑ Inspect module mounting hardware for any signs of corrosion or other damage.
- ❑ Check that the inverter is being kept clean and dry and that the proper indicator lights are on.
- ❑ Check circuit breakers.
- ❑ Look for any loose electrical connections and any deterioration of the weatherproofing of electrical components.

Regular Maintenance – As with solar thermal panels, the glass surface rarely needs cleaning as rain does a good job of this. If there is a need to remove a layer of dust and dirt from the modules, simply wash them with plain water.

Resources

The Northeast Sustainable Energy Association (NESEA) maintains a searchable library of solar and other renewable energy resources: http://www.nesea.org/

Solar Energy Industries Association: http://www.seia.org/

The Florida Solar Energy Center has been active in solar energy research since the mid-1970s: http://www.fsec.ucf.edu

Solar Industry Magazine publishes many online articles concerning the maintenance of solar systems: http://www.solarindustrymag.com

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Site Installed Wind Systems

Wind turbines are electro-mechanical devices that require the same attention to maintenance as any such device. The following excerpt is from the American Wind Association article, *Wind System Operation and Maintenance Costs*:

". . . things do wear out, or just plain wear. Alternator bearings cannot be expected to spin for years without replacement. The same holds true for yaw bearings with their significant loading. Dust, debris, and even insects in the wind will eventually erode the most durable blade materials, leading edge tapes, and paint coatings. Tail bushings and governor components, subjected to dirt and moisture, inevitably wear as the turbine governs in storms or during windy periods. Paint coatings, subjected to sunlight, moisture, and temperature extremes will eventually deteriorate. If your system has a gearbox, the lubricant will degrade over time, just as the oil in your car engine does. So, don't assume that your wind turbine will spin for 20 years carefree. While today's turbines are vastly improved over past offerings, you will need to allocate some money for repairs."

Wind system owners should work with their system manufacturer and installer to develop a regular maintenance plan. As with solar systems, the recording of performance over time will supply much valuable information.

Resources

American Wind Energy Association: http://www.awea.org/

The Northeast Sustainable Energy Association (NESEA) maintains a searchable library of renewable energy resources: http://www.nesea.org/

World Wind Energy Association: http://www.wwindea.org

MicroHydro Power Generation

Another option for select locations is small or micro hydro power generation. Hydro power technology is very well developed and can provide generating power from streams and small rivers reliably for long lifetimes. However, it is necessary that an appropriate site is located in close proximity to an appropriate water source that has the flow necessary to meet demand requirements. Additionally, acquiring permits for such equipment can be more involved than other types of renewables.

Resources

Microhydropower Systems: http://energy.gov/energysaver/articles/microhydropower-systems

Microhydropower: http://www.microhydropower.net/

VI. Commissioning and Retro-commissioning

Commissioning and retro-commissioning are procedures that verify that fundamental building elements and systems are designed, installed, and calibrated to operate as intended and provide for the ongoing accountability and optimization of building energy performance over time. High performance buildings are healthy, efficient, environmentally sensitive structures whose performance can be significantly affected if the building cannot be operated according to the designers' specifications. Commissioning is a rigorous quality assurance program that seeks to ensure that the building performs as expected.

Commissioning Existing Buildings and Systems

Retro-commissioning is essentially the commissioning process applied to equipment and/or systems that were never commissioned properly after being installed, or are no longer operating to specification. This later form of retro-commissioning is sometimes referred to as re-commissioning.

The following retro-commissioning procedures are recommended:

1. **Engage a commissioning agent** – The commissioning agent (CA) directs the commissioning process and should be performed by an independent third party

2. **Develop a retro-commissioning plan** – The retro-commissioning plan includes a list of all equipment and systems to be retro-commissioned, delineation of roles for each of the primary retro-commissioning participants, and details on the scope, timeline, and deliverables throughout the retro-commissioning process. Examples of equipment to consider for retro-commissioning include:

   - ❑ Lighting Controls
   - ❑ HVAC Controls
   - ❑ Energy Management Systems

3. **Perform verification** – Verify installation, functional performance, training, and operations and maintenance documentation for each retro-commissioned system and feature. This is the heart of the retro-commissioning process.

4. **Complete a retro-commissioning report** – The report should show that the building's systems have met the design intent and specifications, have been properly installed, are performing as expected, and that proper O&M documentation and training have been

See it in Action:

Sachem High School East (Farmingville, NY)

Shortly after its opening, higher than expected energy costs at the newly constructed Sachem High School East (SHSE) in Farmingville, New York led the school administration to require commissioning work be done on the facility. The school was constructed under the Whole Building Approach guidelines. The Long Island Power Authority (LIPA) provided the incentives for the construction and the subsequent commissioning services. The actual billings revealed more than three times the energy use than that estimated by the energy model.

It was recommended that the school officials and maintenance staff significantly reorganize the Building Management System and occupancy schedule, including the HVAC units operating outside of the allotting schedules and over-illuminated corridor spaces. A potential of $200,000 in annual savings could be realized if the recommendations from the commissioning projects were implemented. See additional detailed information in this commissioning case study from LIPA.

provided. The report should include a compilation of all commissioning documentation, including complete functional testing results and forms and should note any items that have not been resolved.

5. **Develop a system operational manual** – This manual should cover the operations and maintenance of all commissioned systems, and the facility staff should be trained in the use of the manual.

Retro-commissioning, maintenance, and training are critical to the performance of buildings and their installed systems and are key to maintaining energy efficiency. Retro-commissioning involves a rigorous quality assurance program that ensures the building and its systems are built and operated as designed and that the facility managers receives the proper training and documentation needed to operate and maintain the building. No building can perform optimally without adequate maintenance. Training is critically important for maintenance staff to thoroughly understand how to maintain and operate the building systems. When staff turnover occurs, appropriate documentation must be on hand in order to train new team members.

Commissioning Newly Installed Systems

The commissioning of systems that are newly installed in existing facilities varies only somewhat from the retro-commissioning procedures listed above. It will be important to work closely with the installation contractors to be certain of the various activities that will be performed by the installers, facility staff, and the commissioning agent.

The following commissioning procedures are recommended:

1. **Engage a commissioning agent** – The commissioning agent (CA) directs the commissioning process and should be engaged as early in the design process as possible. If complex systems are involved, the commissioning services should be performed by an independent third party, or performed under separate contract with a member of the design team.

2. **Develop design intent and basis of design documentation** – The design engineer or contractor should work with the facility personnel to create a document that lists the owner's requirements and design intent for each of the systems or features to be commissioned.

3. **Include commissioning requirements in the contract documents** – All commissioning requirements should be integrated into the project contracts to clearly specify the responsibilities and tasks to be performed. Of particular importance is the delineation of the contractors' responsibilities regarding documentation, functional performance testing, occupant and operator training, and the creation of the O&M manuals.

4. **Develop a commissioning plan** – The commissioning plan includes a list of all equipment and systems to be commissioned, delineation of roles for each of the primary commissioning participants, and details on the scope, timeline, and deliverables throughout the commissioning process.

5. **Perform verification** – Verify installation, functional performance, training, and O&M documentation for each commissioned system and feature.

6. **Complete a commissioning report** – The report should demonstrate that the installed systems have met the design intent and specifications, have been properly installed, are performing as expected, and that proper O&M documentation and training have been provided.

7. **Develop a system operational manual** – This manual should cover the operations and maintenance of all commissioned systems, and the facility staff should be trained in the use of the manual.

For more information and details on how to develop and implement a retro-commissioning plan, please see "A Retrocommissioning Guide for Building Owners," compiled by the EPA and Portland Energy Conservation, Inc:
http://www.peci.org/sites/default/files/documents/epaguide.pdf.

Training Building Operators in the Operations and Maintenance of Commissioned Systems

Providing effective and complete training and documentation on the operation and maintenance of building systems is an integral part of the effort. Training programs for maintenance staff, administrators, teachers, and other staff must be developed and completed. Training is an essential step to protect indoor air quality and maintain superior energy performance.

The following guidelines help ensure that the intended operational procedures of the energy using systems are well-documented and provided to the appropriate facility staff. Additionally, the training of facility staff will ensure that the critical importance of proper operations and maintenance is understood and that design goals are met. These requirements are often included in the contract with third-party building commissioning agents.

1. **Compile operations & maintenance manual** - Provide maintenance and facility staff with detailed operations and maintenance information for all equipment and products in use in the buildings.

2. **Create a short workplace "user's guide"** - Provide an explanation for staff on how to operate their room lighting and HVAC systems.

3. **Conduct operations & maintenance training** - Provide a short introduction for all staff and then feature a special hands-on workshop for facility and maintenance personnel. Training should include the interaction of the equipment operating together as a system.

4. **Ensure that maintenance and record keeping on building occupancy should include**:

   - ❑ Annual inspections of the HVAC system. Problems found during these inspections should be corrected within a reasonable time. Air conditioning systems should be inspected twice each year – before the cooling season and again after the cooling season.
   - ❑ Inspections and maintenance of the HVAC system documented in writing. The facilities manager (or individual responsible for oversight of facilities maintenance and operation) shall record the name of the individual(s) inspecting and/or maintaining the system, the date of the inspection and/or maintenance, and the specific findings and

actions taken. The facilities manager should ensure that such records are retained for at least five years.

- ❑ Calibrations of all sensors that are part of the HVAC system on a routine basis including CO_2 sensors for CO_2 demand controlled ventilation. Sensors should be calibrated by experts such as controls contractors.

Resources

Building Commissioning Association Certification Program: http://www.bcxa.org/

ASHRAE Commissioning Process Management Professional (CPMP) program: http://www.ashrae.org/certification/page/2086

CHPS Best Practices Manual, vol. 2, Guideline GC5: Contractor's Commissioning Responsibilities: http://www.chps.net/

ASHRAE Guideline 1-1996: The HVAC Commissioning Process and ASHRAE Guideline 4-1993: Preparation of Operations & Maintenance Documentation for Building Systems: http://www.ashrae.org.

Additional retro-commissioning case studies:

- Silver Falls School District (Salem, OR)
- Sexton Mountain Elementary School (Beaverton, OR)

VII. Transportation

Municipal fleets, including cars, trucks, and buses, can be expensive to operate. However, the investment in regularly scheduled maintenance can reduce costs over the life of the vehicle, while reducing harmful emissions and ensuring the health and safety of passengers. Regular maintenance will also prolong the life of the vehicle, reducing the frequency new vehicles will need to be purchased. School buses in particular should be targeted for routine maintenance due to the frequency of their use, but the same principles can be applied to other vehicle types, as well.

When possible, municipalities should establish a fuel-efficient vehicle purchasing policy. Though typically a greater up-front cost, high-efficiency vehicles cost less to operate and can result in an overall reduced life-cycle-cost to the owner compared to standard efficiency vehicles.

School Bus Maintenance

Aggressive preventative maintenance practices can ensure that vehicles not only respond well in variable conditions but also perform efficiently – thus reducing emissions, cost and health risks. The following are some recommended strategies for improved maintenance on municipal fleets.

Meet minimum compliance with manufacturer recommended maintenance. Visually "inspect" vehicle at least every 41 working days or 15,000 miles.

- ❑ Cracked water hoses, frayed belts, leaking water pump or radiator – while not directly associated with emissions – can contribute to poor performance or reduce efficiency, effectively undermining the vehicle's ability to "run clean."

Visually, audibly and physically inspect the exhaust system. Checking the exhaust system for sounds of holes or fractures should complement an inspection for visible exhaust. Exhaust systems that are not intact can result in fumes entering the cabin and increased exposure for passengers.

- ❑ Special care should be taken to ensure that exhaust systems are fully intact and secure, and that engine compartments are completely sealed from interior passage space. Place a piece of cardboard or firm paper against the muffler as a means of forcing exhaust through any existing holes in other parts of the exhaust system. This test can identify existing fractures within the system. Drivers should be aware of and check for the visible indicators of smoke and color.

Inspect windows, doors and gaskets for "leaks." Rubber sealants, windows and weather stripping can wear over time and produce holes through which emissions can enter the interior of the vehicle.

- ❑ Every emergency window or door, as well as the driver's windshield and main cabin door can be "kicked-out" in case of emergencies and are sealed by rubber or a similar substitute. As the rubber or other sealants deteriorate over time, exhaust can enter the bus. Checking the weather-stripping around the rear emergency door (or whatever exit is closest to the muffler) to prevent exhaust fumes from entering the bus is critical. Replace broken or cracked window glass and check to see that all windows

close securely. A school bus may have as many as 12 (depending upon bus size) emergency exit points (windows and doors) that are sealed by rubber gaskets.

Check and change air filters annually. Visible smoke is generally an indication that fuel remains unburned and, therefore, an engine is not performing at its optimal level.

- ❑ Frequent air filter changes can provide better fuel combustion and can decrease unhealthy soot output by as much as 70 percent.[1] Poor combustion not only wastes fuel and creates smoke, but it coats the cylinder walls with fuel that washes protective oil from sealant rings creating more wear. Left unchecked, this can lead to total engine replacement (cost can be $6,000 or greater). Air filters generally cost between $5 and $25.

Change oil every 3,000 miles or 3 months.

- ❑ Synthetic oils can be used to help reduce the possibility of gelling. While the initial costs are higher, it can be a cost effective choice because they do not break down and do not oxidize. Synthetic oils withstand colder temperatures as a result of lower pour points. If synthetic oils are not used, the bus should run on the highest grade petroleum oil.

Maintain Proper Tire Pressure.

- ❑ You can improve gas mileage by around 3.3 percent by keeping tires inflated to the proper pressure. Under-inflated tires can lower gas mileage by 0.3 percent for every 1 psi drop in pressure of all four tires. Properly inflated tires are also safer and last longer.

Use blended fuels or fuels that will not gel. Gelling of diesel fuel makes it difficult for the engine to start and to run cleanly or efficiently.

- ❑ In cold weather, diesel fuel can thicken or gel to the point that it will not flow through the fuel system. Reduced cranking speed at cold temperatures may produce insufficient heat during compression to ignite the air/fuel mixture. Winter blends (diesel and kerosene) are used to withstand colder temperatures. Fuel additives will reduce gelling and clean the fuel injectors at the same time. Cleaner fuel injectors help the engine run cleaner as well.

Service EGR (exhaust gas recirculation) valve regularly. This helps reduced potential nitrogen oxide (NOx) emissions.

- ❑ During certain conditions of engine operation, measured amounts of cooled exhaust gas are routed to the intake manifold. The cooled exhaust gas mixes with the incoming fresh air and displaces some of the oxygen. With less oxygen in the air, the peak temperatures created in the combustion chamber are reduced, and the levels of NOx are also reduced. The lower the temperature, the lower the production of NOx.

[1] Iowa Department of Natural Resources, Air Quality Division

Other Vehicles

The same maintenance procedures outlined above for school buses can also be applied to other municipal fleets where appropriate. In particular, following the manufacturer's maintenance guidelines, regularly checking tire pressures and changing the oil every 3,000 miles are all practices that will enhance the performance and prolong the life of all vehicles.

Fuel-Efficient Vehicle Purchasing Policy

Municipalities should adopt policies requiring the purchase of fuel efficient vehicles, when appropriate. Vehicles with high fuel economies create less pollution and emit less greenhouse gas into the atmosphere. Additionally, these vehicles use less fuel and therefore cost less to operate.

Such a policy will need to differentiate between passenger vehicles, light and heavy duty trucks, emergency response vehicles (such as police cruisers), and buses. Each of these vehicle classes can be expected to have greatly differing fuel economies, and fuel-efficient alternatives might not be practical or available.

As an example, the Green Communities Program in Massachusetts includes the following fuel efficiency criteria for cities or towns seeking designation. The figures below represent minimum combined city and highway MPG:

- 2 wheel drive car: 29 MPG
- 4 wheel drive car: 24 MPG
- 2 wheel drive small pick-up truck: 21 MPG
- 4 wheel drive small pick-up truck: 19 MPG
- 2 wheel drive standard pick-up truck: 17 MPG
- 4 wheel drive standard pick-up truck: 16 MPG
- 2 wheel drive sport utility vehicle: 21 MPG
- 4 wheel drive sport utility vehicle: 18 MPG
- Hybrid or electric vehicles meet the criteria without restriction

Resources

Asthma Regional Council of New England – Clean Buses Initiative:
http://asthmaregionalcouncil.org/indoor-and-ambient-air-quality

US-DOE Fuel Economy Information: http://www.fueleconomy.gov/

School Bus Fleet Website: http://www.schoolbusfleet.com/Channel/Bus-Maintenance.aspx/

Massachusetts Green Communities Program:
http://www.mass.gov/eea/energy-utilities-clean-tech/green-communities/gc-grant-program/

VIII. Water Efficiency

Outdoor Water Systems

Eliminate Irrigation for Non-Playing Field Landscaping

Significant amounts of potable water are currently used to irrigate landscaping and playing fields. Although the Northeast and Mid-Atlantic regions receive an average of several inches of rainfall per month, expanding development increases the demand for potable water. As more and more water is withdrawn, aquifers and rivers can be stressed to the point of creating water shortages and ecological changes to rivers and streams. Summer dry spells cause the most stress to underground and surface waters as water is withdrawn for irrigation and other outdoor activities but is not replaced by rainfall.

The use of potable water for irrigation can be minimized or eliminated by specifying drought tolerant plants and grasses, collecting and using rainwater for irrigation, and/or using highly water-efficient irrigation systems. When specifying water conservative plants determine soil composition and ensure that existing soils will support the plants to be specified. Consider all operating and maintenance costs of any irrigation equipment specified. If irrigation is necessary, make arrangements to irrigate during morning hours to maximize irrigation benefits and minimize evaporation.

The best types of soil for playing fields are 3 percent to 7 percent organic content and fall into the following U.S. Department of Agriculture soil categories:

Soil Type	Watering Requirements
Loamy sand	1" per week
Sandy loam	1" per week
Loam	1" per week

Resources

State cooperative extension services: http://www.csrees.usda.gov/Extension/index.html

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Maximize Irrigation System Efficiency

If an irrigation system is in place, focus on strategies that maximize irrigation system performance and efficiency. Sustain the landscape by updating irrigation systems according to the dynamic water needs of turf and ornamentals. Incorporate evapotranspiration (ET), which is the combined effects of evaporation from the soil and transpiration of moisture into the surrounding plants, and precipitation data in irrigation scheduling. Develop an efficient irrigation system by using data from audits.

Irrigation controllers and systems should include the following features:

- ❑ Flow Sensor- Capable of monitoring how much water is being used and communicating this to a controller with a master valve.

- Master Valve- Able to shut down zones or systems due to unscheduled flow conditions, main line brakes, or increased flows due to broken sprinkler heads.
- Rain Sensor- Shut off controller due to rain.
- Remote Hand Controller- Very useful tool to assist with sprinkler head and maintenance inspections.
- Central Control Irrigation Controller with ET incorporated data (only when maintenance is properly trained and can support this technically advanced and beneficial system).

Perform regular inspections to optimize irrigation equipment. It is good practice to perform in-depth inspections of irrigation systems after annual activation in the spring, and bring systems up to specified operating conditions. Components to consider include:

- Water Valves: (1) Adjusted for proper flow and operation and (2) To ensure proper shutdown of valves.
- Sprinkler Heads: (1) Adjusted properly and (2) Cleaned to remove debris that might cause blockage or buildup.
- Sensors: (1) Adjusted properly and (2) Calibrated according to specifications.

If and when irrigation water runs onto hardscape such as sidewalks, streets, or driveways, immediately shut off irrigation systems and adjust. Look for signs of leakage, such as overgrown or particularly green turf areas, soggy areas around spray heads and aboveground hoses, jammed spray heads and torn hoses.

Adjust water pressure as needed. Make sure that water pressure is properly set to minimize wind effects. Make sure that the water supply and pressure meet design specifications. Differences in the sprinkler system's required design operating pressure and actual water pressure can affect operation and efficiency. Install pressure reducing valves (PRVs) where needed to stop misting due to excessive pressure.

Regularly update and adjust the irrigation system in response to the changing/seasonal landscape water needs using specific measures, which include:

- Modify and inspect automatic controllers according to the seasonal needs of plants.
- Understand and use a reliable source for reference evapotranspiration rates. Appropriately modify the reference evapotranspiration to calculate local water needs for the needs for the various plant materials and turfgrass in the landscape. Use the California Irrigation Management Information System (CIMIS) for accurate evapotranspiration data (www.cimis.water.ca.gov) Local water providers may also supply evapotranspiration data.
- Periodically verify that plant material is healthy and that soil moisture is adequate. Use a soil probe to visually inspect root depth, soil structure and moisture.
- The irrigation system is a management tool and cannot replace the sound judgment of trained professionals. The best-designed irrigation system will fail without regular maintenance.

Resources

American Society of Landscape Architects (ASLA): http://www.asla.org/nonmembers/sewin.cfm.

LEED for Existing Buildings, Operations & Maintenance: http://www.usgbc.org/ShowFile.aspx?DocumentID=3617, page 27

Boston Schoolyard Initiative: http://www.schoolyards.org.

Green Industries of Colorado, Best Management Practices for the Conservation and Protection of Water Resources: http://www.greenco.org/best-management-practices.html.

International School Ground Alliance: http://greenschoolyards.org/.

National Clearinghouse for Educational Facilities, Resource List – Water Conservation in Schools: http://www.ncef.org/rl/water.cfm?date=4

Professional Grounds Management Society: http://www.pgms.org/.

Sports Turf Managers Association: http://www.stma.org/.

University of Massachusetts, Plant Culture and Maintenance: http://www.umassgreeninfo.org/fact_sheets/plantculture.html.

Water Systems on School Grounds: http://www.ecoschools.com/Water/Water_wSidebar.html.

CHPS Best Practices Manual, vol. 4, Guideline LP7: Irrigation Systems: http://www.chps.net/

Indoor Water Systems

The growing value of potable water underscores the importance of lowering demand. Efficient water consumption naturally reduces the amount of water pumped from the ground or transported from reservoirs to cities and towns. In addition, water efficiency reduces the cost and amount of sewage needing treatment after use. Also, in some larger districts irrigation has a large impact on water usage and may be a better focus for water conservation programs.

New requirements mandate the use of low-flow faucets and showerheads. Schools must provide proper training on water conservation so that devices are used properly. Students will find ways to tamper with devices if they are unhappy with the lower flow or unaware of the benefits. Providing training to the users is critical to the success of water conservation measures.

Ultra-low-flush (ULF) devices for toilets in urinals will significantly reduce water usage. It is important to distinguish low-flush from low-flow. Low-flush toilets and urinals may reduce the consumption per flush by reducing flush time; piping for these fixtures should be sized for the

same flow rate. Assuming a lower flow rate in the design can lead to water hammer and other problems. Verify the recommended flow rate for low-flush devices.

Waterless urinals have the benefits of lower maintenance, since they do not use mechanical parts to flush and remove waste. Their low maintenance requirements are also an obstacle to their use: since they do not require the same daily cleaning procedure, odors can develop before the cartridges require replacement.

Before installing waterless urinals or other similar devices, it is essential that an assessment of the existing plumbing and septic system be completed to ensure it is compatible with the new equipment. Most toilet fixtures specify minimum drainpipe pitch and/or limit type and number of connectors. Budget item should include costs for cartridge replacement.

Fixtures

Routine maintenance should be performed on all terminal devices and associated piping. Such devices include drinking fountains, sinks, showerheads, emergency wash stations and kitchens. Maintenance procedures should include:

- ❑ Check piping monthly for leaks, corrosion or signs of deterioration. Check insulation on pipes prone to condensation. Fix any leaks as soon as possible to prevent water damage and pest attraction.
- ❑ Check the seals of all fittings and valves for leaks, scaling or other signs of deterioration.
- ❑ Check drainage piping for blocked lines. Check water piping joints – corrosion build-up may occur if there is a pH imbalance or improperly joined metals.
- ❑ Verify that shut-off valves and backflow devices are fully operational for all equipment. Verify that emergency shut-off valves for gas-fired equipment in kitchens and labs and for gas-fired water heaters are functioning properly.
- ❑ Clean showerheads to remove any accumulated mineral deposits.
- ❑ Provide shutoff valves to isolate sections of the building when problems occur. Isolate group restrooms, building wings or groups of rooms to minimize impacts of problems.

See it in Action:

Huntington Veterans Affairs Medical Center (Huntington, WV) – Faucet, Showerhead, & Toilet Replacement Project

In 2007, the **Huntington VA Medical Center** located in Huntington, West Virginia completed a large-scale retrofit of faucet and showerheads in its 1-South Section containing offices, clinics, surgery units, patient rooms and laboratories. The retrofit was part of the Green Environmental Management initiative.

The project includes the replacement of:

- o 178 faucets (2.5 to 1.5 gallon per minute)
- o 33 showerheads (2.2 to 1.7 gallon per minute)
- o 87 toilets (replaced with both 1.6 gallon per flush and dual flush)

According to a US DOE study, the retrofit project saves the Huntington VA Medical Center more than 1.5 million gallons of water each year. The Center enjoys annual cost savings of $12,900 of combined water and sewer costs. In addition, energy savings from reduced use of hot water generate an additional $7,200 in annual cost savings. The Center spent a total of $3,400 for material and labor costs for the project.

- ❑ Wall-mounted water closets that have blowout-design flush valves can reduce maintenance requirements.
- ❑ Activate eyewash and shower equipment at least monthly to flush the line and verify proper operation.
- ❑ Hot and cold-water piping systems are typically copper; steam and gas piping are usually constructed from malleable iron. Maintenance staffs spend a lot of their time responding to stoppages and leaks of fixtures and fittings. With piping, problems occur most often with the fittings, the result of corrosion, erosion and mineral buildup. Water hammer can crack piping and cause leaks in header piping and heating coils. Discoloration (or rust, for steel pipes) may be one of the first noticeable signs of a small leak. Seldom exercised valves should be routinely checked, at least once a year, so that mineral deposits don't "lock" them in place.

Science labs often have special plumbing requirements. Acid-resistant sinks and plumbing to accommodate acid waste may be required. Sinks should have (basket) strainers. Labs may require a natural gas shut-off valve for safety.

How to Clean and Maintain Waterless Urinals

A waterless urinal looks very much like a conventional urinal. Many times, all that is different is the missing flush valve or piping that normally sits above the unit (because waterless urinals, as the name implies, do not need water to operate).

Instead, waterless systems have a vertical-trap design that incorporates a cylinder or trap filled with a thin layer of liquid sealant sitting atop the drain area of the urinal. Urine passes through the cylinder and sealant; as the cylinder fills, it flows under the barrier layer and into the waste line where it is drained, much the same way a conventional urinal works.

Since the urinal surface is dry, it helps inhibit bacteria growth and odor, and makes the unit easier to clean. Additionally, there are no water deposits or rust stains to build up as with a water-based urinal.

Although there are some differences depending on the manufacturer, cleaning a waterless urinal follows most of the same steps and procedures as a conventional urinal:

- ❑ Wear gloves (and goggles) to clean any restroom fixture.
- ❑ Remove any foreign objects in the urinal. The trap is designed to prevent larger objects from entering the drain area.
- ❑ Do not use abrasive cleaners, towels, or brushes.
- ❑ Mist all urinal surfaces with a neutral or all-purpose cleaner, or use a Johnny Mop with water and cleaner on all surfaces.
- ❑ Allow for dwell time (if indicated by the chemical manufacturer).
- ❑ Wipe clean with a soft sponge, a Johnny Mop dipped in a bucket of clean water, or a cleaning cloth.
- ❑ Dry the surfaces with a soft cloth.
- ❑ Do not pour excess or soiled water down the waterless urinal trap - it can flush the sealant out of the trap insert.

Sealant and Trap Replacement

In most cases, cleaning professionals are asked to handle the trap's maintenance. Although maintenance requirements may differ depending on the product, they usually involve replenishing the liquid sealant and/or replacing the cylinder as necessary.

As the urinal is used, small amounts of the sealant will be drained into the waste line and need to be replenished (usually after 1,500 uses). This typically amounts to one or two refills per month.

To add sealant, use the "portion aid" device that comes with the sealant; this will accurately measure the 3 ounces of sealant needed, which is poured directly into the cylinder.

The cylinder on some waterless urinals lasts several months and may only need to be changed two to four times per year. To replace the cylinder:

- ❑ Use the metal tool provided by the manufacturer to remove the trap.
- ❑ Insert it into the trap, gently pulling it out using a back-and-forth motion.
- ❑ Drain any excess liquids from the cylinder down the drain; discard in an appropriate manner.
- ❑ With the trap removed, pour a bucket of (preferably) hot water down the drain to flush any sediment in the line.
- ❑ Insert a new trap, add about 12 ounces of water, and fill with 3 ounces of sealant.
- ❑ For some manufacturers, the trap cannot be replaced and the trap needs to be taken apart and cleaned.

Resources

American Society of Plumbing Engineers: http://www.aspe.org

American Water Works Association. Provides information on drinking water standards and regulations, and information on cross connection control: http://www.awwa.org.

LEED for Existing Buildings, Operations & Maintenance:
http://www.usgbc.org/ShowFile.aspx?DocumentID=3617, Pages 23 -30

Arizona School Facilities Board, Preventive Maintenance Checklist:
http://www.azsfb.gov/sfb/agency/pages/formDoc.asp?theType=0&section=7

Collaborative for High Performance Schools, Best Practices Manual, Volume II – Design:
http://www.chps.net.

Fitzemeyer, Ted, "Construction Guide: Plugging Leaks", School Designs, 2004. Primedia Business Magazines & Media, a PRIMEDIA company:
http://www.schooldesigns.com/constr_PluggingLeaks.html.

Florida Department of Education, Maintenance and Operations Guidelines for School Districts and Community Colleges, Office of Educational Facilities, 1054 Turlington Building, 325 West

Gaines Street, Tallahassee, Florida 32399-0400. Telephone: (850) 245-0494, SUNCOM: 205-0494, Fax: (850) 245-9236 SUNCOM: 205-9236: http://www.fldoe.org/edfacil/manoguid.asp

National Clearinghouse for Educational Facilities, Resource Lists – Water Conservation in Schools: http://www.ncef.org/rl/water.cfm?date=4

Plumbing & Drainage Institute, 800 Turnpike Street, Suite 300, North Andover, MA 01845 USA Phone: 1-978-557-0720, 1-800-589-8956, Fax: 1-978-557-0721, Email: info@PDIonline.org. This organization provides information on products and standards. http://www.pdionline.org.

CHPS Best Practices Manual, vol. 4, Guideline PM2: Fixtures: http://www.chps.net/

IX. Materials Selection and Specification

Cleaning Products and Equipment

Assessing the Needs of the Facilities

The first step in developing a Green Cleaning Strategy is to assess the overall needs of the facilities. This entails looking at the size and age of the facility, the floor and wall coverings, and the condition of each area. Special attention should be paid to the resources available versus the amount of space to be cared for, and the complexity of each task to be performed. It is very important to use cleaning products that contain less-toxic ingredients and to eliminate all products that put custodians and occupants at high risk. It is also important to educate occupants about the benefits of using green cleaning products and a toxic chemical-free indoor environment.

Environmentally Preferable Purchasing (EPP)

The main focus of an EPP strategy is to reduce the impacts of a product or service on both health and the environment compared to similar products and services used for the same purpose. EPP is a simple recognition of the enormous technological advances found in many industries, including those which supply products used for cleaning schools by increasing the importance of health, safety and environmental attributes when making a "best value" purchasing decision. It also recognizes that many public buildings are currently using 50+ year old technologies, and while these products are not "bad" or placing people at imminent risk, there are newer, safer, better technologies available.

EPP is an important opportunity especially for schools and other buildings with sensitive populations (i.e., young children, asthmatics and those with chemical sensitivities).

A more comprehensive definition of EPP can be found in Executive Order 13101, located at: http://www.epa.gov/epp/pubs/13101.pdf or the Network for Business Innovation and Sustainability at: http://nbis.org/nbisresources/greening_the_office/sustainable_purchasing_resources.pdf.

"Green" Cleaners

Approximately five billion pounds of chemicals are used in the U.S. each year to clean and maintain institutional and commercial buildings. The majority of these products are derived from non-renewable natural resources and for the vast majority of the 70,000+ ingredients used to make these products, little testing has been conducted to evaluate their long-term effects on children or the environment.

One way to find safer and environmentally preferable chemicals is to purchase products that have been Green Seal Certified, or have equivalent specifications. Executive Order 13101 provides a definition that is useful. The Environmentally Preferable Products Purchasing Guide produced by U.S. Environmental Protection Agency is helpful and can be found at: http://www.epa.gov/epp/pubs/cleaning.htm

Specific to standards for cleaning products, Green Seal, a non-profit, consensus-based standards setting organization, has produced widely adopted industry standards for

sustainable, healthy and safe materials, cleaning supplies and their proper use. The Green Seal Standard for Industrial and Institutional Cleaners (see GS-37) address health, environmental & performance attributes.

By using Green Seal Standard 37, or an equivalent set of specifications, it is much easier to develop a cleaning product program for the needs of an entire municipality as compared to individual facility managers developing their own unique specification addressing health, safety, environmental, performance and other criterion. Furthermore, when purchasing Green Seal Certified products the purchaser can be confident that the product meets the health, environmental and performance requirements because Green Seal audits the manufacturer's facility to insure compliance. More information on Green Seal's Standard 37 can be found at www.greenseal.org/gs37.aspx .

See it in Action:

Vermont Legislation for Green Cleaning in Schools

In 2012, Vermont passed Senate Bill 92, titled *An Act Relating to the Protection of Students' Health by Requiring the Use of Safe Cleaning Products in Schools*. The Act requires manufacturers and distributors of cleaning products to only sell green cleaning supplies to schools. Vermont schools may only use environmentally preferable cleaning products certified by an independent third party, or those used by the department of buildings and general services under state contracts. For more information, see Vermont's Green Cleaning Products Law Summary and the Department of Health's Basics of Green Cleaning Guide.

The typical custodial contractor buys its chemical products from a number of sources and keeps an inventory sufficient to cover about a month's consumption. Custodians working for a site also buy from a variety of sources, but can keep more supplies on hand. Some municipalities purchase supplies on an annual basis. One desirable goal in purchasing is to establish a single source of compatible, environmentally friendly products that carry the Green Seal label. This is not just safe and healthy, but also good business, since buying in quantity allows for lower costs per unit volume purchased.

Product Ingredients

Preferable Ingredients

There are two critical elements in deciding when a product is environmentally preferable. The first critical element is choosing a product that has comparatively fewer human health and safety risks than others. The second critical element is to minimize or eliminate negative environmental impacts as much as possible. These elements form a decision-making model and can be developed using a decision matrix which takes advantage of the opportunity to reduce health risks to humans, create fewer environmental impacts, and allow custodians to perform their work more safely.

Incorporating environmentally preferable products into purchasing decisions requires a comparison based on health and environmental factors.

Ingredients to Avoid

According to the Pennsylvania Green Building Maintenance Manual, all-purpose cleaners consist of a broad array of possible formulations. The following are some of the specific issues to compare for this product category:

- ❑ pH: Prefer those with a neutral pH (closer to 7) as compared to those with extreme pH (closer to 1 or 14)
- ❑ Biodegradability: Prefer those that are readily biodegradable as compared to those that are slower to degrade. Unfortunately, many older formulations contain excellent performing ingredients that have been found to have serious environmental and health concerns.
- ❑ Dyes and fragrances: Prefer those with no or low levels of dyes and fragrances compared to those products that are heavily dyed or fragranced. If dyes are necessary use those that are approved for foods and cosmetics (F&C).
- ❑ Volatile organic compounds (VOCs): Prefer those that have no or low VOCs as compared to alternatives with higher levels. Consider detergent-based products compared to those containing solvents.
- ❑ Surfactants: More preferable surfactants are those containing terms such as lauryl, amides, and glycosides as they are sustainably derived from bio-based and renewable resources.
- ❑ Less preferable ingredients: Nonyl Phenol Ethoxylates, NTA, EDTA, glycol ethers, sodium hydroxide, potassium hydroxide, sodium metasilicate, and phosphates, as these common ingredients each have some significant adverse health or environmental impact.

Minimize Product Use

Before using a product, an analysis must first be done as to whether the task for which the product is needed is a task that should be performed at all. Find out which products contain the most dangerous ingredients and focus on changing those first.

Next, do research to find out the alternative products that are available. Figure out how to perform the same work with fewer chemicals. Initially restrict the use of highest risk chemicals using a sign-out system to control inventories, and be sure to train custodians on how to minimize chemical use. Eliminate highest risk chemicals by shifting from the old products after finding, testing, and introducing preferable substitutes.

Safe Chemical Use, Storage and Disposal

- ❑ Read the label and directions for use, storage, and disposal. Hazard warning labels must include a description of the hazard(s), personal protection information and first aid for accidental exposure.
- ❑ Avoid skin and eye contact. Use appropriate personal protective equipment.
- ❑ Never mix products or different brands of the same product. Follow the instructions on the label.
- ❑ Keep products in their original containers if possible. If not, be sure that containers are properly labeled, and use a different color for each chemical to prevent accidental misuse of cleaning solutions.
- ❑ Buy the appropriate products for the job, in the appropriate quantity. Use non-hazardous or less hazardous products as described above.

- ❑ Provide adequate ventilation. For example, mixing of solutions or dilution procedures should take place in a well-ventilated area, negatively pressurized area, or outdoors.
- ❑ Store all cleaning materials in a well-ventilated closet, away from highly trafficked areas.

Aerosols

In most situations the use of aerosols indoors is not a sustainable, healthy or cost effective practice. The negative effects of most propellants and/or the high relative cost per unit of volume can be easily demonstrated in most cases. If they exist or are used, dispose of the empty containers in the trash—do not burn or put them into a trash compactor where they may rupture or explode. Some aerosol cans that are steel or aluminum are recycled in some areas of the U.S. Contact the local health department or refuse disposal facility to learn more about what can be done in your area. Pump products are a non-aerosol alternative to most aerosol formulations.

- ❑ Aluminum cleaners. Although most schools do not purchase these types of cleaners, if they are used, treat them as follows: If they contain phosphoric acid and only a small quantity remains, they can be discarded in the septic system. Pour the product down a drain (not a storm sewer—some garage drains may empty into the storm sewer) and flush with plenty of water. Rinse the container and throw it away.
- ❑ Ammonia: DO NOT MIX WITH CHLORINE BLEACH. The product can be discarded in small quantities in the septic system, in the same method as aluminum cleaners.
- ❑ Bleach: DO NOT MIX WITH AMMONIA. The product can be discarded in small quantities in septic system, in the same method as aluminum cleaners.
- ❑ Detergents: The product can be discarded in small amounts down a sanitary drain, in the same method as aluminum cleaners.
- ❑ Drain openers: If the product contains a solvent (organic solvent), take it to a household hazardous waste collection program. In most cases, allowing the volatile solvents to evaporate is not recommended. State, and local rules and insurance policies should be carefully checked before considering evaporation, and if evaporation of solvents is allowed, it is only recommended in a ventilated chemical laboratory hood. Many types of chemical disposal programs for schools are becoming more common nationwide. Contact risk management, health agencies and environmental authorities for local guidance on disposal programs and facilities that will accept organic solvents from schools for proper disposal. If it does not contain a solvent, the product may the discarded in the same method as aluminum cleaners. Wear eye protection when discarding drain cleaners.
- ❑ Floor care products: If the product contains an organic solvent, it can be disposed of in the same method as either aerosols or drain openers. If the product does not contain a solvent, it can be discarded in the same method as aluminum cleaners.
- ❑ Furniture polish: The product can be disposed of in the same method as aerosols or by evaporating in the same method as drain openers.
- ❑ General home liquid cleaners: If the product contains a solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent, it can be discarded in the same method as aluminum cleaners.

- Germicides/disinfectants: If the product contains a solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent, it may be able to be discarded in the same method as aluminum cleaners. Save the product for a hazardous waste collection if "germicide or disinfectant" is listed in the ingredients. Technically, disinfectants or germicides fall under pesticide labeling regulations. Try to avoid disposal in septic systems.
- Metal polish with solvent: The product may be evaporated in the same method as aluminum cleaners.
- Oven cleaner: If the product contains a solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent and is not an aerosol, it can be discarded in the same method as aluminum cleaners.
- Rug upholstery cleaners: If the product contains a dry-cleaning solvent, it can be disposed of in the same method as aerosols or drain openers. If the product does not contain a solvent, it can be discarded in the same method as aluminum cleaners.
- Toilet, tub, and tile cleaners: The product may be discarded in the septic system, in the same method as aluminum cleaners.
- Window cleaner: The product may be discarded in the septic system, in the same method as aluminum cleaners. If the product contains a solvent, dispose of through evaporation.

Pollutant Source Control

Whenever possible it is best to keep chemical usage and storage isolated from the rest of the facility. This includes housekeeping areas, chemical mixing areas, copying/print rooms, photo labs, science labs, and vocational spaces. It is recommended that these areas be partitioned off, physically isolating activities associated with chemical contaminants from other locations in the building. Dedicated exhaust should be installed for a ventilation rate of at least 0.50 cubic feet per minute per square foot with adequate make-up air. The air from these areas should not be re-circulated, and negative air pressure should be maintained.

In photo-lab areas, table vents should be used to draw chemical vapors away from the breathing zone of darkroom users. Other high hazard areas including all housekeeping chemical storage and mixing areas should allow for locked secure product storage.

Resources

Ashkin, Stephen, "The All-Purpose Solution," American School and University, v76 n2, October 2003. This article discusses improved worker and student performance through improved cleaning practices. The author cites studies showing significant improvement in indoor air quality and improved health of occupants through deep-cleaning strategies: http://asumag.com/mag/university_allpurpose_solution/.

Bigger, Alan; Bigger, Linda, "Keeping it Clean by Going 'Green'," Maintenance Solutions, June 2003, This piece discusses how to integrate highly productive equipment with environmentally friendly and cost-effective products to enhance the level of cleanliness in restrooms: http://www.facilitiesnet.com/green/article/Keeping-It-Clean-by-Going-'Green'--1900#.

California Department of Resources Recycling and Recovery, Environmentally Preferable Purchasing: http://www.calrecycle.ca.gov/epp/.

Commonwealth of Pennsylvania, "Pennsylvania Green Building Maintenance Manual: A Manual for the Commonwealth of Pennsylvania on Environmentally Preferable Building Operations and Maintenance." April 1, 2002.

Green Seal: http://www.greenseal.org.

Healthy Schools Network Inc., Sanitizers and Disinfectants Guide. 773 Madison Avenue, Albany, NY 12208; Tel: 518-462-0632: http://www.cleaningforhealthyschools.org/

National Clearinghouse for Educational Facilities, Resource List – Cleaning and Maintenance Practices in Schools: http://www.ncef.org/rl/green_cleaning.cfm

U.S. Environmental Protection Agency, Database of Environmental Information for Products and Services: http://yosemite1.epa.gov/oppt/eppstand2.nsf

CHPS Best Practices Manual, vol. 4, Guideline CP2: Cleaning Products and Equipment: http://www.chps.net/

Maintaining Interior Surfaces

"Green" Janitorial Equipment

Public buildings use janitorial equipment, such as vacuum cleaners, floor buffers and burnishers, to maintain carpeting and hard flooring materials. Studies have shown that the soils being removed by these pieces of equipment can be contaminated with toxic materials including lead, pesticides, VOCs, mold spores and other materials that can affect health. Unfortunately, some commonly used equipment can actually contribute to these problems.

Some of the problems which can be caused by these pieces of equipment include vacuum cleaners with poor quality cloth bags containing no inner liners that inadequately capture fine particles and can actually contribute to indoor air quality problems as they pull contaminants that would otherwise be trapped in a carpet and make them air-borne. Another example is high speed burnishers without filter attachments which grind floor finish off the floor and send them into the air to be inhaled and resettle as dust on furnishings and other services. Specifying and utilizing janitorial equipment that not only create a good appearance, but more importantly capture and remove dust is essential for maintaining a healthy indoor environment.

In order to avoid some of the health hazards listed above, cleaning equipment should meet the following requirements:

Vacuum Cleaners

- ❑ Vacuum cleaners should meet the Carpet & Rug Institute's Green Label Program. Information on the Green Label Program can be found at: http://www.carpet-rug.org.

It is desirable that vacuums exceed the minimum requirements of the Green Label Program in the following ways:

a. Higher ability to capture and contain fine/respirable particles (capture 96 percent of particulates 0.3 microns in size).

b. Powerful air flow (>90 CFM) and suction (static lift of >80 inches) for enhanced cleaning performance.

c. Durable to reduce impacts on resources and disposal (manufacturer's warranty on parts and labor >2 years).

d. Carpet extraction equipment should be capable of removing sufficient moisture such that carpets can dry in less than 24 hours.

Other Surface-Cleaning Equipment

- ❑ Powered floor maintenance equipment should be equipped with vacuums, guards and/or other devices for capturing fine particulates, and shall operate with a sound level less than 70dBA.
- ❑ Propane-powered floor equipment should have high-efficiency, low-emission engines.
- ❑ Automated scrubbing machines should be equipped with variable-speed feed pumps to optimize the use of cleaning fluids.
- ❑ Battery-powered equipment should be equipped with environmentally-preferable gel batteries.
- ❑ Where appropriate, active micro fiber technology should be used to reduce cleaning chemical consumption and prolong life of disposable scrubbing pads.

Facilities managers should keep a log for all powered janitorial equipment. The log should identify the date of purchase and all repair and maintenance activities. Include vendor cut sheets for each type of equipment in use in the logbook.

All powered equipment including those for both hard floor and carpet care should be ergonomically designed to minimize vibration, noise and user fatigue. Additionally, consider weight, ease of motion, tools and accessories, and profile of equipment when evaluating ergonomically designed equipment.

Asbestos

Asbestos is a naturally occurring mineral fiber, once widely used in building materials for its thermal insulating properties and fire resistance. Although the removal of asbestos from buildings is an option, many building owners have chosen to manage some asbestos-containing building material in place.

Intact, undisturbed asbestos-containing materials generally do not pose a health risk. These materials may become hazardous and pose increased risk if they are damaged, are disturbed in some manner, or deteriorate over time and release asbestos fibers into building air.

A number of building materials still in use today contain asbestos. Asbestos remains in use as an acoustic insulator, and in thermal insulation, fire proofing, roofing, flooring and other materials. There are several simple things you can do to minimize exposure to asbestos. The

most important one is to find out which materials in your building contain asbestos. Once you know where asbestos is, use special care to insure that any day-to-day activities, such as repair or maintenance work, do not disturb the material. In fact, special training is required to participate in any maintenance activities which might disturb asbestos. In schools, asbestos-containing materials can also be damaged by student activities. For example, an asbestos ceiling in a gym may be disturbed if basketballs or other objects are thrown up against it. Students and others who use the gym should be warned to avoid such activities.

Resources

US EPA: *The ABC's of Asbestos in Schools*: Published by the EPA, August 2003:
http://www.epa.gov/asbestos/

http://www.epa.gov/asbestos/pubs/asbestos_in_schools.html

CHPS Best Practices Manual, vol. 4, Guideline CP2: Cleaning Products and Equipment:
http://www.chps.net/

US Department of Labor Occupational Safety & Health Administration – Asbestos:
http://www.osha.gov/SLTC/asbestos/

Selecting Low Emitting Materials

Just as with selecting materials for the construction of a new building, selecting low emitting materials when adding furnishings, or renovating spaces can have significant impact on indoor air quality. Many common indoor building and surfacing materials contain a variety of potentially carcinogenic and/or toxic chemicals. These chemicals are released into the air and can cause a variety of health problems, from minor irritation to major health problems. Recent studies have implicated volatile organic compounds (VOCs) as significant risk factors for asthma. Exposure to VOCs emitting from sources such as cleaning agents, solvents, furnishings, paint, flooring products, and building materials, may increase the risk of asthma and other ailments. This is especially important in schools because children are typically more sensitive to indoor air pollutants than adults.

Low VOC content should be specified for the following materials:

- ❑ Adhesives and sealants
- ❑ Acoustic ceiling tiles and acoustic wall panels
- ❑ Carpeting
- ❑ Interior paint
- ❑ Wall coverings (do not use vinyl wall paper)
- ❑ Solid and composite wood flooring
- ❑ Insulation installed interior to the building vapor barrier
- ❑ Resilient flooring

Resources

CHPS Products Database: https://www.chpsregistry.com/live/

Green Spec: http://www.buildinggreen.com

The following programs certify low VOC products:

Scientific Certification Systems Indoor Advantage – Gold:
http://www.scscertified.com/gbc/indooradvgold.php

Resilient Floor Covering Institute (RFCI) Floor Score: http://www.rfci.com/

GREENGUARD Certification Program: http://www.greenguard.org/

Carpet and Rug Institute Program - Green Label Plus:
http://www.carpet-rug.org/commercial-customers/index.cfm

Establishing A Donation Policy

Some jurisdictions have policies that allow for the donation of furniture, appliances, and other equipment and materials, to be used in public buildings. While this can be a low- or no-cost alternative to buying new products, some of these used items can contain harmful materials or chemicals. In the case of donated appliances, used refrigerators and microwaves are typically very inefficient and can be very costly to operate.

Municipalities and institutions should develop a donation policy that specifically outlines the criteria for acceptable donated items.

Specific examples can include:

- ❑ Appliances must be 5 years old or newer and/or carry the ENERGY STAR rating
- ❑ Furniture must be intact with no damage that would result in airborne material
- ❑ Furniture brought into the schools must be rated as fire retardant
- ❑ Light fixtures must be equipped with CFLs, T8 linear fluorescent or other high-efficiency lamps
- ❑ Cleaning supplies must adhere to the recommendations previously mentioned in Section IX.

X. Recycling

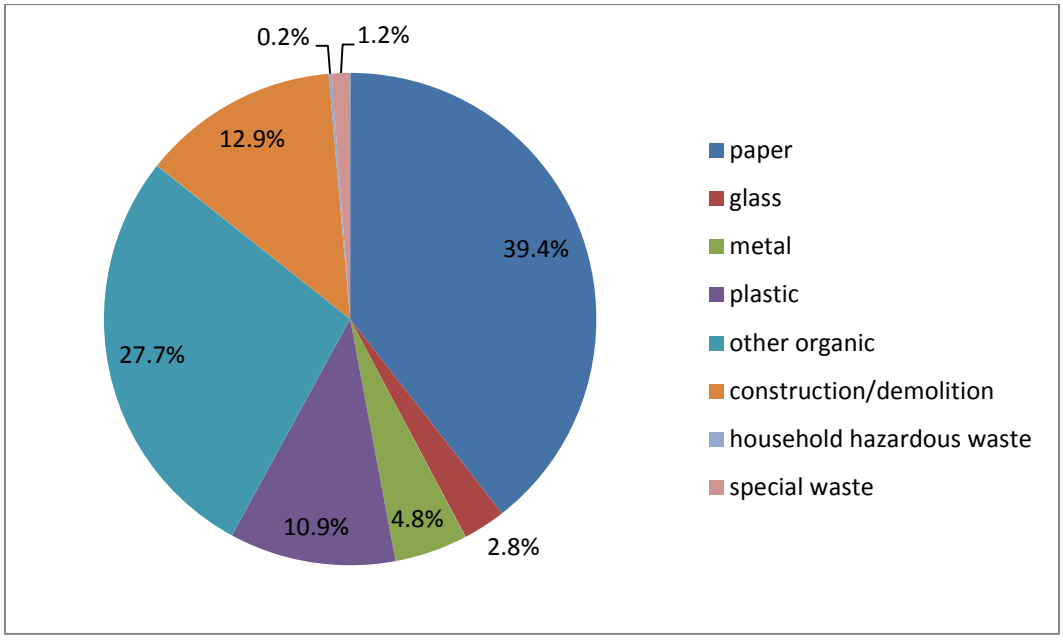
Storage and Collection of Recyclables

The recycling of many common materials is promoted throughout the Northeast and Mid-Atlantic region with a variety of recycling programs and services. Typical recyclables include aluminum cans, steel cans, newspaper, white paper, corrugated cardboard, single polymer plastics, and glass bottles. Place recycling bins next to trashcans to provide occupants with disposal options, and reduce or prevent contamination of recycling bins with trash. Ensure that the recycling bins are marked clearly. Many recycling services can provide appropriate signage.

The types of recycling that are accepted should be advertised to make it obvious to the occupants what should and shouldn't be recycled. The collection process should be made as easy as possible by locating collection bins in convenient locations near exits and trash bins.

M&O staff should have a clear idea of the main types and amounts of waste that are generated on the facility site. Recycling programs should target those areas. While many types of materials can and should be part of a facility recycling program, this guideline focuses on the three materials that are generally the most common waste types: paper, plastics, and organic materials. Figure 5 shows a typical breakdown of waste generated in public buildings.

Figure 5 – Typical Breakdown of Facility Generated Waste



Source: CalRecycle Solid Waste Characterization Database

It is important that staff and students are reminded on a regular basis of the proper items and the correct methods of preparation. Collected recyclables are a raw material for industry and therefore they must meet manufacturers' specifications just like any other raw material. Improperly prepared recyclables may lose value or become so contaminated that they cannot

be recovered and must be disposed of as trash instead. For example, the addition of a broken ceramic cup to a load of glass containers at a glass recycling plant might result in rejection of the entire load. Recyclables contaminated with food residue may cause odor or pest problems.

Common Recycled Materials

Paper

Paper is generally the largest waste material generated in schools and other public buildings. Design your program to maximize both the quality and the quantity of waste paper collection. Consider installing a baler for cardboard and mixed paper to facilitate the management of some recyclables and to increase storage space.

Plastics

Public buildings also generate a lot of plastic waste, mainly from food and beverage containers. Check with your local recycling service about plastics collection. Most services collect PET and HDPE plastic containers. It is important that staff knows which plastic types will be collected and which are not appropriate for recycling.

Figure 6 contains a list of various types of plastic.

Figure 6 – Plastic Types

NUMBERED CODE	NAME AND CHARACTERISTICS	ITEMS MADE FROM THIS PLASTIC	PRODUCTS MADE FROM THIS RECYCLED PLASTIC
1	**Polyethylene Terephthalate (PET):** Clear, strong, holds carbonation	Soft drink, beer, water, mouth wash, salad dressing and ketchup bottles and peanut butter containers	Fiber, tote bags, bottles, clothing, furniture, carpet and car upholstery
2	**High Density Polyethylene (HDPE):** Clear or bright colored	Milk, water and juice containers, trash bags, liquid detergent bottles, yogurt and margarine tubs	Liquid laundry detergent containers, drainage pipe, oil bottles, recycling bins, benches, pens, dog houses, vitamin bottles, floor tiles, picnic tables, lumber, mail box posts and fencing
3	**Vinyl (polyvinyl chloride or PVC):** Clear, strong, resistant to oil, grease and chemicals	Clear food packaging, shampoo bottles, medical tubing, wire and cable insulation	Packaging, binders, decking, paneling, roadway gutters, mud flaps, flooring, cable, speed bumps and mats
4	**Low Density Polyethylene (LDPE):** Clear, flexible, easy to shape	Bread bags, frozen food bags, some squeeze bottles, fiber, tote bags, clothing, furniture and carpet	Shipping envelopes, garbage can liners, floor tiles, furniture, compost bins, paneling, trash cans, landscape timber and lumber
5	**Polypropylene (PP):** Strong, chemical resistant, will not scratch	Ketchup bottles, yogurt containers, margarine tubs and medicine bottles	Auto battery cases, battery cables, brooms, brushes, ice scrapers, oil funnels, landscape borders, rakes, bins, pallets, bicycle racks and trays
6	**Polystyrene (PS):** Clear, rigid or foam	Compact disc jackets, grocery store meat trays, egg cartons, aspirin bottles, cups and plates	Thermometers, light switch plates, thermal insulation, egg cartons, desk trays, rulers and carryout containers
7	**Other:** Package is made with a resin other than the six listed above or of more than one resin used in combination	Three- and five-gallon water bottles, citrus juice and ketchup bottles	Plastic lumber and custom products

Source: South Carolina Department of Health and Environmental Control Office of Solid Waste Reduction and Recycling.

Organic Material

Organic materials make up almost one-third of a typical school building waste production, due mostly to food service. For other public buildings the percentage will vary greatly. A significant amount of that material can be diverted from the waste stream by:

- ❑ Collecting grass clippings and other yard waste in bins to be picked up by local green waste recyclers.
- ❑ Donating excess food not served to students to local shelters or food assistance programs.
- ❑ Purchasing bulk foods and drink and offering dispensers instead of individual servings.
- ❑ Storing food waste in special bins that can be sent to composting facilities and/or local farms where it can be used as feed for livestock. Also consider implementing onsite composting and/or vermicomposting (composting with worms).

For more information on composting, see section XIII. Cafeteria Practices.

Mercury

Recycle spent fluorescent lamps properly to reduce risk of exposure to hazardous wastes. Fluorescent lamps contain mercury, which is released into the atmosphere when tubes are broken in trash. Collecting them in their original containers and shipping them to a fluorescent lamp recycler reduces the risk of exposure to hazardous wastes.

A searchable database of facilities nationwide where you can take lamps and other equipment containing mercury for recycling can be found at the following website: http://earth911.com/

Other Materials

Provide separate collection bins for glass and aluminum containers generated from food preparation, vending machines, and packed lunches, if your recycling service is not single stream. Almost all glass food and beverage containers, as well as scrap metal, lumber, concrete and asphalt are recyclable.

Single-Sort Recycling

Some jurisdictions offer single-sort recycling that allows consumers to combine all recyclable materials into one container, which is then picked-up and sorted downstream. By making it easier to

See it in Action:

Washington D.C. Recycling Pilot Programs, John A. Wilson Building

In 2004, a pilot program at the John A. Wilson Building began, involving 550 employees with the goal to reduce waste and increase recycling and diversion rates. The building reduced trash by 23 tons in 2005 by removing trash bins from desks, and replacing with miniature bins in order to raise awareness of one's waste. As a result, the employees improved their diversion rate from 18 percent to 41 percent in 2004 to 2005. This pilot project was expanded to include additional municipal buildings in Washington D.C. including, the District's other Core Buildings: Frank D. Reeves, the One Judiciary Square Building, and the Henry Daly Municipal Buildings. The District reached a 40 percent diversion rate in 2007 for the first time, according to its Public Report on Recycling for 2005-2007.

collect recyclable material, this approach results in a greater percentage of recyclable waste to be correctly disposed of. However, by not relying on the consumer to sort the recyclable material on the front end, this task is instead transferred to a facility downstream that typically relies on mechanical methods of sorting. This process can be very energy intensive, and also results in an end product that is commonly more contaminated than if the material was sorted at the disposal site. The cost difference between these two recycling methods, if any, can vary greatly from region to region. Before new construction and major renovation, plan to include bid specification to require contractors to recycle construction debris when applicable.

Monitoring

Monitoring is important for the success of all waste management and recycling programs. Annually, waste collection and recycling services should be evaluated to determine if either or both need to be reduced or increased, as well as to track the amounts of recyclables being collected. Such monitoring can help document success in diverting materials from the landfills and money saved on waste collection.

Recycling station at New Hampshire school

Resources

Broward County Public Schools Recycling Program, Broward County, Florida: http://www.browardschoolsgogreen.com/

The California Department of Resources Recycling and Recovery: http://www.calrecycle.ca.gov/

CalRecycle – School Waste Management Education and Assistance: http://www.calrecycle.ca.gov/Education/

Environmental Protection Agency. WasteWise Program (5306W): U.S. Environmental Protection Agency; Ariel Rios Building; 1200 Pennsylvania Avenue, N.W.; Washington, DC 20460. Website: http://www.epa.gov/epawaste/conserve/smm/wastewise/index.htm

Earth 911. Find Recycling Centers: http://earth911.com/

Northeast Recycling Council: http://www.nerc.org/

Technical assistance is available from the Northeast Resource Recovery association: http://www.nrra.net/ and the following state contacts:

Connecticut Department of Environmental Protection:
http://www.ct.gov/dep/site/default.asp

Maine State Planning Office Waste Management and Recycling Program:
http://www.state.me.us/spo/recycle/

Massachusetts Department of Environmental Protection:
http://www.mass.gov/eea/agencies/massdep/recycle/

New Hampshire Department of Environmental Services:
http://des.nh.gov/organization/divisions/waste/index.htm

Rhode Island Resource Recovery Corporation: http://www.rirrc.org/

Vermont Agency of Natural Resources:
http://www.anr.state.vt.us/dec/wastediv/R3/recycle.htm

CHPS Best Practices Manual: vol. 4: Guideline ED3: Recycling: http://www.chps.net/

XI. Landscaping to Reduce "Heat Island Effect"

Although the "heat island effect" is largely an urban phenomenon, dark surfaces, such as pavement, cladding, and roofing absorb heat and radiate it back to surrounding areas. In cities, where there are many dark, heat absorbing surfaces, infrared radiation can boost temperatures by 10ºF or more. The heat island effect increases the need for air conditioning (and therefore electricity consumption) and is detrimental to site plantings, local wildlife, and maintaining comfortable temperatures.

Employing design strategies, materials, and landscaping designs that reduce heat absorption of exterior materials, will help to keep surrounding cool in urban environments. Recommended strategies include:

- ❑ Provide shade using native or climate-tolerant trees and large shrubs, vegetated trellises, or other exterior structures supporting vegetation
- ❑ Substitute vegetated surfaces for hard surfaces
- ❑ Explore the elimination of blacktop with the use of new coatings with integral colorants to achieve light colored surfaces
- ❑ Use white or light-colored roofing materials
- ❑ Develop green roof

See it in Action:

Green Roof: Relief from Above
A Case Study of U.S. Postal Service (USPS) Morgan Processing and Distribution Center (New York, NY)

One of New York City's largest and U.S. Postal Service's first, the green roof atop the Morgan Processing and Distribution Center covers 109,000 square feet of rooftop above the street of Manhattan. By the time the project was completed in July 2009, USPS also replaced 1,600 windows and completed other energy efficient upgrades. The green roof provides a safe outdoor oasis for postal employees with several environmental and energy-saving benefits. The use of all native plants and ground cover helps to reduce the amount of storm water runoff by as much as 75 percent in summer and 40 percent in winter. In addition, the green roof results in $30,000 in annual savings for the Postal Service from reduced heating and cooling costs. The estimated savings are attributed to 40 percent reduction in facility's energy use.

Click here to learn more about the project or visit the International Greenroof & Greenwall Projects Database for existing case studies.

Resources

CHPS Best Practices Manual, vol. 2, Guideline GC4: http://www.chps.net/

US EPA, Heat Island Effect: http://www.epa.gov/heatisld/

US EPA, Reducing Heat Urban Islands: Compendium of Strategies – Green Roofs: http://www.epa.gov/heatisland/resources/pdf/GreenRoofsCompendium.pdf

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XII. Innovative Financing Options

As many municipalities and school districts find themselves confronted with tightening budgets, it is important to note that there are other methods of financing projects in addition to paying for them directly out of allocated budgets.

Investing in energy efficiency is an ideal approach to reducing the cost of operation for a building while maintaining a comfortable work environment, but very often the up-front cost of those measures is cost-prohibitive. An energy service company, or ESCO, can provide energy saving solutions for a commercial or institutional building, in addition to being able to offer various financing options to help pay for the measures.

While all energy conservation projects require an investment on behalf of the building owner, there are many energy efficiency programs around the country that offer rebates or incentives for premium efficiency equipment. These offerings immediately offset part of the cost of a project, and when combined with creating financing options, can make an energy conservation measure very feasible. For more information on energy efficiency programs, see section.

There are three typical ways to finance energy projects using an ESCO:

- Performance Contract – Projects are paid for with realized energy savings. This option includes paying an ESCO for energy conservation measures with the energy savings generated by the project. For example, an ESCO would upgrade the lighting and HVAC equipment in a building without charging the building owner, and the building owner would continue to pay the same or similar amount as they would have had to pay the utility before the project. The ESCO is compensated based on the savings; the difference between what the previous utility bills would have been and the current utility bills with the high-efficiency equipment installed. Following full payment for the project, the building owner realizes the energy savings resulting from the project through paying lower utility expenses.
- Leasing – In this approach, the building owner leases the equipment from an ESCO at an amount that is less than the amount of savings generated by the efficiency measures.
- Fixed-Price Contract – The building owner signs a contract with the ESCO at a fixed monthly price. The contract allows the ESCO to implement energy efficiency projects throughout the facility for a defined period of time. The result is intended to be a net reduced monthly operating expense

While Contracting with an ESCO can help to make a project financially feasible, certain steps should be taken to avoid risks with such arrangements. Doing so will ensure that the projected savings are realized and the installed equipment performs to the satisfaction of building occupants:

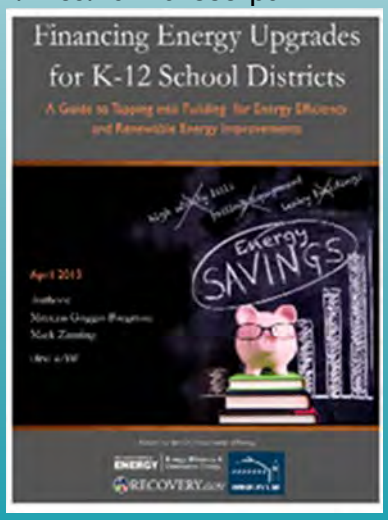
- It is essential that the building owner have a thorough and comprehensive analysis that arrives at their baseline energy consumption, as all energy savings claims will be made in relation to this data.
- All energy conservation measures proposed should be thoroughly vetted to ensure that they are appropriate for the facility. Often measures with long payback are combined with measures that have shorter payback periods in order to produce a project that has attractive net economics.
- It is important to ensure the energy saving measures proposed do not create a situation that negatively impacts building occupants, such as the de-lamping of light fixtures that results in an inappropriate reduction in light levels, or an HVAC project that results in lowered ventilation rates.

Aside from working with an ESCO, building owners can pursue other financing opportunities, as well. These alternatives can potentially be combined to result in a financial package that reduces the upfront cost to the building owner, while ensuring long-term energy savings. For example, bonds are available from the US Department of Treasury called Qualified Energy Conservation Bonds. These are available for projects that reduce the energy consumption in a building, among other projects, and are typically offered with very low rates. For more information, visit the US DOE Qualified Energy Conservation Bond website: http://www1.eere.energy.gov/wip/solutioncenter/qecb.html

Resource Spotlight:

U.S. Department of Energy's Lawrence Berkeley National Laboratory released in April 2013 a financing guide for schools. While the main focus is school districts many of the resources and lessons learned can be applied to a variety of public buildings

http://emp.lbl.gov/sites/all/files/lbnl-6133e.pdf



For site-installed renewable energy projects, and in particular solar PV projects, there is often the opportunity to enter into a "power purchase" agreement. In such an agreement, instead of purchasing the PV system, the owner purchases the systems metered electricity that is consumed at the site. A third-party project developer owns, operates, and maintains the photovoltaic (PV) system, and the host customer purchases the system's electric output from the solar services provider for a predetermined period. In most cases, the financial arrangement is cash flow positive for the host customer.

Resources

National Association of Energy Service Companies: http://naesco.org/

Energy Services Coalition: http://www.energyservicescoalition.org/

EPA – Introduction to Energy Performance Contracting: http://www.energystar.gov/ia/partners/spp_res/Introduction_to_Performance_Contracting.pdf

State and Local Energy Efficiency Action Network – Financing Solutions: http://www1.eere.energy.gov/seeaction/financing_solutions.html

Solar power purchase arrangements; http://www.epa.gov/greenpower/buygp/solarpower.htm

The Database of State Incentives for Renewables & Efficiency (DSIRE): http://www.dsireusa.org/

XIII. Cafeteria Practices

Cafeterias are a hub of activity in schools and often also in public administration buildings. For any building, cafeterias typically experience higher energy consumption than the other common areas. This is because of the requirements of various cooking equipment, the high level of lighting needed for food preparation, and the ventilation requirements.

High efficiency equipment such as refrigerators, ovens and dishwashers should be chosen by consulting the Energy Star website and programs should be implemented to reduce the amount of waste produced, such as composting and cooking oil recycling. Also, reusable eating utensils, trays and cups should be used if when possible to reduce waste. So for more info about recycling programs see section X. Recycling.

Training for kitchen staff can reduce overall energy consumption by knowing which equipment to turn on for food preparation based on each day's menu.

Several small schools in New York City were able to reduce their number of used trash bags per day to one fifth the original number by incorporating an organized waste and recycle program at lunch periods. More information can be found at the Environmental Protection Agency's webinars webpage here: http://www.epa.gov/region2/webinars/pdfs/Cafeteria_Waste_Webinar.pdf

See it in Action:

Somerville, MA Public Schools' Food Service Program

The Somerville Food Service program incorporates innovative policies into schools to ensure better nutrition and sustainable food delivery. The program develops recipes featuring fresh fruits and vegetables, incorporating student involvement by holding taste tests for new recipes. Somerville Public Schools hold campaigns for a vegetable of the month, link sustainable and healthy eating to science and nutrition education, and purchase as much produce from local farmers as possible, taking advantage of the Massachusetts Farm to School

Composting

Leftover food that is thrown away adds great weight and volume to trash bags. This generally increases disposal costs. By diverting food to composting a useful end product can be created from what otherwise goes to a landfill. Certain steps can be taken towards implementing a composting program. The following are some best practices from The Environmental Resource

Center which is dedicated to helping higher education facilities increase efficiency and reduce waste but these practices apply to all buildings.

- ❑ If possible, locate a suitable on-site compost location.
- ❑ Designate an area in the kitchen for compost collection bins.
- ❑ If on-site composting is not an option, identify local composting facilities/haulers to determine if a composting program is feasible.

Recycling Center at Manchester Essex (MA) High School Names after the School Facilities Director

Recycling

Materials

Implementing recycling programs can reduce waste immensely. In order to facilitate occupant's compliance with recycling programs, separate bins should be provided for the different types of recycling typically available which are paper, tin, glass or plastic. The types of recycling that are accepted should be advertised to make it more obvious to the occupants what should and should not be recycled. Additionally, waste can be further reduced by purchasing bulk foods and drink and offering dispensers instead of individual servings.

More information can be found at the Environmental Protection Agency's webinars webpage here: http://www.epa.gov/region2/webinars/pdfs/Cafeteria_Waste_Webinar.pdf

Used Oil

If the cafeteria uses or handles oil there are certain practices that should be maintained to prevent oil spills and contaminations. In many cases there are avenues for oil recycling such as biodiesel production facilities that will take, and even pickup, used oil and recycle it into

fuel for vehicles. The University of Berkeley takes advantage of such an opportunity by collecting canola oil from the deep fryers as well as other sources of grease such as bacon in a 55 gallon drum that then is shipped to a nearby biodiesel oil refinery (resources).

If oil cannot be recycled action should be taken to insure the safe handling of waste oil.

- ❑ Label all containers of oil appropriately and keep containers in good condition.
- ❑ Keep equipment and machinery handling oil in good condition and keep absorbent materials available in case of spills.
- ❑ If there is a spill work to contain it and fix the leak at its source to prevent environmental contamination.

Resources

The Campus Environmental Resource Center – Cafeteria/Dining Best Practices:
http://www.campuserc.org/virtualtour/cafeteria/BestPractices/Pages/default.aspx

The Environmental Protection Agencies webinars - Cafeteria Waste:
http://www.epa.gov/region2/webinars/pdfs/Cafeteria_Waste_Webinar.pdf

The University of Berkeley – Green Cafeteria Practices:
https://commons.lbl.gov/download/attachments/76186960/Green+Cafeteria+Practices.pdf?version=1&modificationDate=1320699559063

A Massachusetts-based vegetable oil recycling service:
http://www.savethatstuff.com/collect-vegetable-oil/

XIV. Zero Net Energy Buildings

Although there is no universal definition, it is accepted that zero net energy buildings refer to those facilities that consume no more energy than they are able to produce. Typically this moniker is reserved for new construction, or major renovation projects that achieve net zero consumption through efficient design and the use of on-site renewable energy generation. Standard retrofit projects are not likely to be capable of net-zero consumptions, but can achieve deep energy savings which is often classified as 30 percent or more energy savings.

Because renewable generation is an inherent part of zero net energy building construction, locations with different renewable potential and HVAC requirements will be more or less conducive to net-zero construction. Buildings in New York have high heating energy requirements and less access to solar energy while buildings in the Southwest have high cooling loads and access to more solar energy. In addition locational differences in net-zero parameters, there are certain tradeoffs and barriers inherent to reach these high performance standards.

Buildings that achieve net-zero or deep energy savings status can be quantified by their energy usage intensity or EUI. The EUI is a number that represents how much energy a building consumes normalized by its size. This allows different sized buildings to be compared with ease.

Maintenance of Zero Net Energy Buildings

Renewable Energy Generation

Net-zero buildings are almost certain to include renewable energy generation, with solar photovoltaic (PV) being the most prevalent. PV systems have specific maintenance requirements such as routine cleaning and monitoring of the electrical systems. These requirements will be different depending on the location of the site. Dusty locations without much rain will need to be washed occasionally to maintain efficiency but locations in wetter environments may only need to be washed during part of the year or not at all.

Systems such as wind turbines will have other maintenance requirements such as the routine replacement of bearings and lubrication.

This maintenance might not be accessible to normal staff such as the lubrication of wind mills or replacement of wiring in a photovoltaic system. In which case, a professional specializing in such systems should be called in to service the systems. Please refer to the alternative and renewable energy section V for more information on wind and photovoltaic systems.

High Performance Mechanical Systems

Net-zero buildings will have other maintenance specific characteristics, such as the critical sizing, of HVAC systems requiring attention to make sure that loads are not exceeded, and thereby exceeding the equipment's abilities.

Complex systems such as geothermal heat pumps or natural ventilation interlock systems may require seasonal adjustments. Well planned maintenance schedules, sometimes referred to as "continuous commissioning," will be an integral part of maintaining net-zero building

See it in Action:

Net Zero Energy Building: John W. Olver Transit Center (Greenfield, MA)

The John W. Olver Transit Center (Greenfield, MA) serves as the main transportation hub for Franklin County. Funded by the American Recovery and Reinvestment Act (ARRA), the 24,000-square-foot building completed in 2012 is the first net-zero-energy transit center in the country. According to Charles Rose Architects, the main design firm, the Center is designed to achieve net-zero energy consumption through the generation of renewable energy sources with 7,300 square-foot ground-mounted solar photovoltaic array of 98 kW in capacity, 22 geothermal wells for efficient heating and cooling and 750 MBH on-site wood pellet boiler for additional heating. The Center's design is highly innovative, while it is still mindful of the historic nature of Greenfield's downtown district through the use of brick, cooper, and locally-sourced stone. Notably, the western façade of the building features a computer-generated screen that minimizes direct solar heat gain, while windows are strategically placed to maximize day lighting; Located within the Greenfield Bank Row Urban Renewable Zone, the Center is intended to catalyze economic revitalization and sustainable development in Greenfield's Downtown Business District.

N

systems.

Resources

Whole Building Design Guide – Net Zero Energy Buildings: http://www.wbdg.org/resources/netzeroenergybuildings.php

International Living Future Institute – Net Zero Energy Building Certification: http://living-future.org/netzero

The University of Utah, College of Architecture and Planning – The Road to Net Zero: Operations and Maintenance: http://www.arch.utah.edu/net_zero_energy_project/documentation/Group3_OperationsandManagement.pdf

NEEP - Greening the Public Sector, Maximizing Energy Efficiency: http://www.neep.org/Assets/uploads/files/public-policy/high-performance-buildings/Greening-public-sector-2013.pdf

NEEP – Roadmap to Zero Net Energy Roadmap Public Buildings http://www.neep.org/public-policy/energy-efficient-buildings/high-performance-public-buildings/roadmap-for-zero-net-energy-buildings

NEEP Model Progressive Building Energy Code Policy http://www.neep.org/public-policy/energy-efficient-buildings/building-energy-codes/model-progressive-building-energy-codes-policy
ASHRAE's Advanced Energy Design Guides: https://www.ashrae.org/standards-research--technology/advanced-energy-design-guides

XV. Specialized Building Types

While the principles and procedures outlined in this guide can be applied to the following building types, their composition and operational characteristics are unique and may require more complex solutions. With a goal of providing initial guidance, general descriptions and resources are presented.

Water Supply and Waste Water Treatment Plants

The maintenance of equipment that is classified as "industrial," is beyond the scope of this document. However, municipalities often are tasked with maintaining pumping and filtrations systems associated with water supply and waste water treatment facilities.

Both water supply and waste water treatment facilities offer the potential for energy efficiency upgrades. Potential upgrades that should be considered, include:

See it in Action:

Essex Junction Waste Water Treatment Facility (Essex Junction, VT) – 60 kW CHP

In 2003, Essex Junction Waste Water Treatment installed two 30-kw dual fuel (methane and natural gas) micro-turbines CHP systems. The systems use primarily methane gas produced by the facility's anaerobic digester to generate electricity and recapture the exhaust to heat the digester. The use of cogeneration not only helps the facility to meet its electric demand but save more than $37,000 per year in utility bill. The facility's CHP system demonstrates the successful use of nearly 100 percent of its waste methane compared to 50 percent in the facility's previous boiler.

- ❑ High efficiency pumping improvements which can include new pumps, or specialized maintenance procedures.
- ❑ Variable speed drives and associated controls for fans, pumps, and compressed air systems.
- ❑ Manage demand charges
- ❑ Control of water aeration and the monitoring of dissolved oxygen content.
- ❑ Compressed air system upgrades and leak detection/repair.
- ❑ Heat recovery from effluent and/or compressed air systems.

Resources

EPA – Water & Energy Efficiency in Water and Wastewater Facilities:
http://www.epa.gov/region9/waterinfrastructure/technology.html

CEE – National Municipal Water and Wastewater Facility Initiative
http://library.cee1.org/sites/default/files/library/2650/ww-init-des.pdf

National Renewable Energy Laboratory: Energy Efficiency Strategies for Municipal Wastewater Treatment Facilities: **http://www.nrel.gov/docs/fy12osti/53341.pdf**

Correctional Facilities

Correctional facilities operate 24 hours a day, 365 days a year, and are therefore excellent candidates for energy efficiency upgrades. Due to their constant operation, lights are constantly in use, HVAC systems are nearly always providing heated or cooled air, and large amounts of hot and cold water are consumed. Upgrading the lighting, HVAC, and water systems generates substantial savings at these facilities.

Kitchens in correctional facilities also represent a good opportunity to improve the efficiency of the facility. High-efficiency cooking equipment, such as gas-fired ovens and stoves, may be a good alternative to electric cooking equipment. Composting systems can reduce the amount of waste generated, and can be used on site for gardens or landscaping.

Finally, due to the high volume of laundry at these facilities, consideration should be made to invest in high-efficiency clothes washers and dryers.

See it in Action:

New York State Department of Corrections and Community Supervision (DOCCS) recently completed a series of energy efficiency improvements at several of its correctional facilities. The work was done in collaboration with Constellation Energy and New York State Energy Research Development Authority.

The series of work took place at three different facilities including the Green Haven Correctional Facility in Stormville, the Bedford/Taconic Correctional Facilities, and the Sing Sing Correctional Facility in Ossining. The scope of these projects encompass various different measures from installing high-efficient boilers, to commissioning heating and steam distribution systems, as well as installing a new CHP plant in one of the facilities. A recent report by Constellation Energy estimates a projected savings of over $1 million.

See it in Action:

Bridgewater, MA Correctional Facility Won 2009 EPA's CHP Energy Star Award

In 2009, the Bridgewater Correctional Complex Cogeneration Plant received the EPA's Combined Heat and Power Energy Star Award for its 1,500 kW CHP system. The facility's CHP system operates at a nearly 70 percent efficiency and reduces greenhouse gas emissions equivalent to the annual emissions of 600 cars, according to an EPA's press release.

The CHP system, which was installed as part of a larger comprehensive energy retrofit project in 2007, utilizes a natural-fired combustion turbine to generate 80 percent of the complex's annual energy demand while meeting the state NOx emission requirements. Official saving figures from MA state government were reported to reach over $27.6 million through the entire lifetime of the project and over $1.5 million in annual savings.

Resources

Case Study – Michigan Department of Corrections:
http://www.michigan.gov/documents/State_of_MI_Correctional_Facility_Case_Study_01-0026_121538_7.pdf

California Department of Corrections and Rehabilitation: Energy Savings Projects Summary:
http://www.cdcr.ca.gov/cdcr_going_green/Energy_Savings.html

ENERGY STAR Commercial Ovens:
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=COO

ENERGY STAR Commercial Clothes Washers:
http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CCW

Labs/Hospitals

Laboratories and hospitals are energy intensive facilities that are often associated with 24 hour operations and continuous loads. Because hospitals have many areas that require continuous lighting, one of the primary considerations is the incorporation of high efficiency lighting systems. Because of the high electric and heating loads, co-generation systems are becoming common-place. With careful planning, such systems can offer higher efficiencies than separate systems for the heating and electrical energy needs of the building.

The resources below both offer guidelines and suggestions for maintenance measures as well as retrofit actions that can be taken to reduce consumption of the building without adversely affecting functionality.

See it in Action:

Darthmouth-Hitchcock Medical Center (Lebanon, NH)

The state-state-of-art medical facility incorporates the Darthmouth College Medical School, Mary Hitchcock Memorial Hospital, Dartmouth-Hitchcock Clinic, and the White River Junction Veterans Affairs Medical Center. An extensive water conservation retrofit was initiated in June 2000 with a total project cost of $350,000 and expected payback period of three and a half year. Annual savings in terms of water, sewer, and energy costs reductions amount to $100,000.

The scope of the water efficiency project encompasses both domestic and process water measures. As part of its strategy to improve domestic water uses efficiency, DHMC installed low flow toilets, retrofitted urinals, and placed flow restrictors on sink faucets. On the other hand, it addressed process water efficiency on the tempering systems for autoclave wastewater and boiler blowdown, recirculation system on the reverse osmosis/deionized water filtration units, and circulation technique on the medical air and vacuum pumps.

See it in Action:

Resource Management Plan at Lemmuel Shattuck Hospital (Jamaica Plain, MA)

Operating under the MA Department of Public Health, Lemmuel Shattuck Hospital is a public health care provider of outpatient and inpatient services for the urban population of Boston. Since entering in the Resource Management Plan in 2003, Shattuck has made significant improvements to its waste management program leading to substantial reduction in the waste stream and increase in recycling practice. Shattuck and its waste and recycling service contractor, Save that Stuffs (STS), estimate savings of $32,000 in solid waste management costs over the last 10 years and a 5-fold increase in the volume of cardboard and organics diverted from landfill.

Implementations to its waste management program include the replacement of a 35 yard compactor with 40 yard compactors and reduce service level from three to two times per week resulting in savings of $400 per month. The facility also added recycling programs for cardboard, commingled containers, food waste, scrap metal, pallets and electronics.

One of the keys to success in Shattuck's Resource Management Plan is the establishment of a cross-function "Green Team" that enabling better communication between its contractors (STS) and on-site facility staff. The monitoring of waste and recycling tonnage broken down by waste stream and compiled in monthly reports performed by STS gives Shattuck a transparent tracking of its progress, performance and cost savings.

Resources

Building Technologies Program, Researching Energy Use in Hospitals:
http://www1.eere.energy.gov/buildings/commercial/hospital_energy_use.html

Leading Techniques for Energy Savings in Healthcare Facilities:
http://www.tac.com/data/internal/data/07/98/1237406294867/WP_HEALTHCARE_ENERGY_white_paper.pdf

Guidelines for Energy Efficiency in Hospitals:
http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=LIFE04ENVGR114-EE.pdf

Healthcare Without Harm's Green Guide for Health Care:
http://www.gghc.org/tools.2.2overview.php

EnergyStar Energy Use and Energy Efficiency in Health Care:
http://www.energystar.gov/ia/business/challenge/learn_more/Healthcare.pdf

Historic Buildings

Care should be taken to ensure that historic buildings are updated with sensitivity to historic preservation needs. Nearly all jurisdictions have adopted guidelines and/or mandates for the renovation and retrofit of historic buildings. While assessing such buildings for improvements, systems should be evaluated to ensure that the older electrical and mechanical systems are updated to modern efficiency and safety standards, without violating preservation policies.

See it in Action:
Thetford Community Center (Thetford, VT)

Thetford Community Center is a historic schoolhouse that currently serves several community purposes. Thetford Energy Committee working in partnership with Sustainable Energy Resource Group completed the weatherization project in 2010. Because it is an historic building, members of the historic preservation community, including the Preservation Trust of Vermont and Division of Historic Preservation, were engaged early on in the process in order to assess and provide input upon reviewing the design and implementation strategies of the energy efficiency plan. A historic preservationist was also available on-site to train volunteers during on-going project. In the end, over 70 percent of annual energy savings was achieved from sealing to reduce air leakage, adding additional insulation, and putting in place a higher energy-efficient combustion furnace. TCC project profile was featured in 2011 report on community's energy efficiency initiatives by the Vermont Natural Resources Council.

Resources

Building Technologies Program, Preserving Historic Homes:
http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/historic_homes_guide.pdf

FEMP, Historic Preservation and Energy Efficiency in Federal Buildings:
http://www1.eere.energy.gov/femp/news/news_detail.html?news_id=10482

NPS, Weatherization and Improving the Energy Efficiency of Historic Buildings:
http://www.nps.gov/tps/sustainability/energy-efficiency/weatherization.htm

New Buildings Institute, "Toward a Future Model Energy Code for Existing and Historic Buildings":
http://newbuildings.org/sites/default/files/ACEEE_2010_Denniston_0.pdf

National Trust for Historic Preservation, "Greening Older and Historic Buildings":
http://www.preservationnation.org/information-center/sustainable-communities/buildings/#.UYbWr7XCaSo

Multifamily Buildings

Multifamily housing, defined as having five or more units, is an important part of the housing stock in the Northeast and Mid-Atlantic regions. Due to being distinct from residential and commercial buildings, it presents special challenges and opportunities. There has been relatively little focus on the energy efficiency performance of the operational issues around multifamily buildings. Because most of the multifamily buildings are more than 50 years old, there is great potential for energy savings in multifamily buildings. Common areas such as the lobby, parking lots and laundry can account for much of the energy use. Many utilities and energy efficiency program administrators offer programs specifically for multifamily buildings which include rebates and incentives. Many of these programs require building audits as the first step in the retrofit process. Air sealing, insulation, replacement of existing light bulbs

with high efficiency bulbs, replacement Energy Star appliances, and programmable

See it in Action:

Boa Vista Apartment (New Bedford, MA) – 75 kW CHP

Owned and operated by the New Bedford Housing Authority (NBHA), the high-rise senior living community includes 6 units with 99 single-bedroom apartment. Facilities managers look to the use of CHP as a way to reduce energy costs which make up of 40 percent of the operating budget. NBHA and Constellation Energy Services contracted with Aegis Energy Services to install a package CHP system to provide both electricity and heating and hot water to the multi-unit building. The natural-gas fired engine provides 75 kW of electricity meeting 52 percent of the total building load, while the exhaust is captured through various heat exchanger mechanisms to provide 74 percent of the building's total space heating and 100 percent of residents' hot water needs. According to the case study, the Boa Vista will save $34,000 in the first year in energy operating costs and tem-year net saving of nearly $400,000 with payback of 6.5 years. The project also takes advantage of an $18,000 utility rebate from NSTAR.

thermostats are the most common measures.

Resources

Multifamily Energy Efficiency Program in Northeast and Mid-Atlantic States:
http://www.neep.org/public-policy/energy-efficient-buildings/multifamily-retrofit/multifamily-retrofit-regional-activities

Efficiency Maine's Multifamily Program:
http://www.efficiencymaine.com/docs/at_work/Bangor-Project-Case-Study.pdf

Department of Energy Multifamily Weatherization Assistance Program Eligibility:
http://www.nhtinc.org/wap_multifamily_regulations.php

Glossary

ASTM – American Society for Testing and Materials.

B-20 –The term for a blend of 20% renewable bio-derived diesel fuel with 80% petroleum-based diesel fuel.

biodiesel – A domestic, renewable fuel for diesel engines derived from natural oils like soybean oil, which meets the specifications of American Society for Testing and Materials D 6751. Biodiesel is not the same thing as raw vegetable oil. It is produced by a chemical process that removes the glycerin from the oil.

biogas – Gas, rich in methane, which is produced by the fermentation of animal dung, human sewage, or crop residues in an airtight container. It is used as a fuel to heat stoves and lamps, run small machines, and generate electricity. The residues of biogas production can be used as a low-grade organic fertilizer.

bio-oil – A liquid created from biomass (see below) found in forestry and agricultural residues. The biomass is thermochemically converted to bio-oil by using processes called direct liquefaction or fast pyrolysis. The high water and oxygen content of bio-oils reduces their heating value to less than half the value of petroleum. However, bio-oils are low in viscosity and have been successfully burned in boilers, kilns, turbines, and diesel engines.

biomass –Any biological material that can be used as fuel. Biomass fuel is burned or converted in systems that produce heat, electricity, or both. In this document, biomass-fired systems refer to systems that are fueled by clean wood chips from forestry or saw mill operations.

brownfields –Industrial or commercial property that is abandoned or underused, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.

CSI – Construction Specifications Institute.

CHPS – Collaborative for High Performance Schools.

COM*check* – Software developed by the U.S. DOE to help commercial projects demonstrate compliance with all commercial energy code requirements for envelope, lighting, and mechanical systems. For more information, see http://www.energycodes.gov/comcheck/.

commissioning – A systematic process of ensuring that all building systems perform interactively according to the contract documents, the design intent, and the schools operational needs. Commissioning involves three phases: pre-design, construction, and warranty.

commissioning plan – A plan that includes a list of all equipment to be commissioned, delineation of roles for each of the primary commissioning participants, and details on the scope, timeline, and deliverables throughout the commissioning process.

cool roof – A roof that reflects most of the sun's energy instead of absorbing it into the interior spaces below.

daylighting –The practice of placing windows and reflective surfaces so that the natural light of day provides effective internal illumination. Optimize the daylighting design to minimize glare and eliminate direct-beam light in the classroom and use daylighting controls designed to dim or turn off electric lights when sufficient daylight is available.

design-build – A construction-project delivery process in which a single entity assumes the obligation of furnishing the design, supervision, and construction services required to complete a project.

DOE-2 – Software that was developed by the U.S. DOE to predict the fuel consumption (both electric and fossil fuel) of a building based on its design. Later iterations include DOE 2.2, a more advanced form of the original software.

DOE-2.1E – An updated version of DOE-2 software.

e-QUEST – (**Qu**ick **E**nergy **S**imulation **T**ool) – Sophisticated software that allows for detailed energy analysis of a designed building. It also allows users to build 2-D and 3-D displays of the building geometry.

ENERGY STAR- A program that maintains a database of compliant manufacturers and products. Partial list of products include computers, monitors, copy machines, water coolers, printers, scanners, refrigerators, and washing machines.

gray water system – Water that has been used in showers, sinks, and laundry machines that may be reused for other purposes, especially landscape irrigation. Toilet water is not used in this system.

greenfields- Parcels of land not previously developed beyond that of agriculture or forestry use. The opposite of brownfield.

heat island – An effect caused when exterior surfaces absorb the sun's energy and heat the air near the ground. On a school site, rising temperatures make the school's air conditioning work harder, increasing energy cost.

HEPA filters – High Efficiency Particulate Air filters

integrated pest management (IPM) – A sustainable approach to managing pests that minimizes economic, health, and environmental risks.

integrated design – The consideration and design of all building systems and components. It brings together the various disciplines involved in designing a building and reviews their recommendations as a whole. It also recognizes that each discipline's recommendation has an impact on other aspects of the building project.

life cycle costing – A means of calculating and comparing different designs, equipment, and products to identity the best investment.

recycled content – Materials that have been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process (pre-consumer) or after consumer use (post consumer).

OSHA – Occupational Safety and Health Administration.

operations and maintenance manual – Provides detailed operations and maintenance information for all equipment and products used in the school.

operations and maintenance training – Provides a short introduction on operations and maintenance of equipment and products for all school staff and then features hands-on workshops for facility personnel.

potable water – Water of sufficient quality to serve as drinking water.

PowerDOE – Software that allows users to detail the predicted energy consumption of a building. Like e-QUEST, it is very graphical in its presentation of both the building description and the display of results. It includes 2-D and 3-D displays of the building geometry.

rain water collection system – A system that supplies water year round by harvesting both potable and non-potable water.

rapidly renewable materials – Materials that substantially replenish themselves faster than traditional extraction demand (e.g., planted and harvested in less than a 10-year cycle), do not result in significant biodiversity loss or increased erosion, positively impact air quality, and can be sustainably managed. Products in this category include, but are not limited to, bamboo products, wheat grass cabinetry, oriented strand board, and other wood products made from fast-growing pine trees.

responsibly produced – Materials that are extracted, harvested, or manufactured in an environmentally friendly manner (includes certified wood products).

retro-commissioning - Retro-commissioning (RCx) is a systematic, documented process that identifies low-cost operational and maintenance improvements in existing buildings and brings the buildings up to the design intentions of its current usage.

salvaged or reused – Materials that are refurbished and used for a similar purpose rather than processed or remanufactured for different use.

thermal comfort – A condition of mind that expresses satisfaction with the surrounding environment. It is determined by taking into account environmental factors (such as humidity, A/C, heat) and personal factors (what an occupant is wearing).

VisualDOE – Energy modeling software that is based on DOE-2 and allows users to evaluate energy and demand impacts of design alternatives.

VOC – Volatile Organic Compounds

wetlands –Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation adapted for life in saturated soil. Wetlands generally include swamps, marshes, bogs, and other similar areas.

Appendix A: Financial Implications of School Operations and Maintenance

Deferring maintenance projects can actually cost a school more in the long run as repairs become more critical and costly – whereas a dollar spent today can save several dollars over time. However, the American Association of School Administrators recently reported that "the percentage of schools deferring maintenance increased from 21 percent in 2008-09 to 33 percent in 2009-10." As school budgets shrink, operations and maintenance costs are often cut. Understanding the financial benefits of a comprehensive operations and maintenance plan is critical for school districts in the current economic climate. The following resources provide data and information about the financial impacts of such programs.

Recommended Reading:

"Looking Back, Looking Forward: How the Economic Downturn Continues to Impact School Districts," American Association of School Administrators, March 2009: http://www.aasa.org/uploadedFiles/Resources/files/LookingBackLookingForward.pdf

"Review of Deferred Maintenance in the Commonwealth of Virginia," The Auditor of Public Accounts, December 2004: http://www.dgs.virginia.gov/LinkClick.aspx?fileticket=H9qi9xI3nO4%3D&tabid=370

"Repair for Success: An Analysis of the Need and Possibilities for a Federal Investment in PK-12 School Maintenance and Repair," The 21st Century School Fund, November 2009: http://www.21csf.org/csf-home/documents/repairforsuccessaugust2011.pdf

"2013 Infrastructure Report Card: Schools Overview", The American Society of Civil Engineers: http://www.infrastructurereportcard.org/a/#p/schools/overview

Many additional resources can be found here:

National Clearinghouse for Educational Facilities, School Maintenance and Operations Costs Resources List: http://www.ncef.org/rl/mo_costs.cfm?date