ENERGY BEST PRACTICES GUIDE:

SCHOOL & GOVERNMENT FACILITIES

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School & Government Facilities Energy Best Practices Guide

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Focus on Energy, Wisconsin utilities' statewide program for energy efficiency and renewable energy, helps eligible residents and businesses save energy and money while protecting the environment. Focus on Energy information, resources and financial incentives help to implement energy efficiency and renewable energy projects that otherwise would not be completed.

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INTRODUCTION

Wisconsin school and government facilities, with thousands of buildings in various locations, are one of the largest energy consumers in the state. Nationally, school and government facilities spend millions of dollars annually on electric and gas expenses. According to the U.S. Department of Energy, as much as 30 percent of all energy may be used inefficiently. By creating awareness and implementing changes in the way these facilities are operated, school and government facilities can better use taxpayer dollars and resources, conserve energy, improve efficiency, and increase occupant comfort. Additionally, costs reduced through these changes can be reallocated into alternative areas of the budget, such as for extra staffing, technology, or other facility needs.

While it may not be realistic to completely eliminate energy expenses in school and government facilities, there are many ways to decrease energy use. This can include anything from making basic behavioral adjustments to major equipment upgrades. In the end, it's up to you to decide which modifications and improvements are best suited for your facility. This guidebook details energy saving strategies and best practices to decrease energy expenses so you can make an informed decision.

WHY ENERGY MANAGEMENT?

A strategic energy plan provides your organization with a systematic approach for assessing energy costs and ensuring you are doing projects or actions that meet your organization's project payback criteria. A proactive approach to energy management can:

- Control your energy use
- Save five to ten percent on your annual energy bill by starting an energy awareness program
- Achieve 20 to 30 percent in savings by digging deeper into the way building systems operate and identifying deficiencies in equipment

GETTING STARTED

Start with a motivated, cross-functional team of employees with a passion for conservation and a vested interest in positive facility outcomes. The team should include:

- Budget or financial manager
- Facility or maintenance manager
- Upper-level manager (administrator, principal, etc.)
- Interested building occupants (staff members, custodians, etc.)
- Utility representative
- Energy Advisor or another functional expert from outside the organization

Once key players of the energy team have been identified, create a communication process that incorporates how communication will take place on the team and who will be involved. The team must understand energy management is an ongoing process that incorporates innovative procedures into existing business practices. After the energy team and communication module have been established, you're ready to develop a strategic energy plan.

ENERGY PLANNING

Identifying energy saving opportunities in facilities is important, but building a long-term culture around proactive energy savings, reduction of waste, and investing in new technology will prepare your facility for long-term benefits. Energy planning is a continuous effort, requiring long-term support. It is imperative facility managers properly document, analyze, and support energy-related decisions. They must also be willing to continuously monitor and assess areas where additional energy efficiency can be achieved.

The following energy planning cycle can help your facility's energy team get started with evaluating, developing, implementing, and verifying an energy plan that's right for your facility.

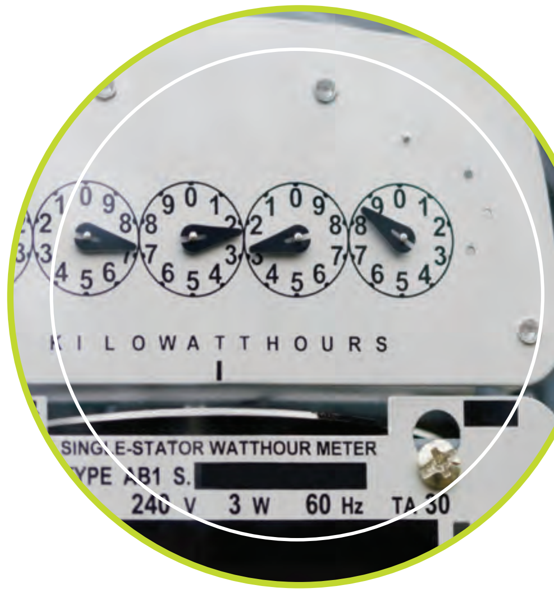

STEP 1
Establish Your Energy Use Baselines
STEP 2
Set Energy Saving Goals
STEP 3
Complete Equipment Usage Information
STEP 4
Develop Your Energy Plan
STEP 5
Implement Your Energy Plan
STEP 6
Verify the Impact and Communicate Success
STRATEGIC ENERGY PLAN

STEP 1 ESTABLISH YOUR ENERGY USE BASELINES

To develop accurate energy saving goals and identify appropriate facility improvement measures, you must know how much energy major systems and existing equipment currently consume. Building a utility history or baseline for your facility will help provide the big picture of overall energy usage. Gather utility bills for a minimum of one year (two or three years is better) and develop a baseline for each of the facilities in your organization. Information from the utility bills should include:

- Electric energy use in kilowatt hours (kWh)
- Demand in kilowatts (kW)
- Natural gas in therms
- Energy costs
- Billing cycle dates
- Water usage if applicable (CCF)

Review the building's energy bill and divide the cost by the total kWh to find out $/kWh. Apply this amount to the metered kWh. A typical $/kWh for a school/office building is $0.10/kWh. In addition to utility bill data, review building plans to obtain accurate square footage and other useful information.



Review Appendix - Understanding your Electric Bill to better understand these common terms and where to find them on your utility bill. Once you're familiar with the terminology, enter all data into a utility tracking tool. Contact your Energy Advisor for this worksheet, use a spreadsheet you've created, or utilize an alternate benchmarking tool that has been developed for this purpose. ENERGY STAR Portfolio Manager® is an example of free utility tracking tool to measure and track energy and water consumption. Whichever tool you use should:

- Track energy costs
- Show year-to-year comparisons of energy use and costs
- Assist in identifying energy saving opportunities

Establishing a baseline will help compare your facility's performance against others with similar characteristics. This insight will help you gauge your facility's overall operation while providing a comparison as improvements are implemented along the way. Studies have demonstrated even the process of investigating energy use and improving awareness among staff can provide measurable energy efficiency savings ranging from three to five percent.

BEHAVIORAL TIPS

✔ Talk to your energy advisor to help weather normalize your facility and compare to other similar building types.

STEP 2

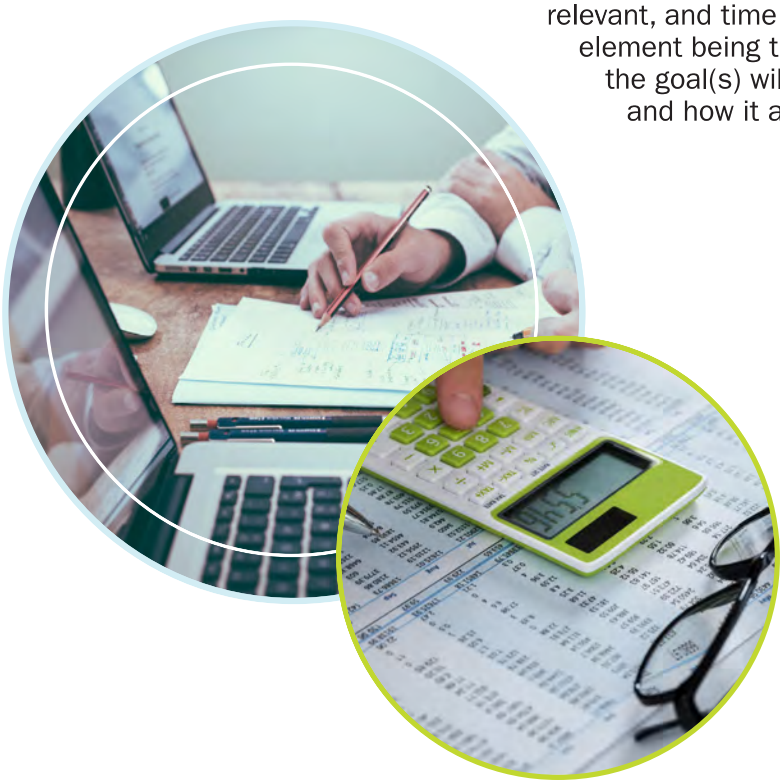
SET ENERGY SAVING GOALS

While it may seem simple, this step is critical to the success of an energy plan. Successful energy planning requires a focused, coordinated, and empowered effort. Once your energy team is established, processes created, and baselines determined, the written energy goal(s) should be developed. Examples of energy goals include:

- Our school district will reduce operating costs by three percent through utility reductions by the end of the school year.
- Our facility plan will include reducing our overall BTU per square foot per Heating Degree Day by five percent in the next fiscal year.
- Our board policy will be to analyze energy usage reductions and project payback for every measure brought forward in the coming fiscal year.

Once an energy goal has been developed, it needs to be effectively communicated to the surrounding community, which could include students, staff, employees, and other community members. The team you've assembled is critical to providing the tools, motivation, and funding for projects or promotional pieces to drive facility participants towards achieving each goal.

Written energy goals should be SMART – specific, measurable, attainable, relevant, and time based. Goals should be clearly stated, with an essential element being the timeframe for execution. Remember to highlight how the goal(s) will be measured, including key performance indicators, and how it aligns with the mission and vision of your organization.



STEP 3 COMPLETE EQUIPMENT USAGE INFORMATION

There are two ways to complete the equipment usage breakdown. The first method utilizes State Energy Profile Data provided by the U.S. Energy Information Administration to apply a percentage profile per type of facility to the overall annual usage. This method looks at seven categories for facility use:

- Lighting
- HVAC – Space heating, space cooling fans, and pumps
- Office Equipment
- Refrigeration
- Kitchen equipment
- Domestic and service hot water
- Miscellaneous

Whereas Step 1 derives information from historical records, Step 3 relies on collecting data from current operations. This step may require additional help from internal or external experts. Interviewing supervisory, operations, maintenance staff, and contacting an Energy Advisor or utility personnel early in this step of the process is recommended. These interviews can help verify understanding of energy use, identify limitations for future actions, and provide helpful suggestions for energy projects.

These profiles can be found at www.eia.gov/state/data, and will provide a convenient estimate for your specific facilities, allowing for the quick creation of an average energy profile. This method will help narrow your focus to systems that use the most energy and provide a starting point of where to look deeper for savings.

The second method entails completing a detailed inventory of equipment within each facility. This technique is more time-consuming and involves:

- Walking the facilities
- Examining building plans
- Inspecting equipment
- Compiling an energy breakdown with the documented information

Involving the energy team in this process will further their understanding of the equipment and how it operates. Working with an energy expert will allow you to build a specific energy profile. Regardless of who's involved, a working knowledge of operating hours and calculations of mechanical and electrical systems will be needed to successfully create an accurate energy profile. This method helps highlight operating costs per year for each piece of equipment, which aids in determining the energy culprits in your facility.

STEP 4 DEVELOP YOUR ENERGY PLAN

After creating an energy usage breakdown for each facility and identifying equipment with high energy use, the energy team can begin to develop a prioritized energy plan. The plan should include:

- Description of projects
- Schedule for completion
- Budget
- Task assignments
- Relationships of energy projects to each other
- Potential changes to existing processes or schedules
- Expected results

Energy improvement best practices should first be considered whenever possible as the savings on your utility bill can be used to help fund future projects. A best practice is a substantiated practice or technology with a good track record and proven results. They have economic benefits and have been verified through multiple field applications. This guidebook will provide best practice recommendations in the areas of:

- Lighting
- HVAC
- Plumbing
- Kitchen Equipment
- Technology
- Building Envelope
- Renewable/Alternative Energy

These best practices can be further categorized into simple low cost/no cost operations and maintenance procedures, behavioral changes, or larger capital investments with varying implementation costs. Some best practices should be incorporated into a standard preventative maintenance plan, others brought to the attention of frequent building users for a sustainable culture shift, and others brought to the administrative/board level for financial consideration. Examples include:

LOW COST/NO COST OPERATIONAL CHANGES - MAINTENANCE PRACTICES

- Change filters to improve airflow and efficiency
- Reduce outside air intake through a program setting or mechanical adjustment

BEHAVIORAL CHANGES - BREAKING HABITS

- Turn off lights when leaving a room
- Use kitchen ventilation only when cooking

EQUIPMENT OR SYSTEM UPGRADES - FUNDING/CAPITAL PLANNING

- Replace roof and add insulation
- Upgrade lighting to LED
- Upgrade heating system to condensing boilers

While each best practice requires different financial evaluation and approval, they all require the support of relevant stakeholders and ongoing communication among all parties.

STEP 5

IMPLEMENT YOUR ENERGY PLAN

Execution of a successful energy plan requires the commitment of a knowledgeable and dedicated team. Besides managing the technical aspects of project implementation, how you and your team communicate information across your organization will also be critical for success. To ensure proper plan execution, the team should:

- Consist of inside and outside professionals to aid in project implementation
- Confirm technical and financial details to move the project forward
- Hire an architect or engineer to help with design/redesign if needed
- Understand and weigh challenges and risks that may affect the project scope and timeline
- Be prepared to address issues up front to reduce barriers and resistance down the road

In addition, a well-documented business case can provide the necessary information to aid decision-makers and other stakeholders in their support of the plan. The business case may also be needed to organize and communicate information. A business case should include the following elements:

- **Executive Summary** – Project overview, states how it will improve the existing situation and how it will increase net operating income.
- **Business Issues** – Highlights how each problem or inefficiency is affecting the facility.
- **Solution** – Describes the scope of work and how it will address business issues.
- **Positive Impact** – Explains how the solution, if implemented, will positively impact the facility and its occupants.
- **Financial Analysis** – Illustrates how quickly the investment in the solution will pay for itself.
- **Implementation Plan** – Identifies the activities, resources, and timelines for implementing each project.
- **Appendix** – Holds supporting product literature, savings calculations, case studies, and all other relevant documents that support the business case.

Review Appendix - Sample Business Case to better understand this process. A well executed business case can help:

- Alleviate misconceptions and skepticism
- Provide factual support of an effective plan
- Gain the approval needed to move forward in the implementation process

Once you've received approval for the project, communication is key. Written and verbal updates should be provided to all relevant stakeholders on an ongoing basis. This communication should include a checklist of what's been completed, a schedule for upcoming work, any problems encountered, and the expected resolution.

STEP 6 VERIFY THE IMPACT AND COMMUNICATE SUCCESS

After the project is complete, take the time to celebrate a job well done. Consider issuing a press release, holding a team or employee recognition event, and honoring the city/county/school board for their support of the project. Communication can take place through newsletters, websites, social media, or any other publication relevant to your organization. For example, a well-placed flyer or brochure stand in a county facility would allow every community member who walks past to see you are actively pursuing ways to reduce energy costs in your facility.

The results of your energy management plan need to be measured and verified to properly gauge if your goals were met. This should be an ongoing practice involving a continuous review of utility data to monitor usage variances or differences as compared to historical data. These usage variations or differences often lead to energy saving opportunities. Continue to look for energy saving opportunities and repeat the six-step process as needed.

BEHAVIORAL TIPS

✔ Evaluate your plan every two years to keep it up to date and show your progress.

BEST PRACTICES FOR LIGHTING

LIGHTING

Lighting upgrades provide one of the quickest and most cost-effective energy improvements in a facility. Rapid changes in lighting technology mean new products that provide brighter and longer lasting light are becoming more affordable and available for a variety of applications. Upgrading to a well-designed lighting system can provide ample light levels while lowering energy costs.

BEST PRACTICES

UPGRADE YOUR FIXTURES

Upgrading to energy efficient fixtures, especially on lights that operate the most hours, can save a large amount of energy. There are many different lighting technologies available, such as light-emitting diodes (LEDs) and fluorescents, each having a direct impact on energy savings, the most efficient and longest life being LEDs. For example, overhead lighting in an office or classroom may still be using an old technology, such as fluorescent lamps or incandescent task lighting. Replace this with linear LED lamps or LED fixtures for a significant decrease in energy usage. In the current market, always consider an LED solution to replace older technology lighting systems.

Retrofit high bay/low bay lighting with new, more efficient technology. LED technology has the highest efficiency widely available today, along with the least maintenance required. Fluorescent T8 lamps are also available, if you are looking for a lower capital investment and faster payback. If considering fluorescents, purchase low wattage and long life lamps to make your system as efficient as possible.

High bay/low bay lighting is defined as an indoor fixture mounted at a height above 12 feet. Common examples of this type of lighting can be found in gyms, industrial shops, jails, maintenance shops, garages, etc. Existing inefficient fixtures are most likely high-intensity discharge (HID) or inefficient fluorescents (T12 fixtures). These fixtures should be upgraded to LED technology to increase efficiency and reduce energy costs.

Improved Fixture Layout: It is highly recommended to work with a lighting professional who has experience designing lighting systems for your type of facility. The lighting professional will take light level measurements at various locations throughout your facility and explore the most appropriate layouts to reach maximum energy efficiency. This will often result in fewer fixtures or lamps installed with optimized working or learning environments.

When considering a lighting upgrade, it is important to take into account all parts of the facility, including both interior and exterior lighting. Facilities require varying amounts of light for the tasks at hand. For example, a classroom requires more light than a computer lab. The Illumination Engineering Society (IES) provides standard lighting levels based on room types and their function. The chart to the right indicates recommended foot candle levels for several common areas. If your current lighting levels exceed these levels, the area may be a good candidate for de-lamping, re-lamping or lighting redesign.

ROOM TYPE	RECOMMENDED FOOTCANDLES*
Schools and Government Facilities	
Cafeteria	20-30
Classroom	30-50
Corridor	5-10
Gymnasium	30-50
Kitchen	30-75
Library	30-50
Lounge/Break Room	10-30
Office	30-50
Restroom	10-30
Storage area	5-20

Source: IESNA and IECC (2015), Midwest Plan Service (2006, 2009)

* A unit of illumination (now little used) equal to that given by a source of one candela at a distance of one foot (equivalent to one lumen per square foot or 10.764 lux).

MATCH THE NEEDS OF YOUR SPACE

Re-lamping: Re-lamping refers to removing less efficient lamps and replacing them with lower wattage lamps. For example, you can replace 32-watt T8 fluorescent lamps with more efficient 18 or 15-watt TLED lamps. Reducing wattage does not significantly impact light output, but does make a difference in curbing energy use. Switching from 32-watt to 18-watt TLED lamps can reduce lighting costs by more than 40 percent!

Replacing outdated equipment with newly qualified lighting systems can be a fast and efficient way to save energy and money. Coupling LED upgrades with integrated lighting controls can add an estimated 10 to 20 percent in additional energy savings. Integrated lighting controls use the Building Automation System (BAS) to control lights. This allows lights to turn on and off based on a schedule or occupancy.

De-lamping: De-lamping involves removing unnecessary light fixtures or lamps. With de-lamping, individual lamps are removed from a fixture, or an entire light fixture is removed in areas that are over lit. Follow these helpful tips to determine where it is appropriate to de-lamp:

- Use a light meter to take foot-candle readings
- Determine which areas are over lit by comparing actual foot-candle levels with the recommended level indicated by the chart on page 18
- Remove lamps and retest lighting level
- Verify the ballast(s) function after removing lamp(s)

De-lamping or re-lamping your facility is an easy, inexpensive way to cut energy costs. Not only can it reduce lighting costs by 50 to 60 percent, it also requires minimal time and investment to start seeing energy savings.

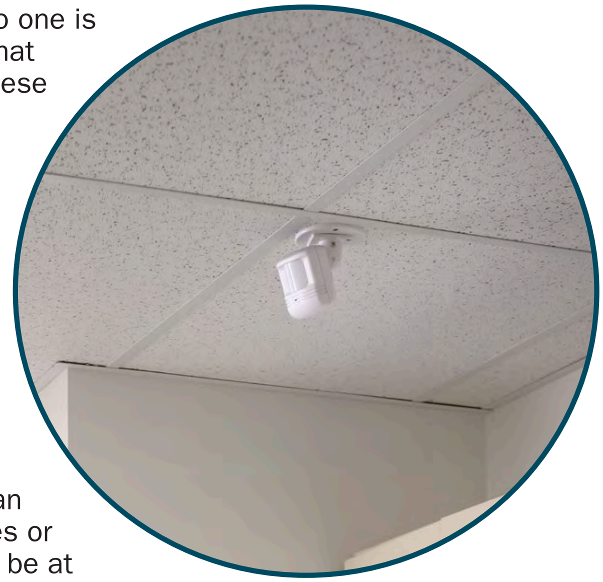
BEHAVIORAL TIPS

✔ Installing LED high-bay lighting over standard high-bay HID or T8 lighting applications will save significant energy and labor costs for maintenance. The longer burn hours and reliability of LED high-bay applications results in more time, money and labor for other projects.

BEST PRACTICES 3 LIGHTING

TAKE CONTROL OF YOUR SPACE

Lighting any space costs money, yet money is lost every day by operating lights in unoccupied rooms. A better solution is to install sensors that switch lights on and off based on occupancy, the room's ambient light level, or time of day.



Occupancy Sensors turn off the lights in a space when no one is present in the room. They typically consist of a detector that either senses heat or detects motion. Consider setting these up so they are vacancy sensors that will turn off after a predetermined amount of time with no movement. Angle mounted sensors toward the center of the space to minimize hallway traffic turning lights on.

Daylighting Sensors turn lights off along walls with windows when a certain light level is reached from exterior sources. Placement of these is important for maximum efficiency. Install photocell sensors to control exterior lights that automatically turn on at dusk and off at dawn.

Timers/ Dimmers are advanced control strategies that can effectively save energy by turning lights off at certain times or dimming fixtures. For example, hallway lights only need to be at full light levels between class periods. Dimming or shutting lights off during classes can substantially reduce energy usage.

Note: Gymnasiums have different foot-candle requirements for general activities like class periods and athletic events. Having multi-level switching can help save money in this situation.

Multi-level switching allows varying degrees of lighting to be switched off while still maintaining adequate light levels.

BEST PRACTICES 4 LIGHTING

PREVENTATIVE MAINTENANCE

A simple step to decrease energy costs is to perform ongoing, preventative maintenance on lamps and fixtures. This will help extend their usable life and reduce the need to replace lamps as frequently. Poorly maintained lighting systems cost far more in lost productivity than in wasted energy. Basic maintenance steps include:

- **Keep light fixtures clean**: Clean fixtures, lamps, and lenses by wiping off dirt with a moist cloth. Repeat every six months to two years, depending on how much dust and debris is in the surrounding environment.
- **Implement a schedule**: Implement a schedule for re-lamping fixtures during unoccupied times. Allow for some lights to burn out, then re-lamp all fixtures (called group re-lamping) at once to save on labor.
- **Review timers and sensors**: Review timers and sensors on an ongoing basis to ensure they are operational and all seasonal and event schedules are up to date.

BEST PRACTICES 5 LIGHTING

OBTAIN MULTIPLE BIDS AND EVALUATE DIFFERENT TECHNOLOGY

Contact your Focus on Energy Trade Ally contractor Energy Advisor to determine the next steps in selecting products that are eligible for financial incentives. Obtaining multiple bids for new products will help compare different prices and features of the rapidly changing lighting market. If possible, mock up a test room to determine if you like the technology before committing to the entire building.

BEHAVIORAL TIPS

- ✔ If multi-level switching is available – use minimum lights needed.
- ✔ Shut off lights when leaving a room.
- ✔ Use natural light whenever possible by opening blinds and turning off overhead lights.
- ✔ Utilize task lighting in place of excessive overhead lights whenever possible.

BEST PRACTICES

FOR HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

GENERAL HVAC

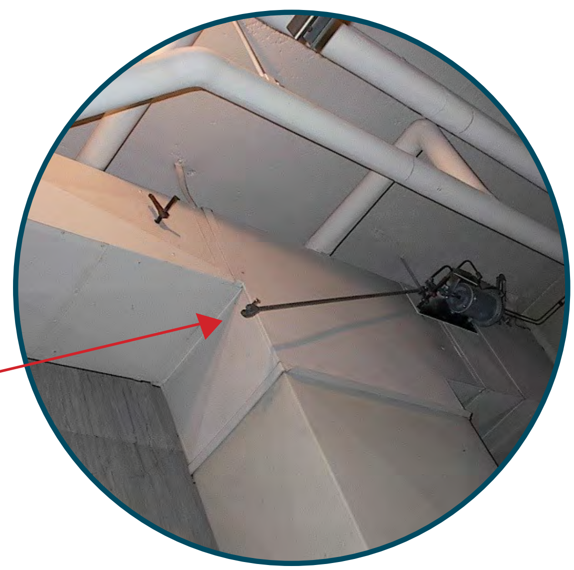
A handful of general best practices apply to nearly all HVAC systems. The following best practices should be considered across every function of an HVAC system. Best practices outlined in this section are described in greater detail in subsequent sections.

BEST PRACTICES

PERFORM ROUTINE MAINTENANCE

Performing routine maintenance will provide significant energy savings. Properly maintained equipment and processes are necessary to keep the facility functioning efficiently. Utilize a continuous improvement approach to optimize function, improve energy efficiency, and reduce capital expenditures. Develop an inventory of facility equipment and keep maintenance logs to track maintenance needs for individual pieces of equipment. Typical maintenance items include:

- Changing air filters
- Cleaning coils
- Surveying and repairing/replacing failed steam traps
- Testing and chemically treating boiler water
- Checking for and repairing leaks
- Lubricating motors
- Adjusting/replacing loose or broken belts
- Checking, calibrating, and/or replacing sensors, controllers, and actuators



Broken pneumatic damper linkage

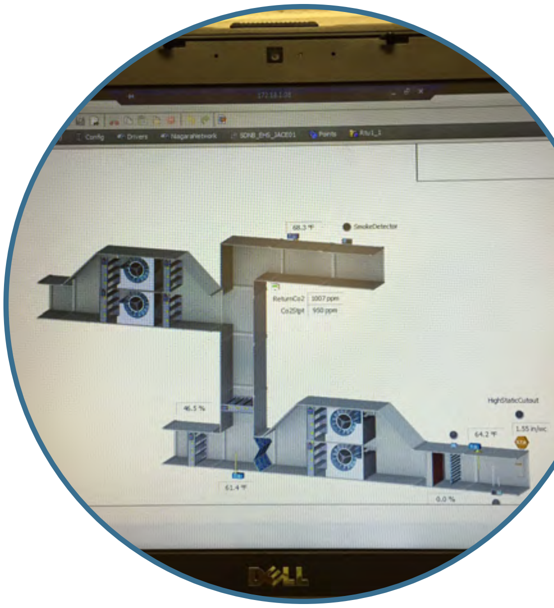
PRACTICE COMMISSIONING AND RETRO-COMMISSIONING

Commissioning is recommended when building a new facility or doing large-scale retrofits. The process of commissioning ensures the new facility functions as intended and the staff is prepared to operate and maintain all systems and equipment. Hire a commissioning agent to plan and conduct the commissioning process. A commissioning agent is typically a third party, independent and unbiased representative not directly involved in the design or construction of the facility.

Retro-commissioning is the same process as commissioning, but for existing equipment. Set points, time schedules, usage, and other control functions of a facility's mechanical system may change over time. Sensors, controllers, actuators, valves, and other components may drift or fail completely. Retro-commissioning includes full-scale testing, balancing, and repair of all functions and components of a facility's energy system. Hire a retro-commissioning agent to plan and conduct the retro-commissioning process.

INSTALL DIRECT DIGITAL CONTROLS

Consider installing direct digital controls (DDC) for all components of an HVAC system. DDC provides flexibility within a control system and additional control possibilities that are unattainable with a pneumatic control system. For example, DDC controllers and actuators for dampers/valves are more accurate than pneumatic ones, providing more precise control of HVAC components which can result in energy savings.



DDC controllers and sensors, along with lighting and security systems, can all be integrated into a building automation system (BAS). BAS allows facility staff to tailor set points, flows, and time schedules to each individual section of the building, dependent upon need. The acute control variability with DDC integrated into a BAS provides deeper energy savings compared to pneumatic controls with a basic computer control system. One example is to reduce building warm-up periods (the hour before occupancy) and cool-down periods (last hour of occupancy) to achieve the greatest space temperature set-back or set-up as possible and increase energy savings.

BAS can be integrated with mobile devices, allowing facility staff to make adjustments and receive alarms remotely. It can also provide real-time energy monitoring and trend logging, which can be used to make informed energy saving decisions. Use this trended data to automatically optimize system performance through the use of algorithm and control schematics.

INVEST IN PREMIUM EFFICIENCY AND ULTRA EFFICIENCY MOTORS

Currently, most electric motors manufactured and imported into the United States used for commercial applications are mandated to be premium efficiency, due to the Energy Independence and Security Act of 2007. However, manufacturers have already developed motors above premium efficiency called ultra efficiency motors. Since electricity costs are typically 95 percent of an electric motors' lifecycle cost, consider ultra efficiency motors for new construction. Also consider replacing existing standard and high efficiency motors near the end of their useful life with ultra efficiency motors for efficiency gains of up to 30 percent compared to NEMA Premium® induction motors.

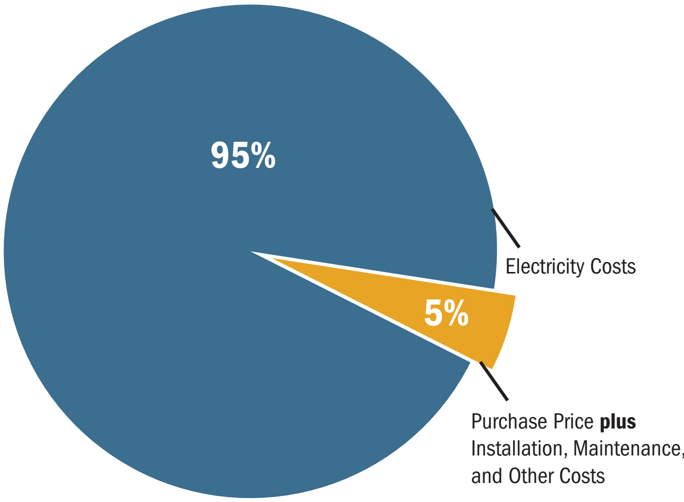


Figure 1. Lifetime Motor Costs
Source: MDM "Motor Planning Kit", www.motorsmatter.org

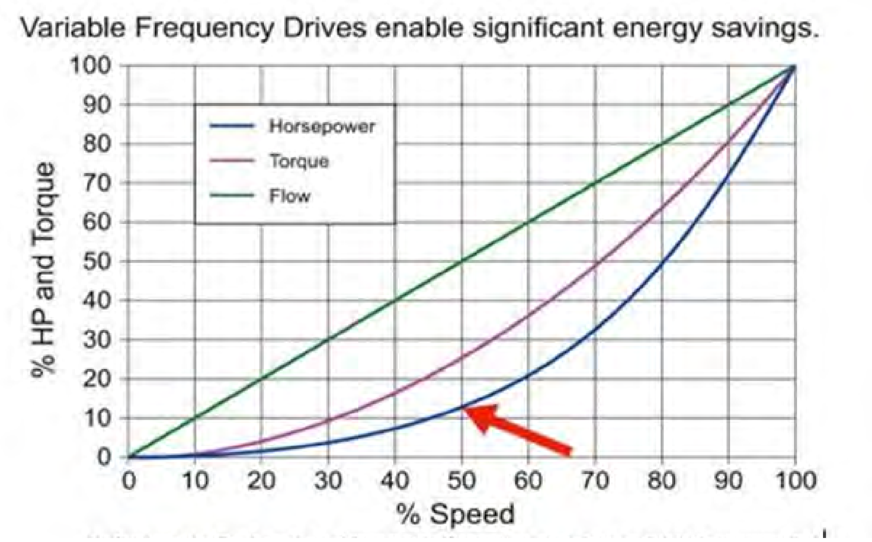
BEST PRACTICES 5 GENERAL HVAC

INSTALL VARIABLE FREQUENCY DRIVES

Install variable frequency drives (VFDs) on pumps and fans where variable flow or pressure conditions occur or are desired. VFDs provide the ability to increase or decrease the speed of the pump or fan based on desired flow, pressure, or temperature conditions. Slowing the speed of the pump or fan is more energy efficient than using throttling valves, discharge dampers, or inlet guide vanes for regulating flow.

Centrifugal pumps and fans are often subject to the Affinity Laws, which is why VFDs become extremely beneficial and can save significant energy. The Affinity Laws state:

- Flow is proportional to the pump speed
- Pressure is proportional to the square of the pump speed
- Power is proportional to the cube of the pump speed



Half volume (or flow) can be achieved at half speed using only one-eighth the energy (hp).

THE AFFINITY LAWS ARE NOT APPLICABLE TO ALL PUMPS AND FANS

For example, if a pump or fan's speed is reduced by 15 percent, then the power consumption is potentially reduced by 39 percent. If a pump or fan's speed is reduced by 30 percent, then the power consumption is potentially reduced by 65 percent.

BEHAVIORAL TIPS

✔ Keep thermostats free and clear of obstructions and heat generating equipment.

✔ Do not block heating/cooling vents (supply or return).

✔ Dress in layers for comfort as heating/cooling system is making adjustments throughout the day.

HEATING SYSTEMS

Boilers are often the primary source of heating for a school or government facility. They are used to heat water or create steam, which is then transferred through a distribution piping system to areas of need. Boilers, burners, controls, heat recovery systems, and distribution systems are all important components of a boiler system.

BEST PRACTICES

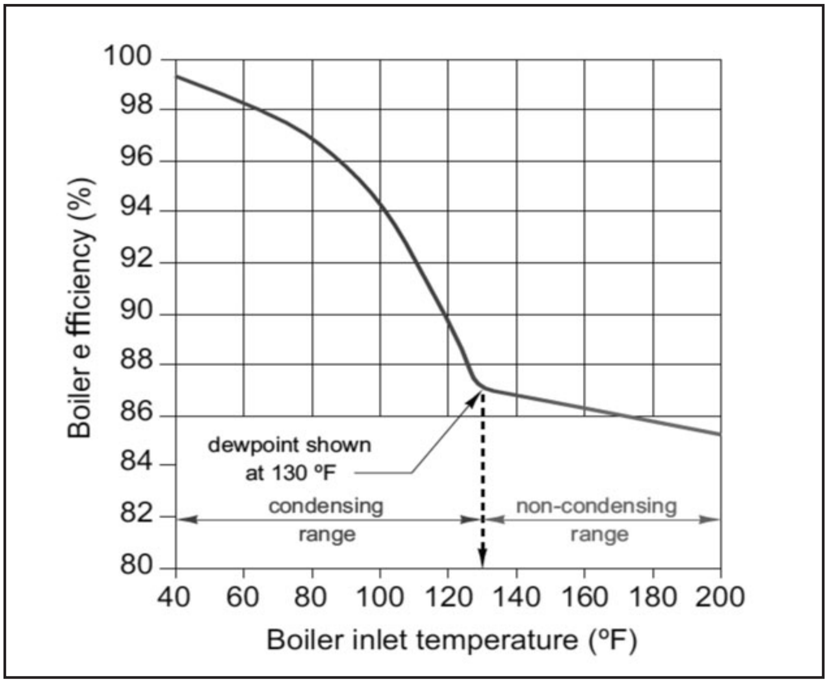
SIZE BOILERS APPROPRIATELY

Appropriately-sized boilers will operate within the best efficiency range for the majority of the heating season. If a boiler is grossly oversized, short-cycling can occur. Short-cycling wastes energy by exhausting heat through the stack during pre- and post-purge cycles of the burner. Consider installing several smaller boilers to be staged during shoulder months such as April and October.

INSTALL HIGH-EFFICIENCY BOILERS

It is recommended to install high efficiency boilers. Use condensing boilers (90%+ efficient) when return water temperatures to the boiler will be less than 130 °F, as condensing only happens when return water temperatures are below 130 °F. The lower the return water temperature is, the more condensing happens, and the more efficient the boiler will operate. Utilize near-condensing boilers (85 to 90 percent efficient) when return water temperatures are greater than 130° F.

Another option is to install a hybrid boiler plant. Hybrid boiler plants have non-condensing boilers for the heating season's peak, where return water temperatures are typically higher than 130 °F, and smaller condensing boilers for shoulder months, where lower water temperatures can be run.



BEST PRACTICES 3 HEATING SYSTEMS

UPGRADE BURNERS

Linkageless controls, oxygen (O2) trim, and high turndown are features that can improve a burner system's efficiency. These features can be built into a new boiler system or retrofitted into an existing one by replacing the entire burner unit.

Linkageless controls allow for a tighter fuel to air ratio. Old controls are physically linked by adjustable metal linkages. Wear and tear can cause those linkages to become inaccurate. Linkageless units use individually driven servomechanisms to ensure the fuel to air ratios are mixed more precisely over the burner's operating range.

O2 trim is a programmable logic controller (PLC) based control system that maintains the proper fuel to air ratio based on different burner air temperatures, atmospheric pressures, or fuel characteristics. This can improve burner efficiency.

High turndown provides higher boiler efficiency during periods of lower heating demand. The ability for the burner to operate at partial firing rates provides the opportunity to reduce pre- and post-purge cycling, which wastes energy. The ability to run at low-fire rates instead of cycling on/off provides energy and maintenance savings.

BEST PRACTICES 4 HEATING SYSTEMS

INSTALL CONTROLS

Install DDC and incorporate the boiler system into the BAS to allow for greater control and increased efficiencies. Digital controls on boilers and their heating distribution systems provide the opportunity to implement energy saving strategies such as hot water reset, unoccupied hot water setback, boiler sequencing dependent upon load, and steam header pressure control and setbacks.

BEST PRACTICES 5 HEATING SYSTEMS

UTILIZE VARIABLE FREQUENCY DRIVES

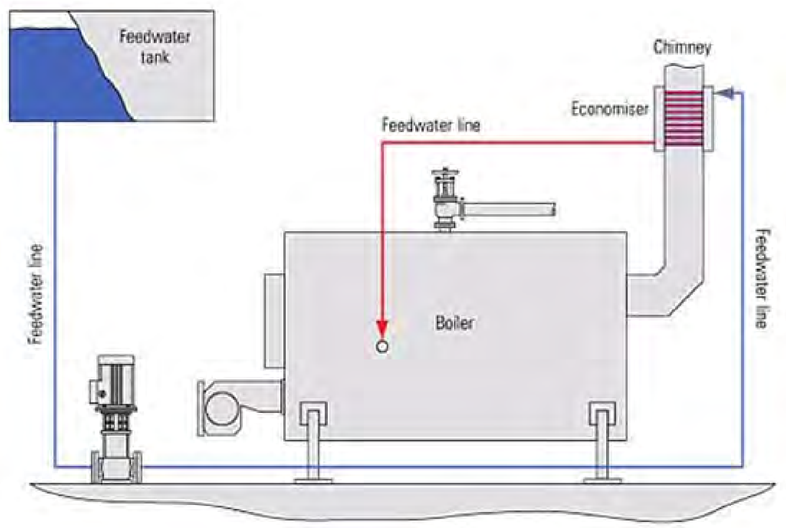
Utilize VFDs for various boiler system functions, such as hot water supply distribution pumps. In variable flow systems, controlling hot water distribution pumps can allow the distribution pump to operate at slower speeds and flows. Conversely, in constant flow systems, slowing the pump down to match design flows can take the place of throttling valves, which waste energy. Either of these strategies will save pump energy. In smaller boiler systems, which use inline circulating pumps, consider using electronically commutated motor (ECM) variable speed circulating pumps to reduce energy use.

If the boiler is large enough, consider using VFDs for the burner combustion air fan. On larger boilers, combustion air supply fans can be several horsepower. By eliminating the control damper and slowing down the fan, appropriate air flows are supplied across all firing ranges, while saving fan motor energy.

BEST PRACTICES 6 HEATING SYSTEMS

CONSIDERATIONS FOR STEAM SYSTEMS

For steam boilers, the lower the steam pressure, the more efficient the boiler will operate. Consider stack economizers for steam boilers. Significant energy is wasted up the exhaust stack of the boiler, due to the high operating temperatures of steam systems. A stack economizer can recover that energy for a beneficial use, most commonly to pre-heat boiler feed water.



Source: cleanboiler.org

BEST PRACTICES 7 HEATING SYSTEMS

SURVEY STEAM TRAPS AND CONDENSATE RETURN

Steam traps in steam distribution systems catch condensate and return it to the boiler while allowing steam to continue through the distribution piping. Steam traps fail when they allow steam to pass into the condensate collection system or they allow condensate to continue through the distribution piping.

Perform regular surveillance, maintenance, and replacement of steam traps. Returning as much hot condensate to the boiler as possible, and chemically treating it properly, will save natural gas and water because less boiler feed (or makeup) water is required.

BEST PRACTICES 8 HEATING SYSTEMS

INSULATE PIPES, FITTINGS, AND VALVES

Insulate hot water and steam pipes, fittings, and valves, to prevent heat loss to areas where it doesn't belong. By insulating these components, heat will be preserved and transferred to the terminal units, coils, and radiators where it is needed and belongs.

BEST PRACTICES 9 HEATING SYSTEMS

INSTALL HIGH-EFFICIENCY FURNACES, UNIT HEATERS, AND ROOFTOP UNITS

Furnaces and unit heaters are available in a wide range of efficiencies. Rooftop units (RTUs) are also available in high efficiencies but are much less common due to condensate issues in Wisconsin's cold, outside environment. Consider high-efficiency condensing furnaces and unit heaters (>90 percent efficient). These have a significantly higher annualized fuel utilization efficiency (AFUE) compared to standard efficiency units (80 to 85 percent efficient). Condensing units must be vented and condensate drained per manufacturers specifications.

In addition to higher thermal efficiencies, furnaces should also have a variable speed ECM blower motor and multiple burner firing stages. These features allow the furnace to output variable amounts of heat, depending on the heating load. The heat exchanger operates more efficiently at lower firing rates, which means additional energy is saved during times of low heating load.

BEST PRACTICES 10 HEATING SYSTEMS

INSTALL INFRARED HEATERS

Consider Infrared heaters for spaces with large overhead doors that frequently or semi-frequently open, such as school auto shops, county/city garages, and fire department truck bays. Infrared heaters use infrared radiation to transfer heat to another surface. Therefore, infrared heaters heat the occupants and other things (within line of sight of the heater), instead of heating the air with convection. A good way to think of it is if you step out into the sunlight, a portion of the heat you feel is from infrared radiation. Even though the outside air temperature may be cold, you feel the warmth of the sun. In spaces where doors are frequently opened, it is much more energy efficient to heat the occupants than to try and heat the whole air space with forced air heating units.

BEST PRACTICES • 11 • HEATING SYSTEMS

ELIMINATE ELECTRIC RESISTANCE HEAT WHEN POSSIBLE

Electric resistance heat is commonly found in school and government facilities as baseboard or unit wall heaters in building entrance ways, utility rooms, and other spaces located far from the hot water distribution system. Electric heat is also common in areas where ignitable fluids or gases can be present.

Electric resistance heat is expensive. When electricity costs $0.10/kWh and gas costs $0.60/therm, the cost to heat a BTU is approximately $2.93 per 100,000 Btu of heat for electricity and roughly $.60 per 100,000 Btu of heat for natural gas**. Replace electric heat with either gas fired or hot water heat from a boiler system when possible.

**Calculated using $.10/kwh and $.60/therm

BEST PRACTICES • 12 • HEATING SYSTEMS

INSTALL HIGH-EFFICIENCY HEAT PUMPS

Install high-efficiency heat pumps in your facility. Heat pumps utilize a reversing valve allowing the condenser to become the evaporator and the evaporator to become the condenser. They can be used to supply or reject heat from a wide variety of terminal units including cabinets, unit ventilators, variable air volume (VAV) boxes, and more. Heat pumps are measured in coefficient of performance (COP), the ratio of useful heating provided compared to the work required. Electric resistance heating has a COP of 1.0, meaning for every Btu of heat output the system consumes the electrical equivalent of one Btu. The higher the COP, the more efficient the system. Therefore, a COP of 2.0 is twice as efficient as electric resistance heat.

Consider air source, water source, and ground source (geothermal) heat pumps as alternative sources of heat. Air source heat pumps are only suitable for certain applications and may require a backup heat source. Water source and ground source typically have COPs of 3.5 and greater. Geothermal systems are common in Wisconsin and should be considered, especially if LEED certification is being pursued.

Also, consider a variable refrigerant flow (VRF) system. VRF is a heating/cooling system configuration with one outdoor condensing unit and multiple indoor units. A VRF system controls the amount of refrigerant flowing to each of the evaporators, enabling simultaneous heating and cooling in different zones, and heat recovery from one zone to another. High efficiencies and increased control of a VRF system compared to a conventional system make them attractive, although the design and upfront cost can be prohibitive.

VENTILATION SYSTEMS

A ventilation system is comprised of motors, ducts, fans, controls, and heat exchange units which deliver heated or cooled air to various parts of the facility. The purpose of a ventilation system is to add or remove heat and moisture and remove undesirable air components to maintain the desired environmental conditions for occupants.

BEST PRACTICES

BEST PRACTICES 1 VENTILATION

PERFORM ROUTINE MAINTENANCE

Properly maintain equipment and processes to keep the facility functioning at optimum conditions and energy efficiency. Utilize a continuous improvement approach to optimize function, improve energy efficiency, and reduce capital expenditures. Develop an inventory of equipment and keep up-to-date maintenance logs to track maintenance functions for individual pieces of equipment.

With ventilation systems, it's common for damper actuators and pressure/flow/temperature sensors to fail or become inaccurate. Recalibrate and repair or replace these components to maintain a high-efficiency HVAC system.

BEST PRACTICES 2 VENTILATION

OUTSIDE AIR REDUCTION

Reduce outside air to code requirements to save heating and cooling energy. The best option is to implement a demand controlled ventilation strategy. If that is not possible, simply reducing outside air (OA) to code minimums is beneficial. Utilize an outside air ventilation reset strategy to save energy while still enabling code minimum ventilation rates throughout all zones.

DEMAND CONTROLLED VENTILATION (DCV)

Demand controlled ventilation (DCV) is a control strategy that responds to the actual “demand” (need) for outside air in a zone by varying the rate at which outdoor air is delivered to that zone. The goal of DCV is to reduce the intake of outside air during periods of reduced occupancy, thereby reducing the energy needed to condition that outside air.

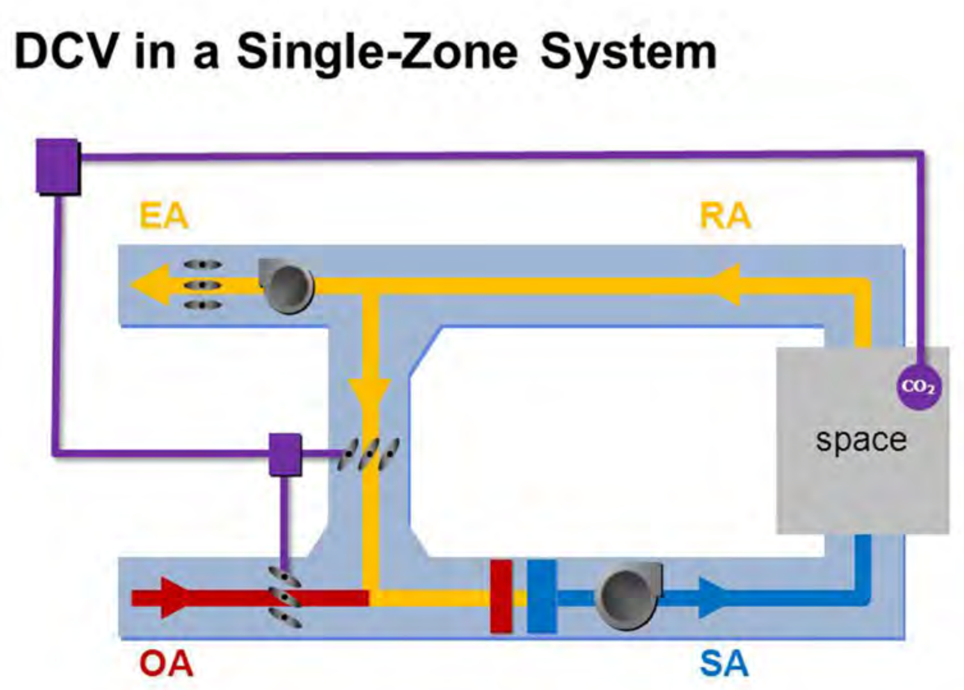
Common outside air reset methods for DCV are population counters, carbon dioxide (CO_2) sensors, timers, occupancy schedules, or occupancy sensors. If CO_2 sensors are used, make sure to calibrate or replace sensors every one to two years. ASHRAE Standard 62.1-2010, Section 6.2.7.1 provides further information about DCV strategies and minimum air flow calculations based on those strategies. Apply DCV to single zone, multi-zone, and 100 percent OA zone units.

EA = EXHAUST AIR

RA = RETURN AIR

OA = OUTDOOR AIR

SA = SUPPLY AIR



You can also apply DCV to commercial kitchen exhaust hoods. Use temperature and optical sensors to detect when the griddle, fryers, or ovens are operating.

Use a VFD on the kitchen exhaust fan to vary the fan speed depending on the temperature and amount of smoke created during the cooking process. Link make-up air units (MAUs), which supply 100 percent outside air to the kitchen, with the exhaust hoods. The less air exhausted by the hood, the less air the MAUs need to provide to the kitchen, thus reducing the energy needed to condition the outside air.

Finally, apply DCV to welding booths, wood shops, and auto shops. Use occupancy sensors to automatically turn on and off dust and smoke collection systems in welding booths or at each piece of machinery. When an occupant is sensed or the machine turns on, a gate opens on the dust or smoke collection hood and a controller tells the exhaust fan to speed up to maintain the specified duct pressure.

BEST PRACTICES 4 VENTILATION

EXHAUST FAN CONTROL

Only operate exhaust fans in locker rooms and bathrooms during occupied hours. Install timers or tie the fans into the BAS and program them to not operate during unoccupied hours.

BEST PRACTICES 5 VENTILATION

EXHAUST AIR ENERGY RECOVERY

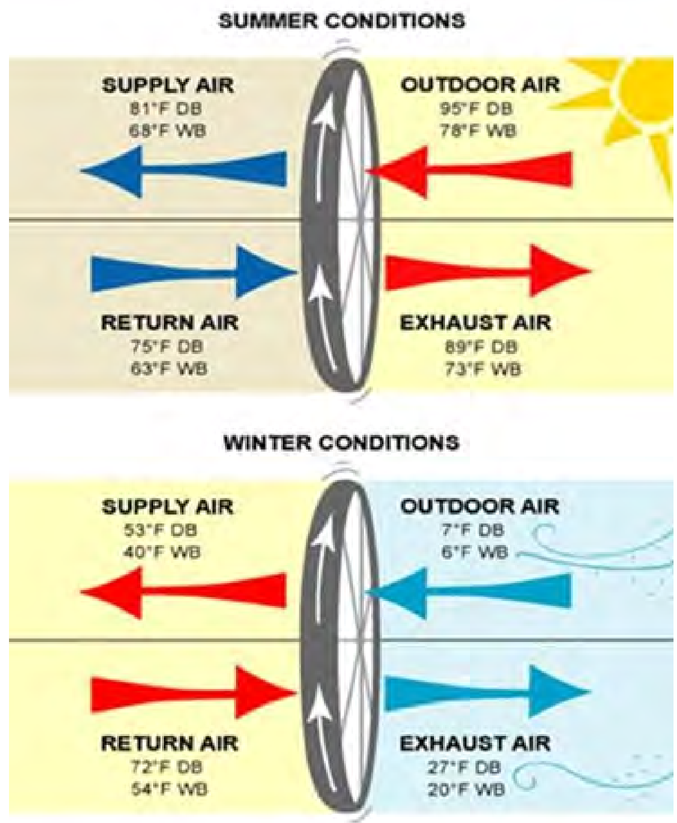
Exhaust air energy recovery is the process of exchanging energy contained in exhaust air from a building and using it to treat incoming outdoor air. During heating months, transfer heat from a warm building's exhaust air to heat the cold outside air. This pre-heats the air prior to passing over the heating coils for further heating. During cooling months, use a cool building's exhaust air to chill and dehumidify warm, humid outside air prior to it passing over the cooling coils for further cooling and dehumidification.

Ventilation heat recovery often allows for downsizing of heating and cooling plants. Types of energy recovery devices include:

- Run around coils
- Heat pipes
- Fixed plate heat exchangers
- Fixed membrane heat exchangers
- Rotary enthalpy wheels

Rotary enthalpy wheels and fixed membrane heat exchangers are more efficient than the others because they allow for latent heat transfer in addition to sensible heat transfer, whereas the others only allow for sensible heat transfer.

Sensible heat is related to air temperature that is shielded by radiation and moisture (dry bulb). Latent heat is the amount of heat contained in the moisture of the air (humidity) – warmer air will hold more moisture or relative humidity. For example, a domestic air conditioning unit removes the latent heat by removing the moisture (condenses the humidity) from the outside air is it lowers the temperature (dry bulb) of the outside air.



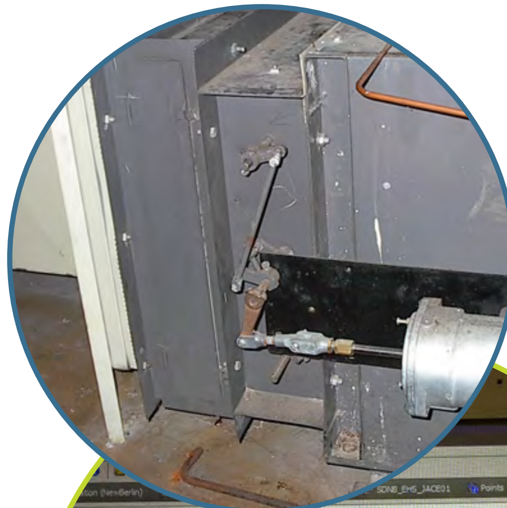
BEHAVIORAL TIPS

- ✔ Do not block ventilation supply of fresh air.
- ✔ Do not block ventilation return vents.
- ✔ Only turn on task-specific exhaust systems when necessary (i.e. welding, brazing, fume hoods).

BEST PRACTICES 6 VENTILATION

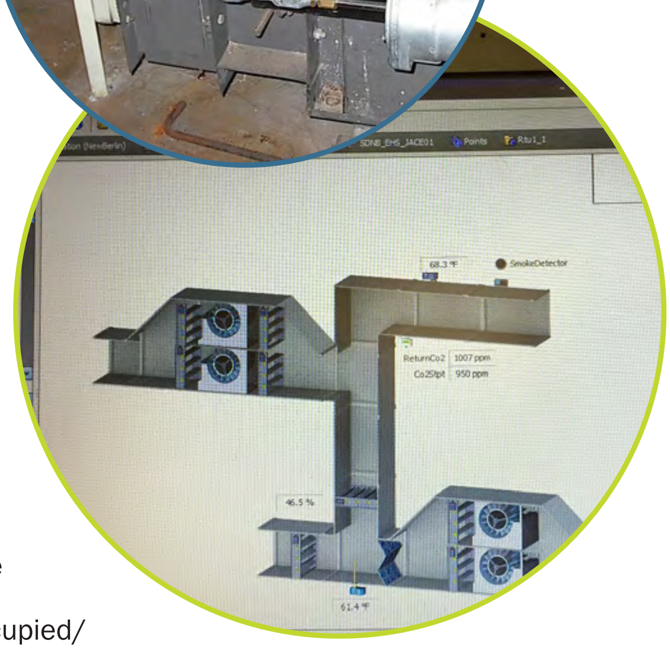
ECONOMIZING

Economizing uses more than the minimum amount of outside air to maintain a zone's temperature set point when outside air temperatures and humidity are favorable. This usually occurs in the during the early morning hours in the Spring and Fall, when cooler outdoor air temperatures and low relative humidity can be used to condition the space. A good range to allow economizing is between 50 to 65 °F. To include humidity into the economizing control sequence, an outdoor humidity sensor is needed and the control sequence calculates enthalpy. This is commonly referred to as enthalpy controlled economizer. Within a building, there are internal heat gains, such as people, computers, and lighting. When outdoor air conditions are favorable, bring large quantities of outside air into a zone to offset the internal heat loads and keep the zone temperature at its set point.



According to ASHRAE Standard 90, Section 6.5.1, economizing must be used in systems greater than 11 tons in Wisconsin.

Expand your economizer window (the outdoor air temperature when economizing occurs) to save additional energy. Use differential enthalpy, fixed enthalpy, or dew point and dry bulb temperature, instead of fixed dry bulb temperature for high-limit shutoff to help expand your economizer window.



BEST PRACTICES 7 VENTILATION

UTILIZE CONTROLS

Utilize DDC for all components of a ventilation system. DDC allows for flexibility within a control system and additional control possibilities that may not be possible with a pneumatic control system. For example, DDC controllers and actuators for dampers/valves are more accurate than pneumatic controllers and actuators, providing more precise control of HVAC components. This results in increased energy savings.

Install digital controls on ventilation systems to provide greater opportunity and control to implement demand controlled ventilation, supply air temperature reset, occupied/unoccupied schedules , outside air control, economizer operation, variable air volume flow, and more.

School districts and municipalities can benefit from utilizing DDC for scheduling purposes. Adjust schedules based on facility occupancy including weekends, holidays, and arranged school breaks. Review and update schedules often to incorporate changes in classroom schedules, summer hours, and any other fluctuating events.

BEST PRACTICES 8 VENTILATION

CONVERT VARIABLE AIR VOLUME (VAV) SYSTEMS

Convert constant volume (CV) systems or VAV with inlet guide vanes to a VAV system with a VFD to save fan energy as well as heating/cooling energy. Enable a ventilation reset strategy and VAV box minimum reset strategy to help save more energy. Demand controlled ventilation strategies will further maximize energy savings.

BEST PRACTICES 9 VENTILATION

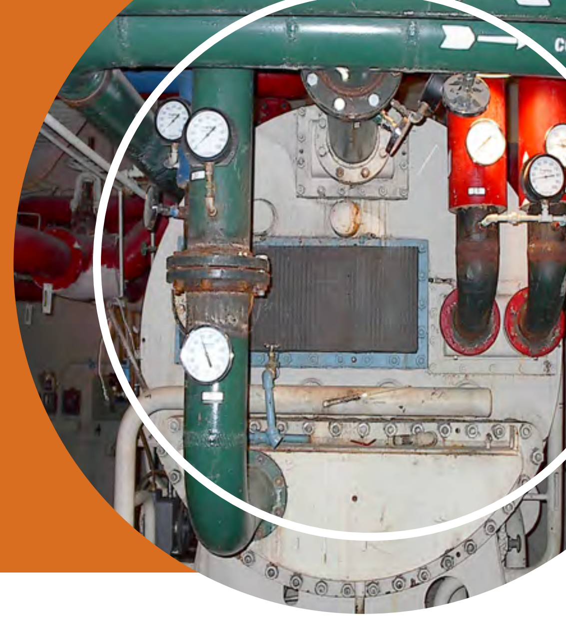
CONSIDER VARIABLE FREQUENCY DRIVES

Consider VFDs for fans where variable flow or pressure conditions will occur or are desired. Variable frequency drives provide the ability to vary fan speed based on the desired flow, pressure, or temperature conditions. Slowing the speed of the fan is more energy efficient than using discharge dampers or inlet guide vanes for regulating flow.

Common applications for VFDs in ventilation systems are supply, return, and exhaust fans.

COOLING SYSTEMS

Chillers are often the primary source of cooling for a school or government facility with substantial cooling loads. Chillers are used to cool water, which is then transferred through a distribution piping system to areas of use. Chillers, cooling towers, controls, and distribution systems are important pieces of a chiller system. Two types of chillers are air-cooled and water-cooled. As a general rule, air-cooled chillers are more cost effective if the chiller plant is <300 tons, while water-cooled chillers are more cost effective if the chiller plant is >300 tons. However, other factors may be considered when selecting an appropriate type of chiller. There are also various types of compressors for chillers, such as reciprocating, centrifugal, and screw.



BEST PRACTICES

BEST PRACTICES 1 COOLING SYSTEMS

SIZE CHILLERS AND SELECT TYPE APPROPRIATELY

Appropriately-sized chillers will operate within the best efficiency range for the majority of the cooling season. Often the chiller will be operating at part-load. Select a chiller for the best efficiency in the loading range it will most often operate.

Different types of chillers are better for small versus large installations, and partial load versus full load operating ranges. For example, centrifugal chillers typically have high, full-load efficiencies but have lower, part-load efficiencies. Therefore, centrifugal chillers are often used in larger chiller installations. Alternatively, screw chillers typically have slightly lower full-load efficiencies but have higher part-load efficiency at low cooling load ratios. They are often used in small chiller installations.

The Integrated Part Load Value (IPLV) is a performance characteristic developed by the Air-Conditioning, Heating and Refrigeration Institute used to describe the performance of a chiller capable of capacity modulation. Unlike an energy efficiency ratio (EER) or coefficient of performance (COP), which describes efficiency at full load conditions, the IPLV is calculated using the equipment's efficiency while operating at capacities ranging from 25 to 100 percent. Since a chiller does not always run at full capacity, the EER or COP is not an ideal representation of typical equipment performance.

BEST PRACTICES 2 COOLING SYSTEMS

INSTALL HIGH-EFFICIENCY CHILLERS

Install high-efficiency chillers at your facility. Depending on the cooling load characteristics of the facility, a chiller with high, part-load efficiencies will most likely do best in a school/government facility. In general, chillers with low kW/ton values are more efficient.

Chillers are frequently rated by their Energy Efficiency Ratio (EER). As the EER increases, efficiency increases. Chillers with high efficiencies often have multiple compressors they can load and unload. It is common for high-efficiency chillers to have variable speed compressors to further control cooling capacity.

BEST PRACTICES 3 COOLING SYSTEMS

UTILIZE CHILLER HEAT RECOVERY

Compressors in a chiller system, especially large systems, produce a significant amount of heat. If there is a simultaneous use of heat while the chiller system is operating, harvest the heat from the compressor with a heat recovery device and send it to the heating load (such as domestic hot water).

BEST PRACTICES 4 COOLING SYSTEMS

INSTALL DIRECT DIGITAL CONTROLS (DDC)

Install DDC and incorporate the chiller system into the BAS to allow for greater control and increased efficiencies. Digital controls on chillers and chilled water distribution systems provide the opportunity to implement energy saving strategies such as chilled water reset, unoccupied chilled water setup, condenser water reset, demand (kW) limiting, and staging of multiple chillers, if applicable.

BEST PRACTICES 5 COOLING SYSTEMS

INCORPORATE VARIABLE FREQUENCY DRIVES

Incorporate VFDs for various functions of a chiller system, such as the chilled water distribution pumps. In variable flow systems, controlling chilled water distribution pumps dependent upon loop pressure, return water temperature, or various other means, allows the distribution pump to operate at slower speeds and flows. Additionally, in constant flow systems, slowing the pump down to match design flows can replace throttling valves, which waste energy. These strategies will save pump energy.

Additionally, if a water-cooled chiller system has a cooling tower, consider VFDs for the cooling tower fan. Often, the cooling tower fan doesn’t need to be operated at the full speed to achieve the desired return condensing water temperatures. Slowing the fan speed down to match cooling tower needs will save energy.

Finally, on larger chiller systems, utilize VFDs to replace throttling valves on condenser water pumps. These VFDs control return condenser water temperatures.

BEST PRACTICES 6 COOLING SYSTEMS

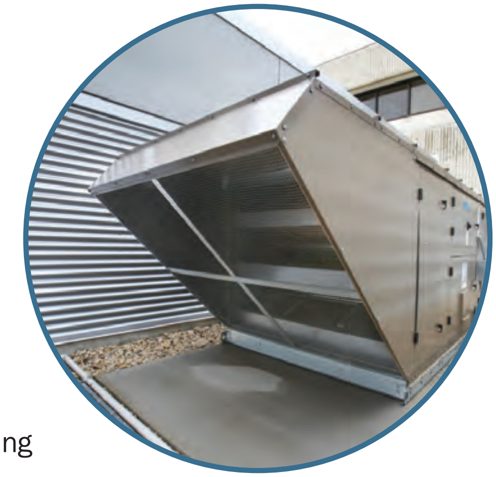
UTILIZE ICE STORAGE

Utilize ice storage to load shift from on-peak to off-peak hours. Ice storage uses thermal energy storage, in the form of ice, to shift cooling loads. Chillers create ice during off-peak hours (night time). During on-peak hours (daytime), water is run through the ice bank to create chilled water without the use of the compressor. This can result in significant savings on energy utility bills by reducing customer demand charges but does not necessarily save energy consumption (kWh).

INSULATE PIPES, FITTINGS, AND VALVES

Insulate chilled water and condenser water pipes, fittings, and valves to prevent condensation and wasted energy. Insulating these components allows the discharge temperature of the chilled water to be preserved. The chilled water is transferred to terminal units and coils, where it efficiently removes heat from the supply air.

INSTALL HIGH-EFFICIENCY DIRECT EXPANSION COOLING



Install high-efficiency direct expansion (DX) cooling units in your facility. This includes packaged rooftop units, split systems, and mini-split systems. Cooling efficiency is rated by the equipment's Energy Efficiency Ratio (EER), Seasonal Energy Efficiency Ratio (SEER), and Integrated Energy Efficiency Ratio (IEER). These measurements are determined by the cooling output divided by the electrical power input at certain rating conditions. SEER is a function of performance for units under six tons. EER and IEER are functions of performance for units over six tons. IEER is a performance rating at part-load conditions.

The higher the EER, SEER, or IEER, the more efficient the unit. Select a unit with high IEER values, as it will typically operate most of the cooling season at part-load.

INSTALL HIGH-EFFICIENCY HEAT PUMPS

Consider installing high-efficiency heat pumps. Heat pumps utilize a reversing valve, which allows the condenser to become the evaporator and the evaporator to become the condenser. Heat pumps can supply or reject heat from a wide variety of terminal units including cabinets, unit ventilators, variable air volume (VAV) boxes, and more. Heat pumps are measured in Coefficient of Performance (COP). Electric resistance heating has a COP of 1.0, this means every BTU of heat output the system consumes is the electrical equivalent of one BTU. The higher the COP, the more efficient the system. Therefore, a COP of 2.0 is twice as efficient as electric resistance heat.

Air source, water source, and ground source (geothermal) heat pumps are also available. Air source heat pumps are not recommended for Wisconsin's cold climate. Water source and ground source typically have COPs of 3.5 and greater. Geothermal systems are common in Wisconsin and should be considered, especially if LEED certification is being pursued.

BEST PRACTICES FOR PLUMBING

WATER HEATING

Most people look to replace their existing water heater after it fails, leaving little time to research and consider the many factors that influence energy use in the water heating system. Conventional water heaters generally have a lifespan of 10-15 years, therefore replacing an inefficient water heating system before it fails makes good financial sense. Facility managers need to consider which type of system will work best, the long-term energy use (efficiency) of the system, the size and capacity of the system, and available fuel options. Solar hot water and other renewable energy options can be found in the Renewable Energy section.

BEST PRACTICES

STUDY FUEL OPTIONS

Switch from electric to natural gas water heaters to save on energy costs when natural gas is less expensive to operate than electricity. However, be prepared to pay a larger upfront cost for a natural gas water heater. Some utility companies offer special off-peak rates to lower electricity costs. They may even connect the water heating system to a separate meter with a timer that only allows electricity to be drawn through that meter during off-peak periods when electricity costs are cheaper. Take the time to decide which fuel option is right for your facility.

DETERMINE APPROPRIATE SIZING

When sizing a hot water system, keep in mind the first-hour rating (FHR) for a tank water heater included in the water heater energy usage comparison. This information, located on the EnergyGuide label as capacity (first-hour rating), indicates how much hot water will be delivered in the first hour. This can be compared to the time the heater requires to return to its full FHR. Times will vary with each specific model. Look for water heater models with a first-hour rating that matches within one or two gallons of your peak-hour demand. The U.S. Department of Energy offers a formula to help with sizing a water heater based on existing water use at energy.gov/energysaver/selecting-new-water-heater. You may need to buy a larger water heater to provide hot water for on-peak periods when electricity is not available, to take advantage of off-peak electric rates offered by your utility company. Before purchasing a new hot water heating system, consider water conservation efforts to reduce your current water heating needs.

PERFORM ROUTINE MAINTENANCE

Periodic water heater maintenance will significantly extend your water heater's life and minimize loss of efficiency. Read your owner's manual for specific maintenance recommendations and contact a qualified plumbing and heating contractor for assistance, if needed. Adding tank insulation or adjusting the temperature setting are examples of simple adjustments that will add to your water heater's useful life. Routine maintenance for storage water heaters, depending on what type/model you have, include:

- Flushing the storage tank each year to remove sediment and scale build-up
- Checking the temperature and pressure valve every six months
- Inspecting the anode rod every three to four years
- Fixing, replacing, or adding insulation to the water heater and distribution piping

TYPES OF WATER HEATERS

CONVENTIONAL STORAGE WATER HEATING - The lowest-priced storage water heater may be the most expensive to operate and maintain over its lifetime. While an oversized unit may be alluring, it carries a higher purchase price and increased energy costs due to high standby energy losses. Since water is constantly heated in the tank, energy is wasted even when a hot water tap isn't running. This is called standby heat loss. Some storage water heater models have heavily insulated tanks, which significantly reduce standby heat losses and lower annual operating costs. Look for models with tanks that have a thermal resistance (R-Value) of R-12 to R-25.

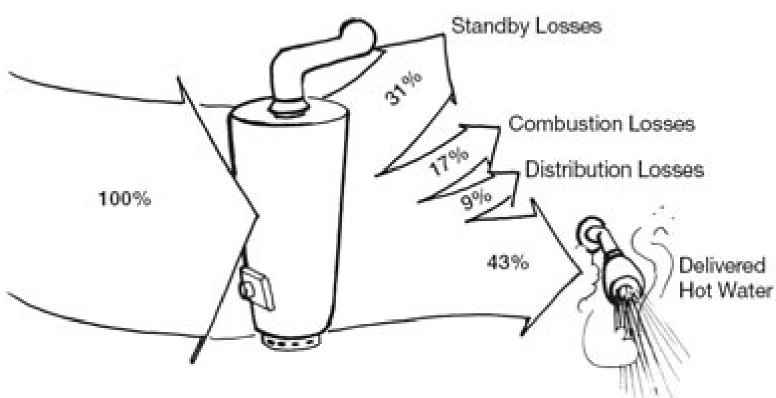
The energy efficiency of a storage water heater is indicated by its energy factor (EF), an overall measure of efficiency based on the assumed use of 64-gallons of hot water per day, regardless of tank size. A general rule of thumb is the smaller the water heater tank, the higher the efficiency rating. The most efficient conventional gas-fired storage water heaters are ENERGY STAR® models with energy factors between 0.67 and 0.70. New, larger commercial water heaters have a thermal efficiency rating rather than EF, with values of 0.90 and above. The minimum efficiency of electric resistance storage water heaters is approximately 0.90 (depending on tank volume). The best available is close to 0.95 EF.

(United States Department of Energy, 2017)

Replace constant speed permanent split capacitor (PSC) motor pumps with variable speed (ECM) pumps on:

- Domestic hot water recirculation pumps
- Heating system hot water circulation pumps
- Cooling water circulation pumps
- Water loop heat pump circulation pumps

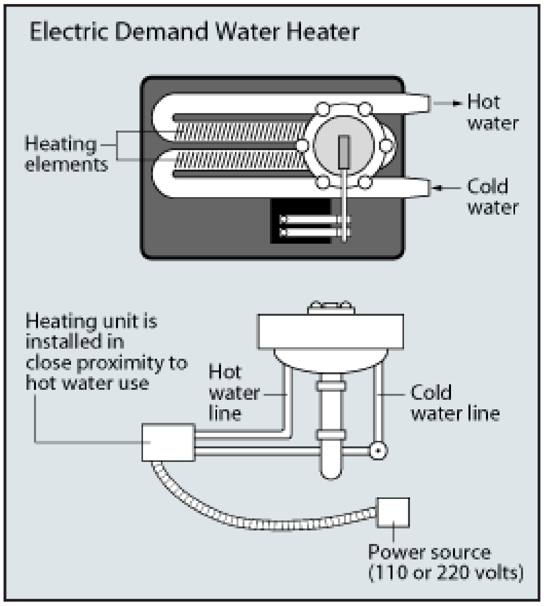
Install a time clock on the domestic hot water circulation pumps. Circulation pumps ensure hot water is at the sink or other point of use when needed. Since most buildings do not require hot water 24 hours a day, installing an inexpensive time clock on circulation pumps will shut them off when the building is unoccupied.



(ACEEE, 2017)

DEMAND (TANKLESS) WATER HEATING - Demand or instantaneous water heaters do not have a storage tank. A gas burner or electric element heats water only when there is a demand, therefore hot water never runs out. By minimizing standby losses from the tank, energy consumption can typically be reduced by 10 to 15 percent. The initial cost for a tankless water heater is greater than a conventional storage water heater, but tankless water heaters typically last longer and have lower operating costs, which may offset the higher purchase price. Most tankless water heaters have a life expectancy of over 20 years, with easily replaceable parts to extend their life by many more years.

Gas fired and electric demand water heaters are available, however, demand water heaters are not appropriate for every facility. The flow rate is limited in demand units and there is often a minimum flow rate required before the unit starts to heat. The largest readily available gas-fired demand water heaters supply approximately five gallons of hot water per minute, with a temperature rise of 77 °F, and an EF rating of 0.8 or better. Electric demand water heaters provide fewer gallons per minute of hot water but usually have a higher EF than gas-fueled heaters. Install demand water heaters as close as possible to the area being supplied with hot water, and use a demand water heater as a booster for areas requiring higher water temperatures for the most cost-effective addition to your centralized water heating system.



(United States Department of Energy, 2017)

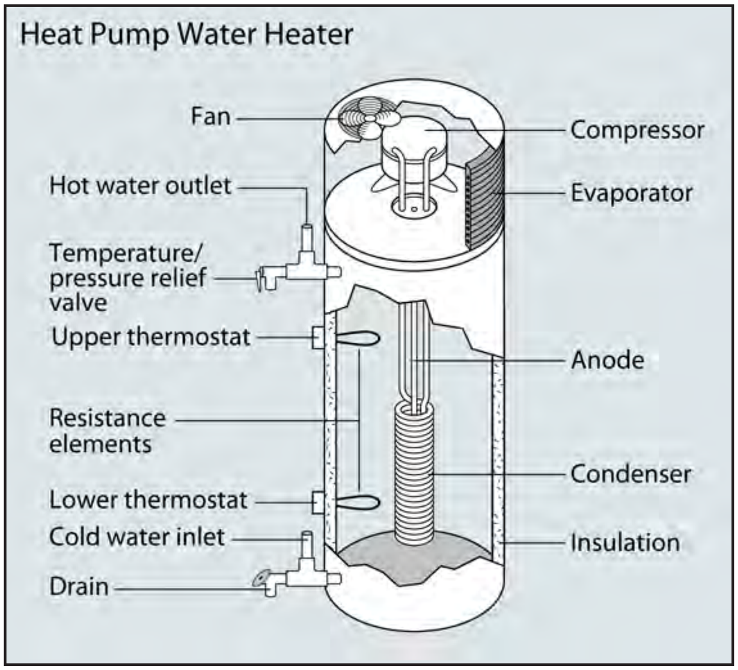
BEHAVIORAL TIPS

- ✔ Install natural gas demand water heaters in kitchens with natural gas equipment to optimize energy savings potential.

HEAT PUMP WATER HEATING - Heat pump water heaters use electricity to move heat from one place to another, instead of directly generating heat. Therefore, since they are essentially capturing waste heat, they are two to three times more energy efficient than conventional electric resistance water heaters and boast an EF rating of 3.0 or greater.

Purchase a stand-alone heat pump water heating system as an integrated unit with a built-in water storage tank and back-up resistance heating elements, or retrofit heat pumps to work with an existing conventional storage water heater. An air-source heat pump system combines heating, cooling, and water heating. These combination systems pull heat indoors from outdoor air in the winter and indoor air in the summer. A desuperheater is a small, auxiliary heat exchanger. This used in conjunction with a geothermal heat pump system uses superheated gases from the heat pump's compressor to heat water.

Another application for heat pump water heaters is for heating swimming pools. As the pool pump circulates the swimming pool's water, the water drawn from the pool passes through a filter and the heat pump heater. Note: Higher efficiency heat pump pool heaters generally use scroll compressors versus the reciprocal compressors of standard units. Heat pump pool heaters cost more than gas pool heaters, but they typically have lower annual operating costs due to their higher efficiencies. With proper maintenance, heat pump pool heaters last longer than gas pool heaters.



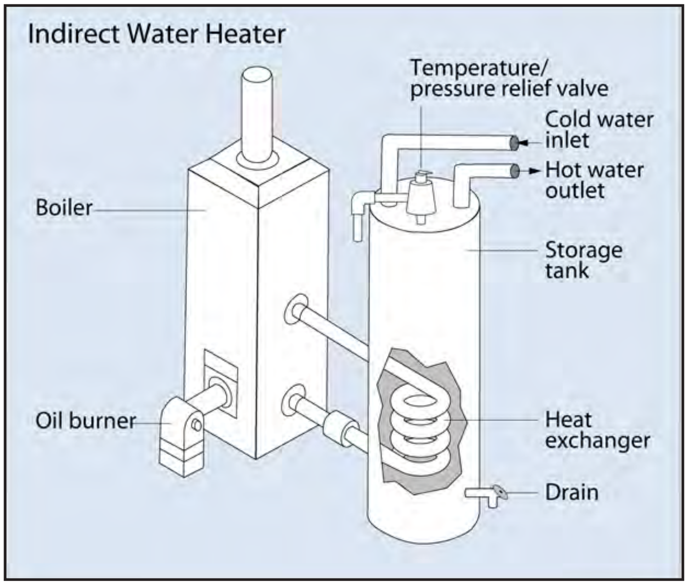
(United States Department of Energy, 2017)

INTEGRATED WATER AND SPACE HEATING - Tankless coil and indirect water heaters use a building's space heating system to heat water. A tankless coil water heater provides hot water on demand without a tank. When hot water is needed, water is heated as it flows through a heating coil or heat exchanger installed in a main furnace or boiler. Tankless coil water heaters are most efficient during cold months when the heating system is frequently used.

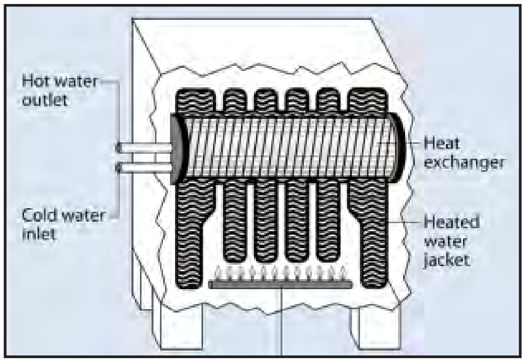
An indirect water heater uses the main furnace or boiler to heat a fluid circulated through a heat exchanger in the storage tank. The energy stored in the water tank allows the furnace to turn off and on less often, which saves energy. An indirect water heater, if used with a high-efficiency boiler and well-insulated tank, can be the least expensive means of providing hot water during winter months, particularly if the heat source boiler is set to cold start.

Indirect water heating systems lose efficiency during the shoulder and summer months when the boiler is less active or only used to heat hot water. Add a smaller boiler to heat a hot water storage tank during the shoulder and non-heating months to increase the efficiency of those systems. Another option is to switch to a stand-alone water heating system during the warmer months and shut down the building's heating system altogether.

Indirect systems are fired by gas, oil, propane, electric, solar energy, or a combination of any of these. Tankless systems are typically electric, oil, or gas-fired and used in combination with forced air systems and hydronic or radiant floor heating systems.



(United States Department of Energy, 2017)



HOT WATER CONSERVATION

Water conservation strategies, specifically heated water, have a positive effect on utility bills while allowing you to save on costs to upgrade or maintain water heating equipment. In addition to heating water more efficiently, you can significantly reduce the energy required for water heating if you adjust water use behavior, fix water leaks, insulate hot water pipes, and install low-flow fixtures and energy efficient appliances.

BEST PRACTICES

1 INCREASE WATER USE AWARENESS

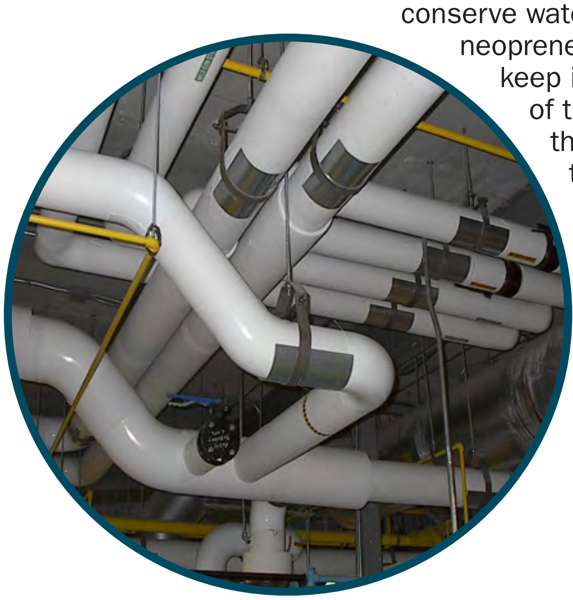
Educate building occupants on best water reduction practices. Organize discussions about water use in your facility, seek suggestions for conservation strategies, assign responsibilities, and post signs to lead to more responsible water and energy use. Adopt a water conservation policy to aid in your efforts. Keep your water setpoint to 140°F. This temperature setting efficiently limits the amount of cold water mixing and is hot enough to prevent legionella bacteria from growing. (United States Department of Labor, 2017)

2 FIX LEAKS

Repair drips and leaks in fixtures, faucets, showerheads, and pipes to significantly reduce hot water use. A leak of one drip per second wastes 1,661 gallons of water per year. If the leak is coming from a hot water pipe or faucet, the water heating system is also wasting energy to heat this unused water.

3 INSULATE HOT WATER PIPES

Insulating hot water pipes will reduce heat loss and raise the delivered water temperature by 2 to 4 degrees. This will allow you to lower your water temperature setting at the water heater. You also won't have to wait as long for hot water when you turn on a faucet or shower head, which helps conserve water. For electric water heaters, pipe sleeves made with polyethylene or neoprene foam are the most commonly used insulation. On gas water heaters, keep insulation at least six inches from the flue. If pipes are within eight inches of the flue, your safest option is to use fiberglass pipe-wrap (at least one-inch thick) without a facing and use either wire or aluminum foil tape to secure it to the pipe.



BEHAVIORAL TIP

✔ Report shower and faucet leaks to facility staff right away.

BEST PRACTICES 4 HOT WATER

INSTALL LOW-FLOW FIXTURES AND APPLIANCES

Install quality, low-flow fixtures and appliances to reduce water consumption by 25 to 90 percent and significantly reduce water heating costs. Examples include:

SHOWERHEADS - There are two basic types of low-flow showerheads: aerating and laminar-flow. Aerating showerheads mix air with water, forming a misty spray. Laminar-flow showerheads form individual streams of water. For maximum water efficiency, select a shower head with a flow rate of fewer than 2.5 gallons per minute (GPM).

FAUCETS - The aerator ultimately determines the maximum flow rate of a faucet. Aerators are inexpensive to replace and are one of the most cost-effective water conservation measures. Typically, new kitchen faucets come equipped with aerators that restrict flow rates to 2.2 GPM, while new bathroom faucets have ones that restrict flow rates from 1.5 to 0.5 GPM. For maximum water efficiency, purchase aerators with flow rates of no more than 1.0 GPM. Motion sensor-activated faucets are also a good way to reduce unnecessary hot water consumption.

Pre-rinse spray valves also present an opportunity to reduce water heating costs through increasing pressure and reducing water flow for pre-rinsing. The Center for Energy Efficiency and US Environmental Protection Agency both certify pre-rinse spray valves that meet specifications for maximum flow rate.

CLOTHES WASHERS - An inefficient clothes washer can cost three times as much to operate than an energy efficient one. Select a machine that allows you to adjust the water temperature and levels for different loads. Clothes washers don’t require a minimum temperature for optimum cleaning, so using either cold or warm water is sufficient for most laundry loads. Cold water is always sufficient for rinsing. Efficient washers spin-dry your clothes more effectively, saving energy when drying. Look for a front-loading machine that uses less water and has an ENERGY STAR® label when you purchase a new washing machine.

BEST PRACTICES FOR EFFICIENT KITCHEN OPERATION

KITCHEN OPERATION

Many opportunities for energy efficiency improvements exist when working in a commercial kitchen. Multiple pieces of equipment work to heat or cool food, while others supply or maintain hot water temperatures. Ventilation is required to remove odors and fumes given off during the cooking process. Most, if not all, of this equipment and processes can lead to energy savings. However, it is important to keep occupant health and safety in mind when reviewing for potential energy saving opportunities.

BEST PRACTICES

PURCHASE ENERGY STAR KITCHEN EQUIPMENT

Look for the ENERGY STAR® rating and pre-qualification information when purchasing new equipment for your commercial kitchen. Several pieces of equipment have a higher efficiency rating and will qualify for incentives. While it may not make sense to replace an older, but still functional, piece of equipment based on energy efficiency alone, it does make sense to invest in ENERGY STAR® equipment when the time comes for replacement. This includes:

- Steam cookers – electric and gas
- Fryers – electric and gas
- Griddles
- Holding cabinets
- Convection ovens
- Combination ovens
- Rack ovens
- Commercial coffee brewers
- Ice makers
- Refrigerators
- Freezers

PURCHASE ENERGY STAR DISHWASHING EQUIPMENT

Look for the ENERGY STAR® rating and pre-qualification information when replacing dishwasher equipment. ENERGY STAR® rated dishwashers are 40 percent more energy efficient and save an additional 40 percent on water usage over standard models. (ENERGY STAR®, 2017)

REVIEW BOOSTER HEATER USE FOR DISHWASHING

Update electric booster heaters to the gas-fired equivalent to reduce demand charges on your electric bill. Depending on operating hours, costs can be reduced 60 to 80 percent. For example, by replacing a 24 kW electric booster heater on a dishwasher that operates 80 hours per week, you will save more than $2,000 annually (based on a cost of $0.08 per kWh and $0.45 per therm). This would provide a payback of less than two years. (Madison Gas and Electric, 2017)

UPDATE KITCHEN VENTILATION EQUIPMENT

Commercial kitchen ventilation equipment is designed to remove excessive heat, fumes, and odors generated during the cooking process from the kitchen preparation area as well as to prevent it from reaching other areas of the facility. During operation, makeup air must be supplied to the space. If done incorrectly, a large amount of conditioned (heated or cooled) air can be lost through this process. This requires additional heating and cooling. Provide a dedicated system or kitchen hood that provides make-up air without pulling from the facility. This will result in energy savings.

Install a demand controlled kitchen ventilation (DCKV) system to realize energy savings of 60 percent or more, depending on the type of operation and facility. DCKV controls the ventilation system by modulating speed based on the cooking activity. Traditionally, commercial kitchen ventilation systems either operate at the maximum designed speed/volume or provide manual control over two speeds throughout the kitchen's operating hours. DCKV provides automatic, continuous control over fan speed in response to temperature, optical, or infrared sensors that monitor cooking activities or direct communications with cooking appliances.

Install temperature and/or optical sensing controls to reduce unnecessary exhaust fan operation. Tie these controls with the make-up air fan to limit operation to only when the exhaust fan is operating.

INSTALL LOW-FLOW FIXTURES AND APPLIANCES

Install quality, low-flow fixtures and appliances to reduce water consumption by 25 to 90 percent and significantly reduce water heating costs. Examples include:

DISHWASHERS - When it's time to replace dishwashing equipment, remember to install an energy efficient dishwasher and only operate it with full loads. Look for an ENERGY STAR® certified product and compare ratings on the EnergyGuide label before making your purchase.

Many dishwashers include booster heaters that increase the water temperature to the recommended 180 °F for cleaning. Dishwashers with booster heaters typically cost more but pay for themselves in energy savings if they allow for lower temperature set points on the central water heating system. Using a separate demand heating system as a booster will also achieve this effect.

COOKING EQUIPMENT - ENERGY STAR® certified steam cookers reduce water use by 90 percent or more and are up to 50 percent more energy efficient when compared to standard steam cooker models. Energy efficient steam cookers shorten cook times, increase production rates, and reduce heat loss due to better insulation and a more efficient steam delivery system. ENERGY STAR® certified steam cookers include both electric and gas models.

BEHAVIORAL TIPS

- ✔ Use cooking equipment to capacity.
- ✔ Use minimum settings to preheat cooking equipment (refer to manufacturer's recommendation).
- ✔ Keep refrigerators full to improve energy efficiency (fill with water jugs if needed or consolidate).
- ✔ Unplug coffee pots, toasters, and other appliances when not in use.

BEST PRACTICES FOR TECHNOLOGY

TECHNOLOGY

The best way to decrease energy use with technology – computers, tablets, smartboards, copiers, printers, laminators is to make people aware that their actions make an impact. In most cases, energy-using equipment in a building is never directly controlled by its occupants. For example, everyone knows the benefit of HVAC equipment, yet they have little direct impact on its energy use. Technology is different in this aspect as its energy use is primarily controlled by building occupants. Therefore, education is as important as the equipment purchased. Even the most energy-efficient computer uses large amounts of energy if the user does not use the energy-saving functions.

BEST PRACTICES

EDUCATE BUILDING OCCUPANTS ON COMPUTER USAGE AND POWER MANAGEMENT

Energy saving actions taken by technology users have replaced centralized PC Power Management software. Computers now come with energy saving features and the power can be directly controlled by the user. Educate building occupants on the following energy-saving actions:

- Screen Savers — Avoid screen savers as they use twice as much energy as when the computer is in use.
- Sleep Mode — Instead of a screen saver, set your monitor to go into sleep mode after 5 to 15 minutes of inactivity, and the hard disk to turn off after 30 to 45 minutes of inactivity.
- Monitor Display — Adjust your display/monitor's brightness to be below 50 percent, as the brightest setting consumes twice as much power as the dimmest setting.
- Power Down — Turn off your computer at night and on weekends (if you require remote access, sleep mode is an acceptable alternative).
- Settings — For other appliances, such as smart boards, copiers, and printers, enable similar energy-saving settings.

Building occupants can learn from monitoring equipment energy usage and accompanying utility costs. There are a number of inexpensive energy meters on the market. Plug the meter into a wall socket, then plug the equipment into the meter. Energy use is metered and displayed.

SELECT ENERGY STAR RATED EQUIPMENT

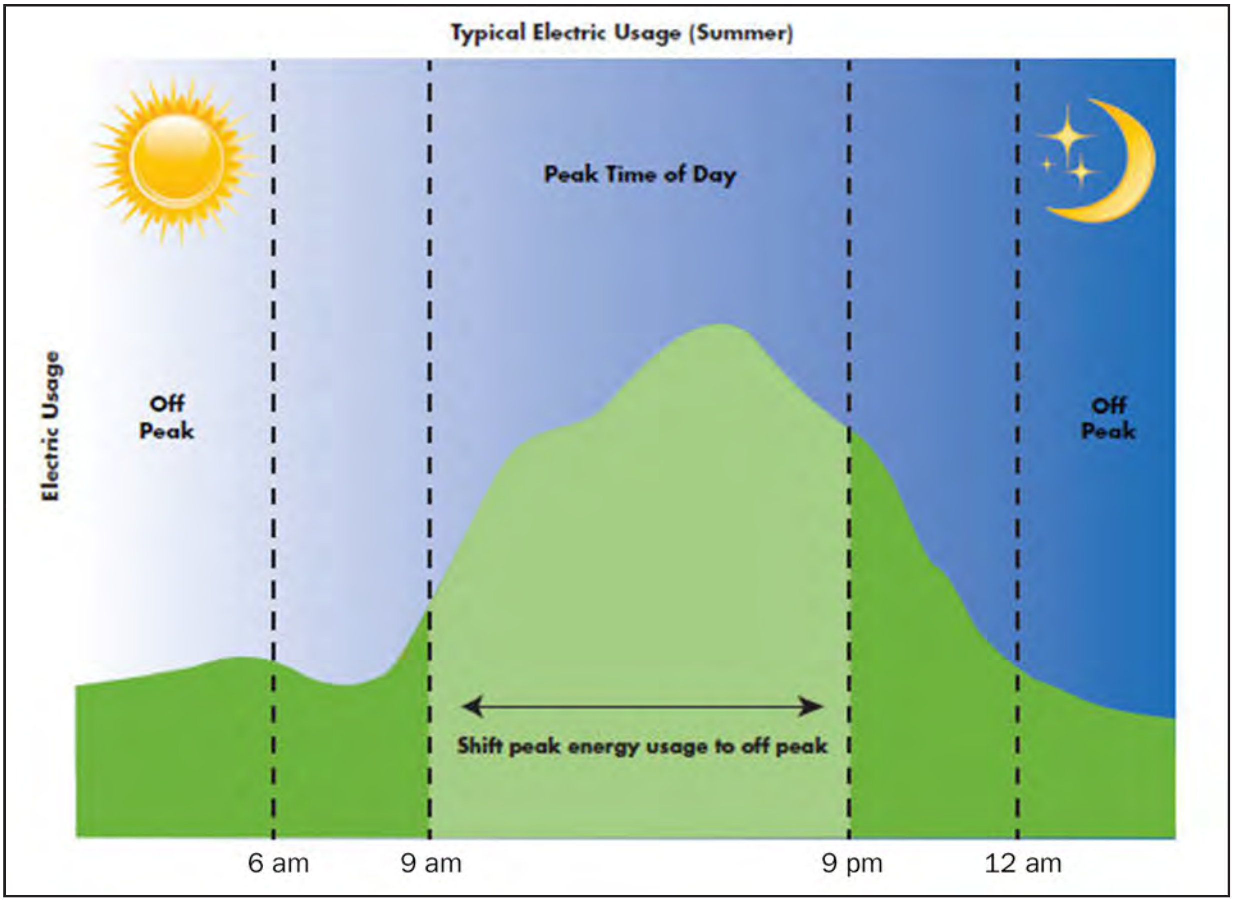
Look for the ENERGY STAR® rating and pre-qualification information when purchasing new technology. ENERGY STAR® technology must meet maximum power consumption requirements. These requirements apply to when the equipment is actively being used and also when in sleep or idle mode.

UTILIZE ADVANCED POWER STRIPS

Utilize power strips with a timer designed to turn off power at a preset time to ensure copiers, printers, and laminators are switched off at the end of the day.

CHARGE COMPUTERS OFF-PEAK

School and government facilities possess many laptops and tablets, which need to be charged for optimal use. Charge these devices during off-peak hours to reduce peak load and kW demand charges on the electric bill. Review your electric bill to determine peak demand times. A typical on-peak time period is 9 am to 9 pm Monday through Friday, excluding legal holidays.



BEST PRACTICES 5 TECHNOLOGY

USE VIRTUAL SERVERS

A computer containing virtual server software replaces multiple computers running a single application. Virtual server software on one computer can have servers for each of the following tasks:

- Security
- Printing
- Building Automation System (BAS)
- Accounting software

By virtualizing servers, IT departments are able to reduce the number of computers and therefore, reduce the amount of energy being used. Server virtualization allows you to add a new server in minutes, instead of hours. If there's ever an issue with an application, simply access a virtual snapshot backup and redeploy it on a newly created virtual server. By consolidating applications on one server, you'll reduce your electricity consumption and save on cooling costs since multiple servers generate considerable heat. When you make the switch, your maintenance costs will decrease, plus you won't have to buy new machines when you need to add a new server.

BEST PRACTICES 6 TECHNOLOGY

MONITOR SERVER ROOM TEMPERATURE

Server rooms are often kept at temperatures lower than the recommended or appropriate temperature. A 2011 study on server fan and cooling levels at various room temperatures identified a sweet spot between 75 and 80 °F as the optimal temperature range for saving energy. (Dell Technologies, 2011) However, newer servers are able to handle even higher temperatures, closer to 90 °F.

The study focused on using economizers in addition to or completely replacing compressor-based cooling, depending on the climate where the server resided. For Wisconsin, it is doubtful a cooling system without a compressor could handle the full range of temperatures and humidity levels. However, economizers, if available, are an excellent way to reduce energy use during times of the year when outside cooling is available.

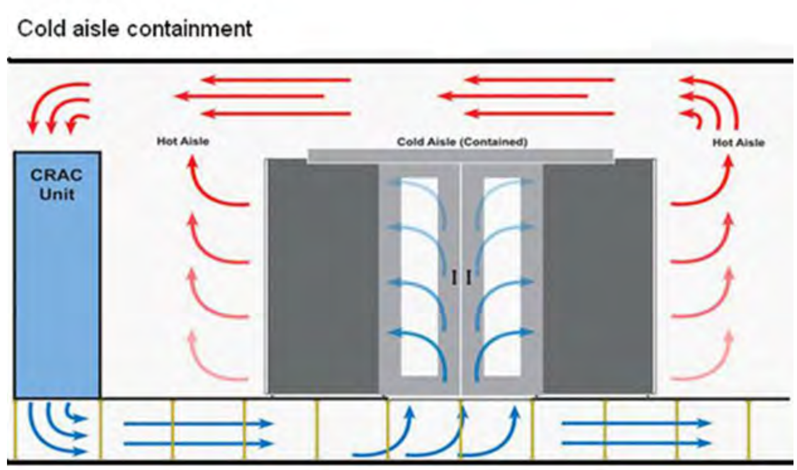
Consult your server supplier or manufacturer for recommended server room temperatures.

BEST PRACTICES 7 TECHNOLOGY

IMPLEMENT COLD-AISLE COOLING

Place cold-aisle cooling partitions in the server room to separate the heating aisle from the cooling aisle. Locate servers in a rack in the center of the server room. The exhaust side (back side) of the server row is the hot aisle while the front side (where cooling needs to be directed) of the server row is the cold aisle. The racks themselves are a barrier between the cold aisle and hot aisle. Use blanking panels to complete the separation. Provide cooling to the cold aisle side underneath a raised floor while return air from the hot aisle feeds the cooling system.

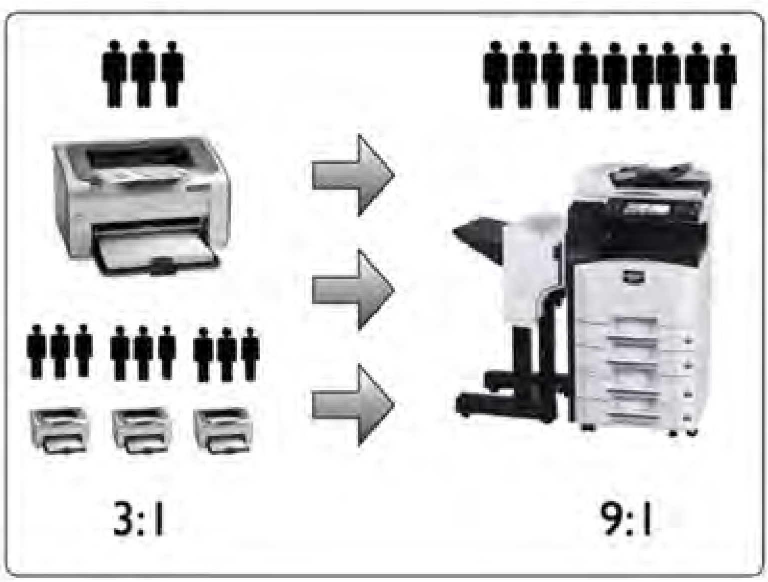
By separating the cold aisle from the hot aisle, cooling capacity will not have to overcome heat from the servers as is typical in a server room being served by split systems or other means of centralized cooling. Efficiency is gained through this more efficient use of cooling capacity.



BEST PRACTICES 8 TECHNOLOGY

CONSOLIDATE PRINTERS

Consolidate large fleets of printers or old printers into fewer, more efficient models. Replace existing printers with newer networked printers and/or multi-function devices to save energy and maintenance costs.



BEHAVIORAL TIPS

- ✔ Turn off printers, copiers, and scanners at the end of the day.
- ✔ Unplug TVs, DVD players and other electronics when not in use.

BEST PRACTICES FOR BUILDING ENVELOPE

BUILDING ENVELOPE

Building envelope includes all external building materials such as walls, windows, floors, roofs, and doors, which enclose the internal space. In short, it's the physical separator between the interior and exterior of a building. A well-designed building should incorporate existing external conditions, such as the local climate, with desired internal elements. These complexities should align within the building envelope to deliver optimal comfort and energy efficiency.

Air leakage is the infiltration of outside air through cracks, holes, and other gaps in the exterior of the facility. It represents the largest source of heat losses or gains through the building envelope. Air leakage should not be relied upon for ventilation, as it can allow too much air into the building during cold or windy weather and too little during warm or fair conditions. Typical savings associated with managing air leakage tend to range from 10 to 25 percent. Not only will reducing air leakage increase energy and cost savings, it will also positively impact occupant comfort, increase indoor air quality, and add to the structural integrity of the building envelope through moisture mitigation.

Proper control of air leakage involves using appropriate materials, such as fire retardant, polyurethane foam, caulks, and weather stripping materials to accurately seal gaps, cracks, and holes. The ultimate goal is to provide a continuous, air-tight seal throughout the building envelope that balances any alterations in pressure.

Ongoing review and maintenance of a facility's building envelope will safeguard the interaction of the building structure with the mechanical system, climate, energy usage, and occupant comfort. Energy is saved through reducing the amount of infiltration into the facility.

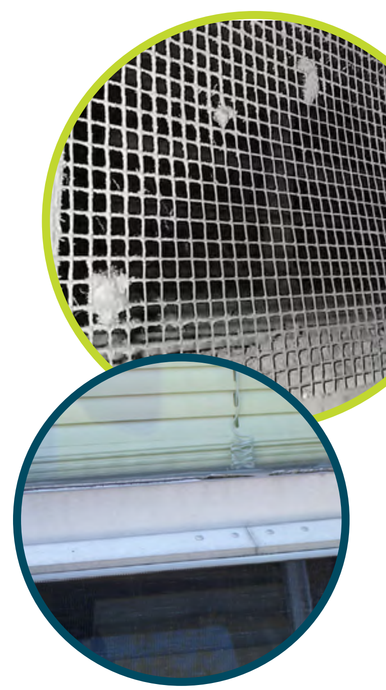
BEST PRACTICES

SCHEDULE REGULAR FACILITY WALK-THROUGHS

Schedule bi-annual facility walk-throughs to visually inspect building envelope flaws or imperfections. Use a camera to document any areas where the building is improperly sealed and/or in need of attention. Consider using an infrared camera to identify cold spots where insulation is missing. Keep a log of these areas to help you document current conditions and properly plan for material repair or replacement. When conducting a walk-through, ask yourself the following questions:

- What is the estimated useful life of the windows and roof of the facility?
- Review plans/specifications to identify the R-factor of the roof or U-factor of the windows. How does this compare to the code minimum of your area?
- Are there any improperly-sealed building penetrations?
- Are the caulk and sealing around windows and doors deteriorated due to the weather or excessive use?

Consult your local Energy Advisor or a building envelope professional with any questions or concerns that arise during walk-throughs.



HIRE A CONTRACTOR TO PERFORM A FACILITY AUDIT

Hiring a contractor to perform an initial facility audit will help determine current building envelope concerns and serve as a benchmark for future building walkthroughs. The auditor will inspect any existing gaps, holes, or cracks, measure and calculate the infiltration, and equate it to energy lost due to air leakage. Typical problem areas include:

- Unsealed doors
- Windows/sills
- Pipe penetrations
- Gaps around vents to the attic or exterior
- Building joints
- Roof to wall connections

The auditor will look for energy saving infiltrations and identify any health and safety issues characteristically associated with air infiltration.

ARRANGE FOR A PROFESSIONAL TO TEST AND BALANCE YOUR FACILITY

Examining building pressure and ensuring a facility is balanced is an important part of the building's health. For example, if a facility is exhausting too much air with an inadequate makeup balance, the infiltration rate will increase. In the same sense, if doors are staying open or are difficult to open, the facility is most likely out of balance. Ensuring proper pressure distribution is formed through the interaction of the building envelope with the mechanical system and climate will lead to optimal commissioning, operations, and maintenance.

BEST PRACTICES 4 BUILDING ENVELOPE

ADD INSULATION DURING A ROOF REPLACEMENT

When preparing to replace a roof on a commercial building, it is recommended that a core sample is taken. This will help to determine what amount of insulation should be added when the old roof membrane is removed. The building code describes the recommended amount of insulation for a roof by region. The recommendation is to add the amount of insulation necessary to bring the building up to “code”. For example: New construction levels in Wisconsin are R-value = 38.

BEST PRACTICES 5 BUILDING ENVELOPE

CONSIDERATIONS WHEN REPLACING WINDOWS

When replacing doors and windows, replace them with a high R-value and low U-value option recommended by ENERGY STAR®. The ENERGY STAR® website makes recommendations for U-factor, solar heat gain coefficient (SHGC), and air leakage. For Example, in Wisconsin's northern zone, the U-factor and SHGC should range from .25 to .30 and .32 to .42 respectively.

BEST PRACTICES 6 BUILDING ENVELOPE

ANNUAL ROOF INSPECTION

An annual roof inspection is recommended and may be required in order to maintain a factory warranty. The qualified installer on a new roof installation may have a very elaborate inspection process but should include a review of the roof penetrations, looking for cracks in the membrane, holes in the seams and puddling of water anywhere on the roof.

BEST PRACTICES 7 BUILDING ENVELOPE

HIGH SPEED OVERHEAD DOORS/TIGHT SEALS

Installing high speed overhead doors and ensuring they make a tight seal, will reduce air flow through the door. This will reduce the infiltration of unconditioned outside air into the building. Provide door openers in vehicles so staff won't need to get out of their vehicles to open or shut the over head doors.

BEHAVIORAL TIPS

- ✔ Close blinds at night and during an extended leave.
- ✔ Keep windows and exterior doors closed if heat or air conditioning is on.
- ✔ Overhead doors should not be open longer than necessary in cold weather (i.e., shipping/receiving, garage).

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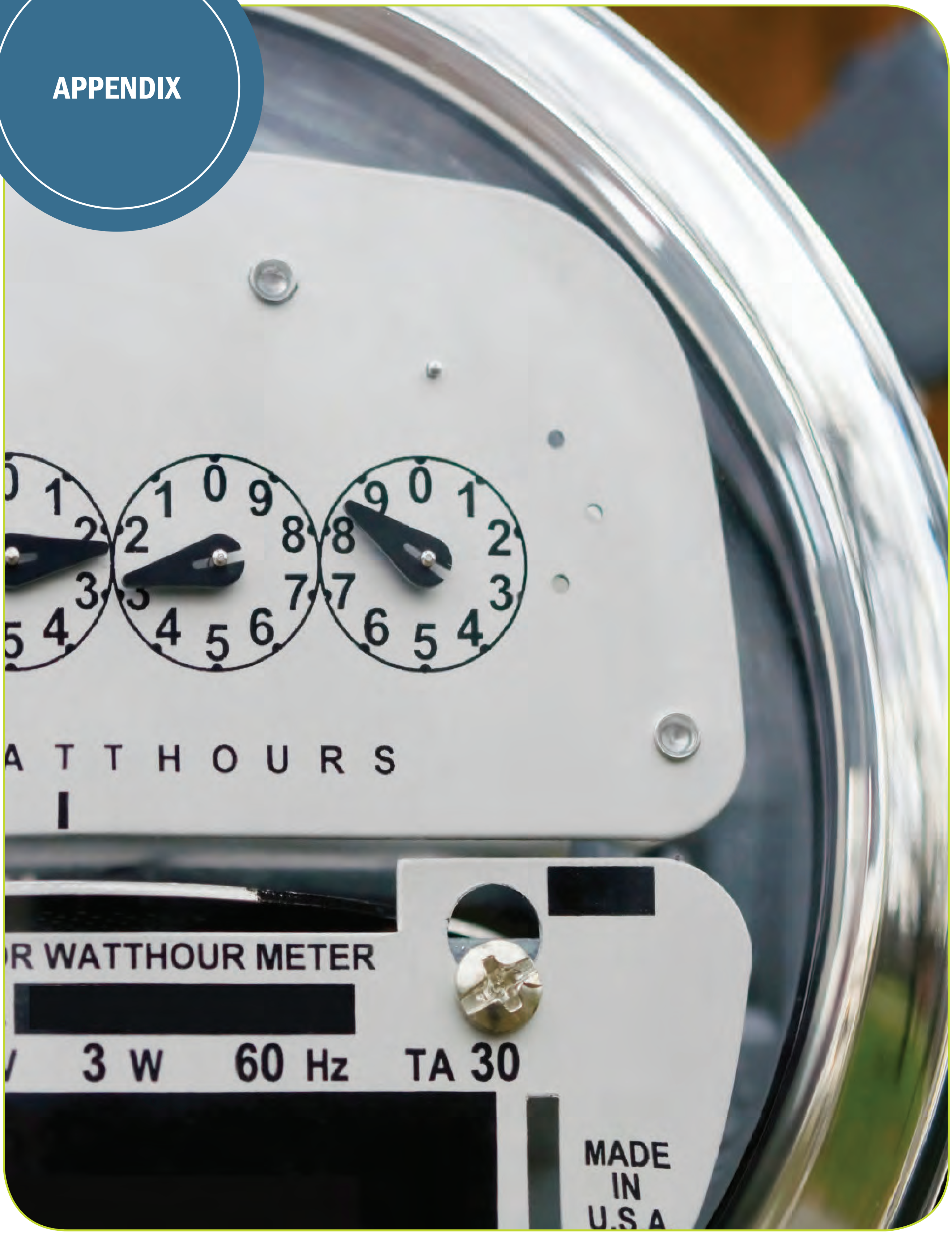
APPENDIX



SAMPLE BUSINESS CASE

Executive Summary

With tighter budgets, it is becoming more vital to limit expenses throughout the school district. Installing a new lighting system in the high school is one area where maintenance and operational costs can be reduced. The proposed project includes updating the current lighting to LED technology and adding occupancy sensors throughout the high school and will cost approximately $80,000. This cost does not include an estimated $8,000 Focus on Energy incentive to help offset initial project costs. Following implementation, light levels will be better suited for a learning environment. Annual maintenance and energy costs will also be significantly reduced.

Business Issues

Current costs for maintenance and repair on the existing lighting fixtures are expensive due to the age of the fixtures. Spare ballasts are no longer available for the models currently installed. As failures occur, each fixture needs a fabricated bracket to hold the new ballast. Replacing old fixtures with new longer lasting ones is easier than taking down, repairing, and reinstalling old equipment.

Existing light levels are higher than the recommended foot-candles in many classrooms, hallways, and areas throughout the facility (see table below). Removing unnecessary lamps can adjust light levels to the appropriate foot-candles for the design and use of the space. De-lamping will also reduce energy use and maintenance costs.

Facility Area	Recommended Foot-candles	Average Foot-candles in High School
Classroom	30-50	100
Gymnasium	30-50	80
Cafeteria	20-30	100
Hallways	5-10	50

Impact

A lighting upgrade will provide a safer and more inviting environment for students and facility, while significantly reducing maintenance and operational costs.

Financial Analysis

Annual savings are estimated at $8,600 in energy usage and $7,000 in maintenance costs, for a total savings of $15,600. The project cost is $80,000 with an $8,000 incentive from Focus on Energy. This results in a less than five-year project payback, as shown in the equation below.

$80,000 - $8,000 (Focus Incentive) = $72,000 / $15,600 = 4.6 Year Payback

Implementation Plan

Install new LED fixtures and occupancy sensors over a three day period with a two to three-week notice. The ideal install date would be during a school break, so as not to disturb the learning environment.

Additional Information

Maintenance Savings

Average $20/hour for labor reduced by four hours per week (50 weeks) for a year period = $4,000
An average of $50 for approximately 60 fixtures – including lamp, ballast, etc. that no longer need to be purchased annually = $3,000

Labor + materials = total maintenance savings

$4,000 + $3,000 = $7,000 in annual maintenance savings

Energy Savings

Estimated kWh saved annually x $0.10/kWh = Savings based on energy reduced

86,000 kWh x $0.10 = $8,600 in energy savings