Energy Best Practices Guide | October 2020

SCHOOL & GOVERNMENT FACILITIES

WISCONSIN

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School & Government Facilities Energy Best Practices Guidebook

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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Table of contents

Introduction

School and government facilities constitute thousands of buildings across Wisconsin and are among the state's largest energy consumers. In 2017, state facilities in Wisconsin spent over $142 million on electricity and natural gas (Energy Use in State Facilities - Fiscal Year 2017 Report, 2018). Additionally, Wisconsin public schools collectively spend over $175 million on energy costs each year (Wisconsin School Benchmarking Results, 2019). According to the U.S. Environmental Protection Agency, as much as 30% of the energy used in commercial buildings is wasted.

By creating awareness and implementing changes in the way these facilities operate, school and government facilities better utilize taxpayer dollars and resources, conserve energy, reduce maintenance costs and increase occupant comfort, safety and productivity. Additionally, costs reduced through these changes can be reallocated to alternative areas of the budget, such as additional staffing, technology or other facility needs.

While it may not be realistic to eliminate energy expenses in school and government facilities altogether, there are many ways to decrease energy use. Successful strategies for reducing energy costs can range from no-cost simple behavioral adjustments to significant capital investment in equipment upgrades. Focus on Energy continues to offer relevant energy-saving strategies and best practices to reduce energy expenses in your facilities.

PRACTICAL ENERGY MANAGEMENT

Why energy management?

Practical energy management provides your organization with a systematic approach to assessing current and future energy costs, defining clear goals, identifying potential opportunities and challenges, and creating a plan for short and long term energy reduction success. Building upon traditional energy management techniques establishes a framework for making smart business decisions. Energy costs are not an uncontrollable expense, and a shift to long term energy management will result in financial and other benefits to your organization. The process starts before an energy audit and continues beyond consideration and implementation of energy conservation measures. When implemented correctly, a proactive approach to energy planning can help you:

- Control your energy use
- Save 5 to 10% on your annual energy bill by starting an energy awareness program
- Achieve an additional 20 to 30% in cost savings by digging deeper into how building systems operate and identifying deficiencies in equipment
- Align with sustainability team efforts
- Plan capital improvement projects

Building an energy team

Start with identifying a group of motivated, cross-functional participants with a passion for conservation and a vested interest in positive facility outcomes. There are three classifications of people involved: approvers/supporters, energy team members and implementers. Approvers/supporters support the energy team goals and approve energy team action plans. Energy team members should include a diverse mix of technical and non-technical staff with a thorough understanding of how the facility is used and a willingness to lead. Bring in outside experts with knowledge of energy management techniques and available resources. Implementers often include building system operators and trained contractors. Even though behavioral programs will be implemented by building occupants, it is important to have operators and contractors present during the planning process.

Table 1: Energy teams

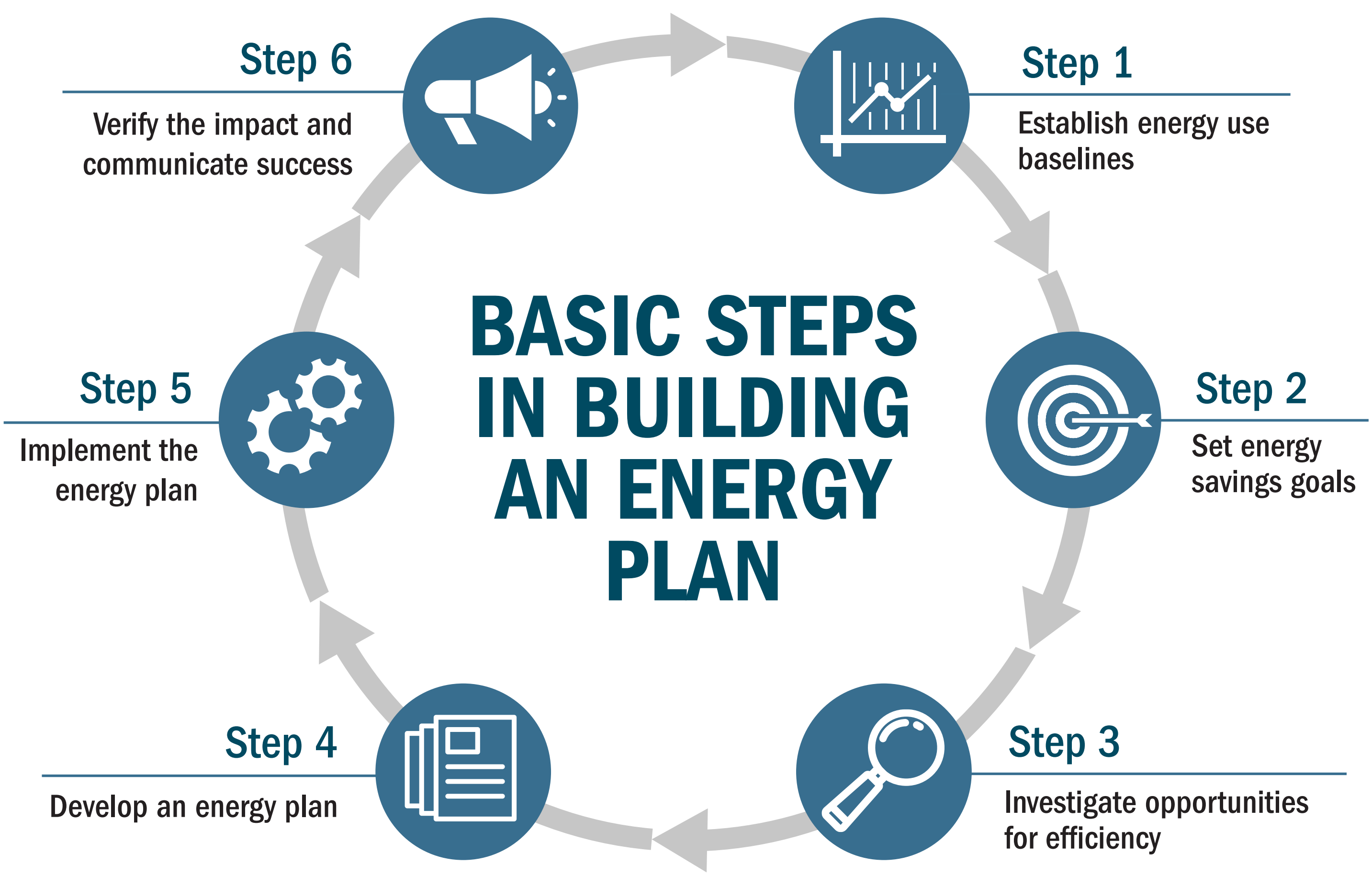
APPROVERS/SUPPORTERS	ENERGY TEAM MEMBERS	IMPLEMENTERS
Budget or financial manager Upper-level manager (administrator, principal, etc.) School boards Building and grounds director Sustainability/green team	Facility or maintenance personnel Principals Head of departments (food service, IT, safety, etc.) Marketing personnel Student council Sustainability/green team interested in building occupants ('champion' employee, custodians, staff members, etc.) Utility representative Energy Advisor or another functional expert outside the organization	End users of the building: • Staff • Students • Community members • Contractors

Every energy team should have one or two leaders or "energy champions." These individuals assist with maintaining communication across team members, organizing regular meetings, setting and keeping the agendas and tracking action items. Keep in mind that effective energy planning is a long-term commitment requiring team members to be creative and flexible to succeed.

Creating a practical energy plan

After establishing the energy team you are ready to develop a practical energy plan. The following energy planning cycle can illustrate how to implement a practical energy plan that continually builds upon success. Keep in mind that the process is cyclical. Ultimately, success depends on the commitment to continuously revisiting and improving your energy plan.

Figure 1: Energy planning cycle



Step 1 – Establish your energy use baselines

To develop specific energy-saving goals and identify appropriate facility improvement measures, you must first understand your current energy use and consumption trends. Building and maintaining a record of energy consumption or baseline for your facility will provide a 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 your organization's facilities. Information from the utility bills should include:

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

Review **Appendix A - Understanding Your Electric Bill** to better understand these standard terms and how to find find examples on your utility bill. Once you are familiar with the terminology, enter all the data into a utility tracking tool. ENERGY STAR Portfolio Manager® is an example of a free benchmarking software that compares your building to similar facilities across the nation. This tool calculates a 1-100 performance score and estimates how much you spend per square foot of building per year. Nearly 25% of U.S. Commercial building space actively uses this tool to track energy and water usage (Use Portfolio Manager, 2020). Whatever method or device you use should help you:

- Track energy costs and project energy savings
- Visualize trends in energy consumption over time
- Assist in managing existing energy loads and identifying energy-saving opportunities

Energy-saving tip:

Talk with a utility representative about getting your data in spreadsheet form. Some utilities will also provide interval data showing trends in consumption over time.

Establishing a baseline will provide a consistent metric to allow you to compare your facility's performance against others with similar characteristics. Using a metric such as cost per square foot per year will provide a real number for administrators to use while managing operating costs. Studies have demonstrated that investigating energy use and improving awareness among staff alone can provide measurable energy efficiency savings of up to 6% (Meng, Hsu, & Han, 2016).

Energy-saving tip:

Review your energy demand (kW) fluctuations. Calculate the load factor of your building:

$$\text{Load Factor} = \left(\frac{\text{Total kWh}}{\text{Days in billing cycle}} \times \text{Peak demand} \right) \times 100\%$$

- The lower the load factor, the more savings may be available by managing peak energy demand.
- This is particularly important for facilities with time-of-use utility rate structures.

Refer to the Focus on Energy [2018 School Benchmarking Study Final Report] for Wisconsin-based school energy use statistics.

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. After establishing your energy team and determining baselines, you can begin developing your written energy goal(s). 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 it will be measured, key performance indicators and how it aligns with your organization's mission and vision. The approvers/supporters must incorporate these goals and schedules into the organization's policy.

Examples of energy goals include:

- By the end of the school year, our school district will reduce operating costs by 3% through utility reductions.
- Our facility plan will involve reducing our overall BTU per square foot per Heating Degree Day by 5% in the next fiscal year.
- Our board policy will analyze energy usage reductions and project payback for every measure brought forward in the coming fiscal year.

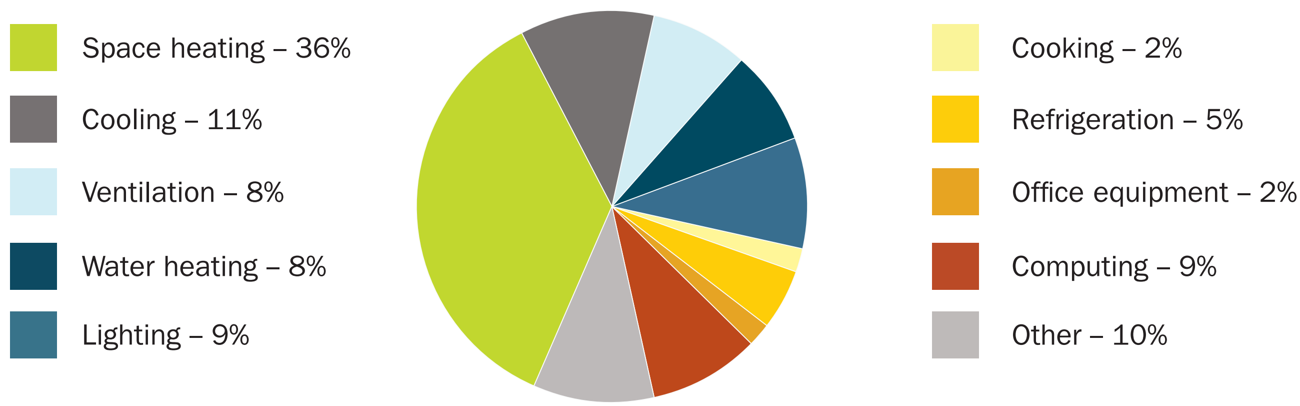
After developing an energy goal, it needs to be communicated with all stakeholders, including students, staff, employees and other community members. The team you've assembled is critical to providing the tools, motivation and funding for projects or promotional pieces to drive organizations towards achieving each goal. The team should also identify a method of how potential projects will be ranked and evaluated. Using metrics including how it aligns with your mission and vision, energy savings and operational savings to score and rank projects can prioritize projects needing completion.

Step 3 – Investigating opportunities for efficiency

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, including your energy advisor, and interviewing building occupants, operators and maintenance staff. These interviews can help the team understand how energy is used within the facility's daily operation, identify limitations for future actions, and provide helpful suggestions for improving energy efficiency. Two methods to understand how energy is used within your facility will be discussed.

Energy profile data – The first method utilizes the U.S. Energy Information Administration (EIA) energy profile data to apply percentages to the overall annual usage. EIA energy profiles can give a general overview of energy consumption trends for a specific building type and explain how your building uses energy. These profiles (found at www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e1.php) can also direct your team where to focus their attention when considering energy efficiency projects. This method will provide typical use characteristics of your building type. However, it is not specific to your building and therefore, will not be as accurate. Figure 2 illustrates that the building systems are broken into ten general categories based on energy consumption trends observed within a specific sector, an educational facility.

Figure 2: Consumption by end use (Btu), education building



Commercial Buildings Energy Consumption Survey (CBECS), 2016

Energy audit – The second method entails completing an energy audit of each facility. This technique is more time consuming but will result in site-specific data to improve the accuracy of where your best energy efficiency opportunity lies in each specific building. This method involves:

- Examining building plans and maintenance/repair records.
- Touring the facilities to inspect the building envelop, HVAC distribution systems and current condition of the equipment.
- Compiling an inventory of existing electrical and mechanical equipment (specifically note nameplate data and hours of operation).
- Examining control system setpoints and capabilities.

Involving the energy team in this process will further their understanding of the equipment and how it operates. Working with an experienced energy expert will give you access to testing equipment and tools and allow you to build an energy profile specific to your facility. Regardless of who is involved, working knowledge of equipment operating hours and analysis of mechanical and electrical systems are needed to create an accurate energy profile. Accounting for each piece of equipment's operating costs allows the energy team to make more informed decisions and eliminate uncertainty.

Energy-saving tip:

Utilize submetering and data logging to further investigate equipment energy usage and identify malfunctions.

Step 4 – Develop your energy plan

After sufficiently assessing your facility's energy use and operation, the energy team can begin to develop a prioritized energy plan. The plan should include:

- Facility audit findings
- Energy consumption and cost data
- An estimated timeline for implementation
- Details about how the initiatives will be measured
- Estimated costs and return-on-investment figures, including potential sources of outside funding
- A detailed description of each project or program and expected results

When prioritizing energy efficiency measures, make sure to cast a wide net and consider projects that will yield the best results aligning with your organization's mission and vision in addition to return-on-investment. Keep a long-term focus that studies operations and maintenance best practices as well as equipment upgrades. Although your energy plan might consider additional topics, this guide will specifically provide best practice recommendations in the areas of:

- Lighting
- HVAC
- Plumbing
- Kitchen operation
- Technology
- Building envelope
- Renewable energy

Categorize these best practices into simple, low-cost/no-cost operations and maintenance procedures, behavioral changes or more substantial capital investments with varying implementation costs. Examples include:

Low-cost/no-cost operational changes – **Maintenance practices**

- Change filters to improve airflow and efficiency
- Control and adjust outside air intake through a program setting or mechanical adjustment
- Create a preventative maintenance plan

Behavioral changes – **Breaking habits**

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

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 need the support of relevant stakeholders and ongoing communication among all parties.

A well-documented business case can provide the necessary information to help decision-makers and other stakeholders support 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.

A well-executed business case can help alleviate misperceptions and skepticism, provide factual support of an effective plan and gain the approval needed to move forward in the implementation process.

Step 5 – Implement your energy plan

Successful execution of an 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 is 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 upfront to reduce barriers and resistance down the road.

Once you've received approval for the project, communication is critical. Provide written and verbal updates to all relevant stakeholders on an ongoing basis. This communication should include a checklist of completed tasks, a schedule for upcoming work, any problems encountered and the expected resolution.

Step 6 – Verify the impact and communicate success

Your energy management plan's results need to be measured and verified to gauge if you accurately met the goals. This process should be an ongoing practice involving a continuous review of utility data to monitor usage variances or differences as compared to historical data.

After a 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. Communication can occur through newsletters, websites, social media or any other publication relevant to your organization. For example, a well-placed flyer or brochure 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.

Energy-saving tip:

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

BEST PRACTICES FOR 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 sufficient light levels while lowering energy costs.

1 Upgrade your fixtures to light-emitting diodes (LEDs)

Upgrading to energy-efficient fixtures, especially on lights that operate the most hours, can save a lot of energy. There are many different lighting technologies in practice, but light-emitting diodes (LEDs) have quickly become the most efficient and cost-effective choice when reviewing operational costs over the lifetime of the fixture. LED lighting produces light approximately 90% more efficiently than incandescent light bulbs and 50% more efficient than fluorescent technology. They are also predicted to last two to five times longer than fluorescent lighting. In addition to the operational savings with more extended life technology and fewer disposal costs, these savings add up.

Overhead lighting in offices and classrooms (ambient light) is a great place to start converting to LED technology. These fixtures are typically on the most hours each week and save a significant amount of money on your utility bills. By replacing 4-foot fluorescent fixtures with LED technology, you will see approximately $15 in energy savings on your utility bill each year for each fixture you replace.

High bay/low bay lighting is an indoor fixture mounted at a height above 12 feet. Gyms, industrial shops, jails, maintenance shops, garages, etc. commonly use this type of lighting. 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. With the extended fixture life of LEDs, your organization will save significant maintenance and equipment costs by not replacing lamps as often.

Improved Fixture Layout - LED technology has a higher efficacy than fluorescent and HID technology. This means it produces higher lumens (light output) per watt. Not only does this result in less energy used (assuming same operating hours), but it could mean a brighter work surface. Higher light levels are not necessarily an asset as they can cause glare and eye strain. To maximize energy savings and optimize light levels, 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. It will often result in fewer fixtures or lamps installed with optimized working or learning environments. Because not all LEDs are created equal, select fixtures certified by DesignLights Consortium (DLC) or ENERGY STAR®.

Energy-saving tip:

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.

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

If you don't have the capital investment needed to convert all of your fixtures to LEDs, there are still ways to reduce energy by utilizing existing four-foot fluorescent fixtures.

Table 2: Recommended foot-candle levels

ROOM TYPE	RECOMMENDED FOOT-CANDLES*
Cafeteria	30-50
Classroom	30-50
Hallways	5-10
Gymnasium	30-50
Kitchen	30-75
Library	30-50
Lounge/Break Room	10-30
Office	30-50
Restroom	10-30
Storage Area	30-50

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

*A unit of illumination 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).

2 Scale back overlit areas

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%!

De-lamping - De-lamping involves removing unnecessary light fixtures or lamps. Scale back overlit areas by removing individual lamps or entire fixtures. Follow these helpful tips to determine where it is appropriate to de-lamp:

- Determine which areas are over lit by comparing actual foot-candle levels with the recommended level indicated by Table 2 above
- Use a light meter to take foot-candle readings
- Remove lamps and retest lighting levels
- 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%, but it also requires a lower investment to start seeing energy savings.

Energy-saving tip:

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.

3 Utilize control strategies

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. Coupling LED upgrades with integrated lighting controls can add an estimated 10 to 20% in additional energy savings. Integrated lighting controls use the Building Automation System (BAS) to control lights by turning on and off based on a schedule or occupancy.

Each strategy has a "savings factor" associated with it, which details the estimated percentage of savings installing that type of control will provide.

Occupancy sensors turn off the lights in a space when no one is present in the room. They typically consist of a detector that 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 but need to be manually turned on. Angle mounted sensors toward the center of the space to minimize hallway traffic turning lights on. **Savings factor:** Up to 60% (Occupancy Sensors, 2019)

Daylighting sensors turn lights off along walls with windows when it reaches a certain brightness level from exterior sources. Placement of these is essential for maximum efficiency. Install photocell sensors to control exterior lights that automatically turn on at dusk and off at dawn. **Savings factor:** 20 to 40% (Daylighting Systems, 2019)

Networked lighting controls consist of fully integrated wireless control systems applied at the fixture level. There are many different systems available; however, most include application modes for open-plan offices, private offices, meeting rooms, hallways and emergency egress. The integrated technology provides dimming in response to both occupancy sensing and daylight harvesting. The result is an optimized light output for occupied areas. The controls may also be integrated with other building systems, such as HVAC, resulting in additional energy savings. The system is flexible with reconfiguration if the space or task uses were to change. **Savings factor:** 47% additional savings after LED conversion (DLC 2017)

Timers/dimmers are advanced control strategies that can effectively save energy by turning lights off at certain times or dimming fixtures on a schedule. 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. **Savings factor:** Depends on the schedule.

Multi-level switching allows varying degrees of lighting to turn off while still maintaining adequate light levels. **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. **Savings factor:** Depends on the schedule.

4 Perform preventative maintenance

A simple step to decrease energy costs is to perform ongoing, preventative maintenance on lamps and fixtures. Extend the 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. Necessary maintenance steps include:

- **Keep light fixtures clean** – Clean fixtures 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.
- **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.

Energy-saving 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.

ENERGY EFFICIENCY CHECKLIST

1. UPGRADE YOUR FIXTURES TO LEDS

- Convert overhead lighting in offices and classrooms (ambient light) to LED technology
- Upgrade high bay/low bay lighting with new, more efficient technology
- Work with a lighting professional who has experience designing lighting systems for your type of facility
- Select fixtures certified by DesignLights Consortium (DLC) or ENERGY STAR®
- Take all parts of the facility into account, including interior and exterior lighting

2. SCALE BACK OVERLIT AREAS

- Remove less efficient lamps and replace them with lower wattage lamps
- Scale back overlit areas by removing individual lamps or entire fixtures
- Determine which areas are over lit by comparing actual foot-candle levels
- Use a light meter to take foot-candle readings
- Remove lamps and retest lighting levels
- Verify the ballast(s) function after removing lamp(s)

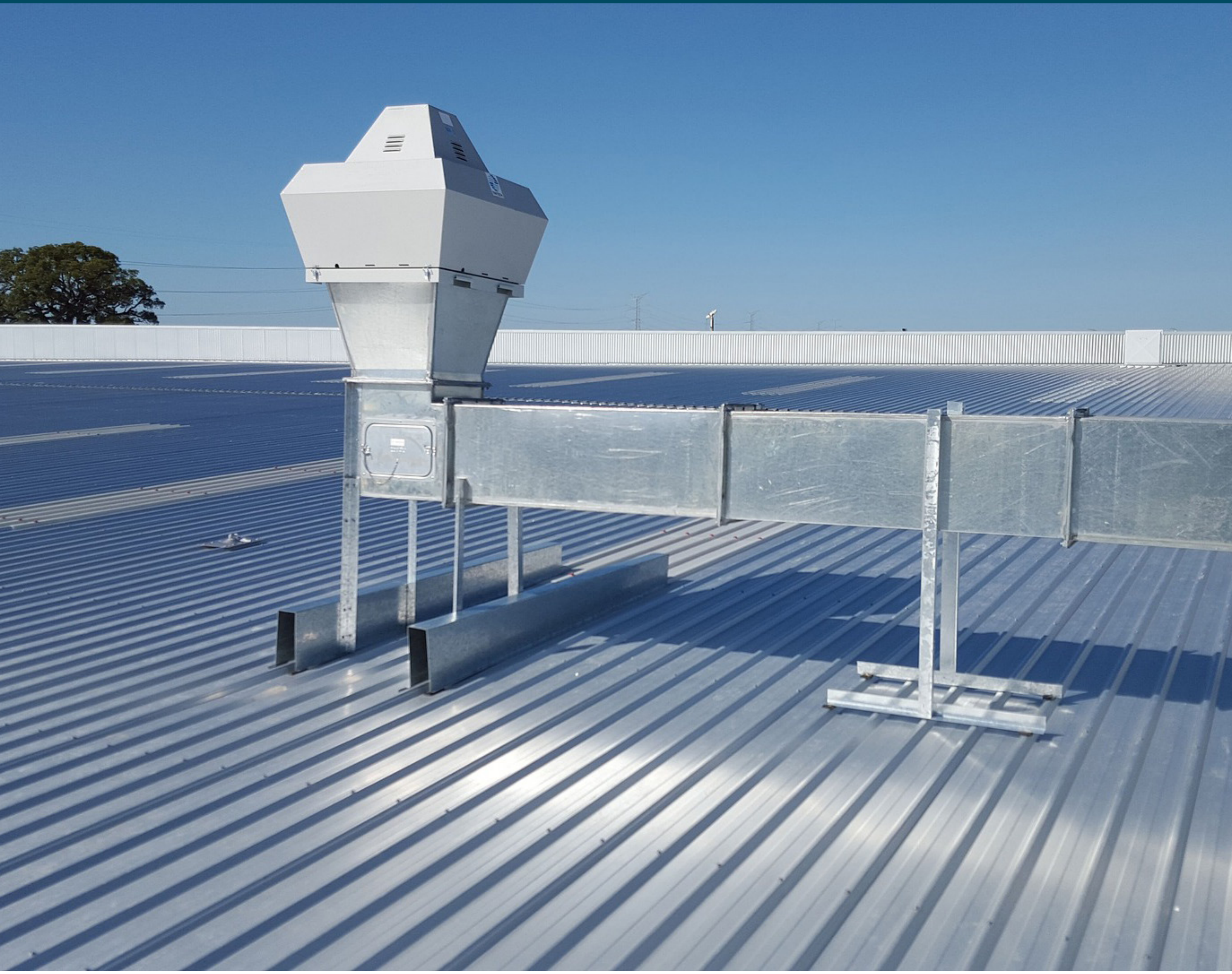
3. UTILIZE CONTROL STRATEGIES

- Install sensors that switch lights on and off based on occupancy, the room's ambient light level, or time of day
- Turn off the lights in a space when no one is present in the room
- Turn lights off along walls with windows when it reaches a certain brightness level from exterior sources
- Integrate networked lighting controls for optimized light output for occupied areas
- Utilize timers/dimmers that turn lights off at certain times or dim fixtures on a schedule
- Install multi-level switching to vary degrees of lighting that turn off while still maintaining adequate light levels

4. PERFORM PREVENTATIVE MAINTENANCE

- Perform ongoing, preventative maintenance on lamps and fixtures
- Clean fixtures by wiping off dirt with a moist cloth
- Review timers and sensors on an ongoing basis to ensure they are operational

BEST PRACTICES FOR HEATING, VENTILATION AND AIR CONDITIONING



1 Perform routine maintenance

Properly maintained equipment and processes are necessary to keep a facility functioning efficiently. Adopt a continuous improvement approach to optimize function and improve energy efficiency of existing equipment and reduce capital expenditures in the long run. 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, worn or broken belts
- Checking, calibrating and/or replacing sensors, controllers and actuators

2 Practice commissioning and retrocommissioning

Commissioning is recommended when building a new facility or doing large-scale retrofits. The commissioning process ensures a 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.

Retrocommissioning is the same process as commissioning, but for existing equipment. Setpoints, 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 altogether. Retrocommissioning includes full-scale testing, balancing and repairing all functions and components of a facility's energy system. Hire a retrocommissioning agent to plan and conduct the retrocommissioning process.

3 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 equipment, providing more precise control of HVAC components, resulting in energy savings.

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

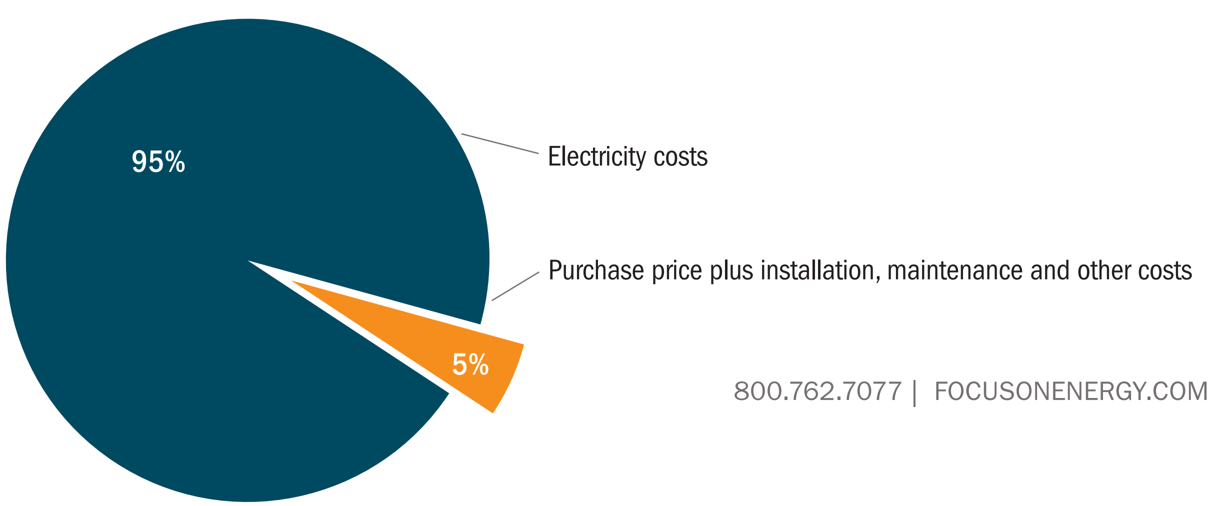
BAS can be integrated with mobile devices, allowing facility staff to make adjustments and receive alarms remotely. This functionality allows you to set facilities to unoccupied modes if the building is unexpectedly closed. By setting buildings to unoccupied you can reduce wasted energy while maintaining space needs. It can also provide real-time energy monitoring and trend logging to make informed energy-saving decisions. Use this trended data to automatically optimize system performance through the use of algorithms and control schematics.

4 Invest in premium efficiency, ultra efficiency or electronically commutated motors (ECMs)

Currently, most electric motors manufactured and imported into the United States mandate premium efficiency for commercial applications, due to the Energy Independence and Security Act of 2007. However, manufacturers have already developed motors above premium efficiency called ultra-efficiency motors or ECM. Since electricity costs are typically 95% of an electric motors' lifecycle cost, the investment in an ultra-efficiency motors can have a good return. Ultra-efficiency motors or ECMs can have efficiency gains of up to 30% compared to NEMA Premium® induction motors.

Figure 3: Lifetime motor costs

(Motor Planning Kit, 2012)



5 Install variable frequency drives (VFDs)

Install VFDs on pumps and fans where variable flow or pressure conditions occur. 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.

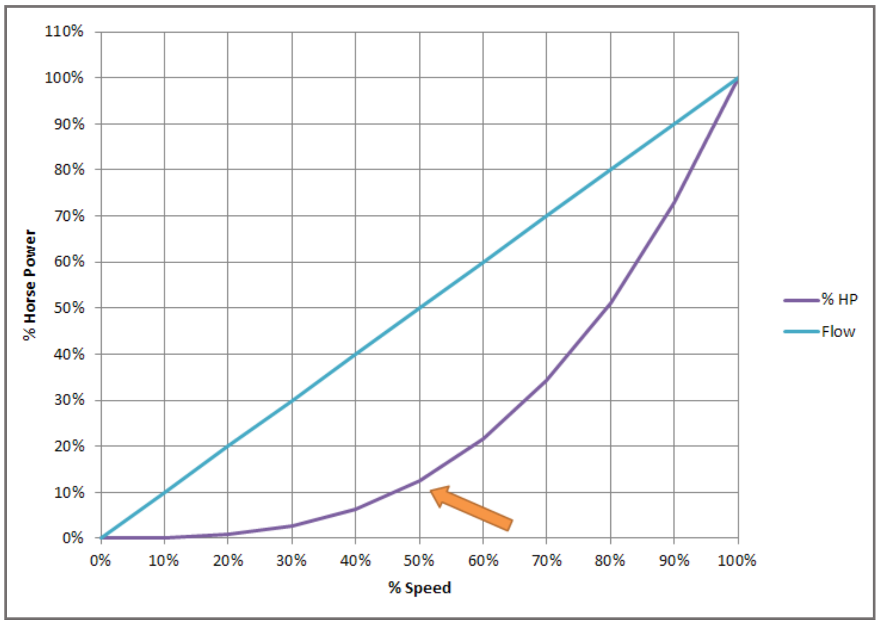
Centrifugal pumps and fans are often subject to the Affinity Laws, which is why VFDs become extremely beneficial and can save significant energy.

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

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

Figure 4: VFDs enable energy savings



THE AFFINITY LAWS ARE NOT APPLICABLE TO ALL PUMPS AND FANS

(Retrocommissioning an existing building: A success story, 2013)

Energy-saving 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.

ENERGY EFFICIENCY CHECKLIST

1. PERFORM ROUTINE MAINTENANCE	
	Adopt a continuous improvement approach to optimize function and improve energy efficiency of existing equipment
	Develop an inventory of facility equipment
	Keep maintenance logs to track maintenance needs for individual pieces of equipment
2. PRACTICE COMMISSIONING AND RETROCOMMISSIONING	
	Hire a commissioning agent to plan and conduct the commissioning process
	Hire a retrocommissioning agent to plan and conduct the retrocommissioning process
3. INSTALL DDC	
	Consider installing DDC for all components of an HVAC system
	Integrate DDC controllers and sensors, along with lighting and security systems into a BAS
	Integrate BAS with mobile devices, allowing facility staff to make adjustments and receive alarms remotely
	Set facilities to unoccupied modes if the building is unexpectedly closed
	Use BAS data to automatically optimize system performance through the use of algorithms and control schematics
4. INVEST IN PREMIUM EFFICIENCY, ULTRA EFFICIENCY OR ECMS	
	Invest in a premium, ultra-efficiency motor or ECMs for an efficiency gain
5. INSTALL VFDS	
	Install VFDs on pumps and fans where variable flow or pressure conditions occur
	Increase or decrease the speed of the pump or fan based on desired flow, pressure or temperature conditions

Boilers are often the primary source of heating for a school or government facility. They are used to heat water or create steam and distribute through a piping system. Boilers, burners, controls, heat recovery systems and distribution systems are all essential components of a boiler system.

1 Size boilers appropriately

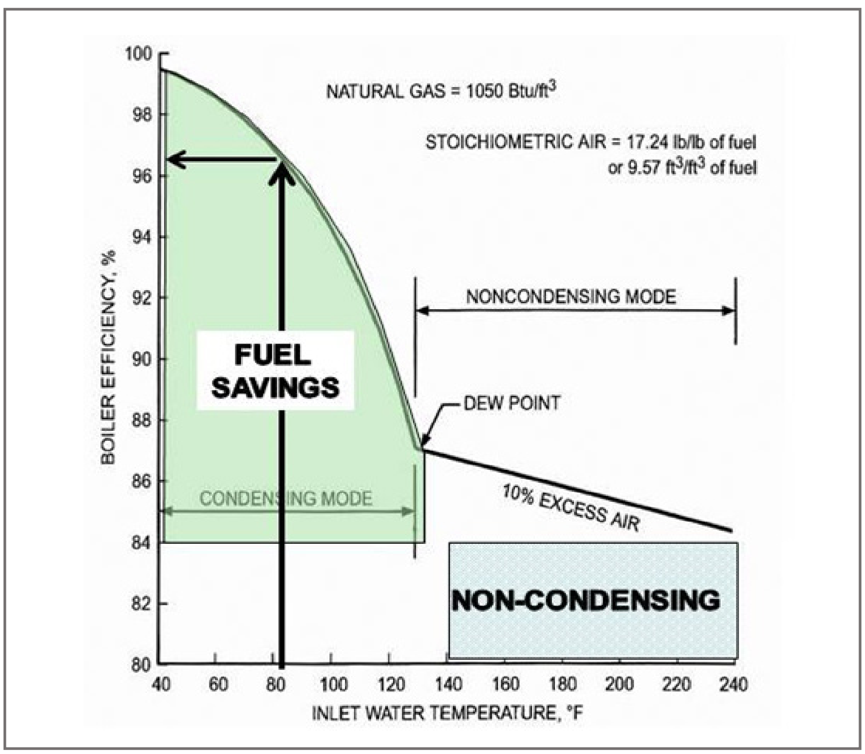
Appropriately-sized boilers will operate within the best efficiency range for the majority of the heating season. If a boiler is grossly oversized, short-cycling can occur. Short-cycling wastes energy by exhausting heat through the stack during pre- and post-purge cycles of the burner. Consider installing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

2 Install high-efficiency boilers

Use condensing boilers (90%+ efficient) when the boiler's return water temperatures are less than 130° F when condensing in the flue can occur. While a conventional boiler exhausts all heat from water vapor being returned to the boiler, a condensing boiler recovers it and uses it in the boiler. The lower the return water temperature is, the more condensing happens and more efficient the boiler operates. Utilize near-condensing boilers (85%-90% 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.

Figure 5: Optimize condensing boiler system for energy savings



(Swanson, 2018)

3 Upgrade burners

Linkageless controls, oxygen (O_2) 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. Adjustable metal linkages physically link old controls. Wear 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.

O_2 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. It can also 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 offers the opportunity to reduce pre- and post-purge cycling, which wastes energy. The ability to run at low-fire speeds instead of cycling on/off provides energy and maintenance savings.

4 Install controls

Install DDC and incorporate the boiler system into the BAS to allow for greater control and increased efficiencies. Digital boiler controls and their heating distribution systems provide the opportunity to implement energy-saving strategies. These strategies include hot water reset, unoccupied hot water setback, boiler sequencing dependent upon load, boiler and pump lockout based on outside air temperature and steam header pressure control and setbacks.

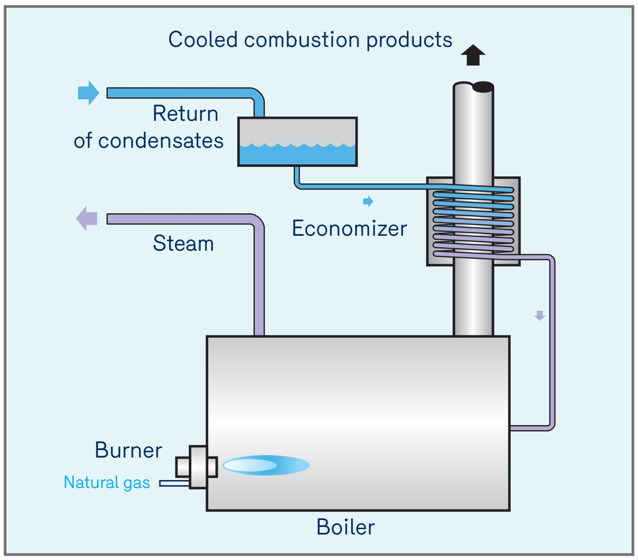
5 Utilize variable frequency drive (VFDs) or electronically computated motors (ECMs)

Utilize VFDs or ECMs 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. ECM pumps used to be limited to smaller boiler systems. Now the technology has made its way into larger motors. ECM pump stacks consisting of smaller pumps can provide greater efficiencies, control and redundancy with less maintenance issues. 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 horsepowers. By eliminating the control damper and slowing down the fan, appropriate air flows are supplied across all firing ranges, while saving fan motor energy.

6 Consider stack economizers for boiler systems

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

Figure 6: Boiler stack economizer



(Benefits of a natural gas condensing stack heat economizer, 2020)

7 Survey steam traps and condensate return

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

8 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.

9 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% efficient). These have a significantly higher annualized fuel utilization efficiency (AFUE) compared to standard efficiency units (80% - 85% efficient). Vent condensing units and condensate drain per manufacturer's specifications.

In addition to higher thermal efficiencies, furnaces should also have a variable speed ECM blower motor and multiple 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 savings during low heating loads.

10 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. An excellent way to think of it is if you step 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. Frequently opened spaces require more energy to comfortably warm occupants than to try and heat the whole air space with forced-air heating units.

11 Eliminate electric resistance heat when possible

It is common to find electric resistance heat 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 typical 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.

12 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. Measure heat pumps by their 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 specific applications and may require a backup heat source. Water source and ground source typically have COPs of 3.5 and higher. Considering geothermal systems is common in Wisconsin primarily if pursuing LEED certification.

13 Control refrigerant flow

A variable refrigerant flow (VRF) system 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. Compared to a conventional system, high efficiencies and increased control of a VRF system make them attractive, although the design and upfront cost can be prohibitive.

ENERGY EFFICIENCY CHECKLIST

1. SIZE BOILERS APPROPRIATELY

- Size boilers to operate within the best efficiency range for the majority of the heating season
- Install several smaller boilers to be staged during shoulder months, such as April and October

2. INSTALL HIGH-EFFICIENCY BOILERS

- Use condensing boilers (90%+ efficient) when the boiler's return water temperatures are less than 130° F
- Utilize near-condensing boilers (85%-90% efficient) when return water temperatures are greater than 130° F
- Install a hybrid boiler plant

3. UPGRADE BURNERS

- Utilize linkageless controls for a tighter fuel to air ratio
- Maintain proper fuel to air ratio with a programmable logic controller (PLC) based control system
- Operate boiler at partial firing rates

4. INSTALL CONTROLS

- Install DDC and incorporate the boiler system into the BAS

5. UTILIZE VFDS OR ECMS

- Utilize VFDs or ECMs for various boiler system functions
- Control hot water distribution pumps to allow the distribution pump to operate at slower speeds and flows
- Slow the pump down to match design flows to take the place of throttling valves
- Consider using VFDs for the burner combustion air fan
- Eliminate the control damper and slow down the fan

6. CONSIDER STACK ECONOMIZERS FOR BOILER SYSTEMS

- Recover steam boiler energy with a stack economizer

7. SURVEY STEAM TRAPS AND CONDENSATE RETURN

- Catch condensate and return it to the boiler by using steam traps in steam distribution systems
- Perform regular surveillance, maintenance and replacement of steam traps

8. INSULATE PIPES, FITTINGS AND VALVES

- Prevent heat loss by insulating hot water and steam pipes, fittings and valves

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

- Consider high-efficiency condensing furnaces and unit heaters (>90% efficient)
- Vent condensing units and condensate drain per manufacturer's specifications

10. INSTALL INFRARED HEATERS

- Consider Infrared heaters for spaces with large overhead doors that frequently or semi-frequently open

11. ELIMINATE ELECTRIC RESISTANCE HEAT WHEN POSSIBLE

- Replace electric heat with either gas-fired or hot water heat from a boiler system when possible

12. INSTALL HIGH-EFFICIENCY HEAT PUMPS	
	Install high-efficiency heat pumps in your facility
	Measure heat pumps by their coefficient of performance (COP)
	Consider air source, water source and ground source (geothermal) heat pumps as alternative sources of heat
13. CONTROL REFRIGERANT FLOW	
	Control the amount of refrigerant flow with a variable refrigerant flow (VRF) system

A ventilation system contains motors, ducts, fans, controls and heat exchange units that 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.

1 Perform routine maintenance

Properly maintain equipment and processes to keep the facility functioning at optimal 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/CO_2/humidity sensors to fail or become inaccurate. Recalibrate and repair or replace these components to maintain a high-efficiency HVAC system.

Figure 7: Ventilation systems – Before/after cleaning the coil

2 Optimize your ventilation strategy

Optimize outside air to occupant needs to save heating and cooling energy. The best option is to implement a demand-controlled ventilation strategy either by utilizing BAS scheduling options or through carbon dioxide (CO_2) sensors. Utilize an outside air ventilation reset strategy to save energy while still enabling occupant required ventilation rates.

3 Utilize 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 of delivering outdoor air to that zone. The goal of DCV is to optimize the intake of outside air during periods of reduced occupancy, reducing the energy needed to condition that outdoor air.

Conventional outside air reset methods for DCV are population counters, carbon dioxide (CO_2) sensors, timers, occupancy schedules or occupancy sensors. If using CO_2 sensors, make sure to calibrate or replace sensors every one to two years. Use CO_2 sensors with a 2% accuracy rating for longer-term reliability. ASHRAE Standard 62.1-2010, Section 6.2.7.1 provides further information about DCV strategies and minimum airflow calculations based on those strategies. Apply DCV to single zone, multi-zone and 100% OA zone units.

Figure 8: DCV in a single-zone system

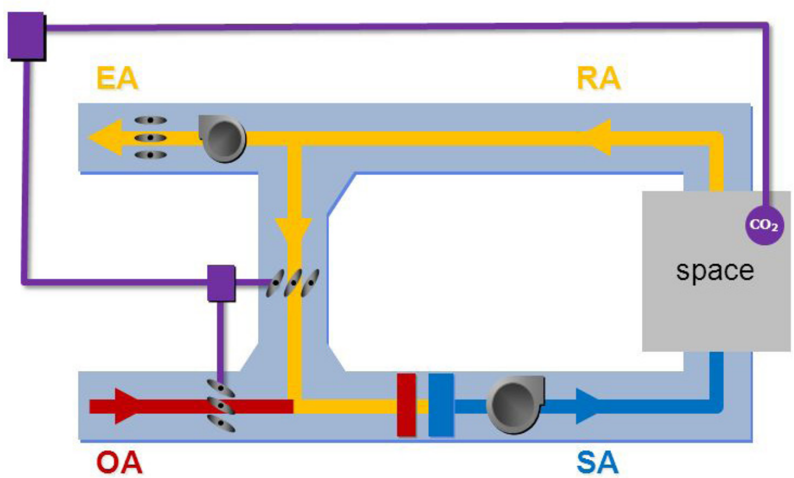
EA = EXHAUST AIR

RA = RETURN AIR

OA = OUTDOOR AIR

SA = SUPPLY AIR

(Murphy, 2016)



You can also apply DCV to commercial kitchen exhaust hoods. Use temperature and optical sensors to detect when the grill, 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 kitchen make-up air units (MAUs), which supply 100% 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 required 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 sensing an occupant, 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.

4 Exhaust fan control

Only operate exhaust fans in locker rooms and bathrooms during working hours. Install occupancy sensors, timers or connect fans to the BAS and program them to not run during unoccupied hours.

5 Exhaust air energy recovery

Exhaust air energy recovery is the process of exchanging the 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. Doing so pre-heats the air before passing over the heating coils for further heating. In cooling months, use exhaust air to chill warm, humid outside air before additional cooling and dehumidification.

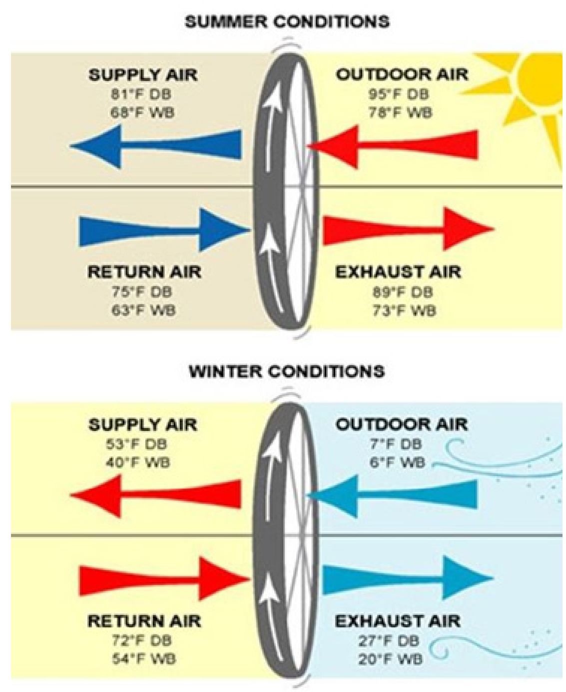
Ventilation heat recovery often allows for downsizing of heating and cooling plants. Types of energy recovery devices include:

- 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 and sensible heat transfer. In contrast, 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 moisture) from the outside air. It lowers the temperature (dry bulb) of the outside air.

Figure 9: Energy exchanged through an enthalpy wheel



(Shiminski, 2012)

Energy-saving tip:

When you are concerned with exchanging indoor and outdoor air, consider increasing the air pressure supply to reduce exchanges but keep the system design intact. Consult the manufacturer for guidance on how this will affect your equipment's performance.

6 Economize temperature set points

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. It usually occurs during the early morning hours in the Spring and Fall months, when using cooler outdoor air temperatures and low relative humidity to condition the space. An excellent range is between 50 - 65° F. To include humidity into the economizing control sequence, an outdoor humidity sensor is needed, and the control sequence calculates enthalpy. It is commonly known as an 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 with cooling capacities 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.

7 Utilize ventilation 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 and results in increased energy savings. DDC also allows for trending data. Trend data logging can be set up for any equipment connected to the DDC and is a valuable tool to troubleshoot problems and identify energy wasting conditions.

Install digital controls on ventilation systems to provide an opportunity 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.

Energy-saving 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).

8 Convert to 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 and heating/cooling energy. Enable a ventilation and VAV box minimum reset strategy to help save more energy. Connecting VAVs to room occupancy sensors is an energy savings strategy that resets the air handler's ventilation rate, along with the fan speed, when sensors signal a room is empty. VAV box minimum reset can lower the CFM signal when the room temperature is satisfied, reducing fan speed. Demand controlled ventilation strategies using CO_2 sensors to open ventilation dampers past their minimum settings, will further maximize energy savings.

9 Consider variable frequency drive (VFDs)

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

Typical applications for VFDs in ventilation systems are supply, return and exhaust fans. ECM fan motors in arrays of multiple smaller units is a technology catching on and can provide the benefits of higher efficiencies, better control and reduced noise when compared to one large fan motor.

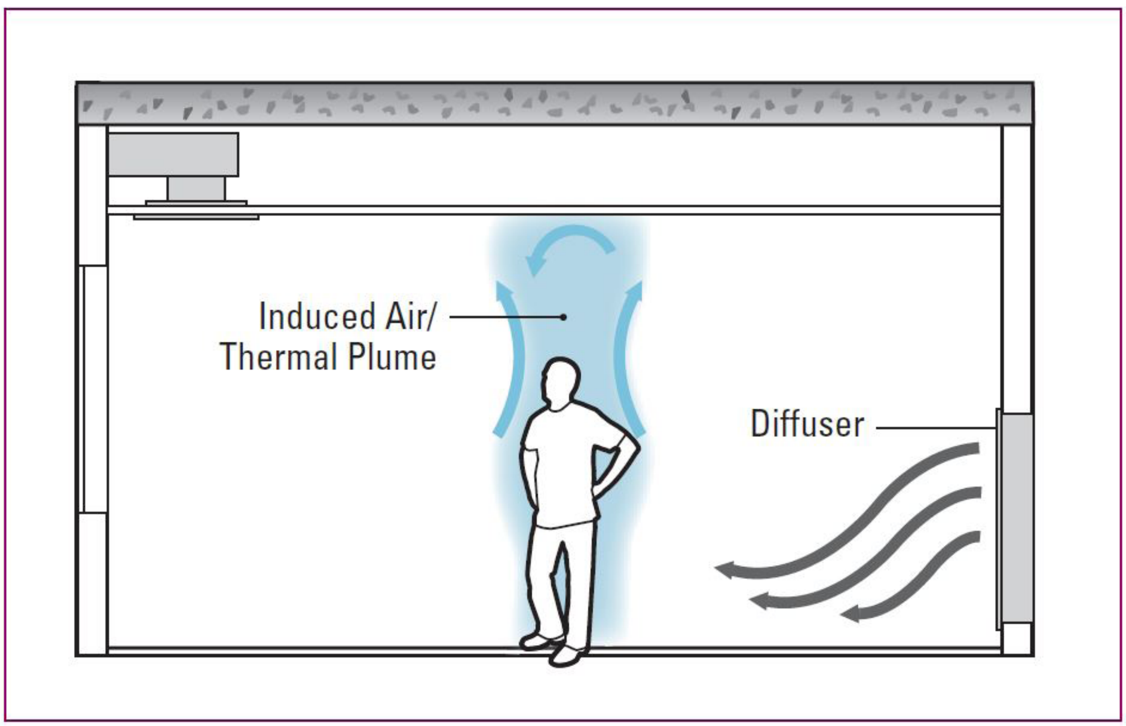
10 Explore displacement ventilation

Explore displacement ventilation when designing HVAC systems for a large number of occupants (Examples: open office spaces, auditoriums, cafeterias, classrooms, casinos, theaters, etc.). The room height should be at least nine feet with few obstructions. Cubicle offices are not ideal candidates. Contaminants should be warmer than the room air, as the supply air is cooler.

The low-velocity air delivered at floor level creates thermal plumes directed at heat sources (bodies, computers, slot machines) as the ventilation air warms and rises to the ceiling and eventually dissolves. Studies have shown improved indoor air quality in applications where heat is also the source of contaminants (Examples: body odor and CO_2 from breathing, casino cigarette smoke and the smell of hot food from cafeterias).

Since fan energy for low-velocity supply air can be reduced, there is potential for energy savings when appropriately applied. Another advantage of displacement ventilation systems is reduced noise levels.

Figure 10: Displacement ventilation



(Engineering Guide Displacement Ventilation, 2016)

ENERGY EFFICIENCY CHECKLIST

1. PERFORM ROUTINE MAINTENANCE

- Properly maintain equipment and processes to keep the facility functioning at optimal conditions
- Utilize a continuous improvement approach
- Develop an inventory of equipment and keep up-to-date maintenance logs to track maintenance functions

2. OPTIMIZE YOUR VENTILATION STRATEGY

- Implement a demand-controlled ventilation strategy
- Utilize an outside air ventilation reset strategy to save energy

3. UTILIZE DCV

- Apply DCV to single zone, multi-zone and 100% OA zone units
- Use temperature and optical sensors to detect when the grill, fryers or ovens are operating
- Use a VFD on the kitchen exhaust fan
- Link kitchen make-up air units (MAUs) to exhaust hoods
- Apply DCV to welding booths, wood shops and auto shops

4. EXHAUST FAN CONTROL

- Operate exhaust fans in locker rooms and bathrooms during working hours
- Install occupancy sensors, timers or connect fans to the BAS and program them to not run during unoccupied hours

5. EXHAUST AIR ENERGY RECOVERY

- Transfer heat from a warm building's exhaust air to heat the cold outside air
- Use exhaust air to chill warm, humid outside air before additional cooling and dehumidification

6. ECONOMIZE TEMPERATURE SET POINTS

- Bring large quantities of OA into a zone to offset the internal heat loads and keep the zone temperature at its set point
- Use differential enthalpy, fixed enthalpy or dew point and dry bulb temperature to help expand the economizer window

7. UTILIZE VENTILATION CONTROLS

- Install digital controls on ventilation systems
- Adjust schedules based on facility occupancy, including weekends, holidays and arranged school breaks
- Review and update schedules to incorporate changes in classroom schedules, summer hours and any other events

8. CONVERT TO VARIABLE AIR VOLUME (VAV) SYSTEMS

- Convert constant volume (CV) systems or VAV with inlet guide vanes to a VAV system with a VFD
- Enable a ventilation and VAV box minimum reset strategy
- Connect VAVs to room occupancy sensors

9. CONSIDER VFDS

- Vary fan speed based on the desired flow, pressure or temperature conditions

10. EXPLORE DISPLACEMENT VENTILATION

- Consider displacement ventilation when designing HVAC systems for a large number of occupants

Chillers are often the primary source of cooling for a school or government facility with substantial cooling loads. Use chillers to cool water, transferred through a distribution piping system to areas of use. Chillers, cooling towers, controls and distribution systems are essential 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, there are other factors to consider when selecting an appropriate type of chiller. There are also various types of compressors for chillers, such as reciprocating, centrifugal and screw.

1 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 running 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 capabilities. Therefore, use centrifugal chillers in larger chiller installations. Alternatively, screw chillers usually have slightly lower full-load abilities but have higher part-load efficiency at low cooling load ratios. Use this type of equipment 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 the coefficient of performance (COP), which describes efficiency at full load conditions, calculate the IPLV using the equipment's efficiency while operating at capacities ranging from 25 to 100%. Since a chiller does not always run at full capacity, the EER or COP is not an ideal representation of typical equipment performance.

2 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.

The Energy Efficiency Ratio (EER) frequently rates chillers. As 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 control cooling capacity further.

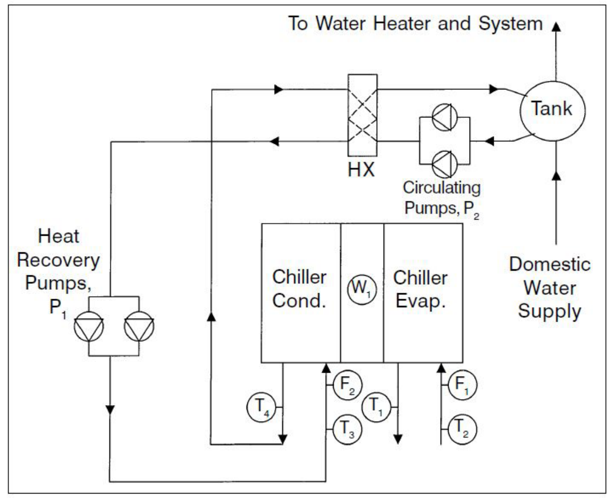
3 Utilize chiller heat recovery

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 or building reheat).

4 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.

Figure 11: Domestic water heating



(Durkin & Rishel, 2003)

5 Incorporate variable frequency drives (VFDs)

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.

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 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 for replacing throttling valves on condenser water pumps. These VFDs control return condenser water temperatures.

6 Utilize ice storage

Utilize ice storage to load shifts 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 produce chilled water without the compressor's use. It can result in significant savings on energy utility bills by reducing customer demand charges but does not necessarily save energy consumption (kWh).

7 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 chilled water to transfer to terminal units and coils, where it efficiently removes heat from the supply air.

8 Install high-efficiency direct expansion cooling

Install high-efficiency direct expansion (DX) cooling units in your facility. These systems include 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 determined by the cooling output is 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.

9 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. The Coefficient of Performance (COP) measures heat pumps. Electric resistance heating has a COP of 1.0, meaning 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. Do not use air source heat pumps for Wisconsin's cold climate. Water source and ground source typically have COPs of 3.5 and higher. Consider geothermal systems in Wisconsin, especially if pursuing LEED certification.

ENERGY EFFICIENCY CHECKLIST

1. SIZE CHILLERS AND SELECT TYPE APPROPRIATELY	
	Select a chiller for the best efficiency in the loading range it will most often operate
2. INSTALL HIGH-EFFICIENCY CHILLERS	
	Install high-efficiency chillers at your facility
3. UTILIZE CHILLER HEAT RECOVERY	
	Utilize a chiller system with a heat recovery device
4. INSTALL DDC	
	Install DDC and incorporate the chiller system into the BAS to allow for greater control and increased efficiencies
5. INCORPORATE VFDS	
	Incorporate VFDs for various functions of a chiller system
	Consider VFDs for the cooling tower fan
	Utilize VFDs for replacing throttling valves on condenser water pumps
6. UTILIZE ICE STORAGE	
	Utilize ice storage to load shifts from on-peak to off-peak hours
7. INSULATE PIPES, FITTINGS AND VALVES	
	Insulate chilled water and condenser water pipes, fittings and valves to prevent condensation and wasted energy
8. INSTALL HIGH-EFFICIENCY DIRECT EXPANSION COOLING	
	Install high-efficiency direct expansion (DX) cooling units in your facility
	Select a unit with high IEER values, as it will typically operate most of the cooling season at part-load
9. INSTALL HIGH-EFFICIENCY HEAT PUMPS	
	Consider installing high-efficiency heat pumps
	Consider geothermal systems in Wisconsin, especially if pursuing LEED certification

BEST PRACTICES FOR PLUMBING

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 method will work best, the long-term energy use (efficiency) of the system, the size and capacity of the system and available fuel options. Additional solar hot water and other renewable energy options are in the Renewable Energy section.

1 Study fuel options

When selecting a new water heating system, you want to ensure it will provide enough hot water in the most energy-efficient way. Not only does this include comparing fuel costs, but you also want to determine the right size and fuel source for your operation. Take the time to decide which type, model and fuel option are suitable for your facility.

2 Determine hot water system sizing

When sizing a hot water system, keep in mind the first-hour rating (FHR) for a tank water heater included in the energy usage comparison. This information, located on the Energy Guide label as capacity (first-hour rating), indicates how much hot water to deliver in the first hour. Compare 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 www.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 unavailable and take advantage of off-peak electric rates offered by your utility company. Before purchasing a new hot water heating system, consider water conservation efforts such as low flow faucets, shower heads and kitchen pre-rinse spray valves to reduce your current water heating needs.

3 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. Adding tank insulation or adjusting the temperature setting are examples of simple adjustments to your water heater's useful life. Routine maintenance for storage water heaters, depending on what type/model you have, include:

- Fixing, replacing or adding insulation to the water heater and distribution piping
- 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

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 heated continuously in the tank, wasted energy even when a hot water tap isn't running known as a 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.

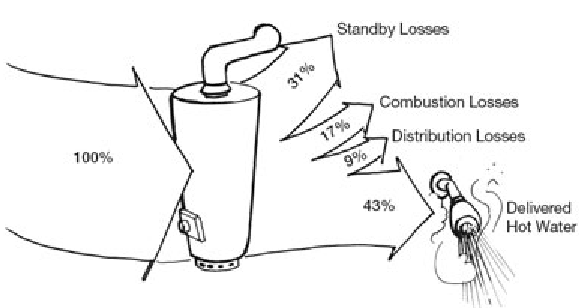
The energy efficiency of a storage water heater is indicated by its energy factor (EF), an overall measure of efficiency based on the assumed use of 64-gallons of hot water per day, regardless of tank size. A general rule of thumb is the smaller the water heater tank, the higher the efficiency rating. 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.

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.

Figure 12: Storage water heater

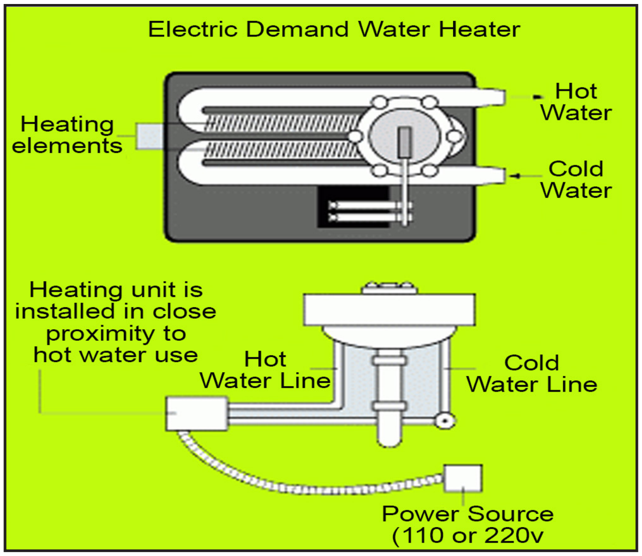


(ACEEE, 2017)

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 is typically reduced by 10 to 15%. The initial cost for a tankless water heater is higher than a conventional storage water heater. Tankless water heaters usually 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 extending their lives by many more years.

Gas-fired and electric tankless water heaters are available. However, tankless water heaters are not appropriate for every facility. The flow rate is limited 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 with hot water supply. 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.

Figure 13: Electric demand water heater



(United States Department of Energy, 2020)

Energy-saving tip:

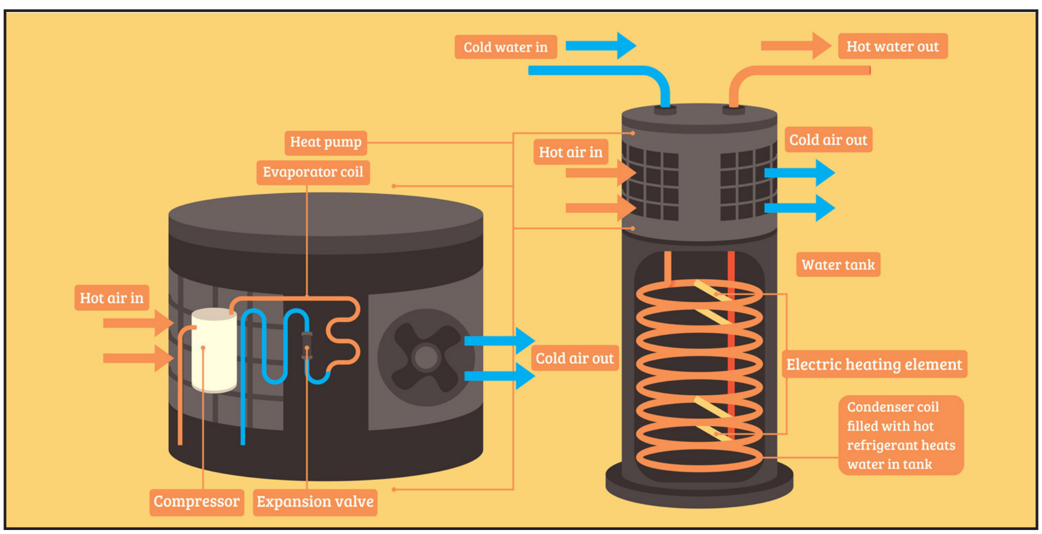
Install natural gas demand water heaters in kitchens with natural gas equipment to optimize energy savings potential.

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 higher.

Purchase a stand-alone water heat pump 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 systems pull heat from the outdoor air in the winter and indoor air in the summer. A desuperheater is a small, auxiliary heat exchanger. In conjunction with a geothermal heat pump system, these systems use 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 pool heat pumps 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.

Figure 14: Heat pump water heater anatomy



(Kar, 2020)

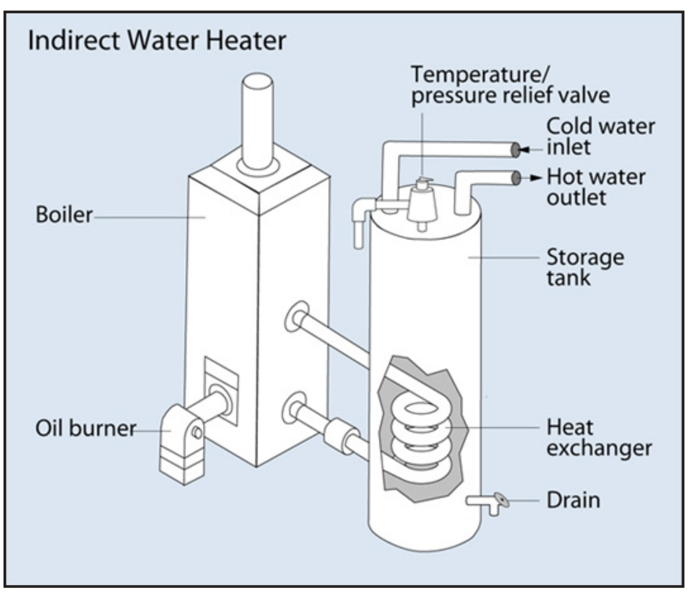
Integrated Water and Space Heating – Tankless coil and indirect water heaters use a building's space heating system to heat water. A tankless coil water heater provides hot water on demand without a tank. When hot water is needed, water is heated as it flows through a heating coil or heat exchanger installed in a central furnace or boiler. Tankless coil water heaters are most efficient during cold months when frequently using heating systems.

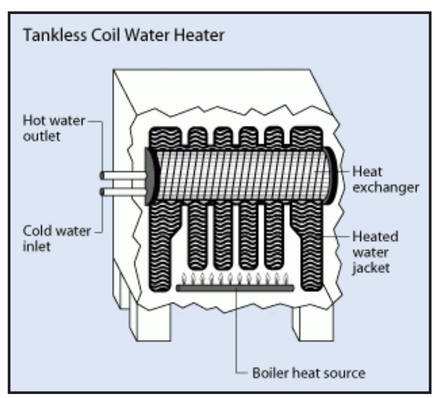
An indirect water heater uses the main furnace or boiler to heat a fluid circulated through a heat exchanger in the storage tank. The energy stored in the water tank allows the furnace to turn off and on less often, which saves energy. An indirect water heater, if used with a high-efficiency boiler and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

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

Figure 15: Indirect water heater





(United States Department of Energy, 2020)

ENERGY EFFICIENCY CHECKLIST

1. STUDY FUEL OPTIONS

- Switch from electric to natural gas water heaters when natural gas is less expensive to operate than electricity
- Be prepared to pay a higher upfront cost for a natural gas water heater
- Take the time to decide which fuel option is right for your facility

2. DETERMINE HOT WATER SYSTEM SIZING

- Keep in mind the first-hour rating (FHR) for a tank water heater included in the energy usage comparison
- Look for water heater models with a first-hour rating that matches within one or two gallons of your peak-hour demand
- Consider water conservation efforts to reduce your current water heating needs

3. PERFORM ROUTINE MAINTENANCE

- Perform periodic water heater maintenance to extend your water heater's life and minimize loss of efficiency
- Read your owner's manual for specific maintenance recommendations
- Contact a qualified plumbing and heating contractor for assistance

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.

1 Increase water use awareness

Educate building occupants on the 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 reduce hot water use significantly. 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. It 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 showerhead, 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.

Energy-saving tip:

Report shower and faucet leaks to facility staff right away.

4 Install low-flow fixtures and appliances

Install quality, low-flow fixtures and appliances to reduce water consumption by 25 to 90% 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 create individual streams of water. For maximum water efficiency, select a shower head with a flow rate of less 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 modern 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 an excellent way to reduce unnecessary hot water consumption.

Pre-rinse spray valves for commercial kitchen valves also present an opportunity to reduce water heating costs by increasing pressure and reducing the amount of water flow for pre-rinsing. The Center for Energy Efficiency and the U.S. 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 more 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.

PLUMBING BEST PRACTICES – HOT WATER CONSERVATION

ENERGY EFFICIENCY CHECKLIST

1. INCREASE WATER USE AWARENESS	
	Educate building occupants on the best water reduction practices
	Organize discussions about water use in your facility
	Take the time to decide which fuel option is right for your facility
	Seek suggestions for conservation strategies
	Assign responsibilities
	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
2. FIX LEAKS	
	Repair drips and leaks in fixtures, faucets, showerheads and pipes to reduce hot water use significantly
3. INSULATE HOT WATER PIPES	
	Insulate hot water pipes to reduce heat loss and raise water temperature by 2 to 4 degrees
	Keep insulation at least six inches from the flue
	Use fiberglass pipe-wrap (at least one-inch thick) and either wire or aluminum foil tape to secure it to the pipe
4. INSTALL LOW-FLOW FIXTURES AND APPLIANCES	
	Install quality, low-flow fixtures and appliances to reduce water consumption by 25 to 90%
	Select a shower head with a flow rate of fewer than 2.5 gallons per minute (GPM)
	Purchase faucet aerators with flow rates of no more than 1.0 GPM
	Reduce unnecessary hot water consumption with motion sensor-activated faucets
	Reduce water heating costs by increasing pressure and reducing the amount of water flow for pre-rinsing
	Select a washing machine that allows you to adjust the water temperature and levels for different loads
	Look for a front-loading machine that uses less water and has an ENERGY STAR label

BEST PRACTICES FOR EFFICIENT 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 crucial to keep occupant health and safety in mind when reviewing potential energy-saving opportunities.

1 Purchase ENERGY STAR® equipment

Look for the ENERGY STAR rating and pre-qualification information when purchasing new equipment for your commercial kitchen. This equipment includes:

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

Install quality, low-flow fixtures and appliances to reduce water consumption by 25 to 90% 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. ENERGY STAR rated dishwashers are 40% more energy efficient and save an additional 50% on water usage over standard models (Commercial Dishwashers, 2020).

Cooking Equipment - ENERGY STAR certified steam cookers reduce water use by 90% or more and are up to 60% more energy-efficient than 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 (Commercial Steam Cookers, 2020).

2 Review booster heater use for dishwashing

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 lower-temperature set points on the central water heating system. Using a separate demand heating system as a booster will also achieve this effect.

Update electric booster heaters to the gas-fired equivalent to reduce demand charges on your electric bill. Depending on operating hours, it can reduce costs by 60 to 80%. 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 equipment would provide a payback of fewer than two years (Madison Gas and Electric, 2017).

3 Update kitchen ventilation equipment

Commercial kitchen ventilation equipment removes 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 space. A large amount of conditioned (heated or cooled) air can be lost through this process if done incorrectly. It requires additional heating and cooling. A dedicated system or kitchen hood that provides makeup air without pulling from the facility will result in energy savings.

Install a demand-controlled kitchen ventilation (DCKV) system to realize energy savings of 60% 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 operate at the maximum designed speed/volume or provide manual control over two speeds throughout the kitchen's working 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 makeup air fan to limit activity when the exhaust fan is operating.

Energy-saving 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.

ENERGY EFFICIENCY CHECKLIST

1. PURCHASE ENERGY STAR® EQUIPMENT	
	Look for the ENERGY STAR rating and pre-qualification information when purchasing new equipment
	Install quality, low-flow fixtures and appliances to reduce water consumption
	Install an energy-efficient dishwasher and only operate it with full loads
	Utilize energy-efficient steam cookers shorten cook times and increase production rates
2. REVIEW BOOSTER HEATER USE FOR DISHWASHING	
	Update electric booster heaters to the gas-fired equivalent to reduce demand charges on your electric bill
3. UPDATE KITCHEN VENTILATION EQUIPMENT	
	Install a demand-controlled kitchen ventilation (DCKV) system
	Install temperature and/or optical sensing controls to reduce unnecessary exhaust fan operation
	Tie controls with the makeup air fan to limit activity when the exhaust fan is operating

BEST PRACTICES FOR 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 a 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 it does not use the energy-saving functions.

1 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 user can directly control the power. 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 (Low Carbon IT Campaign Frequently Asked Questions (FAQs), 2020).
- **Sleep mode –** Instead of a screen saver, set your monitor to sleep mode after 5 - 15 minutes of inactivity, and the hard disk will turn off after 30 – 45 minutes of inactivity.
- **Monitor display –** Adjust your display/monitor's brightness to be below 50%, 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 several 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.

2 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.

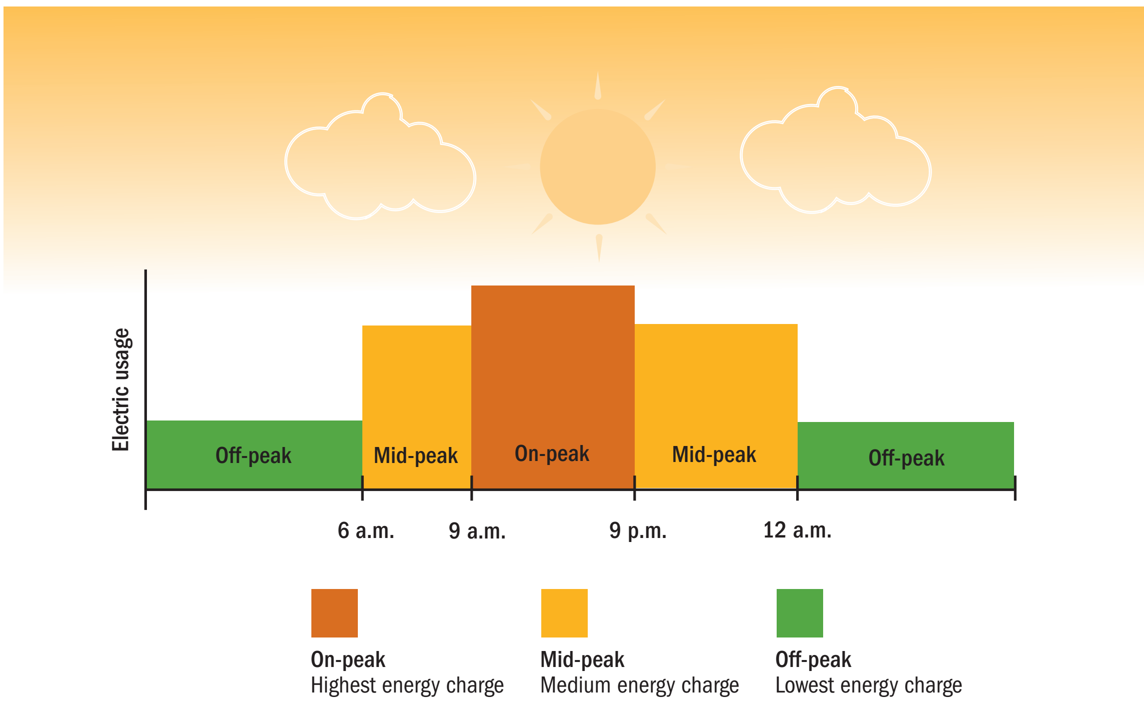
3 Utilize advanced power strips

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

4 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 is 9 a.m. to 9 p.m. Monday through Friday, excluding legal holidays.

Figure 16: Typical electric usage



5 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 can reduce the number of computers and 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, 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.

6 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 degrees Fahrenheit as the optimal temperature range for saving energy. (Dell Technologies, 2011) However, newer servers can handle even higher temperatures, closer to 90 degrees Fahrenheit.

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 the year when outside cooling is available.

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

7 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 (backside) 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, the cooling capacity will not have to overcome heat from the servers, as is typical in a server room served by split systems or other means of centralized cooling. Efficiency is gained through this more efficient use of cooling capacity.

8 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.

Energy-saving tips:

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

ENERGY EFFICIENCY CHECKLIST

1. EDUCATE BUILDING OCCUPANTS ON COMPUTER USAGE AND POWER MANAGEMENT

- Avoid screen savers as they use twice as much energy as when the computer is in use
- Set your monitor to sleep mode after 15 minutes of inactivity, and the hard disk will turn off after 45 minutes of inactivity
- Adjust your display/monitor's brightness to be below 50%
- Turn off your computer at night and on weekends
- Enable energy-saving settings for other appliances, such as smart boards, copiers and printers
- Utilize energy monitoring equipment usage and analyze accompanying utility costs

2. SELECT ENERGY STAR® RATED EQUIPMENT

- Look for the ENERGY STAR rating and pre-qualification information when purchasing new technology

3. UTILIZE ADVANCED POWER STRIPS

- Utilize power strips with a timer to switch off copiers, printers and laminators at the end of the day

4. CHARGE COMPUTERS OFF-PEAK

- Charge laptops and tablets 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

5. USE VIRTUAL SERVERS

- Virtualize servers to reduce the number of computers and the amount of energy being used
- Access a virtual snapshot backup and redeploy it on a newly created virtual server
- Consolidate applications on one server to reduce electricity consumption and save on cooling costs

6. MONITOR SERVER ROOM TEMPERATURE

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

7. 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
- 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

8. 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

BEST PRACTICES FOR 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%. Not only will reducing air leakage increase energy and cost savings, but it will also positively impact occupant comfort, increase indoor air quality and add to the structural integrity of the building envelope through moisture mitigation.

The proper control of air leakage involves using appropriate materials, such as fire retardant, polyurethane foam, caulks and weather-stripping materials, to seal gaps, cracks and holes completely. 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.

1 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 there might be gaps/cracks or insulation is missing. Keep a log of these areas to help you document current conditions and adequately 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.

2 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.

3 Arrange for a professional to test and balance your facility

Examining building pressure and ensuring a facility is balanced is an integral 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.

4 Add insulation during a roof replacement

Take a core sample when preparing to replace a roof on a commercial building. This will help determine how much insulation to add when removing the old roof membrane. The building code describes the recommended amount of insulation for a roof by region. The recommendation is to add the insulation necessary to bring the building up to "code." For example: New construction levels in Wisconsin are R-value = 38.

5 Replace doors and 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.

6 Inspect roofs

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

7 Install high-speed overhead doors/ensure a tight seal

Installing high-speed overhead doors and ensuring they make a tight seal, will reduce airflow through the door. This process 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 overhead doors.

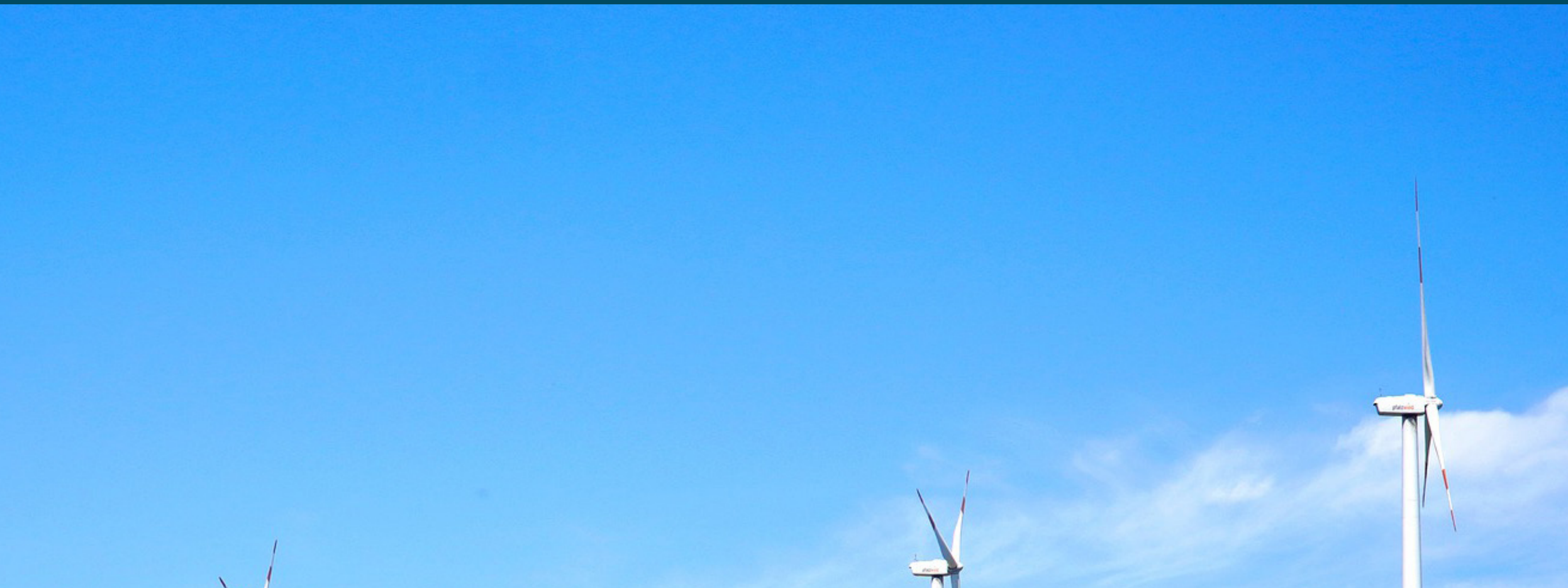
Energy-saving tips:

- 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).

ENERGY EFFICIENCY CHECKLIST

1. 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 there might be gaps/cracks or insulation is missing
	Keep a log of areas to help you document current conditions and adequately plan for material repair or replacement
	Consult with an Energy Advisor a building envelope professional with questions or concerns that arise during walk throughs
2. HIRE A CONTRACTOR TO PERFORM A FACILITY AUDIT	
	Determine current building envelope concerns by hiring a contractor to perform an initial facility audit
3. ARRANGE FOR A PROFESSIONAL TO TEST AND BALANCE YOUR FACILITY	
	Examine building pressure and ensure a facility is balanced by hiring a professional to test the facility
4. ADD INSULATION DURING A ROOF REPLACEMENT	
	Take a core sample when preparing to replace a roof on a commercial building to determine insulation needed
	Add any insulation necessary to bring the building up to “code”
5. REPLACE DOORS AND WINDOWS	
	Replace doors and windows with a high R-value and low U-value option recommended by ENERGY STAR
6. INSPECT ROOFS	
	Consult a qualified roof inspector annually to maintain factory warranty
7. INSTALL HIGH-SPEED OVERHEAD DOORS/ENSURE A TIGHT SEAL	
	Install high-speed overhead doors and ensure they make a tight seal to reduce airflow
	Provide door openers in vehicles so staff won't need to get out of their vehicles to open or shut the overhead doors

BEST PRACTICES FOR RENEWABLE ENERGY



Wisconsin's fossil fuel resources are limited and typically purchased out of state. Investing in renewable energy installations directly in Wisconsin can help grow local businesses and advance the statewide economy.

On-site renewable energy systems provide security and storage. Power outages typically affect normal business operations, but with on-site renewable energy, greater reliability and energy security can be achieved. Costs for renewable energy systems, especially solar photovoltaic (PV), have decreased substantially over the years. It is becoming financially practical to pursue renewable energy options.

Types of renewable energy

Wind – Wind energy describes how the wind is used to generate electricity through turbines converting the kinetic energy of wind into mechanical power. Wind turbines are not as common in Wisconsin as they are in other states. Due to the varying terrain and tree cover, wind resources are considered useful in only a few areas. A finite amount of small or utility-scale wind turbines are installed in the state.

Biomass – Biomass is the burning of solid, combustible organic matter directly for fuel. Examples of biomass include crops and waste materials, tree bark and other wood-derived products and garbage. Biomass can also be converted to biogas or liquid biofuels such as ethanol and bio-diesel. For more details on biomass, visit the U.S. Energy Information Administration website: www.eia.gov/energyexplained/biomass.

Solar Photovoltaic (PV) – PV solar energy is the process of converting sunlight into electricity. This process uses a technology based on the photoelectric effect where certain materials can absorb light particles (photons) and release electrons, generating an electric current. PV panels have increased efficiency and decreased in cost over the last ten years. Paybacks that used to be over 25 years are now under ten years. Standard panel sizes that were 200 watts ten years ago are now 300 watts. PV panels are typically installed in an array sized for the common inverter capacity based on the customer's needs. These arrays can be roof mounted, pole mounted or ground mounted. For more details on solar PV, visit www.energy.gov/eere/solar/articles/solar-photovoltaic-technology-basics.

Biogas – Biogas is a fuel derived from the decomposition process of organic compounds such as animal manure, human waste and landfill waste. Municipal wastewater treatment plants have the opportunity to collect methane from wastewater digesters using waste as a fuel. More details about this technology can be found in the Energy Best Practices Guide: Water & Wastewater Industry available at focusonenergy.com/guidebooks.

Photo caption: Roof mounted PV array

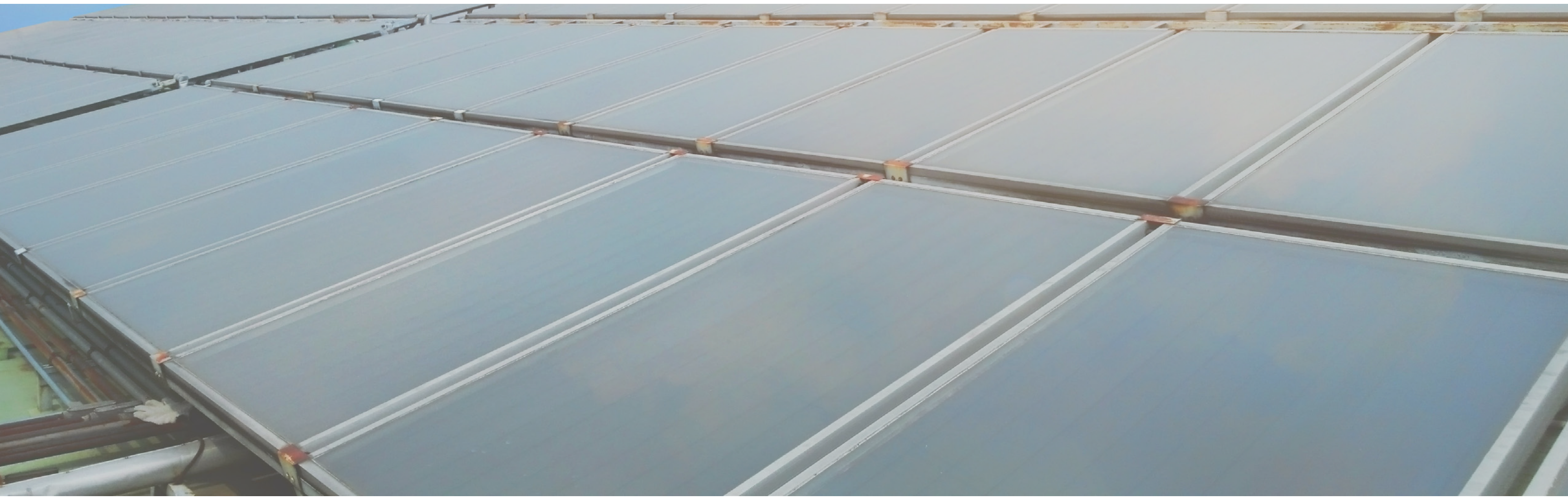
Photo caption: Pole mounted PV array with tracker system

Pole mounted PVs track the sun's daily path and adjust tilting for optimal performance seasonally. Pole mounted arrays can also be in a fixed position.

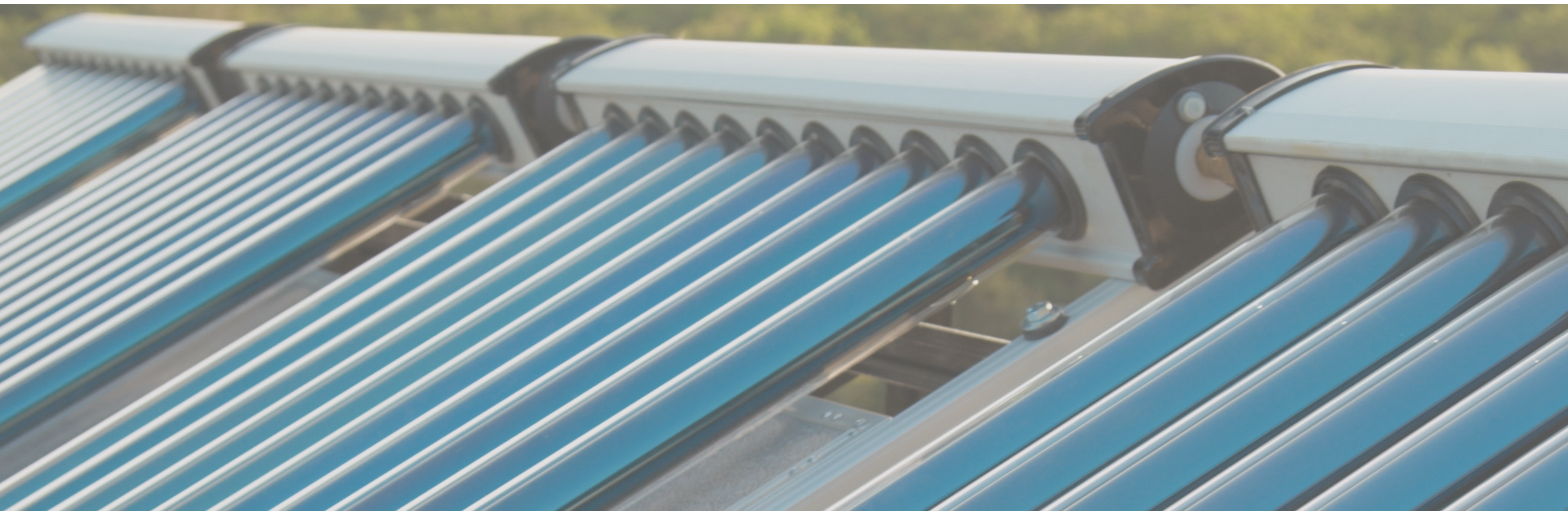
Solar hot water: If you need large amounts of hot water available year-round, then investing in solar panels to heat water might be the perfect solution. Schools or municipalities with pools or extensive laundry/shower uses are excellent examples. If you don't need hot water in the summer when the solar resource is ideal, then it might not be the best investment. For more details on solar heating, visit www.energy.gov/energysaver/water-heating/solar-water-heaters.

There are two types of commercial solar water heating panels:

- **Flat-plate collector -** Glazed flat-plate collectors have an absorber plate consisting of copper painted black and stored in an insulated box covered in glass or plastic. Unglazed flat-plate collectors have an absorber plate made of polymer or metal, typically used for pool heating.



- **Evacuated-tube collector (vacuum tube) -** These collectors consist of rows of glass tubes surrounding a metal absorber tube attached to a fin. The fin's dark coatings absorb solar energy, and the vacuum tube inside maintains heat for efficient transfers.



1 Pursue energy efficiency measures first

There are many energy-efficient opportunities with better paybacks than renewable energy installations. Achieving energy efficiency should be considered first. By upgrading facilities to be as energy-efficient as possible, the size of the renewable energy systems required to meet on-site energy consumption can be scaled back.

2 Consult with a trained professional

Explore renewable energy options with the help of a trained professional. You will need to evaluate your utility rate-structure, net-metering agreements and interconnection requirements. This background information will provide essential details required to complete a cost/benefit analysis, additional ROI calculations and determine the appropriate size of a renewable energy system.

3 Maximize your system's energy potential

States that generate a substantial percentage of their electricity with renewables are also investing in large-scale battery storage. This type of storage allows for energy to be produced at night by wind turbines and then stored for use the following day. With battery storage, PV arrays can be sized large enough to generate excess energy. Creating more energy through renewable sources leads to less dependency on baseload plants, often fueled by coal, natural gas and nuclear power.

4 Utilize available funding mechanisms

Take advantage of federal tax credits, programs and other funding mechanisms such as Focus on Energy incentives or State Energy Office funds.

ENERGY EFFICIENCY CHECKLIST

1. PURSUE ENERGY EFFICIENCY MEASURES FIRST	
	Upgrade facilities to be as energy-efficient as possible before considering renewable energy installations
2. CONSULT WITH A TRAINED PROFESSIONAL	
	Explore renewable energy options with the help of a trained professional
	Evaluate your utility rate-structure, net-metering agreements and interconnection requirements
	Complete a cost/benefit analysis to determine the appropriate size of a renewable energy system
3. MAXIMIZE YOUR SYSTEM'S ENERGY POTENTIAL	
	Generate a substantial percentage of electricity with renewables by investing in large scale battery storage
4. UTILIZE AVAILABLE FUNDING MECHANISMS	
	Take advantage of federal tax credits, programs and other funding mechanisms

APPENDIX


K I L O W A T T H O U R S
SINGLE-STATOR WATTHOUR METER
TYPE AB1 S. [redacted]
CL 240 V 3 W 60 Hz TA 30
MADE IN

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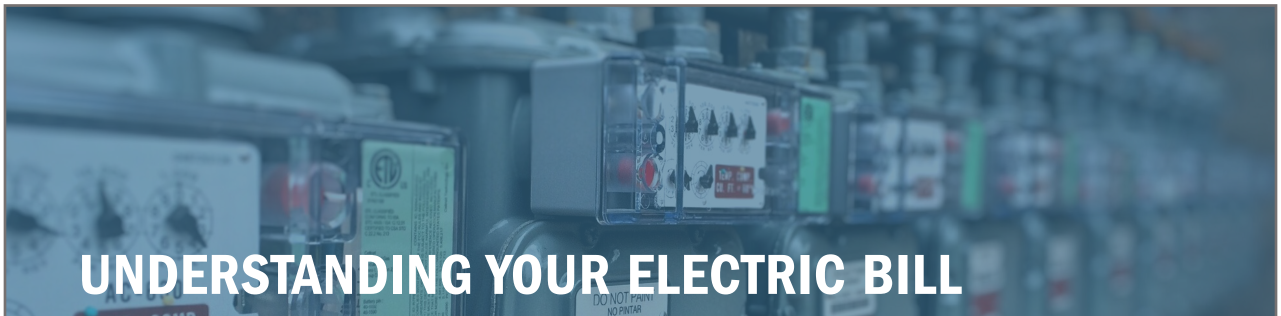

UNDERSTANDING YOUR ELECTRIC BILL

Your monthly electric bill is a valuable tool that you should learn to read and understand. The first step in understanding your facility's statement is to determine when and how much energy you are consuming. To develop this understanding, contact your electric provider account representative to review your daily, weekly and monthly electric use patterns. This knowledge will allow you to evaluate your operating procedures to identify if operational adjustments would reduce your use, costs and provide a strategy to include in your energy management plan.

Table 1, below, is a sample electric bill for an elementary school. This sample provides information and data to help you better understand the standard terms and definitions below. The demand charge (kW) generally represents 30 to 40 percent of the total monthly bill. It is usually an area that can be reduced and provide substantial savings.

1. **Billing dates**
2. **The number of calendar days** during the billing period
3. **On-peak energy**: All energy (kWh) used during peak hours
4. **On-peak maximum demand:** Maximum demand during on-peak hours for the billing period
5. **Off-peak energy:** All energy (kWh) used outside of peak hours
6. **Maximum measured demand:** Demand at any time during billing period both on-peak and off-peak
7. **On-peak period**
8. **Distribution demand (customer demand):** Maximum demand during last 12 months both on-peak and off-peak
9. **Power factor:** Indicator of extra power supplied by the utility to overcome reactive power from inductive loads on-site
10. **Load factor:** Indicator of average demand compared to maximum demand
11. **Customer charge:** Monthly flat fee for administration, meter reading, billing, etc.
12. **Distribution demand charge:** Charge for maximum demand during last 12 months
13. **Billed demand charge:** Charge for on-peak maximum demand during the billing period
14. **On-peak kWh energy use charge:** Charge for energy used during peak hours

Table 1. Sample electric bill

Customer Detail						**Bill Due: 06/20/2018**
ABC ELEMENTARY SCHOOL			Account Number			2205
EDUCATION LANE			Service From		1	03/28/2018
XYZ, WI 00000			Service To			04/28/2018
			Bill Days		2	31
Electric Power Usage						
Energy Usage						
On-Peak	3	29,024 kWh	On-Peak Maximum Demand		4	176.20 kW
Off-Peak	5	14,918 kWh	Date/Time			04/18/2018 1:00 PM
Total Energy		43,942 kWh				
			Maximum Measured Demand		6	176.20 kW
Total Reactive Energy		13,190 kvarh	Date/Time			04/18/2018 1:00 PM
On-Peak = 7am-9pm, M thru F 7			Distribution Demand		8	319.50 kW
			Date/Time			09/18/2017 10:30 AM
Billed Demand = On-Peak Maximum Measured Demand						176.20 kW
Average Power Factor = (Total Energy / SQRT (Total Energy ^2 + Total Reactive Energy ^2)) x 100					9	95.8%
Average Load Factor = (Total Energy / (Maximum Demand x Hours in Billing Period)) x 100					10	33.5%
Bill Computation Under Rate Schedule						**Cp2**
Customer Charge					11	$200.00
Demand Charges						
Distribution Demand		319.50 kW	x	12 $1.75	$559.13	
Demand		176.20 kW	x	13 $8.00	$1,409.60	
Total Demand Charges					$1,968.73	
Energy Charges						
On-Peak		29,024 kWh	x	14 $0.05950	$1,726.93	
Off-Peak		14,918 kWh	x	15 $0.04900	$730.98	
Total Energy Charges		43,942 kWh			$2,457.91	
Subtotal Demand and Energy Charges						$4,426.64
Power Cost Adjustment Clause		43,942 kWh	x	($0.0019)	16	($83.49)
TOTAL POWER COST						$4,543.15
Sales Tax (100.00% Tax Exempt)		$4,543.15	x 5.60% x	0.00%		$0.00
TOTAL POWER BILL						$4,543.15
Commitment to Community Charge					17	$35.00
Late Charge						$0.00
Balance Forward						$0.00
TOTAL ELECTRIC BILL						**$4,578.15**

15. **Off-peak kWh energy use charge:** Charge for energy used during off-peak hours
16. **Power cost adjustment:** Monthly allowable adjustments made by the utility
17. **Community assistance:** A Wisconsin state-mandated fixed fee

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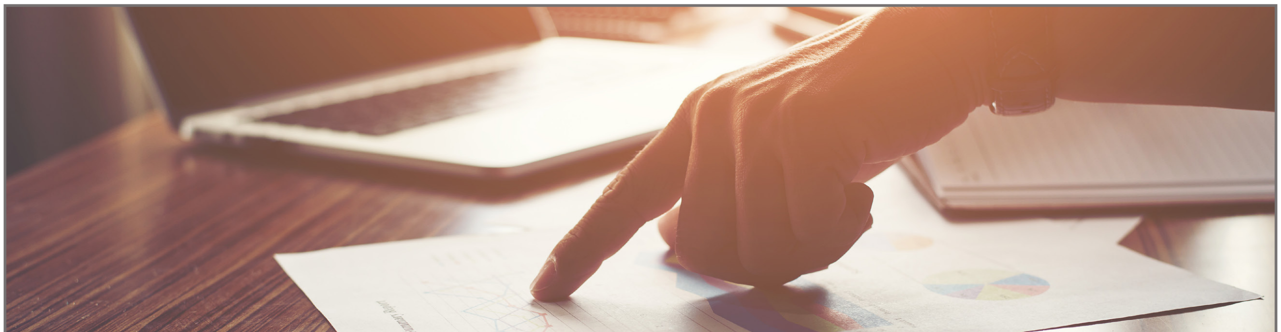
UNDERSTANDING YOUR ELECTRIC BILL



The bill comes due

Your electric bill may contain separate charges for energy consumption and demand. Energy consumption (kWh) is billed at a rate ($/kWh) depending on the time of consumption, on-peak or off-peak, multiplied by the total kWh used during the billing period. Electric demand (kW) is billed at a rate ($/kW) depending on the time of consumption, on-peak or off-peak, that is multiplied by your facility's peak demand during the billing period.

Typically, electric utilities base demand charges on daytime peak demand. Daytime or on-peak is generally 12 hour weekdays (for example, 8 AM to 8 PM). Utilities' generating and distribution systems are heavily loaded during these on-peak use hours. Additional charges include facility costs, taxes and fuel cost adjustments. These charges are generally related to your overall electricity consumption, not your facility's demand charge. The higher your facility's electrical consumption and electric demand is the higher your utility bill.

Taking action

You can better manage your energy consumption when you understand how your facility's electric use is metered and billed. Then you can take steps to make operational changes to reduce these costs.

For example, energy and cost-saving steps can include:

- Identifying the time of your on-peak demand, determine the causes of this peak use, and identify ways to reduce it. Consider possible strategies to shift equipment operations into electric utility off-peak periods.
- Set controls so operations are staggered (for instance, two pumps that need to operate only one hour per day should be controlled, so do not work at the same time).
- Develop a comprehensive energy and cost reduction plan and share it with your operators.
- Benchmark your energy use and evaluate trends over time.

Benefits of understanding your bill:

1. **Reduce expenses:** Electric costs represent a large manageable portion of your yearly budget.
2. **Use the savings on other projects:** When you can show on your utility bill that you reduced your electricity usage and cost, you may be able to use those savings to fund other facility needs.
3. **Manage rising energy costs:** Electricity costs will certainly increase in the years ahead; become proactive and start managing these costs now.

For assistance with understanding your electric bill, and for other energy-efficiency improvement needs contact us at

888.623.2146 or

business@focusonenergy.com

REDUCING ENERGY WASTE ACROSS WISCONSIN

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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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.

Table 3: Recommended and average foot-candle levels

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, resulting in a less than five-year project payback, as shown in the equation below.

$80,000 - $8,000 (Focus on Energy incentive) = $72,000 / $15,600 = 4.6 year payback

Implementation plan

Install new LED fixtures and occupancy sensors over three days 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 = $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 reduced energy.

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