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

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Finally, as this is an update to a previous report, NEEP would like to take this opportunity to reiterate acknowledgement of the original authors and contributors of previous versions of this report, which continue to serve as the foundation upon which this update is based.

About NEEP

Founded in 1996, NEEP is a non-profit whose goal is to assist the Northeast and Mid-Atlantic region to reduce building sector energy consumption three percent per year and carbon emissions 40 percent by 2030 (relative to 2001). Our mission is to accelerate regional collaboration to promote advanced energy efficiency and related solutions in homes, buildings, industry, and communities. We do this by fostering collaboration and innovation, developing tools, and disseminating knowledge to drive market transformation. We envision the region's homes, buildings, and communities transformed into efficient, affordable, low-carbon, resilient places to live, work, and play. To learn more about NEEP, visit our website at http://www.neep.org.

Disclaimer: NEEP verified the data used for this white paper to the best of our ability. This paper reflects the opinion and judgments of the NEEP staff and does not necessarily reflect those of NEEP Board members, NEEP Sponsors, or project participants and funders.

Lastly, NEEP thanks Energy & Resource Solutions, who wrote the first drafts of the Northeast-CHPS Protocol and Operations and Maintenance Guide.

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.

Furthermore, this guide is intended to be one in a suite of resources that communities can utilize to improve the energy efficiency of their buildings stock. NEEP maintains a broader set of resources that can be found through the Community Action Planning for Energy Efficiency (CAPEE) tool. This interactive online resource helps communities plan for and prioritize projects, while connecting them to the most pertinent and useful resources available from various industry groups.

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 our region.

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.

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Why Operations and Maintenance is Important: Using this Guide to Create Efficient, Healthy, and Resilient Buildings

This Regional Operations and Maintenance Guide is intended to provide direction 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 operations and maintenance (O&M) procedures that will help buildings reduce their operating costs, as well as lead to healthier indoor air, improved occupant comfort, reduced water consumption, improved environmental stewardship, and overall improvements in productivity. O&M procedures targeted at energy efficiency can save 5-20 percent on a building's energy bills. These savings can total up to hundreds of thousands dollars annually, and many can be achieved at little to no cost. Embedded throughout the guide are facts, figures, and calculators to help make the case for improving the efficiency of the public building stock.

The importance of incorporating resiliency into public buildings is increasingly prevalent as more communities in the Northeast and Mid-Atlantic region face the devastating impacts of extreme weather events such as blizzards, hurricanes, and torrential rainstorms. *Community* or *coastal resilience* refers to a community's ability to "bounce back" and maintain services after natural or manmade disasters occur. Co-benefits of resiliency include: risk management, business continuity, reduced insurance rates, brand recognition and positive PR, employee health and wellbeing, reduced utility bills, and the ability to capture opportunities as they are. Many of the strategies and best practices found in this guide may also help to improve the resiliency of buildings throughout the region.

Public buildings, more so than others, play an important role in a community's well-being during and after an extreme weather event. Maintaining power and communications at emergency personnel stations is of the utmost importance during these times. Schools and other public facilities often become community shelters during times of need. With this in mind, many high performance design features also enhance the resiliency of the building, coupling cost-savings, and added safety measures for the community.

South Easton, Massachusetts is a noteworthy example of a community focused on providing a high quality, sustainable, and resilient learning environment. Southeastern Regional Vocational Technical (SERVT) High School, a Collaborative for High Performance Schools (CHPS) Verified School, upgraded their energy supply system by installing a tri-generation plant on campus. In addition to reducing their monthly energy costs by $16,000, the tri-generation plant allows the school to retain power, even when the rest of the town is without it. The recent renovations and incorporation of energy efficient measures allows the schools to act as a community safe haven in case of emergency.

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.

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 department, administration, 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.

Develop and Implement an Energy Plan at the Municipal Level

A Municipal Energy Plan is a comprehensive long-term plan designed to improve energy efficiency, reduce energy use and mitigate greenhouse gas emissions within a city or town. Municipalities are establishing energy plans to create community energy conservation in addition to planning ahead for future development, land use planning, growth planning, and energy generation and transmission infrastructure. By creating an energy plan, municipalities have an outline on how to effectively address local energy needs now and for the future. This eliminates decision making based on a single-year, or on an as-needed basis. Included in an energy plan are:

- Existing energy policies and strategies
- Overview of the municipalities energy use
  - Energy usage data and energy sources
- Goals, objectives and strategies for moving forward
- Financing energy improvements
- Energy procurement
- Guiding framework
  - Monitoring and verification

- Tools to use in achieving the energy plan- these should be included in the energy plan to understand how to achieve the goals and objectives
  - Alternative and renewable sources
  - Transportation
  - Municipal energy programs

        - Utility demand side management programs
        - Public energy efficiency; energy efficiency in residential, commercial, and industrial
    - By-laws and regulations to implement energy plan

Guidance on how to put together a plan

The Department of Energy has developed a guide for creating municipal level energy plans. The Guide to Community Energy Strategic Planning outlines 10 strategic steps in creating an effective plan that will create jobs, energy security, a cleaner environment, and resiliency for the community. This guide builds on basic steps from other successful initiates. There are also tools, examples, and resources available to use for each step within the guide. While the guide outlines the steps in a linear process, there is a lot of crossover and it will prove necessary to revisit previous steps as the plan moves on.

To do steps:

1. Identify effective leadership team
    a. Local governments are in the position to lead the process
2. Identify and engage stakeholders
    a. Utilities, energy intensive industries, businesses in the energy sector, environmental organizations, representatives from the community, etc.
3. Develop an energy vision
    a. E.g. Zero energy
    b. Where does the community want to be in 10-20 years?
4. Assess current energy profile
    a. Current and projected future energy use and supply data
    b. An inventory of existing energy-related activities, projects, programs, and policies
    c. Identify future energy supply resources
5. Develop energy goals and strategies
    a. Clear and measurable
        i. "SMART" goals: Specific, Measurable, Attainable, Relevant, Time-bound
        ii. Strategies are designed to articulate the specific approaches that collectively will achieve the goals.
6. Identify and prioritize actions to achieve goals
    a. Establish a ranking systems for ideas
    b. Identify projects, policies and programs to consider
7. Put together a funding and financing strategy
    a. ESCOs, bonding, cost savings from EE and RE, capital reserve funds, short-term financing, fund balance, grants, public/private partnerships, third-party ownership etc.
8. Develop a blueprint for implementation
    a. Who will be responsible for each action, what the specific deliverables will be, and when they will be accomplished.
    b. It also incorporates conclusions from the finance strategy (Step 7) and the plan to do ongoing monitoring and evaluation (Step 9). This portion will be integrated in the final report and can also be used as a standalone document in the implementation phase
9. Monitoring plan

   a. Identify the resources and process for monitoring and evaluation
10. Prepare the final plan and adopt/publicize it
   a. The final plan should be a roadmap, and will be revisited as progress is made and conditions change
   b. incorporates the implementation blueprint, including responsible parties, timelines, financing strategy, and process for tracking progress

See it in Action:

City of Warwick, Rhode Island

In 2013, Warwick established an energy management guide (EMG) in order to minimize the City's impact on the environment and ensure low taxes for residents by practicing sustainable energy management throughout municipal buildings. This guide is used by the city's energy management team, which includes facility managers, building operators, maintenance technicians, custodians' directors, recreation staff, financial officers, etc. The established framework for the plan is the "Plan-Do-Check-Act" framework adapted by the EPA.

Based on the selected framework, the steps included in this plan include:

1. Plan: establish leadership, assess baseline & set goals
2. Do: Implement energy improvement programs
3. Check & Act: monitor, measure and maintain

The EMG offers model standard operating procedures and building codes, energy financing options, information on energy procurement, and a variety of other municipal energy resources from the EPA, the U.S. Department of Energy, the U.S. Department of Housing and Urban Development, etc. In order to maintain relevance, the plan is updated and expanded over time. This plan is used to conserve energy, reduce costs, lower greenhouse gas emissions, and reduce the depletion of non-renewable resources.

SEE Action 2020 Leadership Agenda

In order to harness the full potential of energy efficiency in our buildings stock, state and local governments must take action and lead the public. The SEE Action Network, a state and local lead effort facilitated by the US Department of Energy and Environmental Protection Agency, released the 2020 Leadership Agenda establishes a baseline for all governments to drive energy efficiency and realize the cost and energy savings opportunities. The report focuses on six key areas:

1. Strengthening market demand for energy efficiency
2. Unlocking data related to buildings and energy
3. Expanding public-private partnerships and intergovernmental collaboration
4. Improving access to capital for energy efficiency improvements
5. Improving the energy efficiency of publicly owned facilities
6. Adopting and implementing strong building energy codes.

More information on the Leadership Agenda can be found here.

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, including compliance with the established waste management and recycling procedures, use of less toxic products, etc.

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. A common challenge is when there are multiple groups that use the recreational areas. In this case, all groups should receive clear information on waste management and recycling policies, practices, and expectations, as well as a contact person if there are questions or problems.

District Programs

2030 Districts

2030 Districts commit to reducing building energy use, water consumption, and transportation GHG emissions by 50 percent by 2030. 2030 Districts are led by the private sector, with local building industry leaders coming together with a shared vision for sustainability and economic growth in the built environment. These Districts align with local community groups and government to achieve energy, water and emissions reductions within the commercial sector. The targeted market and audience includes commercial buildings under 50,000 square feet, which represents over 90 percent of all U.S. commercial buildings and consumes over 40 percent of the sector's energy use. A private sector led approach can increase the buy-in across a community leading to improved best practice sharing and collaboration between building owners. To make the most of leading efforts, the 2030 Districts Network, a national effort of local 2030 Districts, was formed to coordinate resources and collaborations. The Network helps leverage the aggregated purchasing power of the District partners to secure reduced costs for products and services, as well as influence national policy on energy efficiency, water use, and transportation infrastructure in the built environment. In addition, the district approach motivates members included to achieve their goals. For building owners, managers and developers a 2030 District means access to exclusive incentives, discounts, and programs, as well as improved competitive positions, special financing programs, and comparative analysis reports.

Key barriers to reducing energy consumption include:

Technical	Programmatic
1) access to centralized, comprehensive, cost-evaluative information about how to achieve energy targets	4) guidance on bringing disparate stakeholders together
2) affordable access to auditing services	5) financial models for district self-sufficiency
3) reduced transaction costs or incentives that make reduction efforts attractive	6) member outreach, including to historically underserved communities

Source: US DOE – 2030 District Program and Small Commercial Toolkit

Targeting small commercial means financial incentives or alternative financing options are a high priority, and without options, may deter some players. Since these districts are led by the private sector, they are inherently driven by profit.

Case Study: Pittsburgh 2030 District

An example of a 2030 District is the Pittsburgh 2030 District in Pennsylvania. The Green Building Alliance founded the District in Downtown on August 21, 2012 and launch a second boundary in nearby Oakland on August 28, 2014. Current commitments to the 50 percent reduction goals by the year 2030 include 438 buildings, totaling 68.2 million square feet, and 85 property partners

Pittsburgh 2030 District achievement through year end 2015:

ENERGY: 12.5 percent reduction, exceeding 2015 incremental goal of 10 percent below baseline

- 868 million kBtu avoided
- Equivalent to the annual energy use of 6,353 homes, 14,673 passenger vehicles, 162,087 barrels of oil, or 1,358 flights between Pittsburgh and Los Angeles

WATER: 10.3 percent reduction, exceeding 2015 incremental goal of 10 percent below baseline

- Equivalent to the annual water use of 624 homes
- Includes the first-ever Oakland-specific water baseline calculations

TRANSPORTATION EMISSIONS: 24.2 percent reduction, exceeding 2020 incremental goal of 20 percent below baseline

- Developed emission baseline for Downtown Oakland

INDOOR AIR QUALITY: Pilot complete.

- Completed development for standard protocol for measurement, tracking and benchmarking

On October 18, 2016, Pittsburgh's City Council passed a citywide Building Benchmarking legislation. This legislation works in conjunction with the city's benchmarking efforts as a 2030 District. The legislation requires owners of nonresidential buildings over 50,000 square feet, or portions of mix-use buildings with at least 50,000 square feet of nonresidential space, to submit a benchmarking report with the whole building energy and water usage to the city on an annual basis. Building owners will use the U.S. Environmental Protection Agency's ENERGY STAR Portfolio Manager to track and share information. This annual building benchmarking report will be published online, which will allow owners, tenants, prospective buyers or lessees, and the general public to view energy and water usage.

EcoDistricts

EcoDistricts are a form of urban development centered on the people within the neighborhoods and the environment. In each neighborhood, EcoDistricts focus on addressing some of the biggest challenges facing cities to date, such as income, education and health disparities, ecological degradation, climate change, and rapid urban growth. EcoDistricts focus on creating neighborhoods that are sustainable, resilient and equitable by attending to the needs of individual communities. With sustainable development at its core, the values upheld by an EcoDistrict include social equity, inclusion and democracy, as well as economic opportunity, community well-being and ecological health.

EcoDistricts can range from affordable housing communities to downtown business districts. This variability allows for application throughout cities. Each district within one city can have different initiates since they are focused on a neighborhood scale. A few examples of programs an EcoDistrict can implement include community-scale energy generation, recycling, urban gardens, and low-carbon transportation options. Economic benefits include operational efficiency cost savings from energy and water. With a commitment to sustainable development, improved infrastructure will allow people to

conserve energy, reduce and manage water consumption and reduce outputs of waste. Communities will see improved public health, more greenspace, and livability within their neighborhood.

Communities can use the EcoDistrict Protocol to achieve their sustainable development goals. The protocol launched globally in April 2016, after five years of development with support from over 100 global advisors and testing across 11 districts in eight North American cities. The protocol includes a rigorous performance framework that is also flexible to adapt to the type of EcoDistrict. It also helps form inclusive governance to create effective planning and project delivery. Essential to planning in the protocol is the integration of equity, resilience and climate protection to ensure continued growth of the district for future generations. It also supports public-private partnerships and cross-sector collaboration. EcoDistricts are often a good fit because there is often times some level of community organizing in place, therefore the process to integrate the protocol can be easier.

There are some gaps in EcoDistricts. Gaps include lack of funding, the need for investment from utilities in existing infrastructure, as well as investment from local businesses for future jobs and development. In order to fill in some of these gaps, there are two phases a community should go through in order to develop a successful EcoDistrict. Phase one is focused on engagement. Engaging stakeholders and creating an EcoDistrict Steering Committee to develop a vision and priorities. Phase two should be focused on governance. This includes determine stakeholders' roles and responsibilities and formalizing the governance structure.

Exemplar: Kendall Square, Cambridge, MA

Five delegates from the Kendall Square neighborhood and the Cambridge Community Development Department gathered in Portland, Oregon for the EcoDistricts Incubator workshop in May, 2013 to accelerate the city's revitalization and sustainable development. Cambridge has taken on sustainable neighborhood revitalization projects in an effort to create jobs, save resources and lower carbon emissions. The EcoDistrict framework provides a platform for Kendall Square to continually improve the area's vibrancy through collective and voluntary actions.

Kendall Square has grown into a bustling, mix-use urban center that is transit oriented and full of innovative industries, such as biotechnology and information technology. These industries, as well as the numerous startups appearing in the square continues to attract professionals who wish to live closer to work. With this atmosphere of innovation and change, the EcoDistrict framework fits in and can build on the existing momentum towards sustainability. The initiatives implemented by the EcoDistrict in Kendall Square foster opportunities for increased energy efficiency and smart energy systems through the neighborhood educational, economic and research activities. Innovative energy efficiency solutions will help decrease local energy use.

Another goal is to increase transit capacity through improved pedestrian and bicycle facilities. It is essential to the continued growth to improve mobility, but also a key element for sustainability not to add cars to meet this need. This will reduce emissions and promote a safe and lively environment.

Projected growth for 2020 indicates that an additional three million square feet of retail, office, and residential space will be added to the existing seven million square feet of development, which includes 11.2 acres of green, open parks and public space. This projected growth embodies the core values of sustainable development, integrated through the EcoDistrict framework.

STAR Communities: Sustainability Tools for Assessing & Rating Communities

The STAR Community Rating System (STAR) is a sustainability framework and certification program for local governments to implement action that address their social, economic, and environmental goals. The rating system is divided into seven thematic sustainability goal areas:

- **Built environment:** quality, choice, and access where people live, work and play
- **Climate and energy:** increase efficiency, reduce impact
- **Economy and jobs:** quality jobs, shared prosperity
- **Education, arts and community:** vibrant, connected, and diverse culture
- **Equity and empowerment:** Inclusion and access for all community members
- **Health and safety:** Strong, resilient, and safe
- **Natural systems:** Protect and restore the resources of life

On this system, a community is rated from three to five stars, based on its total scores in the seven goal areas. There are a total of 44 objectives that are the core areas that contain evaluation measures and metrics to achieve the goals. There are two types of evaluation measures in the rating system, which includes community level outcomes and local actions. Each goal has between five and seven objectives. This systems allows cities and counties to set a clear path towards sustainability, while providing helpful tools that measure and track progress towards meaningful results. This is a robust framework, but necessary for communities to credibly track progress towards the overall objectives, as well as enable communities to compare progress and learn from each other since they are using the same evaluation measures. It is a roadmap tool that encompasses economic, environmental, and social equity indicators. This system can be used for various tasks, such as a planning framework, aid in decision-making, performance based budgeting, to build partnerships, identify and implement best practices, and catalyze local action, etc. STAR provides support as localities benchmark progress, and a third-party review ensures accountability.

Case study: City of Northampton, MA

Northampton, Massachusetts received its STAR Certification May 1, 2014 and was certified as STAR's first 5-STAR community. Northampton joined STAR to gain an understanding and benchmark how the city was doing in becoming more sustainable. The scores that Northampton received for the objectives within the STAR rating system will help inform the city's next steps in their planning process for the Sustainable Northampton Comprehensive Plan. Northampton is one of more than 30 local governments that participated in a year-long pilot program with STAR Communities.

Efforts that helped Northampton receive a 5-STAR rating include:

- Being on track to produce zero waste by 2050, and instituting a "pay as you throw" system
- Setting a target of preserving 25 percent of the city as ecologically intact conservation areas
- A "Buy Local/Buy Fair" policy requiring city departments to purchase locally produced, Fair Trade Certified products whenever possible.

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 paint and asbestos testing and/or inspection
- ❑ 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 degrees Fahrenheit.
- ❑ 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.

Tenant Star

Tenant Star is a tenant-focused version of EPA's successful Energy Star program for commercial buildings, developed in contingency with the Energy Efficiency Improvement Act of 2015 (the Act) that directed the U.S. EPA and the DOE to create a buildings energy efficiency program for tenants. Tenant Star promotes energy efficiency by creating lease structures which equitably align the costs and benefits of efficiency investments between building owners and tenants. The act encourages office tenants to explore cost-effective and energy-efficient solutions to reduce operating costs when designing and constructing tenant improvements, particularly in managing electric plug loads from equipment, lighting and water usage and HVAC systems. There are two programs in Tenant Star:

- **ENERGY STAR recognition for design and construction** of efficient tenant spaces.
- **ENERGY STAR recognition for top energy performance in occupied tenant spaces,** as voluntary ENERGY STAR recognition. Introduction of this recognition will take several years to develop this metric because it relies on data collected by the Energy Information Administration.

When implemented, the Tenant Star recognition aims to address the following objectives:

1) Stimulate greater market adoption of energy efficiency technologies and practices specific to tenant spaces.

2) Provide a mechanism to recognize tenants that voluntarily pursue high levels of energy efficiency in their spaces.

3) Create opportunities for greater tenant-landlord engagement around energy efficiency.

EPA plans to enhance the existing ENERGY STAR strategy for tenant recognition. One way this can be done– for example, is by encouraging tenants to work with building owners and managers to improve efficiency, and share data to enable whole-building benchmarking.

EPA anticipates awarding the recognition to tenants, with the option for landlords, designers, and possibly others involved in design, construction, and/or management of the space to be recognized along with the tenant.

Eligible space types will initially include separate office space within a multi-tenanted building. In the future, EPA hopes to include other types of tenants in multi-tenanted buildings, such as retail stores in shopping centers and warehouse spaces. Tenants leasing an entire building will not be eligible.

EPA proposes five criteria that must be met in order to be eligible for recognition:

1. Estimate Energy Use	2. Meter	3. Light Efficiently	4. Share Data	5. Purchase Efficient Equipment
Provide an estimate of the total energy use intensity of the space, through an energy model or technical analysis.	Document that appropriate metering is in place that enables accurate monitoring and tracking of the tenant's contribution to total building energy use.	***Option One***: Document that the projected lighting energy use intensity for the tenant space is below a specified level. ***Option Two***: Document that all installed lighting within the space consists of LED technology.	Document, through the executed lease or other authorization that the tenant agrees to share monthly (or more frequent) utility consumption data with the landlord upon request.	Demonstrate that all eligible installed equipment will be/is ENERGY STAR certified, including computers, laptops, printers, and kitchen appliances. This requirement also applies to ENERGY STAR eligible HVAC and data center equipment if installed or replaced by the tenant.

In addition, if a public entity is leasing their space, it is important to consider the availability of recycling and/or other waste reduction options as well as consider trash fee or limit on the amount of trash generated for tenants, as an incentive to reduce waste

Resources

United States General Services Administration: 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: https://www.maine.gov/dafs/brem/sites/maine.gov.dafs.brem/files/inline-files/exhibit-i-energy-efficiency.doc

SEE Action, High-Performance Leasing for State and Local Governments: https://www4.eere.energy.gov/seeaction/system/files/documents/commercialbuildings_factsheet_highperformanceleasing_statelocal.pdf

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

Massachusetts Department of Environmental Protection Recommended School Recycling Policy: https://www.mass.gov/files/documents/2016/08/oc/smrpsrpt.pdfh

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 its 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 as a framework to address other environmental health and safety conditions that may arise in schools.

See it in Action:

Hartford, CT Tools for Schools Champion

Connecticut's Public Act 09-81, Chapter 170, Section 10-220 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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There is also the EPA IAQ Design Tools for Schools guidance, which provides strategies for key school construction and renovation issues such as:

- Preliminary Design Phases
- Controlling Pollutants and Sources
- Heating, Ventilation and Air-Conditioning (HVAC) Systems
- Moisture Control
- Construction
- Commissioning
- Renovation and Repair of Existing Schools
- Operations and Maintenance
- Portable (Relocatable) Classrooms

Making the Case

- According to the EPA, more than 46 percent of school buildings have indoor conditions that negatively contribute to poor indoor environmental quality. Maintaining a healthy indoor environment can reduce asthma-related cases in schools, potentially reducing the number of sick days by students and staff. Proper environmental management, including a greater supply of fresh, outdoor air can lead to improved student performance – The Center for Green Schools.

- "Energy-efficient school building designs often use natural daylight to reduce the energy needed to light a building. Natural light has also been proven to have a positive effect on student performance. According to a study for the California Board for Energy Efficiency, students exposed to natural daylight in classrooms progress as much as 20 percent faster on math tests and as much as 26 percent faster on reading tests than students with no daylight exposure" – EPA K-12 Guide

Resources

EPA, Environmental Protection Agency, Region 1 New England office in Boston, Massachusetts, phone: (888) 372-7341: https://www.epa.gov/aboutepa/epa-region-1-new-england

EPA, Healthy School Environment Resources: https://www.epa.gov/schools

EPA, Tools for Schools: https://www.epa.gov/iaq-schools/indoor-air-quality-tools-schools-action-kit

EPA, Indoor Air Quality Design Tools for Schools: https://www.epa.gov/iaq-schools/indoor-air-quality-design-tools-schools

The Building Technologies Program Indoor Air quality Resources:
https://www1.eere.energy.gov/buildings/pdfs/btp_implementation.pdf

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 and potential savings of the new systems. The inventory should track warranties and 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
- ❑ Solid waste, recycling, and other waste reduction practices, as well as safe handling of potentially hazardous materials (e.g. mercury bearing waste)

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.
- ❑ Consider downstream management such as reuse, and recycling and proper disposal of potentially hazardous items (e.g. CRTs, mercury waste, etc).
- ❑ Replacement and updating of signs is also important to ensure accurate information is provided to all building users (e.g., signs indicating which switches to turn off, what is to be recycled, location of emergency response equipment, utility shut-offs, etc.).

See it in Action:

Manchester Essex Regional School District, MA

The MERSD Green Team developed a brand, logo and consistent signage throughout the school to provide information on the ways the building works and how users can help reduce energy and waste.

Photo Credit: MA DEP

Resources

LEED Existing Buildings, Operations & Maintenance: https://s3.amazonaws.com/legacy.usgbc.org/usgbc/docs/Archive/General/Docs3617.pdf ; See page 30

Energy Star: Operations and Maintenance Best Practices Guide for Energy Efficient Buildings: https://www.energystar.gov/buildings/save_energy_commercial_buildings/ways_save/om_best_practices

Energy Star: Guidelines for Energy Management Overview: https://www.energystar.gov/sites/default/files/buildings/tools/Guidelines%20for%20Energy%20Management%206_2013.pdf?e595-4fb6 Overview: Page 2

Facility Energy Management Program: https://www.energy.gov/eere/femp/federal-energy-management-programh

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.
https://contractors.efficiencyvermont.com/Media/Default/bbd/2017/docs/presentations/efficiency-vermont-swain-facilities-operating-plan.pdf

Apples to Apples: the Importance of Training

Improving the operation and maintenance of a building to enhance energy performance requires a highly skilled and qualified workforce. When looking to hire within the commercial building workforce, it is important to ensure potential candidates have gone through an accredited program for their certifications. A workforce should have the proper training that is needed to complete a job in a successful manner, with consistency and quality work. In order to ensure credentials from different certificate and training programs are comparable to national standards, one recourse available is the Better Buildings Workforce Guidelines (BBWG).

In order to develop the BBWG project, the U.S. Department of Energy (DOE) established a partnership with the National Institute of Building Sciences (NIBS) experts in the Commercial Workforce Credentialing Council (CWCC)**.** The National Institute of Building Sciences is a congressionally authorized nonprofit organization and well-respected building industry convener. The Council has numerous resources available and leads the development of voluntary national guidelines to improve the quality and consistency of commercial building workforce credentials. The purpose of the BBWG project is to reduce the confusion and uncertainty around workforce credentialing; lower costs; and support better credentials, better workers and better buildings. The BBWG set an industry-validated Job Task Analysis (JTA) for the different job titles, as well as certification schemes and learning objectives for available training programs.

Industry groups receive the following benefits from the BBWG:
https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Better-Buildings-Workforce-Guidelines-FactSheet.pdf

Certification programs—Recognized by DOE as accredited programs that meet high-quality industry guidelines

Employers and building owners/managers—Objective way to identify high-quality certification programs that train skilled and qualified workers

Governments and utility programs—Objective criteria for specifying workforce certification requirements for contracts on government buildings or for contractors participating in incentive or ratepayer-funded programs.

Workers—Transparency in the training and certification market; clearer professional development pathways; increased skills and greater mobility.

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. Training for custodians responsible for recycling and waste diversion programs can be provided by tours of local recycling or composting facilities.

Resources

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

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

BOMA: https://www.boma.org/BOMA/Education-Events/Energy_Efficiency_Sustainability.aspx

APPA: https://www.appa.org/certification/

State and Local Energy Efficiency Action Network: https://www4.eere.energy.gov/seeaction/

Energy Star Free Online Training: https://www.energystar.gov/buildings/training/training

New Hampshire Department of Education BOC and School Facilities Certification Training:
https://www.education.nh.gov/sites/g/files/ehbemt326/files/inline-documents/sonh/building-operator-training-classes.pdf
https://www.education.nh.gov/sites/g/files/ehbemt326/files/inline-documents/nhasbo-facility-cert-prog.pdf

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

Massachusetts Facilities Administrators Association: http://massfacilities.com/

Eversource Electric Power Utility Technology Program:
https://www.eversource.com/Content/docs/default-source/pdfs/electric-power-utility-technology-program.pdf?sfvrsn=4

National Grid Training Programs: https://www.nationalgridus.com/ProNet/Technical-Resources/Trainings-Events

PEPCO (Maryland Operations) and Maintenance Training:
https://homeenergysavings.pepco.com/business/omtraining

BOC Tuition & Funding Opportunities

Standard national tuition cost is $1,695. Additional registrants from the same organization for the same training qualify for discounted tuition rate of $1,395.

BOC Level 1: $1,695 per participant

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

BOC Level II: $1,695 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), or look up your local registration page from the BOC website above.

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 signs and/or policies that encourage users to:

- ❑ 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.
- ❑ Encourage all users to separate waste in compliance with the waste management program in place. It is important to locate recycling containers adjacent to trash barrels and make sure these sorting stations have consistent color coding, restrictive lids for recycling containers, and good signage.
- ❑ Change default settings on all printers to print double-sided unless users request otherwise.

See it in Action:

Andover, MA

Memorial Hall Library has trash and recycling containers as part of a sorting station with color-coded barrels and signs, restrictive lids and clear photos

Photo Credit: MA DEP

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 of goals, and then work together to accomplish these goals. In a school, it is recommended to include a member of the parent community on the Green Team. ENERGY STAR has a developed a Green Team Checklist to use as a reference that can result in a more energy-efficient and a more engaged workplace.

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 4-75 percent 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 three-week period, a 15.9 percent 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 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://www.energy.gov/eere/buildings/manage-organizational-energy-use-commercial-building

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 – Building Operators' Behavior and Complaint Handling https://cbe.berkeley.edu/project/operations-behavior/

Centerline (CBE Newsletter), Summer 2010 – "Behavior and Buildings – Leveraging Occupants to Improve Energy and Comfort": https://cbe.berkeley.edu/wp-content/uploads/2019/03/centerline-summer-2010.pdf

Teamcore Research Group – "Human-Building Interaction for Energy Conservation in Office Buildings", 2012: https://teamcore.seas.harvard.edu/files/teamcore/files/2012_36_teamcore_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 percent 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 published a guide, Assessing and Reducing Plug and Process Loads in Office Buildings, outlining nine steps that a facility can undertake to reduce plug loads. 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. Institutionalize plug load reduction measures
3. Benchmark current equipment with an audit and possible metering
4. Establish a business case for the proposed actions
5. Identify occupant's true needs
6. Eliminate unneeded equipment and select efficient equipment
7. Turn it off - during non-business hours equipment should be powered down
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, Arts and Math (STEAM) curriculum and to get involved in hands-on plug load reduction activities.

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.

Active Power Management

It is estimated that up to **$100 per computer can be saved annually** on energy costs through active power management. Power management is a mechanism for controlling the power consumption of personal laptop and desktop computers by limiting the power needed to operate hard drives and monitors while they are not in use. This is done by programming the devices to enter low-power states, or "sleep modes" while they are sitting idle. This state slows the spinning of the hard disk and turns off monitor output. By simply moving the mouse or hitting the key board, the computer immediately returns to its normal operating state. Separate power management options for both hard drives and monitors can be reached in the settings menu of all operating systems. EnergyStar provides guidance for configuring these settings for various operating systems on its website.

Case Study: Fairfield School District, Pennsylvania

Source: Bert Case Study

To provide a high quality of education to students and a high level of value for local taxpayers, the Fairfield School District, like all school districts, must make tough decisions on how to spend their limited funds. As the district spends about $400,000 a year on energy costs, they decided to implement a variety of measures to make its buildings more energy efficient. One of these measures was installing a Plug Load Management System, provided by Bert®, which allows district facility managers to remotely schedule and control the entirety of plug-based load of school facilities across the district. As it is estimated that about 25 percent of the total electricity consumed by schools is from plug loads, the Fairfield District now completely controls roughly $100,000 worth of its electricity usage per year used to power the wide variety of devices plugged into traditional outlets. As schools are often closed for more hours per year than they are open, this system will allow the district to save a significant amount of their energy budget, which can then be allocated to other student services.

Additional APS types include “remote switch” and “masterless” power strips. Remote switch power strips can be powered on and off remotely by the user via a control switch, and are especially fit for seldom used and miscellaneous appliances. Masterless power strips turn off to outlets completely when all connected devices are also turned off, which eliminates vampire load.

APS come with numerous benefits, making them a simple and effective way to reduce plug loads. These benefits include:

- Retrofit option for controlling outlets
- Savings potential is 830 trillion Btu primary energy annually
- Automatically turn off outlets when not needed
- Low-procurement cost
- Can be installed in phases
- Applies to all buildings

Resources

NREL Assessing and Reducing Plug and Process Loads in Office Buildings:
http://www.nrel.gov/docs/fy13osti/54175.pdf

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

ACEEE: Plug Load Reduction – Rumsey Engineers:
http://aceee.org/files/proceedings/2010/data/papers/2196.pdf
Plug Load Action Plan Template (EnergySmart Schools):
https://www1.eere.energy.gov/buildings/publications/pdfs/energysmartschools/ess_all-action-plans.pdf

Guide to Operating and Maintaining EnergySmart Schools:
https://www.energy.gov/sites/default/files/2013/11/f5/ess_o-and-m-guide.pdf

Getting to Know Advanced Power Strips, Northeast Energy Efficiency Partnerships (NEEP)
http://www.neep.org/sites/default/files/resources/APSCommonMisconceptionsFinal.pdf

Advanced Power Strip Common Terminology, Northeast Energy Efficiency Partnerships (NEEP)
http://www.neep.org/sites/default/files/resources/APSCommonTerminology.pdf

National Energy Education Development Project (NEED) – Plug Load Curriculum:
https://www.need.org/wp-content/uploads/2020/02/PlugLoads.pdf

New Buildings Institute – Managing Your Office Plug Load:
https://newbuildings.org/sites/default/files/PlugLoadBestPracticesGuide.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
- Reduce lighting loads and maximize daylighting
- 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
- Replace air filters on a regular schedule

Electronics and Appliances (Plug Loads)

- 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
    - Unplug unused electrical equipment such as laptop or cell phone chargers when not in use

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.

- ❑ Put anti-idling signs in bus loading and parent pick-up areas. Explore ways to minimize the number of parent pickups. Publicize the importance of doing this to improve air quality

- ❑ Establish a program to enable school children and parents to help support, explain, and 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.

Be sure to check applicable state laws about anti-idling policies.

Resources

New Hampshire Department of Environmental Services, School Bus Anti-Idling Initiative: https://www.nhsta.org/assets/municipal/1/School_Bus_Driver_In_Service_Workshop_Idling_PowerPoint_-_04.06.19.pdf
Asthma Regional Council of New England – School Bus No Idling Policy: http://asthmaregionalcouncil.org/wp-content/uploads/2014/02/Model-No-Idling-Policy.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.

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

See it in Action:

New York City Greens its Municipal Fleet

New York City's efforts to improve air quality as outlined in OneNYC 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 percent are hybrid or alternative-fuel vehicles, making it the largest clean-fuel municipal fleet in the country. The City's Clean Fleet 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.

Resources

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

DOE's Clean Cities:
https://cleancities.energy.gov/
Fuel Cell School Buses: https://www.hydrogen.energy.gov/pdfs/epact_743_fuel_cell_school_bus.pdfh

Vehicle-to-Grid Electric School Bus Pilot Project Underway in Massachusetts

Massachusetts Department of Energy Resources (DOER) announced the schools that will participate in their Vehicle-to-Grid Electric School Bus pilot program, which aims to reduce petroleum use and test the benefits of electric school bus technology. The project will be administered by the Vermont Energy Investment Corporation (VEIC). The participating schools will receive grants to purchase electric school buses and chargers, and data will be collected on their use of the vehicles. VEIC will conduct an economic analysis of the project in order to determine if this is technology should be more widely adopted. The project goal is to reduce petroleum usage by approximately 22,680 gallons of gasoline equivalent.

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.

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:
https://www.peoplepoweredmovement.org/site/images/uploads/2012-Benchmarking-Report-Final-Draft-WEB.pdf

International Walk to School provides information on encouraging safe walking and biking to school: http://www.iwalktoschool.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. Many local utilities offer a rebate and recycling program to further encourage removal of old appliances.

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 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

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/energy-efficiency/energyeducation/

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: https://www.need.org/educators/curriculum-resources/

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

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/.

Project Green Schools provides innovative environmental education programs to develop the next generation of green schools and students: http://projectgreenschools.org/

Massachusetts Department of Environmental Protection offers curriculum materials for schools that help teachers include recycling and composting education in their classes. http://www.thegreenteam.org

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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.

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 while improving performance. 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

Making the Case

A green school could lead to the following annual emission reductions per school:

- •1,200 pounds of nitrogen oxides (NOx) – a principal component of smog.
- •1,300 pounds of sulfur dioxide (SO2) – a principal cause of acid rain.
- •585,000 pounds of carbon dioxide (CO2) – the principal greenhouse gas and the principal product of combustion.
- •150 pounds of coarse particulate matter (PM10) – a principal cause of respiratory illness and an important contributor to smog
- •2.6 grams of mercury (Hg) –National Review of Green Schools
- •"Controlling exposure to indoor environmental factors, such as carbon monoxide, dust and pollen, could prevent more than 65 percent of asthma cases among elementary school-age children, reports the American Journal of Respiratory and Critical Care Medicine" – AIA Green Schools White Paper
- •Cognitive functioning significantly increases in indoor environments with lower concentrations of volatile organic compounds (VOCs). Cognitive functioning was found to be an average of 61% higher in these environments and 101% higher in environments with both lower concentrations of VOCs and a high rate of outdoor air ventilation. - Environmental Health Perspectives

A Note on Biophilic Design

Biophilia is the innate human connection to the natural world. By spending most of our time in buildings, we can lose our connection to the natural environment. Improving the connection building occupants feel with the outdoors can have a positive impact on health, productivity, and overall well-being. Although biophilic design principles are typically incorporated in the design and construction of new buildings, there are some strategies that existing buildings can undertake, such as:

- ❑ Providing direct, unobstructed views of outside
- ❑ Incorporating pictures of nature throughout the building
- ❑ Proper ventilation and airflow

Facilitating and Maintaining Daylighting Performance

Employees and students typically thrive in spaces with natural daylighting, 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 conditions with natural daylighting. 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
    a. Establish a cleaning schedule for glazing and shades
    b. Avoid displaying school projects on windows
- ❑ 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.
- ❑ Limit the display of school projects on walls that have indirect daylighting potential
- ❑ 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

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit EQ 11
https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf ; See page 111

CHPS Best Practices Manual, vol. 2, "Daylighting and Fenestration Design" chapter:
https://www.15000inc.com/wp/wp-content/uploads/CHPS-II-2006.pdf

LEED Existing Buildings, Operations & Maintenance:
https://s3.amazonaws.com/legacy.usgbc.org/usgbc/docs/Archive/General/Docs3617.pdf; See page 73

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

Pacific Gas and Electric Daylight Initiative - Schools:
http://www.pge.com/includes/docs/pdfs/shared/edusafety/training/pec/daylight/1487DBer_repaginated.pdf

Heschong Mahone Group, Inc., Daylighting Studies:
https://h-m-g.com/Projects/daylighting/projects-PIER.htm

U.S DOE Building Technologies Solid-State Lighting: https://www.energy.gov/eere/ssl/solid-state-lighting

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

Modern public buildings are designed and constructed to meet ASHRAE Standard 62.1 (2007, 2010, 2013, or 2019 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.

Significant Additions to the 2019 ASHRAE 62.1 Update:

- Informative tables of ventilation rates per unit area are included for checking existing buildings and designing new buildings
- The ventilation rate procedure is modified with a new simplified version for determining Ev and a more robust option for determining values of Ez
- The natural ventilation procedure is significantly modified to provide a more accurate calculation methodology and also define the process for designing an engineered system
- Natural ventilation now requires considering the quality of the outdoor air and interaction of the outdoor air with mechanically cooled spaces
- Air cleaning devices that generate ozone are prohibited

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 and more are available on the EPA's website here.

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: https://s3.amazonaws.com/legacy.usgbc.org/usgbc/docs/Archive/General/Docs3617.pdf; 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.

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.

Walk off system at New Hampshire school

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 experts, it costs about $750 per pound to remove dirt tracked into a building (International Sanitary Supply Association); thus, capturing more dirt and contaminants by walk-off mats further reduces facility cleaning costs.

Resources

American School & University article focusing on walk-off mats:
https://www.asumag.com/construction/flooring-carpeting/article/20851231/keeping-it-clean

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.

National Floor Safety Institute:
https://nfsi.org/

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

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. The best practice for maximizing filter efficiency is to use the highest rated filter that will fit in your filter rack (HEPA filter racks are quite large and include clamps to hold in filter cartridges) and to seal the edges with metal tape.

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 three 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 20 and will capture particles as small as .3 microns or even smaller in some instances. 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.

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.

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.

Resources

Maintenance World article on selecting filters: http://www.maintenanceworld.com/hvac-attack-how-to-select-the-right-hvac-filter-for-the-job/

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

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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:
https://www.contractingbusiness.com/service/article/20860555/seven-steps-to-hrverv-maintenance

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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. Burning fossil fuels produces a wide range of hazardous air pollutants like nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbons, and particulate matter (PM). These pollutants are hazardous to health and can manifest in many different health outcomes. Most cause inflammation of airways, decrease lung function, increase respiratory sensitivity, aggravate serious lung conditions, increase the risk of respiratory infection and increase the risk of developing respiratory conditions – like asthma and chronic obstructive pulmonary disease (COPD). Repeated inflammation can easily compound in to serious cardiovascular outcomes like ischemic heart disease, and myocardial infarction (heart attack). Exposure to nitrogen oxides is one of the largest contributors to early onset and childhood asthmas. Some pollutants, such as PM, can also penetrate the alveolar membrane and enter the bloodstream where they produce changes in blood chemistry and further propagate cardiovascular outcomes. By replacing fossil fuel combustion equipment with electric equipment, localized exposure to these pollutants can be reduced. Electric powered alternatives are available for all such equipment, and have the added benefit of being significantly quieter.

Minimizing Mercury Exposure

Many thermostats, Fluorescent lamps, high intensity discharge lamps, batteries, flat screen monitors, and backlit electronic devices 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. All fluorescent lamps need to be managed in accordance with universal waste regulations. A common problem is improper storage of end-of-life fluorescent bulbs until they can be collected for recycling.

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:

> "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 the Recycling Section of this guide for more information on mercury recycling.

Resources

United States EPA:
https://www.epa.gov/mercury

Other Resources:
http://www.pprc.org/
http://www.newmoa.org/prevention/mercury/imerc/FactSheets/lighting.cfm
http://www.lamprecycle.org/
http://www.mass.gov/eea/agencies/massdep/toxics/sources/mercury.html

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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. Often rodents and insects can serve as vectors for disease transmission. 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.
- ❑ Detailed information including; benefits, strategies, a model policy and more can be found on the EPA's Integrated Pest Management Tools: Resources to Support IPM Implementation website.

Resources

BIRC IPM for schools: http://www.birc.org/SchoolManual.pdf

State and Regional IPM Coordinators https://www.epa.gov/managing-pests-schools/integrated-pest-management-tools-resources-support-ipm-implementation

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

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.

Making the Case

- "On average, green schools use 33 percent less energy and 32 percent less water than their conventional counterparts, and save $100,000 per year on direct operating costs" - USGBC
- Energy costs are second only to personnel costs in K-12 school district operating budgets, totaling approximately $8 billion annually nationwide. An estimated $2 billion of that total can be saved by improving energy efficiency in K-12 schools, an amount equivalent to the cost of nearly 40 million new textbooks – EPA K-12 Guide
- "Schools spend approximately $75 per student on gas bills and $130 per student on electricity each year…By implementing energy efficiency measures, many K-12 schools have been able to reduce energy costs by as much as 30 percent in existing facilities" – EPA K-12 Guide
- Annual utilities cost per employee in green facilities was $675.26 lower than in non-green facilities. - Business Case for Green Building
- Green schools use an average of 33 percent less energy than conventionally designed schools. - USGBC
- Cognitive performance scores for the participants who work in the green+ environments are, on average, double those of participants who work in conventional environments; scores for those working in green environments were 61 percent higher. Environmental Health Perspectives

Energy Fundamentals & Understanding Your Utility Bill

A basic understanding of energy and utility bills allows for building owners and operators to make informed decisions on energy usage. Being able to know what period of the day/week a building's energy demand is at its highest allows for owners and operators to take the right steps toward reducing usage and shifting demand to a time period to save on costs. Similarly with consumption, knowing when it is at its highest can lead the way in reducing end uses, such as lighting, HVAC, and plug loads to remediate high consumption. Listed below are a few fundamental energy concepts including common fuel types, units of measurements, billing components and rate structures.

Common Building Fuel Types: The three most common fuel types consumed by buildings are electricity, natural gas, and fuel oil; liquidated propane gas (LPG) is used in exchange when natural gas is not a viable option. Below are a few examples:

- Electricity: lights, motors, A/C, plug loads
- Natural Gas: heating, hot water, back-up
- Fuel Oil: heating, hot water, back-up
- LPG: heating, hot water, gas/oil back-up

Units of Measurements

Interpreting commonly used units of measurements for energy is important when comparing energy consumption and understanding usage. Additionally, realizing the difference between energy consumption vs demand is critical when reducing overall energy bills. Demand is measured in kilowatts (kW) and represents the total electrical energy consumed during a specific period of time while consumption is measured in kilowatt-hours (kWh) and represents the rate of electrical energy consumption during a certain period of time. Energy consumption (kWh) requires the utility to provide and pay for the electrical poles, wires, and transformers whereas energy demand (kW) determines the size of the wires and transformers to be able to "keep the lights on" for the consumer. Below are common measurements used throughout your utility bills:

Unit	Definition	Used For
Kilowatt (kW)	kW, or demand, measures the rate of consumption	Electricity
Kilowatt-hour (kWh)	kWh measures the amount of consumption	Electricity
British Thermal Unit (BTU)	BTU is a measure of heat energy and commonly used when comparing energy sources; 1 BTU = a unit of energy equal to the amount of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit	Heating & Cooling
Cubic Foot; Therm	Therm is a unit measuring the amount of energy in natural gas; 1 Therm = 100,000 BTU	Natural Gas
Gallon	Consumption of fuel oil & LPG is measured in gallons	Heating & Cooking

Utility Bill Structure

Understanding the components of an energy bill is very important throughout the process of monitoring, controlling, and reducing energy use in a building. Furthermore, being able to know where, when, and how efficiently energy is being used at your building is essential in attempting to reduce energy demand, decrease energy consumption, and lower utility bills.

Bill Components

Your energy bill is comprised of the charges for the gas and electricity you consumed throughout the month. The typical components of an energy bills include the following:

- Basic Charge: Fixed monthly fee for meter reading, preparing the bill, and other administrative cost
- Energy/Rate Charge: Charge based on total energy use (in kWh) that is determined by the rate schedule
- Demand Charge: Charged based on the rate of consumption (in kW) incorporating "peak" monthly value
- Distribution Charge: Charged when a utility has unbundled their rate to allow for a customer to purchase their own power
- Power Factor Charge: Generally found on large electricity users (C&I) bills, the charge is an adjustment to the demand charge as a result of inductive loads
- Adjustment Charge: Charges as a result of changes in the price of energy purchases made by the utility to obtain fuel and produce electricity

- Special Provisions: To incorporate a primary metering discount for energy losses and additional charges for public purpose and benefits (energy conservation, renewable energy, low-income bill assistance)

Rate Structure

Factoring in and combining all of these charges together for the final utility bill is called the rate structure. A basic rate structure incorporates the fixed rate for energy use, fixed rate for the demand, fixed rate for the power factor, etc. whereas other rate structures entail seasonal rates, time-of-day rates, and block rates. These are important to understand when considering operational strategies to reduce energy use so one can make the best economical decision at the right time.

- Seasonal Rates: Utility's energy costs vary by season due to demand, fuel costs, water levels, season, etc.
- Time-of-Use Rates (TOU): Rates vary during the day and utilities offer TOU rates where the charges are higher during peak hours and lower during off-peak hours. This often encourages customers to decrease their energy usage during peak hours to benefit from the off-peak rates
- Block Rates: Rates are structured differently as the usage increases throughout the month, which also encourages customers to reduce their energy use to take advantage of cheaper rates

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.

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:

CHPS Operations 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.

- ❑ 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 of self-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
- ❑ 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

See it in Action:

Partnering with Local Universities

In 2016, college students from Stockton University in New Jersey conducted energy audits in local high schools. The effort was a part of the University's Energy Practicum class to provide real-world experience to students while also trying to save money in school districts. Students monitored building temperatures, HVAC system efficiencies, and computer energy usage. They then used their findings to develop a report for school officials including current conditions, recommended actions, savings potential, and project costs.

An example of an audit report is available here.

Image Source: Stotockton.edu

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. To find a qualified building energy auditor, check out this helpful qualification list here.

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

Online Audit Tools - The US Department of Energy and its partners developed the Asset Scoring Tool to assess the efficiency of the major physical components of the building. Building assets such as the building envelope, lighting systems, HVAC systems and more have a significant impact on how energy is used regardless of occupant behavior and how the facility is operated. DOE's Asset Score Tool requires information inputted by the user to run a whole-building energy simulation resulting in an Energy Asset Score Report that includes:

- ❑ A score ranging from 1 to 10 based on the energy efficiency of the building envelope and the mechanical, electrical, and service hot water systems
- ❑ An energy efficiency assessment of the building's individual systems
- ❑ Total estimated building energy usage and energy use by end use (lighting, heating, cooling, service hot water) under standard operating conditions
- ❑ Opportunities to upgrade building efficiency, and a "potential" energy efficiency score based on identified upgrades

Information gained from the report can be used by building operators and decision makers to identify and implement energy savings 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.

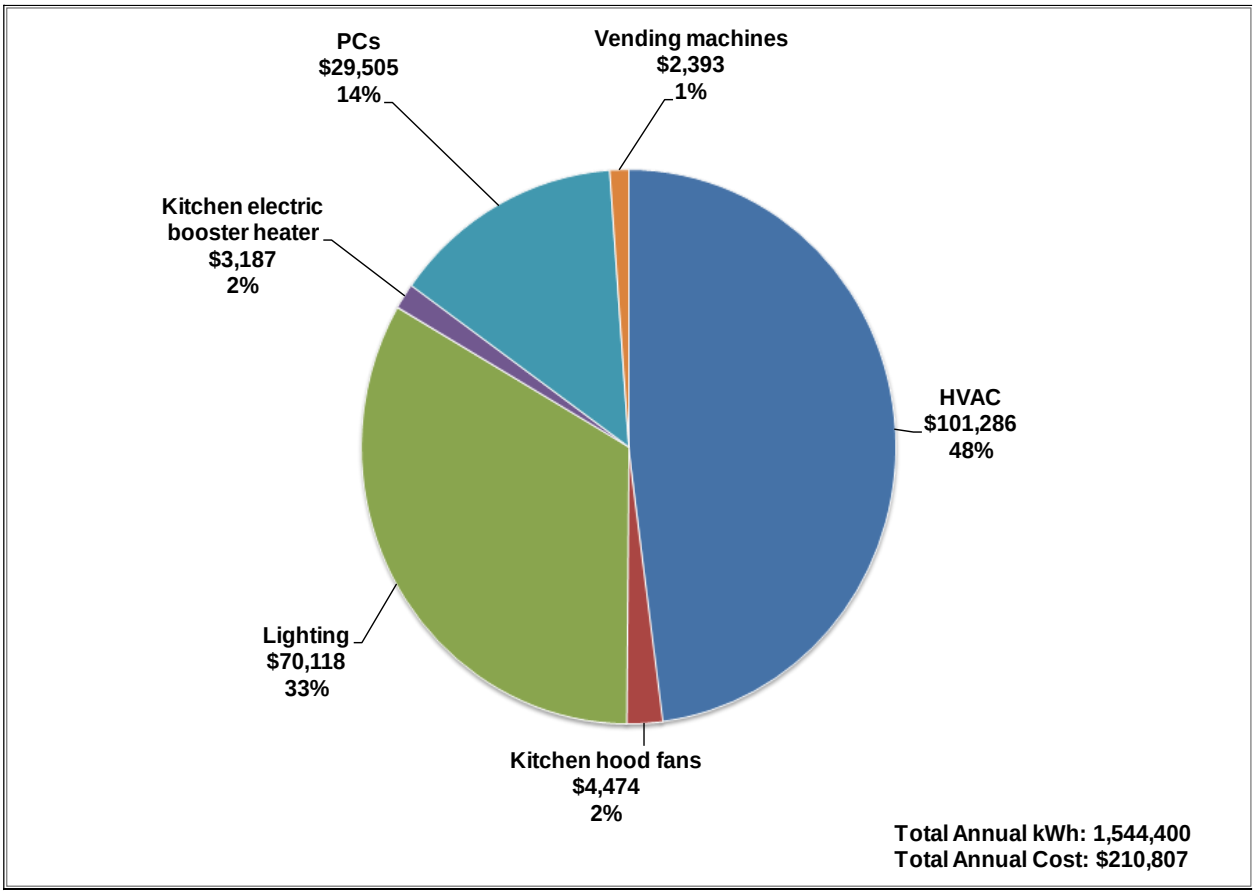
Resources

How to Choose an Energy Assessment for Municipal Buildings in Massachusetts:
https://www.mass.gov/doc/audit-recommendations-for-municipalities/download

Field Guide to New Hampshire's Municipal Buildings & Energy Audit Guidelines
https://www.nhmunicipal.org/town-city-article/new-field-guide-explains-energy-audit-process

SEE Action, Energy Audits and Retro-Commissioning: State and Local Policy Design Guide and Sample Policy Language:
https://www4.eere.energy.gov/seeaction/system/files/documents/commercialbuildings_audits_rcx_policy_guide_0.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. EPA's Portfolio Manager Quick Start Guide provides information on the basic steps to get started using Portfolio Manager. 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*

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 Arlington, VA 22030 (____)____-_____	Jane Smith 1 Washington Blvd Arlington, 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)

Source: EPA – Sample ENERGY STAR performance documents

Resources

Department of Energy – Schools https://www.energy.gov/eere/buildings/efficient-healthy-schools

Department of Energy – Asset Rating
http://energy.gov/eere/buildings/building-energy-asset-score

Massachusetts Pilot: Raising the Bar to Improve Energy Efficiency
Northeast Energy Efficiency Partnerships (NEEP)
http://www.neep.org/sites/default/files/resources/BAR_handout_summit.pdf

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

Building Energy Benchmarking and Disclosure Policies in the Northeast and Mid-Atlantic, Northeast Energy Efficiency Partnerships (NEEP)
https://neep.org/sites/default/files/resources/Benchmarking%20and%20Disclosure%20in%20the%20Northeast%20and%20Mid.Atlantic%20Final%206.12.17.pdf

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.
https://www.mass.gov/service-details/massenergyinsight

The SEE Action Network provides sample policy language for communities looking to implement their own benchmarking and disclosure policy:
https://www4.eere.energy.gov/seeaction/publication/benchmarking-and-disclosure-state-and-local-policy-design-guide-and-sample-policy

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:

Moving Beyond Benchmarking

The District of Columbia passed the Clean and Affordable Energy Act in 2008 which included requirements for the benchmarking of private and public buildings. The act requires all buildings owned and operated by the District to be benchmarked using EPA's Energy Star Portfolio Manager and subsequently publish the data online for public accessibility. The District began leading by example in 2008 by benchmarking 10 public buildings. One year after the act was passed, all public buildings over 10,000 square feet were inputted into Portfolio Manager. Beginning in 2013, all privately owned buildings over 50,000 square feet are required to do benchmarking on an annual basis.

More information and data from previous years is available online at the Department of Energy and Environment.

In 2018, Washington D.C. went beyond simply requiring reporting and disclosure of energy use data. The Clean Energy Omnibus Act of 2018 enabled the District to develop the Building Energy Performance Standards (BEPS) program which requires building owners to improve the energy performance of their properties over time. The BEPS rules were formally adopted in 2021 and similar to the benchmarking program, an increasing number of buildings will be required to adhere to the BEPS program over time.

Other major cities such as New York City, Philadelphia, Boston, Pittsburgh, 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.

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 information click here.

Resources

Benchmarking and Disclosure: State and Local Policy Design Guide
and Sample Policy Language
http://energy.gov/sites/prod/files/2014/05/f15/commercialbuildings_benchmarking_policy.pdf

Benchmarking Fact Sheet
https://www4.eere.energy.gov/seeaction/system/files/documents/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/sites/default/files/resources/BER%20Supplement_FINAL%20DRAFT_2-25-13_0.pdf
or: http://www.neep.org/sites/default/files/resources/NEEP_BER_Report_12.14.09.pdf

Department of Energy Buildings Performance Database
https://www.energy.gov/eere/buildings/building-performance-database-bpd

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 Office provides useful guides and data to assist with making these decisions.

Resources

Core Performance Guide by New Buildings Institute, Inc. 2007 edition: https://newbuildings.org/resource/core-performance-guide/

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: https://www.techstreet.com/ashrae/standards/ashrae-ies-90-1-2007-i-p-errata?gateway_code=ashrae&product_id=1643666

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 O&M Guide: https://www1.eere.energy.gov/buildings/publications/pdfs/energysmartschools/ess_o-and-m-guide.pdf

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: https://www4.eere.energy.gov/seeaction/sites/default/files/pdfs/dews_ecb_strategicenergy_11072012.pdf

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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 trees 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 re-caulk, 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:
https://www.epa.gov/iaq-schools/indoor-air-quality-tools-schools-action-kit

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

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

Energy Services Company (ESCO)

ESCOs are energy service companies that provide performance-based contracting to deliver cost-effective energy and economic savings in large and medium facilities, primarily in the public and industrial sectors. This is often done through the energy savings performance contract (ESPC). These contracts enable customers to finance energy efficiency, onsite generation, and other energy related projects without the need for a significant up-front investment. The ESCO often guarantees a certain annual level of energy savings from the contracted project that will allow the customer to pay back the project installation and financing costs. Roughly 80-85 percent of ESCO industry revenue has come from the "MUSH" market (municipalities, universities, colleges and K-12 schools, state government facilities and healthcare facilities) and federal customers.

A pitfall of ESCOs is the contract. A customer can implement a project with an ESCO, but technology may advance in the near future and the ESCO will prevent the customer from upgrading to more efficient choices that may become available. Important notes to consider when thinking about going with an ESCO approach include whether the equipment's lifetime will exceed the payback period, who maintains the equipment during the ESCO contract, and a performance guarantee.

Case Study: Buffalo School District, New York

The Buffalo School District underwent a $1.4 billion, district-wide project to modernize its facilities and equipment in order to improve their efficiency level, and to create a safe and secure academic environment within each of their 65 facilities. The project included a multi-phase performance contract that guarantees positive cash flow of $20 million over 20 years for the district. The city was awarded an Outstanding Achievement Award in Public/Private Partnerships from the United States Conference of Mayors for the renovation project. The project included three phases:

Phase one: Johnson Controls focused on key instructional and operational needs. This included lighting retrofits, HVAC equipment and controls upgrades, building envelope improvements, steam traps, insulation, pool covers and installation of a Metasys® building management system at select schools. Johnson Controls commissioned all the systems and provided training to employees of Buffalo Schools.

To create a model for any of the District's future sustainable buildings efforts, Johnson Controls worked with design engineers to completely renovate one of the District's grade schools and redesign it around achieving Silver certification under the U.S Green Building Council's Leadership in Energy and Environmental Design (LEED) program.

Phase two: Included an expansion of the Metasys system, lighting retrofits, replacement of burners, boilers and steam traps, installation of boiler controllers and new interior storm windows at an additional 13 schools.

Phase three: Expanded the initiatives to an additional nine schools and began the district-wide security upgrade. The security upgrade included a district-wide technology and security project to increase visibility of the facilities for the District's administrative and security staff.

Johnson Controls supports all installed equipment and controls under a service agreement, which includes an on-site building environment specialist, to ensure optimal energy efficiency and a safe academic environment.

Resources

Department of Energy's Qualified List of Energy Service Companies- September2016: https://www.energy.gov/eere/downloads/department-energy-qualified-list-energy-service-companies

ESCO Trends Report:
https://www.naesco.org/data/industryreports/esco_recent_market_trends_30sep2016.pdf

- http://us.sourcesecurity.com/technology-areas/network-ip/case-studies/co-2900-ga.1588.html

State and Local Solution Center: Energy Savings Performance Contracting:
http://energy.gov/eere/slsc/energy-savings-performance-contracting

Energy Savings Performance Contracting Accelerator:
https://betterbuildingsinitiative.energy.gov/accelerators/energy-savings-performance-contracting

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Energy Management Systems (EMS)

With the installation of an EMS, proper training of maintenance staff is absolutely critical. The community 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.

Resources

US DOE's Smart energy Analytics Campaign: https://smart-energy-analytics.org/

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
- ❑ Retrofit lamps as needed (more details below)
- ❑ A lamp recycling policy and a proper storage place for lamps awaiting recycling (See the Recycling Section of this guide for more information on mercury recycling)

Re-lamping Linear Fixtures

Most linear fixtures are currently installed with fluorescent lamps, though linear LEDs tubes (often referred to as TLED) are growing rapidly in popularity. Both the ballast and the lamp are needed to

function properly and have a good user experience. While LED technology is highly efficient, long lived, and high quality, there can be compatibility issues installing a linear TLED on an existing florescent ballast. As such, the best rule of thumb when selecting new technology is as follows:

- If the fluorescent tube dies, but the ballast still seems in good working order, replace the fluorescent tube with a new, high-efficiency fluorescent T8 or T5. These options for lamp replacements are low cost, low energy, and high quality.
- If the fixture dies and you suspect it is because of the ballast, replace the entire fixture with a new, integrated LED retrofit (preferably with integrated controls for maximum efficiency). These integrated LED fixtures not only offer longer lifetimes, but also improve efficiency and quality.
- Be aware that placing a TLED in a fluorescent ballast can lead to early failure and potentially be hazardous.

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.

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.

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 provides detailed information on PCBs in schools, , as well as a PCBs Inspection Manual. 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.

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

Any 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

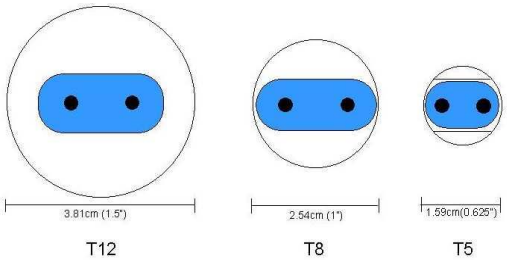
High intensity discharge (HID) lighting includes metal halide, high-pressure sodium, and mercury vapor lighting. Mercury vapor lighting is now rarely seen, but metal halide is often used for gymnasium lighting, and both metal halide and high-pressure sodium are found in exterior lighting fixtures. Although 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 or LED high-bays.

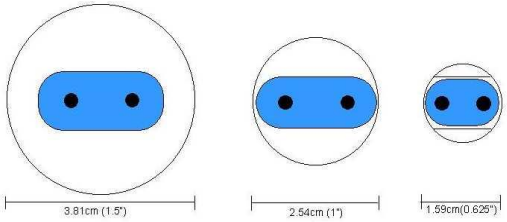
Lighting Retrofits

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. 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 percent 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 percent 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 75 percent 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.

Advanced Lighting Controls

Increasingly, lighting strategies for commercial, institutional and public buildings involve not just the lamps or ballasts, but advanced controls that maximize the efficacy of energy efficient lighting. The U.S. Department of Energy estimates that the installation of advanced lighting control systems can provide savings of approximately 29 percent over the installed base of lighting controls, which, on average, translates to annual savings of $1,889 per advanced lighting control system installed.

NEEP's DesignLights Consortium (DLC) has been working for the last three years on a project to help address the need for Commercial Advanced Lighting Controls (CALC). Part of this work has involved developing a suite of tools and resources to enable more informed and widespread adoption of advanced lighting controls.

In partnership with utilities and other program administrators across the region, as well as with the lighting industry, the DLC this year released both a system specification and a qualified products list for networked lighting control systems. These publicly available lists can help public building operators understand and compare networked lighting control systems as a means of deploying high quality controls that can both cut energy use and reduce operations and maintenance costs. The accompanying qualified products list also identifies those lighting control systems that are eligible for new financial incentives and rebates from utilizes and other program administrators in the Northeast region.

NEEP recommends that as part of any lighting retrofit project, building operators consult the Networked Lighting Control Qualified Products List.

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: https://newbuildings.org/wp-content/uploads/2010/02/ALGFactsheet.pdf

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 starts.

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. The amount of fuel needed to produce that energy would require 9.1 million tons of coal or 32.2 million barrels of oil. Reducing or eliminating exterior nightlight lighting is not only an operational cost saving opportunity for school campuses and public facilities, but also a mechanism to reduce crime and vandalism, as cited in previous case studies by IDA.

Resources

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

IESNA Model Lighting Ordinance (MLO): https://www.darksky.org/wp-content/uploads/bsk-pdf-manager/16_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*: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228832/9780108508547.pdf.pdf

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: https://www1.maine.gov/dacf/municipalplanning/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 as much as 40 percent 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 Municipal Smart Start Program offered by Eversource Energy, 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 15-30 percent of an annual municipal street lighting bill.

Another example of municipalities coming together to upgrade their streetlights can be seen in Delaware Valley Region of Pennsylvania.

Resources

Northeast Energy Efficiency Partnerships,
LED Street Lighting Assessment and Strategies for the Northeast and Mid-Atlantic
http://www.neep.org/led-street-lighting-assessment-and-strategies-northeast-and-mid-atlantic

Department of Energy Municipal Solid-State Street Lighting Consortium:
https://www.energy.gov/eere/ssl/solid-state-lighting

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

Massachusetts Department of Energy Resources Efficient Streetlights: https://www.mass.gov/service-details/efficient-streetlights

Outdoor Lighting Accelerator: http://betterbuildingssolutioncenter.energy.gov/accelerators/outdoor-lighting

HVAC - Maintenance

Boilers

In the Northeastern United States, a 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 under-heating 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 70-85 percent, with the efficiency ratings for condensing boilers reaching as high as 95 percent.

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://energy.gov/sites/prod/files/2013/10/f3/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.

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 20 percent biodiesel blended with 80 percent 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 percent 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 3.8-5.3 percent 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 and State Sponsored Programs

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.

Additionally, many state energy offices offer resources and/or incentives to residents, businesses, and public entities for energy efficiency and renewable energy improvements. The US Department of Energy maintains a list of state energy offices and organizations to link interested parties to what may be offered in their state.

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, https://www.energy.gov/eere/slsc/state-and-local-solution-center

Department of Energy, 179D DOE Calculator, https://www.energy.gov/eere/buildings/179d-commercial-buildings-energy-efficiency-tax-deduction

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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.

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

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.

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 an increasing number of CHP applications at large commercial and institutional sector facilities. 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.

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/

US DOE's CHP Technical Assistance Partnerships (CHP TAPS): http://energy.gov/eere/amo/chp-technical-assistance-partnerships-chp-taps

US DOE's Database of CHP Installations: https://doe.icfwebservices.com/chpdb/

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.

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:

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 Bennington Banner 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.

- ❑ 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

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

Resources

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

US DOE: "Guide To Operating and Maintaining Energy Smart Schools": https://www.energy.gov/eere/downloads/guide-operating-and-maintaining-energysmart-schools

FEMP boiler maintenance recommandations: https://www1.eere.energy.gov/femp/pdfs/om_9.pdf

FEMP Operations & Maintenance Best Practices, Release 3.0, August 2010, pg. 9.2: http://energy.gov/sites/prod/files/2013/10/f3/omguide_complete.pdf

FEMP Operations & Maintenance Best Practices, Release 3.0, August 2010, pg. 9.3: http://energy.gov/sites/prod/files/2013/10/f3/omguide_complete.pdf

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

FEMP Operations & Maintenance Best Practices, Release 3.0, August 2010, pg. 9.3: New England Fuel Institute: https://www1.eere.energy.gov/femp/pdfs/OandM.pdf

National Biodiesel Board: https://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://assets.nationalrenderers.org/final_biofuel_report.pdf

Renewable Energy Vermont – Bioenergy: http://www.revermont.org/technology/bioenergy/

Massachusetts Division of Energy Resources: *Wood Pellet Heating: A Reference on Wood Pellet Fuels & Technology for Small Commercial & Institutional Systems:* https://archives.lib.state.ma.us/bitstream/handle/2452/626355/ocn976169793.pdf?sequence=1&isAllowed=y

Air Source Heat Pumps

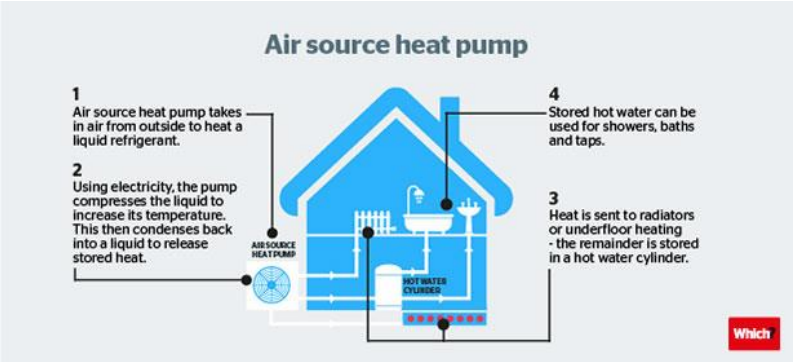
Air source heat pumps (ASHPs) provide space heating and cooling to buildings. An ASHP is a device that moves heat from outdoors to indoors (or vice versa) using a vapor compression cycle. In effect, it is an air conditioner that can run in reverse during cold weather. ASHPs have been installed in homes for decades, but they have primarily been used in warmer climates. In colder weather, the capacity and efficiency of older, conventional ASHPs was quite poor. Most of these heat pumps had backup resistance heating, and it was not uncommon for this resistance heating to be used frequently in cold climates. Over the past decade, many new ASHPs have been introduced to the United States market. Many of these systems use variable-speed compressors which allow for much higher efficiencies. Some of these systems also offer good performance at low outdoor temperatures (below 17°F). In many parts of the world – especially in Asia – variable-speed "ductless" or "mini-split" systems are the standard for space heating in homes. As the technology improves and communities seek to reduce their carbon emissions, ASHPs have become an attractive method of doing so beyond the residential building stock.

How ASHPs Work

ASHPs make use of a vapor compression cycle to move heat from indoors to outdoors (during summer) and from outdoors to indoors (during winter). The principle is very similar to that of a refrigerator/freezer which moves heat from the freezer into the kitchen.

The core components include:

- ❑ An outdoor unit, similar to the outdoor condensing unit with central air conditioners;
- ❑ One or more indoor fan coils;
- ❑ Refrigerant piping connecting the two; wiring and controls



During heating season, the compressor (located in the outdoor unit) compresses the refrigerant and sends this hot gas to the indoor unit. Here the refrigerant releases heat to the home, condenses, and is piped back outdoors. Refrigerant then runs through an expansion device and absorbs heat from outdoors as it evaporates. Refrigerant returns to the compressor where the cycle continues. Condensate (moisture that condenses out of the ambient air when it comes in contact with a cool surface) from the fan coils is piped to an appropriate location or drain. During cooling operation, this cycle is reversed. Warm air is delivered to the home via fan coils. The simplest systems are ductless; these fan coils are usually wall-mounted and provide direct conditioning to a single space. Other systems make use of fan coils that connect to duct systems that carry the warm (or cool) air to different parts of the home.

Help Achieve State and Community Goals: Strategic Electrification

What is it?
Strategic electrification (sometimes referred to as beneficial electrification) means powering end-uses with electricity instead of fossil fuels in a way that increased energy efficiency and reduces pollution, while lowering costs to customers and society, as part of an integrated approach to deep decarbonization.

Why is it important?
Strategic electrification is a path forward for communities as more and more continue to establish aggressive energy and carbon reduction goals to mitigate climate change.

For more information on strategic electrification, see NEEP's Regional Assessment.

Resources

NEEP's Cold Climate Air Source Heat Pump Specification Listing: https://neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump

NEEP's Air Source Heat Pump Market Strategies Report: https://neep.org/sites/default/files/NEEP_ASHP_2016MTStrategy_Report_FINAL.pdf

Department of Energy Air Source Heat Pump Information: https://www.energy.gov/energysaver/heat-pump-systems/air-source-heat-pumps

NEEP's Guide to Installing Air-Source Heat Pumps in Cold Climates: https://neep.org/sites/default/files/Installing%20Air-Source%20Heat%20Pumps%20in%20Cold%20Climates.pdf

NEEP's Guide to Sizing & Selecting Air-Source Heat Pumps in Cold Climates: https://neep.org/sites/default/files/Sizing%20%26%20Selecting%20ASHPs%20In%20Cold%20Climates.pdf

NEEP's Consumer Guide: Getting the Most Out of Your Heat Pump: https://neep.org/sites/default/files/GettingTheMostFromYourHeatPumpConsumerGuideFINAL.pdf

NEEP's 2019 Air-Source Heat Pump Program Incentive Summary: https://neep.org/sites/default/files/2019%20ASHP%20Program%20Summary.UpdatedMay2019_0.pdf

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 with 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 one 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

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/

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 provided. The report should include a

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.

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.

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://documents.goamp.com/Publications/candidateHandbooks/CPMP.pdf

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit EQ 11 https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf ; See page 161

CHPS Best Practices Manual, vol. 2, Guideline GC5: Contractor's Commissioning Responsibilities: https://www.15000inc.com/wp/wp-content/uploads/CHPS-II-2006.pdf

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.

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.

Increasingly as part of an overall energy efficiency strategy, communities are looking at purchasing Electric Vehicle as well as the supporting technology for their fleet and community stakeholders.

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 one 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/wp-content/uploads/2014/02/OptionsforReducingPollutionfromSchoolBuses_000.pdf

US-DOE Fuel Economy Information: https://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/

Electric Vehicles

The transportation sector represents a large percentage of greenhouse gas (GHG) emissions. In Massachusetts alone it represents 40 percent, with the dominant source of emissions coming from passenger vehicles. Electric Vehicles (EVs) emit 70 percent fewer GHG than conventional vehicles and are an important part of a community or state plan to reduce carbon emissions.

Battery-only EVs do not emit tailpipe emissions. EVs are powered by electricity which is increasingly powered by clean renewables; there will never be a renewable version of petroleum.

What can you do?

Charger Installation

- Employers should install workplace charging
- Install EV charging at all schools, starting with high schools, then middle schools then elementary schools. (Serves as workplace charging as well as charging for visitors)
- Encourage EV charging installations at multi-family properties
- Encourage ride sharing

Making the Case

- Employers with charging stations have employees who are 20 times more likely to buy an electric car
- Compared to other employee benefits, EV charging infrastructure is a bargain!
  - $8.25/day for health insurance
  - $4.16/day for gym membership
  - $3.40/day company cell phone
  - $2.50/cup coffee
  - <$2.00/day Level 2 charging
  - <$0.80/day Level 1 charging
- August 2016 MIT Study: 87 percent of U.S. vehicles could be replaced with EVs now
- Would lead to 60 percent reduction in total U.S. gasoline consumption, 30 percent reduction in transportation emissions emitted

Source: Plug In America

Education

- Hold a workplace charging seminars by engaging with chambers of commerce as well as surrounding communities
- Create an EV resource page on community website that includes a charging map
- Have an information table at community sponsored events
- Announce and EV proclamation from Mayor or town selectmen announcing a program to boost EV ownership over next two years

City and State Examples

Raleigh NC

With a focus on economic development, partnerships and environmental protection, Raleigh's Electric Vehicle Infrastructure Project established several goals to prepare for and support the adoption of electric vehicles by its residents and businesses.

Vermont

Adding more electric car charging stations builds on the state's ***comprehensive energy plan***, which hopes to see 25 percent of the state's energy coming from renewable sources by 2025, and climbing to 90 percent by 2050.

Resources

Example Local Laws and Incentives http://www.afdc.energy.gov/laws/local_examples

Plug In America https://pluginamerica.org/

Massachusetts Plug-in Electric Vehicle and Charging Infrastructure Case Study https://avt.inl.gov/sites/default/files/pdf/reports/MassachusettsCaseStudyDec2016.pdf

Best Practice: Designing for High Performance Schools (NE CHPS) http://www.neep.org/northeast-collaborative-high-performance-schools-criteria-ne-chps-version-31

Sierra Club http://content.sierraclub.org/evguide/evguide/blog/2015/04/electric-cars-are-making-cities-cooler-literally

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 region 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 3-7 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.usda.gov/wps/portal/usda/usdahome?contentid=cooperative_research_extension_services.xml

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 turf grass 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): https://www.asla.org/

LEED for Existing Buildings, Operations & Maintenance: https://www.usgbc.org/resources/leed-v41-om-beta-guide, 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: https://www.internationalschoolgrounds.org

National Clearinghouse for Educational Facilities, Resource List – Water Conservation in Schools: https://www2.ed.gov/programs/edfacclearinghouse/index.html

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.

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit: WE 3 https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf ; See page 202

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.

Making the Case

- "Green schools use…32 percent less water than conventionally constructed schools, significantly reducing utility costs over the average 42-year lifecycle of a school" – AIA Green Schools White Paper
- "In Dedham, MA, the school design team, through providing rainwater storage capacity on site, saved the town the cost of enlarging an off-site stormwater retention facility. The city valued this infrastructure improvement at $400,000" – AIA Green Schools White Paper
- If the change from a seven gallon per flush toilet is made to a 1.6 gallon per flush toilet, it can save up to 11,096 gallons of water per year, as calculated by the Massachusetts Water Resources Authority.

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.
- ❑ 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

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:

- 178 faucets (2.5 to 1.5 gallon per minute)
- 33 showerheads (2.2 to 1.7 gallon per minute)
- 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.

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: https://www.usgbc.org/resources/leed-v41-om-beta-guide, Pages 23 -30

Arizona School Facilities Board, Preventive Maintenance Checklist: https://sfb.az.gov/sfb-programs/preventive-maintenance/preventive-forms

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit: WE 3 https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf; See page 111

Collaborative for High Performance Schools, Best Practices Manual, Volume II – Design: https://chps.net/sites/default/files/CHPS_II_2006.pdf

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/core/fileparse.php/5599/urlt/0075327-3_0.pdf

National Clearinghouse for Educational Facilities: https://www2.ed.gov/programs/edfacclearinghouse/index.html

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.

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).

More information about EPP strategies, recommendations and more can be found on EPA's website here.

"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 EPA maintains a list of green products and services on their website here.

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 on their website: https://www.greenseal.org/green-seal-standards/gs-37/.

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.

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.

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: https://www.asumag.com/mag/article/20850621/the-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: https://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/

U.S. Environmental Protection Agency Sustainable Marketplace: Greener Products and Services: https://www.epa.gov/greenerproducts

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit: OM 7 https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf; See page 54

Massachusetts Operational Services Division, Environmentally Preferable Products listing: https://www.mass.gov/info-details/environmentally-preferable-products-index

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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 >two 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/

https://www.epa.gov/sites/default/files/documents/abcsfinal.pdf

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit: OM 7
https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf ; See page 54

US Department of Labor Occupational Safety & Health Administration – Asbestos:
https://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://zerodocs.com/CHPS; https://www.transparencycatalog.com/

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

The following programs certify low VOC products:

Scientific Certification Systems Indoor Advantage – Gold: https://www.scsglobalservices.com/services/indoor-air-quality-certification

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

GREENGUARD Certification Program: https://www.ul.com/resources/ul-greenguard-certification-program

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

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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 five 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.
- ❑ Every school should establish an end-of-year locker clean-out policy that encourages donation and reuse of school materials and recycling of unwanted books and folders.

Resources

MassRecycle Locker Cleanout Recycling Toolkit: http://www.cetonline.org/wp-content/uploads/2013/05/Locker_Cleanout_Toolkit-Rev.pdf

Recycling

Importance of Recycling

Recycling is promoted throughout the Northeast and Mid-Atlantic region with a variety of recycling programs and services. In many states, it is required. Some states, such as Massachusetts, have "waste bans" that prohibit the disposal in the trash of items that are recyclable or hazardous. There are numerous reasons for recycling. It is about more than just saving money! It is one of the participatory actions that students and staff can take to help the environment. The items recycled reduce the demand for natural resources in all the stages from mining, manufacturing, transporting, storage, retailing, and disposal. Recycling is expected in most communities and required in some and recycling in school models good citizenship behavior.

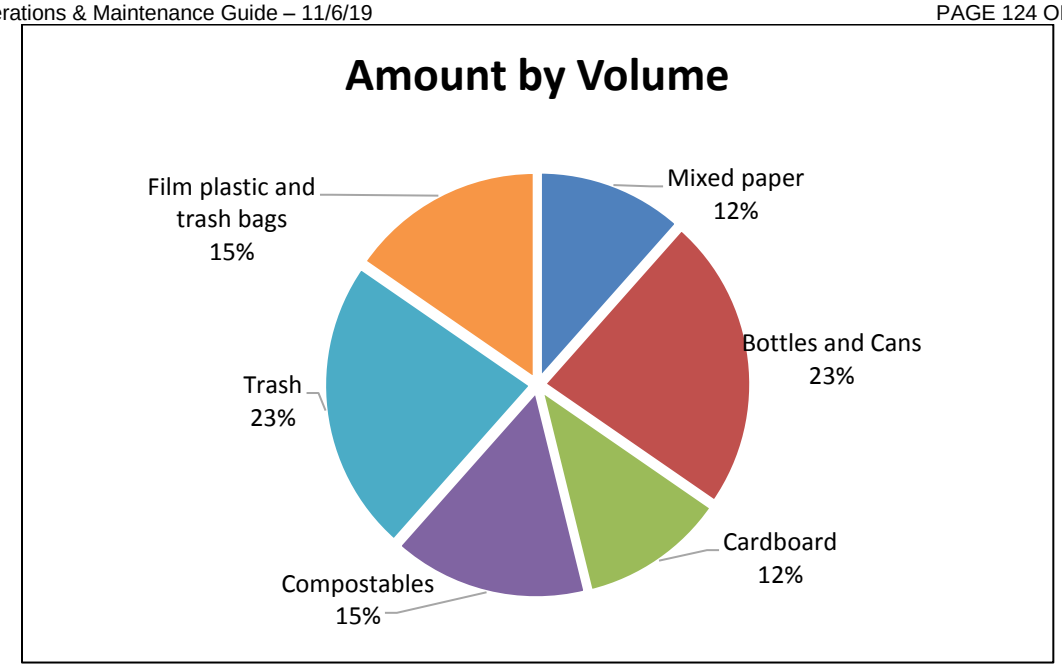
Designing the System for Collection and Storage of Recyclables

Waste Audits

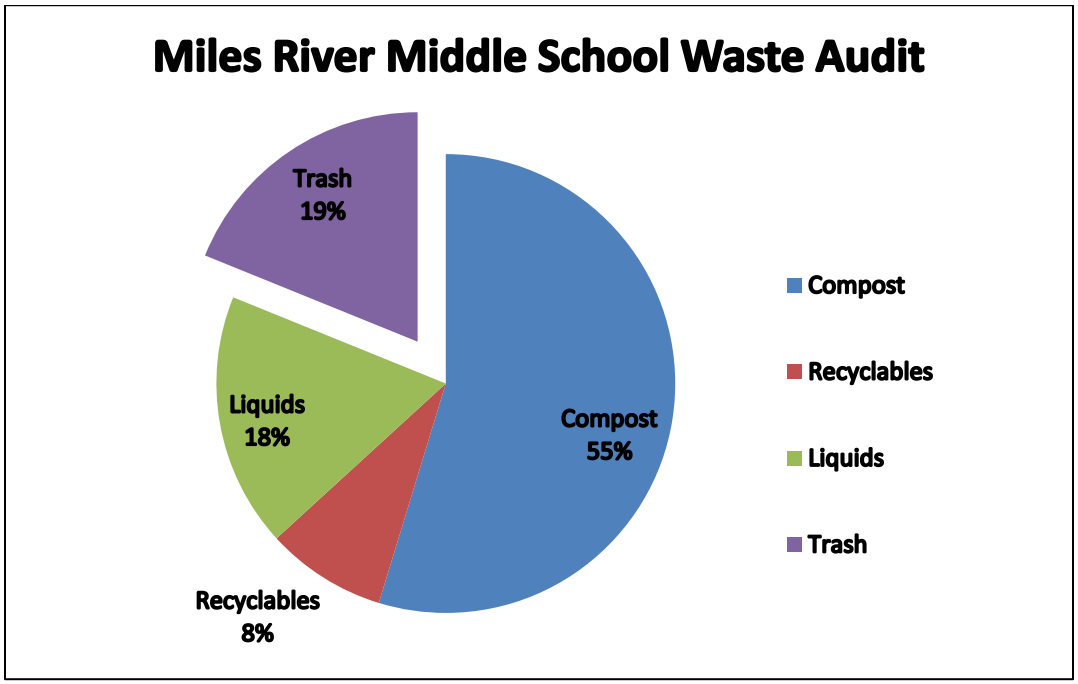
Most schools generate a significant percentage of materials that could be recycled instead of disposed as trash. A waste audit is a useful way to identify the types and quantities of materials discarded in a building. An audit can focus solely on the cafeteria or the entire building. Each area of a school building will have different materials that can be recycled.

- Classrooms and offices generate primarily paper.
- Cafeterias generate liquids, cartons/bottles/cans and food waste.
- Kitchens generate cardboard, metal and plastic containers as well as food waste.

Conducting a waste audit for the cafeteria and/or for the whole school will indicate what specific types of materials can be expected by weight and volume. The two pie charts below show that, even in a High School with a strong paper recycling program, there are bottles, cans, cardboard and food waste that still could be diverted. The second pie chart, from a cafeteria, shows the majority of weight is food waste, liquids and recyclables such as bottles and cans. This school uses reusable trays so the amount of trash might be lower than most other schools.



Waste Audit of Andover High School, Andover MA, 2015
Source: MA DEP



Waste Audit Hamilton-Wenham Middle School Cafeteria, 2013
Source: MA DEP

Local Input

Another key step in designing a recycling program is talking with the local community officials and waste hauler. 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. The cost difference between the Single-sort and multiple sort recycling methods, if any, can vary greatly from region to region. It is important to confirm what types of materials can be recycled or diverted to a compost program. Items that vary from site to site include milk cartons, biodegradable trays, and whether the recyclables can be collected together (also called "single-stream recycling") or whether paper needs to be separated from containers ("dual-stream"). Another key question is whether the recyclables need to be put into a dumpster and is the dumpster easily accessible in all weather and all seasons or can the hauler take recyclables if they are left in wheeled carts.

Recycling Connections

Recyclables need to be moved from their source to the collection point easily. The transfer systems that are most commonly used are wheeled carts. These should be available in all wings and all floors in order for the classroom recycling bins to be emptied as needed. The cart locations should be designed so that the carts do not impede the flow of student traffic or block any emergency exits or stairways.

The carts then need to be able to be transported to a storage area indoors unless there is easy access to a compactor or dumpster. Indoor storage is important to most school systems because the barrels, if left outdoors, will invite vandalism, non-school trash or illegal dumping, and can be in the way of other vehicles or snow plows. Custodians often place the barrels outside just in time for the trucks to collect them. Sometimes this requires a ramp to allow carts to get to ground level. If there are compactors or dumpsters, it is important to get the height and distance correct so that it is just as easy for the custodian to empty the recyclables as it is to empty the trash.

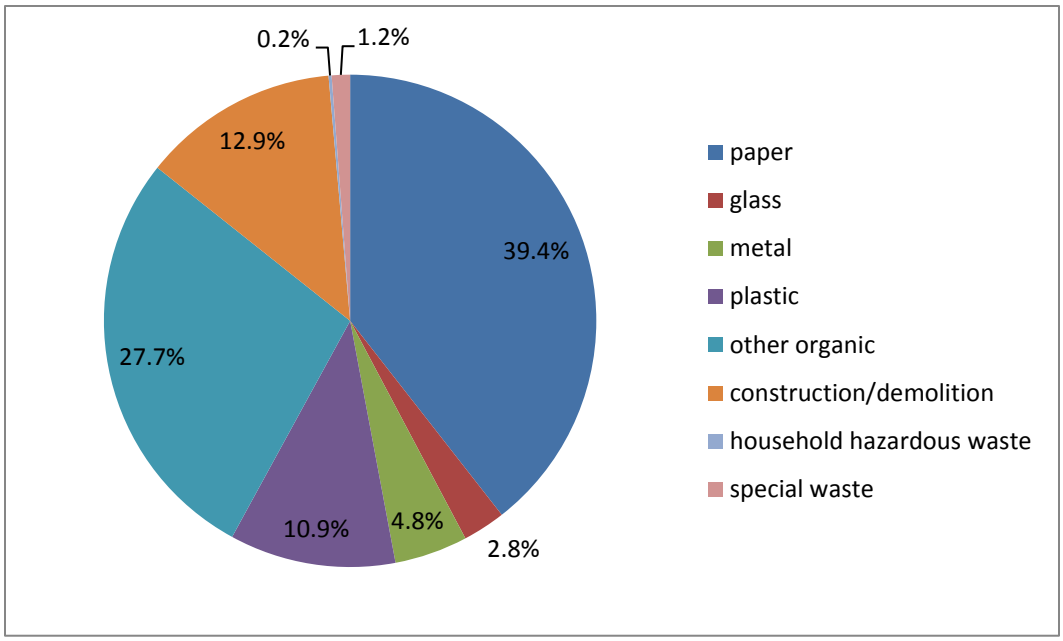
For cafeteria recycling programs, there need to be spaces and easy ways to move the cardboard, containers and food waste from the kitchen and for the liquids, containers, food waste from the cafeteria. Schools will want to have an easily accessible place for custodians to drain liquids. A slop sink or floor drain that is accessible to the cafeteria works well. Also needed is space for the storage of a "tilt truck" or "cube truck" to handle the cardboard and the empty containers from the kitchen.

Recycling Equipment Considerations

Typical recyclables include aluminum cans, steel cans, newspaper, white paper, corrugated cardboard, single polymer plastics, and glass bottles. Place recycling bins next to trash containers in order to provide users with disposal options, and reduce or prevent contamination of recycling bins with trash. Ensure that the recycling bins are marked clearly. The equipment for recycling should be flexible and allow for mobility, especially in the cafeteria. Often the community's recycling program will change and adaptable equipment will be able to adapt at the same time. The equipment chosen for elementary schools should be smaller or lower in height to accommodate the younger students.

The types of recycling that are accepted should be described or pictured on signs to make it obvious t what should and shouldn't be recycled. The collection and consolidation process should be made as easy as possible by placing collection bins in convenient locations near exits and trash bins.

O&M 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. The figure below shows a typical breakdown of waste generated in public buildings.



Typical Breakdown of Facility Generated Waste
Source: CalRecycle Solid Waste Characterization Database

A successful recycling program will include several components:

- A clear understanding and set of instructions for all users and for all custodial staff;
- Efficient movement of materials from deposition points in the facility to outside locations where materials are picked-up;
- Recycling containers need to be clearly differentiated, marked and placed adjacent to all trash containers;
    - Consistent color differentiation (e.g., black for trash, blue for recycling) is very helpful;
    - Consistent signs with clear photos and a minimum number of words also help. Examples of recyclable items that are generated on-site can be used for display purposes as well. Signage should be clear from various directions and easily understandable at a distance;

- Restrictive lids (i.e., lids with round holes for containers) are key to avoiding contamination.

It is also well documented that there are benefits to providing ongoing education about the importance of recycling "right" and providing feedback on the results of the community efforts. For example, 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.

For collection of organic and recyclable materials, the containers should be lined with clear plastic bags instead of black bags or biodegradable bags for organic materials. This allows the custodian to more easily see the location of any contaminant.

Common Problem 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

Keeping the recycled materials separate from trash is important to maintaining the value of the recycled materials. Typical problem materials include plastic bags and liquids or food waste. Plastic bags are a common contaminant in recycling facilities. They can tangle and stop operations. It is important to separate any plastic bags or other items that could tangle from other recyclable materials. Larger plastic items, known as "bulky rigid plastics" are recyclable in some programs. 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.

Organic Material

Organic materials make up almost one-third of a typical school building waste production due, mostly, to food service. Several states are starting to require diversion of food waste in the case of larger generators. Massachusetts, for example, bans organic waste from disposal from those who generate more than one ton of food waste per week from one site. This impacts large institutions such as colleges. For other public buildings the percentage will vary greatly. A significant amount of that material can be diverted from the waste stream by:

- ❑ Separating food waste so it can be collected and taken to a compost facility.

- ❑ 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.
- ❑ Reducing waste by 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. Computer monitors and other flat screen devices often contain fluorescent tubes. These must be handled with care and in Massachusetts they must be disposed of in accordance with the Mercury Management Act.

A searchable database of facilities nationwide where you can take lamps and other equipment containing mercury for recycling can be found here.

Other Materials

If your recycling service is not "single stream", provide separate collection bins for glass and aluminum containers generated from food preparation, vending machines, and packed lunches. Almost all glass, metal or plastic food and beverage containers are recyclable.

Most scrap metal, lumber, concrete and asphalt are also recyclable at specialized recycling centers designed to handle construction and demolition materials. Before new construction and major renovation projects begin, plan to include bid specification to require contractors to recycle construction debris when applicable.

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.

The staff should also be made aware of the cost savings potential if the trash collection frequency or size of dumpster can be reduced.

Single-Sort Recycling

Some jurisdictions offer single-stream 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 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.

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 (disposal) 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: https://www.epa.gov/smm/wastewise

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

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

Massachusetts Department of Environmental Protection: http://www.mass.gov/eea/agencies/massdep/recycle/solid/massachusetts-waste-disposal-bans.html

Mercury Management Act: https://www.mass.gov/guides/massdep-mercury-information#-mercury-management-act-

New Hampshire Department of Environmental Services: https://www.des.nh.gov/waste

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

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit: MW 1 https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf ; See page 273

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 10 degrees Fahrenheit 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

Northeast Collaborative for High Performance Schools Criteria, Version 3.1, Credit: SS 10 https://neep.org/sites/default/files/resources/NE%20CHPS%203.1%20Criteria%20Update_2018.pdf ; See page 254

CHPS Best Practices Manual, vol. 2, Guideline GC4: https://www.15000inc.com/wp/wp-content/uploads/CHPS-II-2006.pdf

US EPA, Heat Island Effect: https://www.epa.gov/heatislands

US EPA, Reducing Heat Urban Islands: Compendium of Strategies – Green Roofs: https://www.epa.gov/sites/default/files/2017-05/documents/reducing_urban_heat_islands_ch_3.pdf

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 as an alternative 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 indoor environment, but very often the up-front cost of those measures is cost-prohibitive. An energy services 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 IV.

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 slightly less than the amount 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.

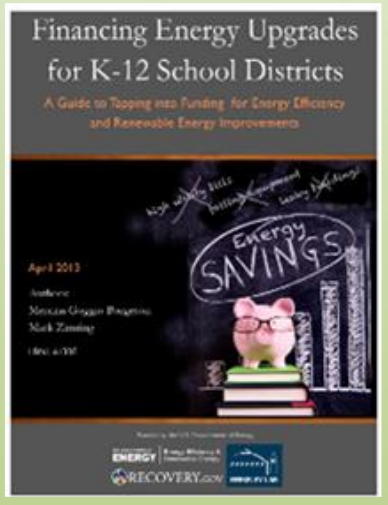
- Resource Management Contract – In a Resource Management contract, the hauler is a partner and has a financial incentive to reduce the overall amount of waste by diverting to recycling, composting and source reduction.

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.

Resource Spotlight

Through the U.S. Department of Energy's ereleased 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



Aside from working with an ESCO, building owners can also pursue other financing opportunities. 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.

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.

DOE's Financing Navigator Tool

The U.S. DOE realizes the many ways to finance energy efficiency and renewable energy projects in buildings can be a bit overwhelming. In turn, they developed an online, no-cost tool to help navigate through the financing options to find the options that best fits your needs. The Navigator allows for users to also connect to the larger Better Buildings Challenge Financial Ally community that contain banks and lenders that are committed to pursuing new opportunities to finance projects. The Navigator can be utilized by the public to access financing for energy efficiency and renewable energy projects and can be useful for building owners, facility and energy managers, sustainability directors, executives, contractors, consultants, brokers, researchers, and other decision-makers.

Project Highlight: Inter-Lakes School District in New Hampshire is a project that utilized utility incentives and performance contracting to upgrade their facilities to high performance.

Inter-Lakes School District

How Laker Blue Went Green

About Inter-Lakes School District

Inter-Lakes School District is a cooperative school district serving approximately 1,060 students from pre-school to 12th grade from the New Hampshire towns of Meredith, Center Harbor, and Sandwich. The district's facilities include three schools (Inter-Lakes Elementary School, Sandwich Central School, and Inter-Lakes Junior/Senior High School) and an administrative building.

Before

- 25% of high school had no mechanical ventilation
- Elementary school had ventilation systems that were too large
- All ventilation systems were running 24/7/365
- Faulty equipment (broken exhaust fans, poor energy recovery units, improper location of vents)
- Improperly installed equipment
- Overheating and cooling of classrooms

After

- Reduced energy costs by 40%
- 46% of baseline energy needs from renewable sources
- 71% baseline oil usage replaced by renewable sources
- 35% baseline electricity usage replaced by renewable sources
- Upgraded HVAC equipment
- Improved building safety, comfort, performance
- Integrated renewable energy and sustainability efforts into classroom curriculum

"A lot of time has been invested in communicating and educating people about how this can work for them. Once Phase I was completed and they could see the benefits, it made it that much easier to make the case for Phase II improvements. The School Board has been so supportive. They realize that energy cost avoidance results in more money available for educational programs."

- ILSD Assistant Superintendent Trish Temperino

Savings

Annual energy savings (kwh/yr)	379,141
Annual energy savings (therms/yr)	10,363
Total savings ($)	203,508
Total project cost ($)	2,480,267
Incentive dollars ($)	455,321
Customer cost ($)	2,024,926
Simple payback (yrs)	10.0

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: https://www4.eere.energy.gov/seeaction/working-group/financing-solutions

Solar power purchase arrangements; https://www.epa.gov/greenpower/solar-power-purchase-agreements

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

State and Local Solution Center: Energy Savings Performance Contracts: http://energy.gov/eere/slsc/energy-savings-performance-contracting

Energy Savings Performance Contracting Accelerator: https://betterbuildingssolutioncenter.energy.gov/accelerators/energy-savings-performance-contracting

State and Local Solution Center: Pay for Clean Energy: http://energy.gov/eere/slsc/financing-solutions

Cafeteria Design and 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.

Kitchens

High efficiency equipment such as refrigerators, ovens and dishwasher machines 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. By designing the kitchen with a dish machine, the school can reduce waste and save money. The disposable trays cost money to buy every year and cost money to dispose of also. Washable foodservice ware, eating utensils, trays and cups can last 10-15 years. Schools in Framingham, MA have added dish machines into their high school and middle schools and found they reduce trash by 50 percent with no noticeable increase in water or energy use and no added labor cost should be used if when possible to reduce waste. Another alternative is to use compostable foodservice ware and trays but it is important to confirm that the compost facility will accept them. For more info about recycling programs see the section of this guide on . Recycling.

Other waste streams from the kitchen that can be diverted if space is provided include: cardboard, plastic and metal containers, cooking oil, and packaged but uneaten food. For each material, the school should have barrels or other containers to store the recyclables, make arrangements for their collection, and should train the staff in how to separate.

See it in Action:

Framingham, MA Public Schools' Food Service Program

The Framingham Food Service program incorporates innovative policies into schools to ensure better nutrition and sustainable food delivery. They have a garden inside the courtyard at the High School where students grow vegetables that they turn into 1400 gallons of tomato sauce, 40 gallons of pesto, plus brussel sprouts, squash, eggplant and herbs. In the kitchens for three of their schools, they have installed dish machines and use reusable trays to reduce waste. They also compost food waste on-site, which is used in the garden.

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. Kitchen staff should also be provided sufficient space and containers for collecting recyclables commonly generated, e.g. cardboard, food cans, plastic containers, plastic food bags and overwrap, etc.

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 about these programs can be found on the EPA website here.

Cafeterias or Dining Areas

Cafeterias or dining areas are a significant source of waste in schools and public buildings. Leftover food and drinks that are thrown away adds great weight and volume to trash bags. This generally increases disposal costs. Cafeteria waste can be reduced by 90 percent if the equipment is provided to allow:

- ❑ Liquids to be poured off from milk, juice, or soda containers;
- ❑ Recycling of the empty containers;
- ❑ Separation of food and compostable trays, if being used; and
- ❑ Disposal of any residual non-recyclable and non-compostable items.

Many schools employ liquid pour off buckets near trash/recycling stations where students empty beverage containers before recycling them. After lunch is done, the custodians can pour the liquids down the drain. Custodians have found that this results in fewer spills from leaking trash bags, cleaner and more time-efficient management of cafeteria waste, and reduced costs for disposal.

Cafeteria sorting stations need to be designed with several factors:

- ❑ Access from both sides to accommodate the maximum number of students at a time;
- ❑ Good signage at eye level indicating what waste goes where;
- ❑ Color-coding and/or restrictive openings to further minimize contamination;
- ❑ Mobility such that the custodian can easily move the station for different seasons or for cleaning purposes; and
- ❑ Flexibility such that the station can accommodate changes in the recycling program over time.

Recycling Center at Manchester Essex (MA) HS Named after the School Facilities Director
Source: MA DEP

Cafeteria Sorting Station at High Plain Elementary School, Andover, MA
Source: MA DEP

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 collecting food waste.
- ❑ If on-site composting is not an option, identify local composting facilities/haulers to determine if a composting program is feasible.

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 typically recycled waste. The types of items 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.

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: https://www.nacubo.org/Topics/Facilities%20and%20Environmental%20Compliance/Campus%20Environmental%20Resources%20Center/Campus%20ERC%20Campus%20Tour/Dining

The Environmental Protection Agencies webinars - Federal Facilities: https://www.epa.gov/sustainable-management-food/webinar-reducing-wasted-food-federal-facilities

A Massachusetts-based vegetable oil recycling service: http://www.savethatstuff.com/services/what-we-collect/
More information can be found at the Environmental Protection Agency's webinars webpage here: https://www.epa.gov/smm/sustainable-materials-management-web-academy

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Zero Energy Buildings

In 2015, The US Department of Energy released a Common Definition for Zero Energy Buildings stating that; *A Zero Energy Building is one where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy*. Typically this moniker is reserved for new construction, or major renovation projects that achieve zero energy through efficient design and the use of on-site renewable energy generation. Standard retrofit projects are not likely to be capable of getting to zero energy status, 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 energy building construction, locations with different renewable potential and HVAC requirements will be more or less conducive to zero energy 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 to

locational differences in zero energy parameters, there are certain tradeoffs and barriers inherent to reach these high performance standards.

Buildings that achieve zero energy 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.

The K-12 Schools Sector is leading the way in terms of zero energy building development. There are two zero-energy ready schools in the state of Rhode Island alone. Zero energy ready facilities have low enough EUI's to get to zero energy but don't yet have the onsite renewable energy generation necessary to offset their energy consumption. The East Bay MET School in Newport, RI was the first zero energy designed school in the region. The Claiborne Pell Elementary School, also located in Newport, RI, is the other zero energy ready school in the state. Both of these schools are designed to meet NE-CHPS criteria, which can be used as a pathway for schools to get to zero energy.

Claiborne Pell Elementary School
Source: Providence Journal

The Financial Case for Zero Energy Buildings

Zero energy buildings significantly reduce a building's energy use, saving owners and occupant's money on their electricity bills while also decreasing greenhouse gas emissions. Meredith Elbaum, Executive Director of USGBC MA, exclaimed, "… zero energy buildings can be constructed or retrofitted for minimal upfront costs, if any, and can owners can start making money off of their investment sooner than they expect." The report, *Zero Energy Buildings in MA: Saving Money from the Start*, examines and reveals key finding related to cost-savings, model performance, and return on investments for zero energy buildings

built in Massachusetts. The study also reviews how practices, regulations, and legislation could change in the upcoming years to increase zero energy buildings. Additionally, there is an included set of recommendations on how to increase the adoption of zero energy building policy in Massachusetts. Breaking down the perception that zero energy buildings cost more and that they are possible today to build with no additional first cost begins here.

Maintenance of Zero Energy Buildings

Renewable Energy Generation

Zero energy buildings are 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.

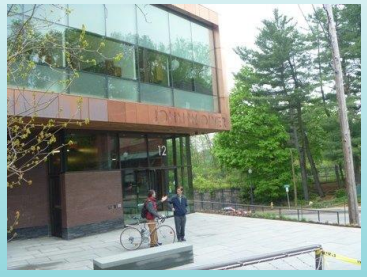
This maintenance might not be accessible to normal staff such as the lubrication of wind mills or replacement of wiring in a photovoltaic system. In which case, a professional specializing in such systems should be called in to service the systems. Please refer to the alternative and renewable energy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

High Performance Mechanical Systems

Zero energy 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 zero energy building systems.

See it in Action:

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 zero-energy transit center in the country. According to Charles Rose Architects, the main design firm, the Center is designed to achieve zero energy 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.

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

NEEP Roadmap to Zero Energy Public Buildings: Progress Report:
http://www.neep.org/sites/default/files/resources/ZE%20Report%20August%202016_0.pdf

NEEP – Roadmap to Zero Net Energy Roadmap Public Buildings
https://neep.org/roadmap-zero-energy-public-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/technical-resources/aedgs

DOE Better Buildings Accelerator: Zero Energy Schools: https://www.epa.gov/smm/sustainable-materials-management-web-academy

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, many municipalities are tasked with maintaining pumping and filtrations systems associated with water supply and Water Resource Recovery Facilities (wastewater treatment plants). These facilities can account for approximately 35 percent of municipal energy budget.

Both water supply and waste water treatment facilities offer the potential for energy efficiency upgrades. Potential upgrades that should be considered, include:

- ❑ 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.

See it in Action:

Essex Junction Waste Water Treatment Facility (Essex Junction, VT) – 60 kW CHP

In 2003, Essex Junction Waste Water Treatment Facility, 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.

Resources

NEEP – Fact Sheet on Water/Wastewater Facilities:
https://neep.org/sites/default/files/Fact%20Sheet%20-%20Wastewater.pdf

NEEP – Opportunities for Strategic Energy Management in the Public Water Sector: https://neep.org/sites/default/files/resources/Opps%20for%20SEM%20in%20Muni%20Water%20Sector.pdf

EPA – Water & Energy Efficiency in Water and Wastewater Facilities: https://www.epa.gov/statelocalenergy/energy-efficiency-water-and-wastewater-facilities-1

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)

NY 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 an Energy Star "Combined Heat and Power" 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

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 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:

Dartmouth-Hitchcock Medical Center (Lebanon, NH)

The state-of-the-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 years. 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:
https://www.energy.gov/eere/researching-energy-use-hospitals

Leading Techniques for Energy Savings in Healthcare Facilities:
https://www.se.com/il/en/download/document/998-2095-03-09-12AR0_EN/

EnergyStar Energy Use and Energy Efficiency in Health Care:
https://www.energystar.gov/ia/partners/publications/pubdocs/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:
https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/historic_homes_guide.pdf

FEMP, Historic Preservation and Energy Efficiency in Federal Buildings:
https://www1.eere.energy.gov/femp/pdfs/ee_historicbldgs_report.pdf

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, typically defined as buildings with five or more housing units, is a significant portion of the housing stock in the Northeast and Mid-Atlantic regions. According to the U.S. Census Bureau, of about 26 million housing units in the region, nearly six million are multifamily. Due to differences in ownership structure and incentives, these buildings present unique challenges and opportunities. There has been relatively little focus on the energy efficiency performance of the operational issues around multifamily buildings. There is great potential for energy savings in multifamily buildings because most of the multifamily buildings in the region are more than 50 years old and according to Fannie Mae, tend to have fewer energy efficiency features than other types of housing (Fannie Mae, 2012). 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 thermostats are the most common measures.

Initiatives to engage and educate tenants can be an effective way to ensure operational efficiency in tenant occupied spaces. Programs that teach tenants about the major sources of energy consumption in their homes can lead to behavioral changes which save energy. These programs are most effective when tenant spaces are individually metered and the actual energy consumption can be easily monitored by residents.

See it in Action:

Cherry Hill (Baltimore, MD)

Cherry Hill is the largest public housing development in Baltimore, MD. It was originally built in 1945 by the Housing Authority of Baltimore City (HABC) and the United States War Housing Administration for African American War Workers. The HABC targeted Cherry Hill for efficiency improvements because of persistent heating issues in parts of the 1,394 unit development and the benefits of installing quick payback measures in so many units. Previously, building managers were not able to control HVAC equipment remotely and were only made aware of problems through comfort complaints from residents. This project included new lighting, water-saving devices, and insulation paired with smart meters and an energy management system utilizing EnergyCAP, an energy management software. This allows residents to use real-time energy information to compare against their utility allowance. HABC also offers an education campaign called “Eye on Energy” to ensure residents are able to cut their energy waste while remaining comfortable. The expected energy savings of this project are nearly $1.2 million per year.

Resources

NEEP Multifamily Retrofit Resources Page: http://www.neep.org/public-policy/energy-efficient-buildings/multifamily-retrofit/multifamily-retrofit-regional-activities

Northeast Regional Multifamily Energy Efficiency Program Matrix: http://www.neep.org/regional-multifamily-program-matrix

U.S. Department of Housing and Urban Development Operations and Maintenance Checklist: http://portal.hud.gov/hudportal/HUD?src=/program_offices/public_indian_housing/programs/ph/phecc/oandm

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.

strategic electrification – powering end-uses with electricity instead of fossil fuels in a way that increases energy efficiency and reduces pollution, while lowering costs to customers, and society, as part of the integrated approach to deep decarbonization.

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.apa.virginia.gov/data/download/deferred_maintenance/Deferred_Maintenance_and_Capital_Outlay_Presentation_for_Implementation_Committee.ppt