

ENERGY TALK CARDS

ON COMMERCIAL ENERGY EFFICIENCY

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2022 EDITION

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CONTACT US

Have an idea or need support?

Reach out to your utility or contact us directly!

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STRATEGIC ENERGY MANAGEMENT

Strategic Energy Management (SEM) is an energy management practice that helps you:

- Get everyone on your team working together to reduce energy use
- Increase the efficiency of facility staff
- Improve building operational practices
- Reduce energy costs
- Reduce operation and maintenance (O&M) expenses
- Reduce equipment failure
- Maintain tenant comfort and indoor air quality

By looking at the whole building and integrated systems, you can diagnose systems that are under-performing, identify ways to reduce energy use and costs, and ensure your equipment is running optimally at all times.

There are a few key things to keep in mind when considering commercial buildings and related technologies. First, it's important to understand that the building is a system in itself. As such, when you make changes to one system, other systems can be impacted. Additionally, it's imperative to stay informed of new building technologies and their applications as they are always evolving. Be sure to keep both of those things in mind as you consider the recommendations outlined in the following Energy Talk Cards.

Note: These cards do not currently cover specialized energy management categories such as food service or health care.

HOW TO USE THESE CARDS

AUDIENCE:

Building managers, engineers, and maintenance or facilities staff.

PURPOSE:

These cards provide key learning points and discussion topics on energy efficiency to engage your team in discussions and provide you with the information needed to pursue energy efficiency in commercial buildings.

TAKE ACTION:

These Energy Talk Cards cover many of the items most commonly contributing to poor building performance. To take what you learn and put it into practice, consider creating an energy checklist based on your unique areas of opportunity. This checklist can serve as a starting point as you walk around your building(s), helping you identify and flag potential problem areas.

USE:

- Pose questions at staff engagement events and meetings to stimulate conversation and learning.
- Upload cards on digital monitors in shared spaces to bring attention to energy usage site wide.
- Share cards digitally via email or newsletters.
- Print cards and post in relevant areas or on energy boards.
- Make card deck easily accessible via internal intranet.
- Create new cards for location-specific needs using the blank cards provided at the end of this deck.

Ideas or opportunities that come out of discussions should be recorded in your project tracking platform and progress shared with your team.

BUILDING ENVELOPE

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QUESTION

In a typical building shell, what is the thermal weak spot, and what are some ways that it can be made stronger?



ANSWER

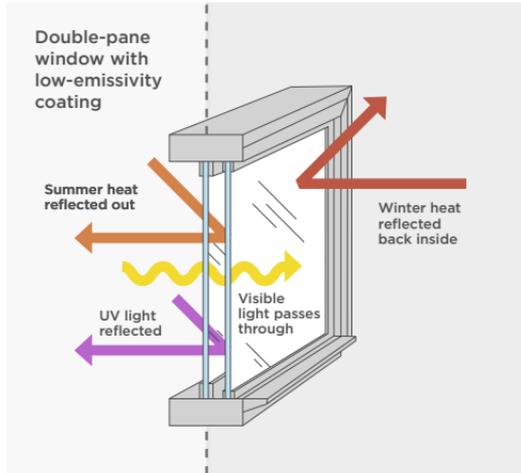
Windows are the thermal weak spot, allowing up to 15 times more heat to be lost or gained, compared to an equal amount of wall space.

DISCUSSION

Approaches to improving window energy efficiency include:

- Replacing low-performing windows with higher performing windows (triple pane or double pane with low-emissivity coating).
- Attaching secondary windows to existing windows (interior or exterior).
- Installing shading devices (e.g., automated interior or exterior shades).
- Installing a window film.
- Using solar screens instead of regular insect screens, prioritizing south-facing windows.
- Planting trees or shrubs for shade.

In addition to saving energy, the above approaches offer many non-energy benefits, including thermal comfort, reduced glare, noise reduction and reduced UV penetration.



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QUESTION

When does it make sense to replace or supplement a building's existing insulation?



ANSWER

Replace or supplement a building's insulation when:

- Roof insulation is well below R-30.
- Wall and floor insulation is well below R-19.

In temperate climates, roof insulation beyond R-30 will not typically make much difference for conventional heating applications. Wall and floor insulation thresholds are about R-19 in similar climate conditions.



DISCUSSION

Many codes require higher insulation levels for new construction, but practical heat transfer considerations for existing building envelopes prioritize eliminating points of high heat loss rather than adding extra insulation to an already reasonably insulated construction element.

Sometimes, money spent on thicker insulation can be better spent elsewhere to save even more energy and money.

Before adding more insulation, consider addressing the following issues:

- Air leakage
- Roof water leakage
- Condensation
- Roofing reflectivity and emissivity
- Window performance issues
- Thermal bridging

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QUESTION

What are some symptoms of building envelope leakage?



ANSWER

Common symptoms of building envelope leakage include:

- The lobby is noticeably colder than the rest of the building.
- Doors are difficult to open or close.
- There's a stack effect in stairwells or lobbies.
- There's excessive dirt, dust or leaves in building entryways, or an excess of dirt and dust on top of window frames.



DISCUSSION

Allowing conditioned air to escape or enter the building in an uncontrolled manner results in wasted energy and uncomfortable tenants. No matter where the air leaks in or out, the amount of air that escapes or enters the building impacts the amount of air that requires conditioning.

DISCUSSION QUESTION

How often should dampers be inspected to ensure they're operating correctly?

What are some problems caused by unintended air leakage?

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QUESTION

When addressing air leakage
in your building envelope,
where should you look?



ANSWER

Points of infiltration, or air leakage, can be distributed throughout a building's envelope. It's best to start at lower levels with points of egress, including major entrances and loading dock doors. As you progress up the building, turn your focus to windows, equipment rooms and roof penetrations.



DISCUSSION

For the most effective building envelope insulation, seal cracks to prevent leaks and unwanted airflow. Note that moisture follows air, so air infiltration can be problematic for a variety of reasons. Leaks can generally be sealed with caulk, spray foam or weather-stripping.

Additional air leakage can occur at points where air is intended to enter or exit the building in a controlled manner, such as at HVAC air intakes or exhaust fan vents. To prevent air from flowing where it's not supposed to, it's important to ensure dampers are working in these locations.

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QUESTION

What is a good way to detect hidden envelope issues?



ANSWER

Hidden envelope issues can be detected by air leakage tests. For larger buildings, consider an ASHRAE Level II Audit with walkthroughs during the day and wintertime night.



DISCUSSION

Sealing, caulking, gasketing or weather-stripping the following areas of the building envelope to help minimize air leakage:

- Joints around manufactured and site-built windows and door frames.
- Junctions between walls and foundations, structural floors, roofs and roof panels, and places where walls meet building corners.
- Utility service openings and penetrations through roofs, walls and floors.
- Building assemblies used as ducts or plenums.
- Joints, seams, soffits and penetrations of vapor retarders.
- Recessed lighting fixtures.

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QUESTION

What are some potential underlying issues if exterior doors are difficult to open, or don't close securely, in a multi-story office tower?



ANSWER

Potential underlying issues include:

- The building is improperly pressurized, with more exhaust than outside air, or vice versa.
- The building's ventilation settings and/or dampers are improperly configured or failed.
- The seasonal stack effect is not under control.
- The connection to other buildings is not under control.



DISCUSSION

When a building is improperly pressurized and has substantial leakage, it means that unwanted/unconditioned outside air is entering the building, or conditioned air is escaping. Both of these scenarios increase energy consumption and will very likely cause occupant discomfort.

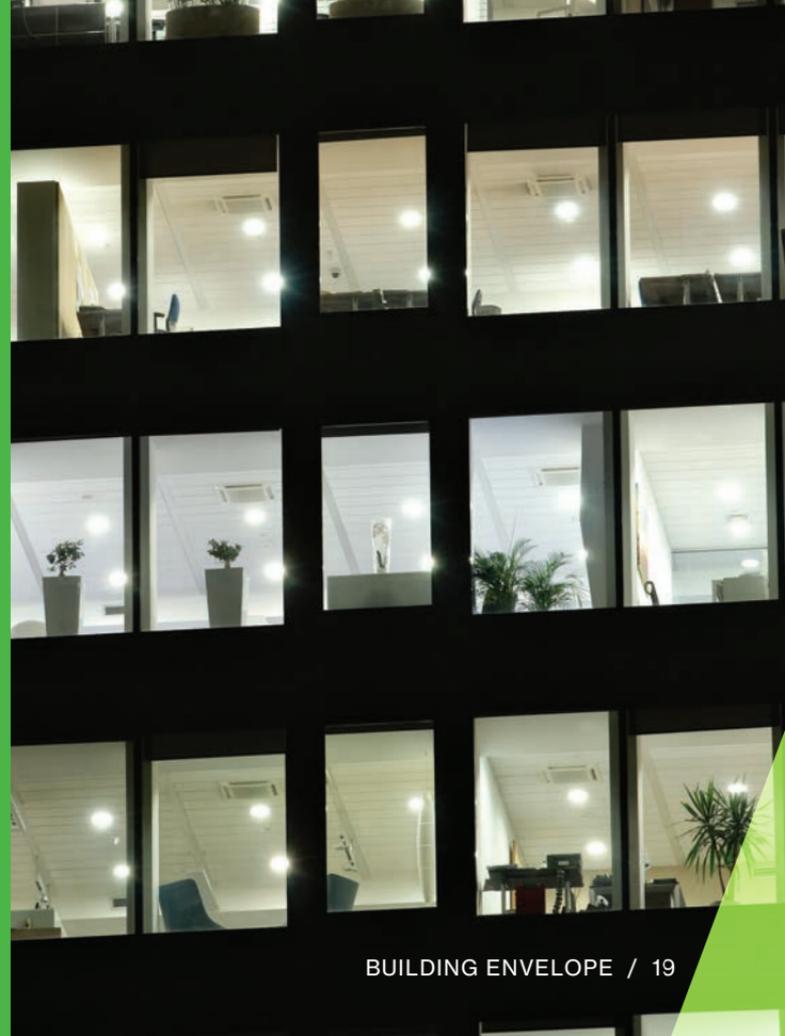
DISCUSSION QUESTION

Why do you think the typical ideal pressurization for a building is slightly positive?

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QUESTION

What building performance issues would you expect to be more noticeable during a wintertime night walk?



ANSWER

During the winter, there's typically a far greater temperature differential between the building's inside and outside. If a building's envelope is compromised, unwanted airflow and temperature loss can be felt, seen or heard throughout the building.



DISCUSSION

Envelope integrity issues are far easier to recognize during cold winter temperatures. Keep an eye or ear out for:

- Airflow around windows or elevator doors.
- Cold air pulling into the lobby.
- Plants, paper or other light materials moving in a draft.
- Doors staying slightly ajar.
- Doors sticking on entry or slamming shut.

Take the time to investigate if any of these signs are present. The building envelope is compromised if air is moving anywhere in your building without the help of the HVAC system. During the winter, start with an examination of the rooftop and look for patches of bare roof in the frost. This could indicate the loss of heated interior air somewhere nearby.

Exterior lighting is especially important in the wintertime. During a winter night walk, always include a review of exterior lighting schedules, performance and safety.

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QUESTION

In hot climates, what can be done to roofs to reduce the required amount of air conditioning?



ANSWER

To reduce the required amount of air conditioning in hot climates, increase roof reflectivity and emissivity.



DISCUSSION

Proper roof design and materials can reduce the amount of heat transferred into the building. This can also reduce energy costs by decreasing the demand for mechanical cooling, and improve occupant comfort in the summer, in any climate.

Roofs that incorporate ENERGY STAR® qualified materials with a reflective membrane reduce the demand for peak cooling by 10–15%.

Additional roof measures include installing onsite generation systems or vegetation, which provide a host of benefits, including absorbing rainwater and atmospheric pollution, providing additional insulation and mitigating urban heat island effects.

INTERIOR LIGHTING

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QUESTION

What are the two most efficient light sources commonly used for indoor lighting?



ANSWER

The most efficient sources of indoor lighting are daylight and LEDs (light-emitting diodes).



DISCUSSION

Natural daylight is the cheapest lighting source, but it is not always sufficient, especially in the winter or in buildings that were designed without daylight in mind. When electrical lighting is necessary, choosing energy-efficient LEDs and lighting controls can significantly reduce energy use when compared to traditional bulbs like incandescents and fluorescents.

DISCUSSION QUESTIONS

What factors should be considered when choosing lighting for your space?

What are some factors that can affect the efficiency of any given lighting technology?

What are the advantages of using LEDs?

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QUESTION

What's the main reason LEDs are more energy efficient than other lighting options?



ANSWER

LEDs are more efficient because they generate light by moving electrons in compound semiconductors. Because these semiconductors create more photons per unit of input energy, they allow LEDs to convert electricity into light much more efficiently than incandescent or fluorescent bulbs.



DISCUSSION

Almost any facility can save energy, operations and maintenance costs by upgrading existing fixtures to LED lamps or a retrofit kit (assuming existing fixtures are in a functional state). LEDs typically use 80% less energy than incandescent bulbs, and they last about 25 times longer. And building operators can further increase savings by incorporating lighting controls like Luminaire Level Lighting Controls (LLLC).

Since 2008, the cost of LEDs has declined by almost 90%. They are now projected to account for as much as 80% of all lighting sales by 2030. Achieving this level of LED use could save Americans \$26 billion per year in electricity costs, while cutting the nation's lighting electricity use by nearly half.

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QUESTION

What is the easiest way to reduce the energy consumed by a lighting system?



ANSWER

Dimming or turning lights off when they are not needed is the easiest way to reduce lighting system energy consumption.

DISCUSSION

Most people don't turn off lights when they leave a room, especially in commercial settings. Installing lighting controls, such as occupancy/vacancy sensors, are an easy to save energy in rooms that are intermittently occupied.

Though time clocks are often effectively used for day/night lighting control in exterior applications, they are often underutilized in interior spaces.

Daylight sensors (aka, photo sensors or photocells) can automatically turn off or dim lights in response to daylight changes throughout the day. LEDs offer smooth dimmability that is often unnoticeable to occupants.

DISCUSSION QUESTIONS

What are some space types that are appropriate for occupancy sensors?

What are some other types of lighting controls that can increase tenant comfort and decrease energy costs?



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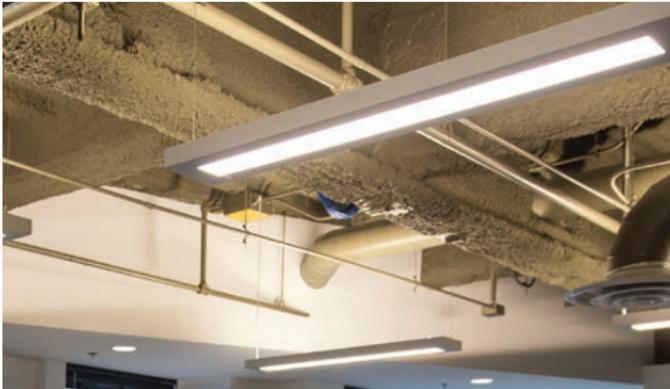
QUESTION

Approximately how much of a building's energy waste can be attributed to occupants leaving the lights on in empty rooms?



ANSWER

Between 30–41% of a building's energy waste can be attributed to unnecessary lighting use.



DISCUSSION

Dimming or turning lights off can save significant energy in a variety of intermittently used commercial spaces, including small offices, conference rooms, storage rooms and bathrooms. Occupied and off-hours lighting audits can help determine whether lights are being left on when they are not needed.

Lighting controls will automatically turn off lights when they're not needed. These controls mainly consist of occupancy sensors that turn lights off in empty rooms, and daylight sensors that dim or turn lights off when there is enough daylight. Most occupancy sensors also offer a vacancy mode that provides even more savings with a manual-on, auto-off operation.

Consider contacting your electric utility to inquire about any incentives available for lighting control upgrades.

DISCUSSION QUESTION

Do you have any rooms or areas that could benefit from lighting controls?

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QUESTION

What are Luminaire Level Lighting Controls (LLLCs), and how do they operate?



ANSWER

LLCs combine LEDs, controls, connectivity and data that can improve occupant comfort and space utilization. This flexible lighting product features built-in strategies including occupancy sensing, daylight harvesting and continuous dimming.

DISCUSSION

By integrating sensors into every fixture, LLC technology allows a building's lighting system to provide significant value beyond illumination. These sensors provide real-time data on occupancy levels, space temperature, asset tracking and much more.

Integrating LLCs with other building systems (e.g., HVAC) can help futureproof spaces while providing significant energy savings. Highly flexible LLCs can offer individual addressability with space

reconfiguration available by mobile app. This flexibility is especially helpful during times of occupancy change, as lighting can be adapted without rewiring or relamping.

Beyond adjusting lighting levels based on occupancy, LLCs can also adjust HVAC levels to increase energy savings even more. LLCs help avoid the energy wasted when heating or cooling is left on in rooms, spaces or entire floors with no occupants. In addition, the occupancy monitoring of LLCs can keep occupants informed of conference room availability and help building managers use an app to track key pieces of equipment.

The significant and varied benefits of LLCs have inspired industrial and medical facilities become early adopters of this technology. Retrofit kits that include LLCs can help lower projects costs, allow for phased upgrades, and often qualify for incentives from local utilities.

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QUESTION

What is an effective way to assess lighting performance?



ANSWER

One effective approach to assessing the suitability and comfort of lighting levels is collecting light-level measurements and comparing them to current IES (Illuminating Engineering Society) recommendations for each space type. It is likely that you will find many spaces are overlit compared to IES recommendations. It's important to provide the appropriate lighting levels in each space to reduce energy waste and improve occupant comfort and productivity.

DISCUSSION

During your walkthrough, consider identifying areas where you can reduce excess lighting. When appropriate, consider asking occupants about their experiences with the current system. Consider LED bulbs or simple retrofit kits (e.g., recessed can lights) that can quickly replace your existing fixtures.

If your building uses occupancy sensors or photocells, confirm they are functioning properly and consider incorporating options that allow occupants to manually dim or turn off lights.

And finally, consider contacting your local electric utility to find out if they offer lighting audit services.

DISCUSSION QUESTIONS

Is there anywhere in the building that could benefit from replacing legacy technologies, such as HID (high intensity discharge) or fluorescents?

What are other ways to reduce the cost of lighting?

When is the last time the lights in this building were cleaned?

What are other ways to reduce the cost of lighting in this building?

When is the last time the lights in this building were cleaned?

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QUESTION

What do the terms color temperature and color rendering index mean?



ANSWER

Color temperature describes the color characteristics of light by assigning a numerical value to the color emitted by a light source, measured in degrees of Kelvin. Color temperatures over 5,000 K are known as “cool colors” (in the bluish white range), while lower color temperatures (2,700–3,000 K) are known as “warm colors” (in the range of yellowish white through red).

Color rendering refers to how accurately a light source renders color when compared to a reference light source of the same color temperature (either ideal or natural light). Color rendering is measured by the Color Rendering Index (CRI), a scale from 0 to 100 percent. The higher the CRI, the better the color rendering of the light source.

DISCUSSION

It is often important to consider the color temperature when lighting building interiors. For example, a warmer (lower color temperature) light is often used in public areas to promote relaxation, while a cooler (higher color temperature) light is used to enhance concentration in offices. LEDs can be installed that offer color tuning, so the effect or mood of the space can be quickly changed based on events, time of day or occupant preference.

The following are examples of common and competitive light sources, color temperatures and CRI values:

Light source	Color Temperature	CRI
High Pressure Sodium	2,100 K	25
Incandescent	2,700 K	100
Cool White	4,100 K	82
Metal Halide	5,500 K	60
Natural Sunlight	5,000–6,000 K	100
LEDs	2,700–6,500 K	75–90+

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QUESTION

What does it mean if an LED claims L70 after 50,000 hours?



ANSWER

L70 describes the brightness of an LED after a number of hours. If a product claims L70 after 50,000 hours, it means that after 50,000 hours of burning, the lights are now 70% as bright as they were when installed.



DISCUSSION

Sometimes, manufacturers will list L80 (or L90) at 50,000 hours. This simply means that after 50,000 hours, the LEDs will be 80% (or 90%) as bright as when they were installed.

Don't confuse L70 with LM-79 or LM-80, the standards used to determine the performance metrics on the product label, including the optional lumen maintenance metric.

LM-79 is an approved method for taking electrical and photometric measurements of SSL (solid-state lighting) products. It covers total flux (light output), electrical power, efficacy, chromaticity and intensity distribution. The five required metrics on the LED Lighting Facts label come from LM-79 test results.

LM-80 is an approved method for measuring the lumen maintenance of LED packages, arrays and modules at various temperatures. LM-80 provides no determination or estimate of expected life or lumen maintenance beyond the test data.

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QUESTION

What are the different lighting distribution types for fixtures?



ANSWER

The lighting distribution types for fixtures are:

- Indirect
- Direct
- Indirect/Direct
- Omni-directional
- Diffuse



DISCUSSION

One way the lighting industry distinguishes between LED, HID and fluorescent is how the light is directed out of them. Each distribution type will change how much light is delivered to a task, how various surfaces in a room are lit, and how the fixture appears in the room. Even when two fixtures look interchangeable, they can light spaces very differently. For example, some LED high bay fixtures have ribbed acrylic lenses, and some have spun aluminum. The light they each produce provides different visual effects, with the acrylic lens usually delivering some light up to the ceiling.

Changing lens types on a fixture can also have a big impact. LED retrofit kits and new fixtures have diffusing lenses that distribute light more uniformly than common 2x4 fluorescent troffers. They offer an opportunity to improve the light quality while saving energy, particularly when they replace the deep cell parabolic fixtures that were popular in the late 1980s and early 2000s.

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QUESTION

How is the light output of an LED affected by ambient temperature?



ANSWER

In general, the cooler the environment, the higher an LED's light output will be.



DISCUSSION

One of the most important aspects of LED system performance is controlling the LED's temperature. Prolonged heat can considerably shorten the useful life of many LED systems.

In general, higher temperatures reduce LED light output by increasing the temperature of the semiconducting element. For a constant current, the light output of an LED varies as a function of its junction temperature. Higher ambient temperatures lead to higher junction temperatures, which can increase the degradation rate of the LED junction element and potentially cause the light output to permanently decrease faster than at lower ambient temperatures.

Dimming LEDs can be an effective way to reduce system temperatures and potentially increase overall life.

EXTERIOR LIGHTING

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QUESTION

What are the three most efficient light sources commonly used for outdoor lighting?



ANSWER

The most efficient sources of outdoor lighting are LEDs (light-emitting diodes), high-pressure sodium (HPS) bulbs and fluorescent bulbs.

For exterior lighting applications, it is industry standard practice to use LEDs as the replacement for legacy sources including HPS and metal-halide (MH) bulbs.



DISCUSSION

When replacing HPS or MH bulbs, LEDs can reduce lighting energy use by 80% while delivering more illumination, higher CRI (color rendering index), and increased control with the ability to adjust brightness and color temperature.

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QUESTION

What is the most effective technology for controlling exterior lighting?



ANSWER

Modern LEDs are the best choice, as they can integrate scheduling, occupancy and safety factors into the control scheme. This leads to significant energy savings and reduced maintenance needs.

While photocell controls or timeclocks were once the preferred control technology, they came with common issues including a tendency to malfunction when dirty, which contributes to energy waste.



DISCUSSION

Today's wireless lighting control systems offer maximum flexibility with capabilities including adjusting lighting from 1 to 4 a.m., either by dimming all bulbs to 10% or switching every other fixture off. This allows any facility to keep safety a priority without wasting energy or increasing light pollution.

DISCUSSION QUESTIONS

Look at your lighting controls. Do you have any? Do they work? If not, most utilities will offer incentives for new controls to replace non-functioning controls.

Are your exterior lights left on during the day?

Are your parking lot lights left on at night, even when few or no cars are present?

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QUESTION

What should be considered when installing exterior lighting that is not a factor with interior lighting?



ANSWER

Since exterior lighting is not usually contained by walls or a ceiling, two related issues can arise: light trespass and light pollution. Light trespass is when the light leaves one property and goes onto another, and light pollution is when light goes upward into the sky.



DISCUSSION

In addition to being wasteful, light trespass and light pollution can lead to glare problems and the presence of unwanted light in areas that don't require it. In some cases, these issues can also violate local ordinances.

Every lighting design strategy should carefully shine light where it is needed for a variety of purposes (e.g., task, ambient and accent), and avoid shining it where it is unneeded. To do so, it is important to use the right fixture types in the right correct locations. This will help to minimize complaints, operational costs and the energy wasted on unwanted light.

LED luminaires are an ideal product for this calibration. In addition to featuring high efficacy (high lumens per watt), they also have excellent optics so the light can be delivered uniformly to a precise location. Each diode on an LED contains a reflector to deliver the light exactly where it needs to be, whereas many legacy sources only have one reflector for a much larger light source.

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QUESTION

Some lamp types that are commonly used in exterior lighting applications are not good candidates for occupancy sensor controls. What are these lamp types and why are they bad candidates?



ANSWER

The following lamp types are bad candidates for occupancy sensor controls:

- **HID light sources** because they feature lengthy cycle and restrike operating characteristics.
- **MH and HPS light sources** because they are not capable of instant on/off switching. In most cases, the lamps must cool for around five minutes before they can be re-energized.

DISCUSSION

Increasingly, facilities are de-energizing most or all of their exterior lights at night and then energizing them by occupancy sensor when a sensing field is disturbed by intruders. This approach is referred to as “dark campus” control. If you’re considering occupancy sensors for exterior lighting control, be sure to apply them to fixtures with LED or fluorescent fixtures. occupancy is detected. It then returns to full output when activity is present.

Institutional and residential facilities can be good candidates for dark campus control sequences, as they frequently feature discrete unoccupied periods at night. Keep in mind that most organizations will require significant internal discussion prior to incorporating a dark campus control model, as the change implies a new way of thinking about nighttime security. For example, with dark campus control, energized lights now indicate a potential intruder that warrants investigation, but nonthreatening nocturnal wildlife (e.g., raccoons, cats and possums) may trip the sensors as well. Despite these considerations, many facilities have found the dark campus approach to be a more effective security lighting model.

If the dark campus control approach is not a possibility, a bi-level control approach is the second-best option. In the bi-level approach, lighting is dimmed to a low level when no occupancy is detected. It then returns to full output when activity is present.

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QUESTION

Should an analysis of exterior lighting always be done at night?



ANSWER

In most cases, yes, an analysis of exterior lighting should be done at night. In addition, walking around the facility during the day can reveal further problems that may not be apparent at night (e.g., lights left on during daytime hours).



DISCUSSION

Lights that remain on during the day are known as “day burners,” and identifying them are one of the primary reasons to patrol the area during the day. Typically, day burners are the result of a failed photocell, but there are many potential causes, including wiring problems or dirt and debris on the sensor. Eradicating day burners can save significant energy and maintenance costs.

Daytime analysis can also reveal fixtures that are particularly dirty or have yellowed or cracked lenses. Looking into a bright fixture at night can make it very difficult to identify these issues – it’s much easier to do so in the daytime when the lights are off.

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QUESTION

Beyond safety and security, what is another function of outdoor lighting?



ANSWER

Most exterior lighting installations contain a number of lighting fixtures that deliver aesthetic night lighting functions. These include signage, façade illumination, landscape-feature illumination and portable decorative lighting (e.g., holiday lights).

DISCUSSION

A comprehensive survey of all exterior lighting fixtures can help you determine which fixtures provide security and safety illumination, and which provide a predominantly aesthetic function. Once you have determined the primary function of each fixture, you can consider replacing or adjusting the lighting controls.

Additionally, you can consider replacing fixtures with LEDs or de-energizing them. Be sure to check with the manufacturer listed on the fixture, as many of them offer fixture-specific LED replacement kits. When the original

aesthetic function of a fixture is no longer meaningful to the facility, the lights can often be permanently de-energized or removed entirely. When adjusting the lighting controls, consider including time-based controls of aesthetic fixtures to allow the fixtures to de-energize at night once their aesthetic value is no longer meaningful. An example might include de-energizing a flagpole uplight at a school facility after 10 p.m. when evening activities have ceased.

Finally, consider wireless controls for LEDs that offer fixture-level, light-level and time control for additional energy savings.



PLUG LOADS

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QUESTION

Approximately how much of a commercial building's energy is consumed by plug and process loads?



ANSWER

Plug and process loads account for about 33% of a commercial building's load.



DISCUSSION

Nationwide, plug and process loads continue to account for more and more of our commercial building energy use. This is due to the increasing number – and associated energy intensity – of plug-in devices.

DISCUSSION QUESTIONS

Is there anywhere in the building where plug load occupancy sensors could be beneficial?

What are some strategies to reduce or control the energy consumption of the building's plug and process load?

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QUESTION

When are likely times that plug load equipment can be de-energized?



ANSWER

Plug load equipment can often be de-energized during periods of non-use, including nighttime, weekends and lunch hours.

DISCUSSION

Typically, plug load equipment operation is only needed when occupants are actively using the equipment.

Walking through the building when it is unoccupied is a smart approach to identifying unnecessary equipment operation. If equipment is running, determine the reason. For example, HVAC equipment may be running in unoccupied spaces to supply a computer room or to accommodate another process load.



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QUESTION

What are some examples of plug load equipment types that often experience scheduling problems?



ANSWER

The following plug load equipment types often experience scheduling problems:

- Vending machines
- Task lights
- Printers and photocopy machines
- Monitors (with extended or disabled sleep modes)



DISCUSSION

It's easy for these scheduling problems to go unnoticed, as occupants rarely complain when equipment runs longer than needed. At least twice a year or after a major tenant change, consider regularly identifying occupant requirements and re-evaluating equipment operation schedules.

Note that both refrigerated and non-refrigerated machines are potential candidates for occupancy sensor controls. These controls can particularly benefit vending machines installed in facilities with discrete occupation patterns, as the controls can de-energize the machines for most of the unoccupied period.

For additional vending machine savings, consider speaking with the vending machine's beverage and snack distributors to discuss permanently de-lamping the vending machine's lighting. And, as always, contact your local electric utility to discuss available incentives.

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QUESTION

What are some methods or technologies that can automatically control plug load equipment?



ANSWER

Methods and technologies to automatically control plug load equipment include:

- Occupancy sensors
- Timers
- Remote scheduling
- Software-based sleep modes



DISCUSSION

Occupancy sensors can control products like power strips, or they can be field installed to control select electrical receptacles. Many current smart plug and power strip technologies offer remote scheduling based on time or specific events like sundown and sunset. Increasingly, these technologies also integrate with plug load metering and data-collection technologies.

Consider regularly checking active and optimized sleep-mode settings for micro-computer products, peripherals, and other office equipment; then reprogram the settings when necessary.

Additionally, consider conducting an audit to evaluate which plug loads are necessary, and which can be put on smart outlets or power strips.

AIR HANDLING SYSTEMS

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QUESTION

For most HVAC applications, what determines airflow requirements?



ANSWER

In most HVAC applications, the peak cooling load determines airflow requirements.



DISCUSSION

Most HVAC systems use air to remove or add heat from spaces within a building. The temperature limits within these systems typically require more air to cool a room by removing heat. For example, air-handling systems (AHUs) typically discharge 55F air when cooling and 105F air when heating.

Because of this, any design strategy that reduces peak cooling loads will also reduce the required airflow. In fact, design strategies such as solar shading can reduce peak load and associated airflow requirements by as much as 50%. Operational strategies such as de-energizing lights and plug loads when a room is not occupied can also reduce airflow requirements. For variable air-volume (VAV) systems, reducing the internal load allows the system to automatically reduce airflow, which results in fan, cooling and reheat energy savings.

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QUESTION

Fan energy use is a function of two factors: fan power and fan operating hours. What are the three factors that determine fan power?



ANSWER

The following factors determine fan power:

- Airflow rate, typically measured in cubic feet per minute (cfm)
- Total developed system pressure, typically measured in inches of water
- Mechanical efficiency of the fan, which typically ranges from 40% to 80%



DISCUSSION

To help determine how fan power can be reduced, take a look at the fan power equation below. Note that this is the equation for density of air at sea level. The units of power are brake horsepower (i.e., shaft power).

$$\text{Power (hp)} = \frac{\text{Air flow (cfm)} \times \text{Total pressure (inches)}}{6356 \times \text{Mechanical efficiency}}$$

This equation demonstrates that airflow and total pressure are directly proportional to fan power. Therefore, when airflow or total pressure increase or decrease, fan power does the same.

Conversely, fan efficiency is inversely proportional to fan power. This means that when fan power increases or decreases, fan efficiency does the opposite.

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QUESTION

If a fan's maximum speed is reduced by 10%, what is the percent reduction in maximum fan power?



ANSWER

Power varies by the cube of fan speed, so reducing fan speed substantially reduces fan power.

A 10% reduction to a fan's maximum speed yields a 27% reduction in full fan power. The 10% reduction to maximum speed is the same as 90% of maximum speed, or .9 and when cubed equals .73 or 73%



DISCUSSION

There are a variety of ways to vary a fan's speed. One of the most common non-mechanical methods is to apply a variable frequency drive (VFD) to the fan's motor. By doing so, a fan can adjust its speed based on its operating mode (e.g., cooling, heating and ventilating). VFDs provide substantial energy savings, as energy use plummets any time fan speed is decreased.

Note that any adjustments or programming of fan speeds should be done by a qualified technician who can maximize fan energy savings while ensuring adequate airflow for each mode.

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QUESTION

In general, what should HVAC fan schedules align with?



ANSWER

HVAC fan schedules should typically align with building occupancy patterns.

DISCUSSION QUESTION

Why might an AHU run during an unoccupied period?



DISCUSSION

In general, AHUs should only operate during occupied periods when they run continuously to maintain proper ventilation, space temperature and humidity levels. AHUs that continue operating when buildings are unoccupied should be the first priority for potential scheduling changes.

Dedicated outdoor air systems (DOAS) make it easy to shut off ventilation fans completely during unoccupied times while the primary heating/cooling system maintains the unoccupied space temperature setpoints.

Regardless of your system, you should consider early morning and end-of-day scheduling opportunities that calculate building warm-up or cool-down periods. When only a few people remain in the building at the end of the day, you have the opportunity to tighten scheduling and reduce operation. Even small reductions in operating periods can result in significant reductions in heating, cooling, fan and pump energy use. For example, reducing daily runtime by one hour in a typical 12-hour day will result in at least an 8% reduction in energy use.

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QUESTION

Do all filters have the same efficiency?



ANSWER

No, filters have varying levels of efficiency.



DISCUSSION

Filters with extended surface areas can help you upgrade your existing filtration systems. These filters have a lower initial pressure drop, higher dust-holding capacity and higher structural ratings. The benefits of extended surface area filters include the reduced fan energy that comes from longer change cycles and lower pressure drop over the life of the filter.

To avoid changing filters before the end of their useful service life, follow manufacturer guidelines and use the pressure drop across the filter bank to determine the optimal filter-change cadence.

DISCUSSION QUESTIONS

How can you measure the pressure differential across a filter?

What effect could a dirty air filter have on the AHU?
How would this affect a tenant's space?

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QUESTION

What are some low-cost ways to improve fan system performance?



ANSWER

Fan system performance can be improved by:

- Identifying and limiting unwanted sources of pressure drop in equipment and ductwork.
- Inspecting and cleaning fan blades.
- Comparing airflows to the original or updated design, and then adjusting to match.



DISCUSSION

Reducing static pressure in the system can reduce overall energy use. Double-check dampers to ensure they are operating properly, and then remove unnecessary elbows and constrictions in ductwork to reduce static pressure.

Make sure that airflows meet design values and aren't overdelivering. Reducing flow to match the load will save energy over the lifetime of the fan system.

Dirt build-up on fan blades and components is a common condition that can lead to deteriorating fan efficiency and performance. Dirt and grime on the leading edge of fan blades, even a build-up as little as 1/16 inches thick, can cause a 10–20% reduction in fan capacity. For the best fan performance, make sure all wheels and blade surfaces are clean and smooth.

When replacing fans, look for fans with a high Fan Efficiency Index (FEI), and always choose fans that perform efficiently at their needed operating point.

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QUESTION

What impact does a dirty filter, dirty coil or blocked duct have on an AHU?



ANSWER

Dirty filters, dirty coils and blocked ducts cause the fan to work harder by adding unwanted static pressure.

DISCUSSION

Static pressure, or total pressure drop, is caused by anything in the airflow path that impedes flow. This occurs in every AHU, with examples including air dampers, filter sections, long duct runs, and most commonly, heating and cooling coils. Note that there are two forms of static pressure: internal (inside the AHU) and external (outside the AHU). When sizing AHU fans, both are considered as total static pressure.

Adequately maintaining filters and other system components can help prevent excessive pressure drop, and thereby avoid excessive fan power conditions. When filters are allowed to excessively load, they can fail and allow air to bypass the filter section. This exposes the central coils to dust and debris, which can foul the

coil. To avoid this, filters should be replaced according to manufacturer guidelines or when they're visibly loaded.

Coils inside AHUs should be checked regularly, including by measuring the pressure drop under full-flow conditions and then comparing those measures to original specifications. In addition, coils with increased pressure drops should be cleaned.

Since HVAC equipment often operates as part of an interconnected system, dirty cooling or heating coils can lead to increased energy use of other HVAC system components, including chilled and hot water pumps.



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QUESTION

What is the Fan Efficiency Index (FEI)?



ANSWER

Offered by most major manufacturers, FEI is a metric that accounts for many of the conditions that affect a fan's efficiency at its operating point. Use the FEI to choose a fan that will operate most efficiently for a given application.

For more information on **Fan Energy Index**, visit Air Movement and Control Association International's website at amca.org.

DISCUSSION

FEI compares a fan's power consumption at a specified airflow and pressure to a baseline fan at the same airflow and pressure. FEI values greater than 1 indicate improvement over the baseline, with fan energy savings represented as a percentage. For example, an FEI of 1.1 indicates a 10% improvement in energy consumption compared to the baseline. FEI varies with airflow and pressure inputs, so it is a useful tool to help select the most efficient fan for the intended application.



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QUESTION

How can preventative maintenance practices be implemented into systems maintenance cultures that haven't formally adopted these practices?



ANSWER

Simple component checkout procedures can be easily added to normal schedule maintenance activities. These procedures can be structured around filter replacements, motor lubrication, seasonal system lay-up and start-up, and/or combustion analysis.

To the right, we provide specific ideas for simple preventative maintenance procedures.



DISCUSSION

During filter change-out:

- Command mixed air dampers through their full stroke to identify damper malfunction.
- Visually inspect dampers, damper linkages and actuators to identify broken, loose or disconnected components.
- Visually inspect coil surfaces (filter-side) for fouling or damage.
- Obtain the pressure drop reading across coils to determine if coils are plugged internally.

During motor lubrication:

- Compare amperage reading to original balancing reports or motor nameplate to determine if the motor is appropriately loaded.
- Visually inspect the motor drive system to confirm general operating condition (e.g., tight belts, appropriate rotational speed and good bearing conditions).
- Compare the pump or fan RPM to the original balancing report to determine if system is operating close to intended conditions.

BUILDING HEATING AND COOLING

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QUESTION

What are steps you can take to ensure the building's HVAC system is performing optimally?



ANSWER

Take the following steps to make sure your building's HVAC system is operating at optimal performance:

- Routinely examine HVAC equipment.
- Inspect building HVAC controls systems and address any errors or faults that arise.
- Fix dampers and valves that are broken, leaky or malfunctioning.
- Verify that outside air dampers are closed during unoccupied hours (unless they're required to maintain indoor air quality).
- Maximize efficiencies by investigating and modifying equipment staging, sequencing and cycling.
- Identify and correct any fans and pumps that are operating at higher than necessary capacities.
- Confirm that motors and drives are operating properly, and check insulation and sealing on all equipment.

DISCUSSION QUESTIONS

When was the last time your building's furnace or boiler was tuned up?

Have you confirmed the accuracy of all critical sensors?

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QUESTION

What is the maximum practical combustion efficiency that can be achieved with a gas-fired furnace?



ANSWER

Most condensing furnace manufacturers publish maximum practical combustion efficiencies of just over 96%, reported as Annual Fuel Utilization Efficiency (AFUE).



DISCUSSION

In a condensing gas-fired furnace, “condensing” refers to the process when some of the gases condense to a moderately acidic liquid when exhaust gas temperatures inside of the furnace are reduced to below the dewpoint. These appliances extract additional useful heat from the hot exhaust gases, but they must be constructed and operated in a manner that addresses the acidic condensate.

For more information, consult the Condensing Rooftop Unit Installation and Best Practices Guide at BetterBricks.com: https://betterbricks.com/uploads/resources/CRTU_Install-Guide.pdf

DISCUSSION QUESTION

What are some of the typical maintenance needs of condensing gas-fired appliances?

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QUESTION

What does COP stand for and what is it used to measure?



ANSWER

COP stands for Coefficient of Performance. It is a standard metric to rate the performance of a heat pump.



DISCUSSION

COP is defined for both heating and cooling performance. Heating COP is the ratio of heat output to electric input, as measured in identical units. For example, for an air-source heat pump with an outdoor

unit in the ambient outdoor environment, the heating COP lowers (i.e., indicates lower efficiency) with colder outdoor air conditions.

Another common heat pump heating performance metric is HSPF (Heating Seasonal Performance Factor). While similar to COP in meaning, HSPF is typically only applied to heat pumps that are 5 tons or fewer. The opposite is true for COP, which is typically used for equipment that is 5 tons or more.

To keep the equipment running efficiently:

- Follow the normal maintenance techniques used for air conditioning units on heat pumps.
- Keep indoor and outdoor coils clean and unobstructed.
- Make sure refrigerant charge and oil levels are properly set.
- Maintain defrost and auxiliary heat controls to avoid extreme wear and tear on the compressor during exceptionally cold weather.

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QUESTION

When is auxiliary electric-resistance heat, or supplemental heat, used in heat pump systems?



ANSWER

Heat pump auxiliary electric-resistance heat, or supplemental heat, is used for two primary reasons:

- When the heat pump is unable to provide adequate heat transfer due to low outdoor air temperatures.
- To maintain supply air temperature when there is a need for heating and the outdoor coil is defrosting.



DISCUSSION

Older heat pumps have a limited functional range compared to modern systems, particularly when heating.

When the outdoor air temperature is so low that heat pumps are unable to pull heat from the atmosphere, they engage supplemental electric heat to make up for the remaining capacity. The temperature at which supplemental heat engages is known as the “changeover” or “balance point.”

The defrost mode for heat pumps operates in one of two ways: 1) shutting down the compressor, or 2) reversing the cycle and operating the heat pump in cooling mode for a short cycle to deliver heat back to the outdoor coil. In either case, supplemental electric heat may be required to meet the indoor temperature setting during this time.

Note that excessive auxiliary heat operation is not uncommon in older and smaller heat pumps. Auxiliary heat is typically electric resistance with an effective COP of 1, and too much of it will reduce the overall heating COP of a heat pump. Consider limiting auxiliary heat operation to defrost conditions only, or ask a technician to investigate an adjustment of your changeover point. Note that quick temperature pick-up conditions can often be reduced with proper thermostat settings and programming.

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QUESTION

What are the common compressor types found in packaged HVAC refrigeration applications?



ANSWER

While older systems utilize reciprocating compressors, almost all newer packaged systems use scroll compressors.

DISCUSSION

Compressors are one of the most important parts of the refrigeration cycle. For the refrigeration cycle to function properly, the refrigerant must be compressed to the pressure corresponding to the saturation temperature higher than the temperature of the naturally available air or water. Compressing the refrigerant to the suitable pressure will ensure proper condensation and circulation throughout the cycle.

DISCUSSION QUESTIONS

Why are reciprocating compressors no longer used?

Which compressors are good matches for variable frequency drives (VFDs)?

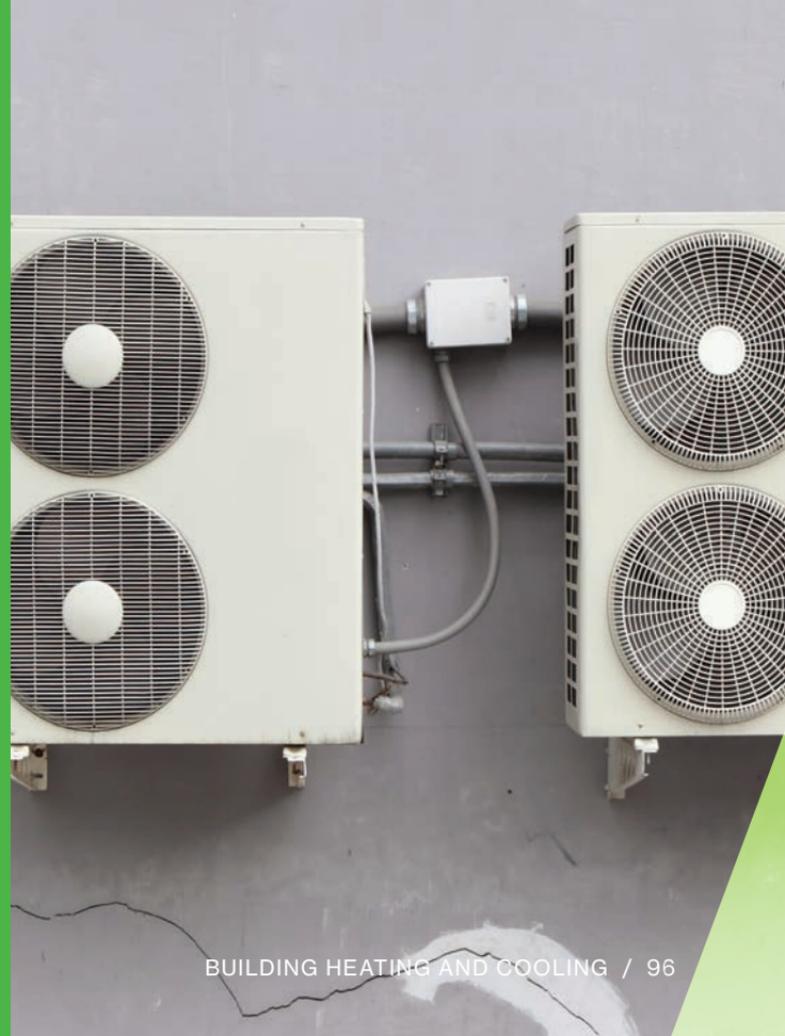
In older reciprocating compressors, what are the most important regular maintenance activities?



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QUESTION

How do fouled or damaged outdoor condenser coils affect cooling efficiency in packaged air-cooled HVAC refrigeration applications?



ANSWER

Fouled or damaged condenser coils reduce the ability of the refrigerant to completely condense into a liquid and can severely reduce refrigeration system efficiency.

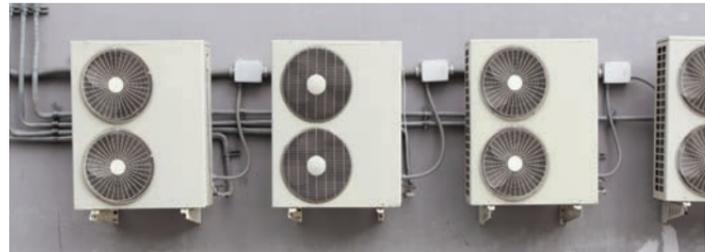
DISCUSSION

Coil cleanliness not only effects the efficiency of heat transfer to and from the air stream, but it also affects the performance of the entire HVAC system. Measured by loss of cooling capacity or increase in required compressor work (for a given capacity), the efficiency of a plugged or dirty condenser coil can be reduced by as much as 50%.

A clean coil lowers fan energy consumption because of its lower air-side pressure drop. Reducing fan energy consumption also reduces fan heat, which is a parasitic load for cooling processes. Cleaning dirty coils can be unpleasant and time-consuming, so it's often deferred.

But the best coil cleaning strategy is regular filter maintenance and cleaning that prevents them from becoming dirty in the first place.

Long-term accumulation of dust and airborne particles is the most common way condenser coils are fouled. This accumulation is what eventually plugs most, if not all, of the free air passages in the coil. Other airborne contaminants can also foul condensers, including salt air that corrodes and erodes coil fins. Additional sources of coil damage include hailstorms and vandalism; if there is risk of either, consider installing hail guards or other condenser coil security options.



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QUESTION

What are symptoms of inadequate refrigerant charge?



ANSWER

Symptoms of inadequate refrigerant charge include:

- Diminished heating and cooling capacity.
- Ice formation on the evaporator (indoor) coil in cooling mode, which is due to inadequate heat transfer.



DISCUSSION

Inadequate refrigerant charge reduces the overall mass flow rate within a refrigerant circuit, which can cause the system to lose heating and cooling capacity.

When the loss of charge is severe, the refrigerant pressures will remain below the threshold necessary for a functioning refrigeration cycle. At that point, heating or cooling will not occur even though the compressor is operating, at least for a time. With little or no refrigerant in the cycle, the compressor will not have the proper lubrication, causing it to fail from excessive internal friction.

DISCUSSION QUESTIONS

What should you do if a compressor fails?

Can an alternate refrigerant be used to recharge a system?

What should be done to manage systems that have outdated or outlawed refrigerants?

QUESTION

In variable air volume terminal units, also known as VAV boxes, reheat is often provided by hot water or electric coils. Optimizing minimum airflow turndown in VAV boxes is a practical way to manage reheat energy use, but what is the lowest practical turndown for most VAV boxes?



ANSWER

For offices, minimum airflow rates can be as low as 10% of the maximum airflow rate. For spaces with higher occupancy densities, minimum flowrates may need to be higher.

DISCUSSION

Minimum airflow rates should always be set as low as possible and practical, typically as low as the code ventilation requirements for a given room. Generally speaking, systems with lower minimum airflow setpoints will accommodate greater central fan turndown and the resulting reduction in overall fan power consumption. VAV boxes regulate the volume of airflow into a specific room or group of rooms served by a centralized VAV system, while damper modulations will maintain flowrates between a set maximum and minimum airflow rate.



DISCUSSION QUESTIONS

Why are low minimum airflow setpoints advantageous in a VAV system?

What are some of the downsides to low minimum airflow setpoints?

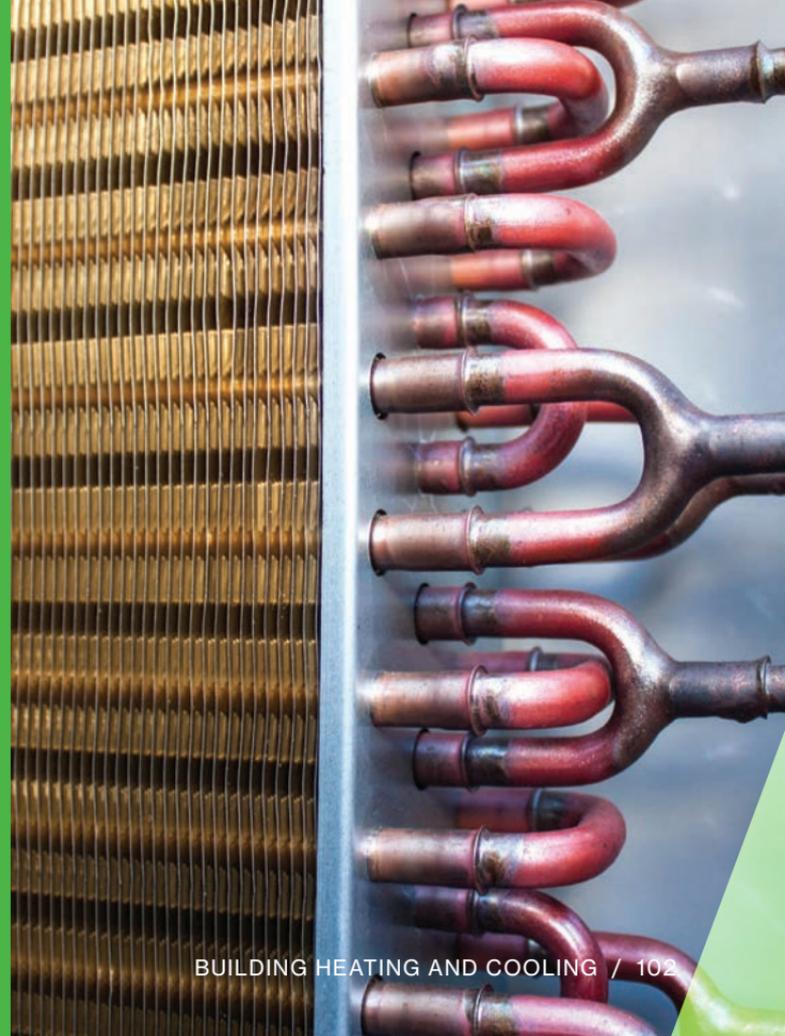
What are the differences between older and newer VAV boxes that can affect minimum airflow setpoints?

How are minimum airflow setpoints established in terminal units with pneumatic controllers?

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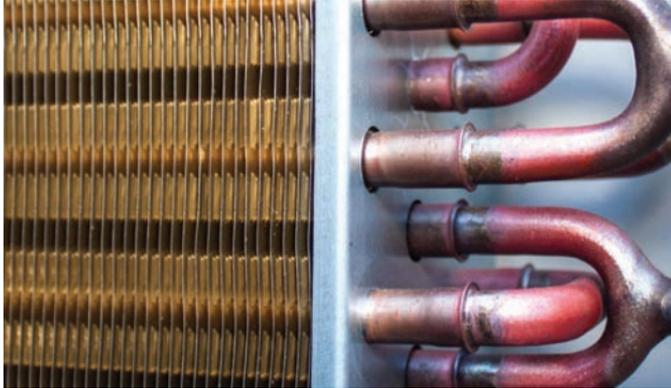
QUESTION

How is fluid flow often controlled in indoor heat exchangers?



ANSWER

Motorized flow control valves often control fluid flow through indoor heat exchangers



DISCUSSION

An important component within the heat exchanger system, flow control valves should open only when the heat exchanger is required to be active. Both inadequate flow and improper flow can cause operations problems with indoor coils and heat exchangers.

Note that condenser coils are not the only heat exchangers in packaged or built-up building heating and cooling systems; other types of heat exchangers, including evaporator or indoor coils, are present in all building HVAC systems.

DISCUSSION QUESTIONS

What are some of the different types of indoor heat exchangers?

How do maintenance requirements differ among heat exchanger types? How are they similar?

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QUESTION

What types of systems are particularly vulnerable to simultaneous heating and cooling?



ANSWER

Dual duct and ducted multi-zone systems are particularly vulnerable to simultaneous heating and cooling. Additionally, large spaces that are served by multiple single-zone systems, including warehouse stores, grocery stores and event spaces, are at risk of simultaneous heating and cooling.



DISCUSSION

Because systems are designed to mix hot and cold air together, some simultaneous heating and cooling is unavoidable. However, energy waste can be minimized by paying careful attention to supply air setpoints and reset strategies.

Careful attention should also be paid to thermostat settings and locations in buildings served by multiple single-zone systems. Simultaneous heating and cooling in these buildings may be the result of thermostats positioned in varying indoor climate conditions. For example, if one thermostat receives direct sunlight while the other is located near refrigeration equipment, one unit will heat while the other unit cools. By making sure thermostat settings align, particularly the set points and dead bands, you can help alleviate adjacent systems competing with one another.

DISCUSSION QUESTION

What are some examples of simultaneous heating and cooling in air distribution? And what are some examples of it in water distribution?

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QUESTION

Can an HVAC system be too big for a commercial building?



ANSWER

Yes, oversized HVAC systems in commercial buildings can lead to a variety of negative outcomes.

DISCUSSION

Oversized HVAC systems can negatively impact occupant comfort. When minimum flowrates result in significantly more cooling than required, space temperatures become difficult to control. When spaces become too cold, energy is used to re-heat the air in an effort to maintain comfortable conditions. In addition to reducing occupant comfort, this can easily and unnecessarily double energy use and its associated costs.

Additional drawbacks of an oversized HVAC system include:

- Frequent short cycling of individual chiller machines.

- Difficulty in maintaining design conditions during periods of high humidity.
- Excessive re-heat energy consumption.

Conversely, if an HVAC system is undersized, it will:

- Spend more hours per year running fully loaded.
- Be unable to hold indoor design conditions even on a design day, let alone hotter days.
- Increase temperatures in air-conditioned spaces.

To make sure your system is rightsized, it's important to consider the changing factors of building occupancy, space use, and other interior aspects like airflow or ventilation requirements. These factors may change more frequently than the actual HVAC system, requiring larger or smaller HVAC capacity than the system currently in place. It's important to consider these changes and periodically rebalance or optimize the HVAC system for current occupancy and load conditions. Note that LLLC technology allows HVAC systems to adjust based on real-time occupancy to improve occupant comfort and provide significant energy savings.

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QUESTION

What are some problems associated with a leak in the hot water distribution loop?



ANSWER

A leak in the hot water distribution loop can result in a variety of problems, including:

- Increased water consumption.
- Increased energy consumption.
- Water damage.



DISCUSSION

Make sure hot water and steam distribution systems are provided with make-up water to replace any steam or water that is lost through a leak in the system. This is an easy way to ensure the system is fully charged with water at all times. Note that it is best practice to install a meter on the make-up line to the system, and then to read it weekly to check for unexpected water loss.

For steam systems, it is best practice to monitor make-up water volume daily. As steam leaks from the system, additional make-up water is required to replace the loss. Monitoring the make-up water will ensure that you are maximizing the return of condensate and reducing the need for make-up water.

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QUESTION

What are the potential benefits of performing regular night walks in a building that is unoccupied for 6,000 hours or more each year?



ANSWER

Performing regular night walks in a building that is unoccupied for 6,000 hours or more per year can help you identify:

- Lighting or HVAC systems running needlessly during unoccupied hours.
- Major systems that have been left in manual mode and are not responding to the controls system.
- Significant loss of conditioned air.
- Controls systems that are improperly set.



DISCUSSION

Whether they're night walks, early morning walks, or emergency call-ins, spending an extra hour or two walking your building outside of its normal operating hours can reveal a variety of performance improving opportunities. Consider incorporating night walks into the standard maintenance schedule, the work order system, the service provider contracts, or after mandatory events like annual life and safety tests.

The time and money spent on night walks is easily recovered with the identification of just one building performance or energy performance issue. A typical building sits unoccupied almost 2/3 of each day, so any system that operates improperly during that period will have a major impact on your energy costs. For example, a few faulty actuators on dampers can easily cause a building to lose all of its heated air overnight. This not only wastes money and energy throughout the night, but it also wastes additional energy in the morning when the HVAC system has to warm the entire building again.

These considerations are even more important as more companies have shifted to hybrid work schedules, resulting in buildings with variable usage and occupancy.

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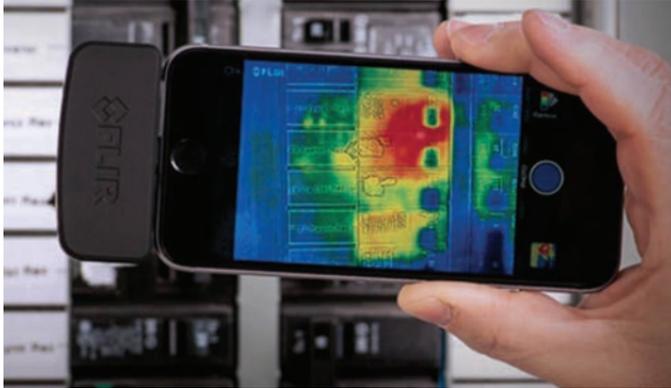
QUESTION

What are some ways that infrared imaging can be used to support HVAC diagnostics?



ANSWER

Infrared imaging can clearly indicate when piping or duct components are warm or cool. This can help determine whether heating or cooling controls and HVAC systems are functioning as intended. For example, thermal imaging of a steam trap during active heating periods can reveal traps that are failing to open. In this case, the condensate discharge piping would be very hot with a temperature similar to that of the live steam piping.



DISCUSSION

Historically, the cost of infrared imaging equipment has been too high to justify using as a regular diagnostics tool. However, the technology is becoming more widespread in the marketplace, and there are inexpensive applications that provide basic color-coded imaging that supports much of the diagnostic use of the technology in HVAC. One example is a smartphone infrared camera attachment that can be purchased for \$300–\$400.

Additional uses for this infrared imaging technology include:

- Envelope heat loss identification.
- Electrical panel thermal imaging to identify poor connections.
- Coil piping evaluation to identify leaking valves.

For more information on smart phone infrared camera attachment equipment, visit www.flir.com/flirone.

PLANT EQUIPMENT

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QUESTION

What are three important factors that affect the efficiency of a chiller?



ANSWER

Important factors that affect chiller efficiency include:

- Compressor type and capacity control
- Temperature lift
- Temperature approach (e.g., heat transfer surface cleanliness and area)



DISCUSSION

Compressors for new water chillers can be of three types - centrifugal, rotary screw, and scroll. Existing chillers are still installed that have reciprocating compressors. Of these types, centrifugal compressors are the most efficient, while reciprocating compressors tend to be the least efficient. Any compressor type can be operated in a manner that is more or less efficient. Operating efficiencies are maximized when temperature lift (the difference in temperature between the high and low pressure sides of the chiller) is minimized. Clean heat exchangers and optimized setpoints both help in minimizing temperature lift.

DISCUSSION QUESTIONS

What other ways can we maintain chiller efficiency?
What are the primary methods for cleaning tubes?
What is a reasonable chilled water supply temperature?
What is a reasonable entering condenser water temperature (for water-cooled chillers)?
What are some techniques to reduce temperature lift on air-cooled chillers?

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QUESTION

What are the primary drivers when establishing the setpoint for chilled-water temperature?



ANSWER

The primary drivers for a chilled-water temperature setpoint are:

- Load
- Chilled-water system configuration
- Coil cleanliness



Photo credit:
Marcela Gara, Resource Media

DISCUSSION

Chilled-water supply temperature must be cold enough to allow peak cooling load to be met at the various air-handling units served by a chilled-water system. This is typically a function of load, chilled-water coil design conditions, and coil cleanliness. If you're uncertain, be sure to check the original coil design schedules, as the ideal entering chilled-water temperature is usually documented in that schedule.

Note that many coils can outperform the original design schedule. For most chillers, chiller efficiency can be increased by 1–2% for each degree that the chilled-water temperature setpoint is increased.

DISCUSSION QUESTIONS

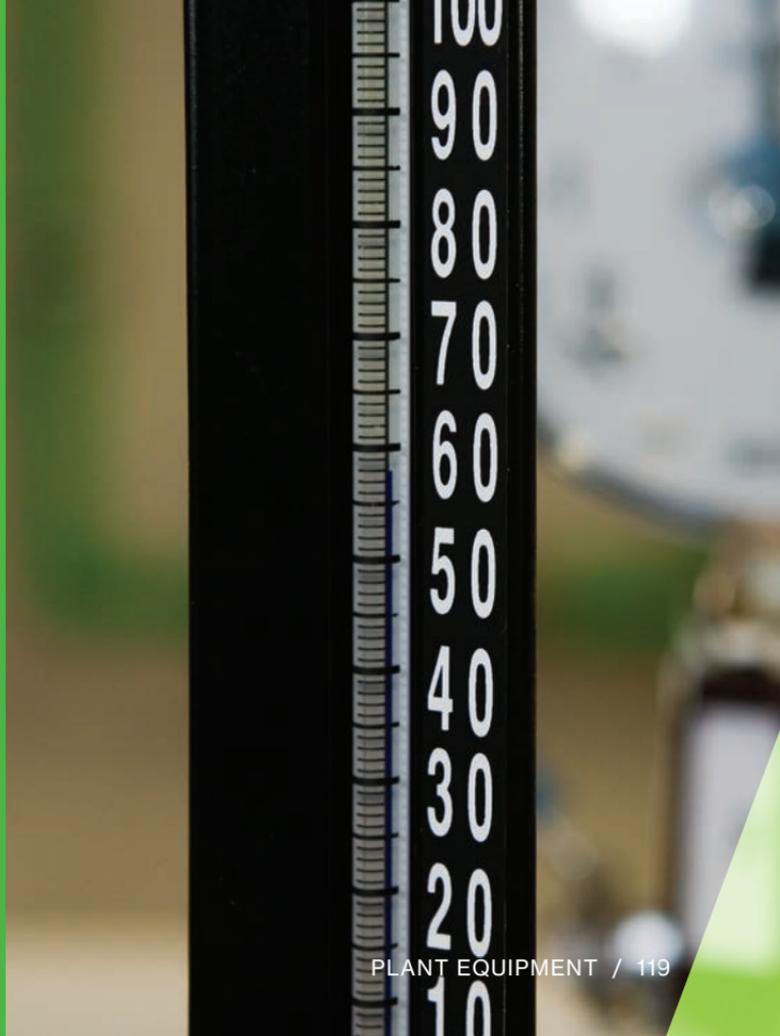
What is a reasonable chilled-water supply temperature?

What are some considerations for implementing chilled-water temperature reset controls?

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QUESTION

What are the primary drivers when establishing condenser-water temperature setpoint?



ANSWER

The primary drivers for condenser-water temperature setpoint are:

- Climate conditions
- Tower size
- Equipment limitations



DISCUSSION

Most chiller manufacturers publish a recommended minimum entering condenser-water temperature. The recommended temperature varies significantly among chillers, but generally, this recommendation should establish a minimum condenser-water temperature. Additionally, most cooling towers will exhibit some performance limits in hot and humid conditions. These limits, determined both by tower size and operating conditions, will contribute significantly to the effective condenser-water temperature that a water-cooled chiller plant can achieve.

Similar to chilled-water setpoint increases, most chillers will experience a 1–2% increase in efficiency for each degree that condenser temperatures are reduced. However, for water-cooled plants, some of this saved energy is offset by the increased energy use of the cooling tower fan.

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QUESTION

Why is it important to have a good condenser-water treatment program?



ANSWER

A strong condenser-water treatment program is important because most chillers use water for heat transfer. Properly treating the water will prevent scale, corrosion and biological growth.

DISCUSSION

A one-time chemical treatment is recommended for closed-water systems, which are typical of chilled-water systems connected to the chiller evaporator.

Open systems are typically used for condenser-water systems connected to the chiller condenser. Condenser systems that use sources such as cooling towers will benefit from continuous chemical water treatment.

DISCUSSION QUESTIONS

How often should water quality be tested?

How often should systems strainers be cleaned?

How can you determine whether cleaning is required?



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QUESTION

Which is the more efficient chiller heat-rejection solution: air-cooled or water-cooled?



ANSWER

Water-cooled is the more efficient chiller heat-rejection solution.



DISCUSSION

In most applications, water-cooled plants deliver better energy performance. Additionally, large plants that use centrifugal chillers are almost exclusively water-cooled. Recent advances in smaller capacity centrifugal compressor technology have led to the market introduction of air-cooled chillers with centrifugal compressors. However, keep in mind that cooling towers and condenser water systems come with significant maintenance considerations.

In moderate climates, such as marine and coastal environments, air-cooled chillers can exhibit reasonably efficient performance due to the relatively cool outside air temperatures in which the chiller operates. This is also true for chillers that are intended to operate primarily at night during cooler weather. Note that all system operating costs should be taken into consideration when making this important life-cycle cost decision.

DISCUSSION QUESTIONS

What are some of the added maintenance costs associated with cooling towers and condenser-water loops?

What are some of the operational downsides of air-cooled chillers?

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QUESTION

Why should the chiller have lockouts based on the outside air temperature?



ANSWER

Lockouts based on the outside air temperature are important because energy is wasted when the chilled-water system operates when economizers can be used for free cooling. Therefore, the chiller should be locked out when the outside air temperature is cool enough to meet the load by itself.



DISCUSSION

Keep an eye out for the following scheduling issues pertaining to chillers and boilers:

- Are chillers locked out when the outside-air temperature is low?
- Are boilers locked out when the outside-air temperature is high?
- Are controls in place to prevent chillers and boilers from unnecessary simultaneous operation?
- Are there controls to shut off the boiler or chiller when there is no load?

Note that economizing strategies may be eligible for utility incentives. Contact your local utility to learn more.

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QUESTION

What are some possible problems that can cause a chiller to operate unnecessarily during low outdoor-air-temperature (OSAT) conditions?

ANSWER

Potential problems that can cause a chiller to operate unnecessarily during low OSAT conditions include:

- OSAT sensor is miscalibrated or improperly located.
- OSAT sensor has failed or lost communication.
- Economizer is malfunctioning.
- Lockout setpoint is overridden, not provided, or has been reset below the design setpoint.



DISCUSSION

Some possible unproblematic explanations of this same scenario include:

- The HVAC system is a medium-temperature system with a low (45-degree) supply-air temperature.
- A small process load (e.g., a server room) may be connected to the system and requires constant chilled water. (Consider adding a small, dedicated chiller to serve this load).
- Lack of air-side economizers.
 - Note that economizers may be eligible for utility incentives. Contact your local utility to learn more.

Keep in mind that the Implications of low-temperature chiller operation can vary significantly between water-cooled and air-cooled equipment.

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QUESTION

What is the primary benefit of variable frequency drive (VFD) control for cooling tower fans?



ANSWER

Even beyond energy savings, the primary benefit of VFD control for cooling tower fans is the improved loading of chiller compressors that comes from control of the entering condenser-water temperature.



DISCUSSION

A VFD works by varying the frequency of the electric source to tower fan motors. Installing them on existing cooling towers is an effective way to improve the overall efficiency of the chiller plant.

Retrofitting an existing cooling tower fan with a VFD can be very beneficial, but it's smart to consider the following before undergoing the retrofit:

- Is the existing motor inverter-duty rated?
- Does the fan gearbox have a minimum speed requirement to stay lubricated?
- Is there room to install the VFD nearby? Will it require an outdoor-rated enclosure?

If you're considering such a retrofit, we recommend engaging an HVAC professional and consulting the VFD manufacturer.

DISCUSSION QUESTION

Under what conditions would it be expected for a tower fan VFD to operate at full speed? How many hours per year should it operate at full speed?

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QUESTION

What are the four basic components of steam systems?



ANSWER

- Generation
- Distribution
- End Use
- Recovery



DISCUSSION

Poorly maintained steam systems are a common issue for older buildings that rely on large boilers for heat. Typically, these buildings have hundreds of small steam traps that control the condensate within the steam system. If these are not regularly maintained, they can get stuck open and return steam back to the boiler system, resulting in wasted heat and wasted energy.

DISCUSSION QUESTIONS

What are some of the ways that steam distribution systems lose steam, and why is this significant?

What are some ways to conduct steam trap testing?

Why is condensate recovery important?

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QUESTION

What is the steam trap failure mode that results in wasted steam, and how can this be diagnosed?



ANSWER

This steam trap failure mode occurs when steam traps allow steam to pass through without reaching the load area. It is typically diagnosed with temperature measurements at the discharge of the trap.



DISCUSSION

Steam traps can fail in two fundamental ways: They do not allow condensate to pass through, or they do allow steam to pass through. It is this second failure mode that results in wasted steam energy. This is typically diagnosed with temperature measurements at the discharge of the trap. Temperatures consistent with steam supply pressure indicate that steam may be blowing through the trap. Ultra-sonic testing equipment can be used for more accurate diagnosis.

Even if there are failed traps in the system, it is not always possible to diagnose traps that are blowing steam. For example, if the steam control valve is closed, it will not allow steam at the trap to pass through.

DISCUSSION QUESTIONS

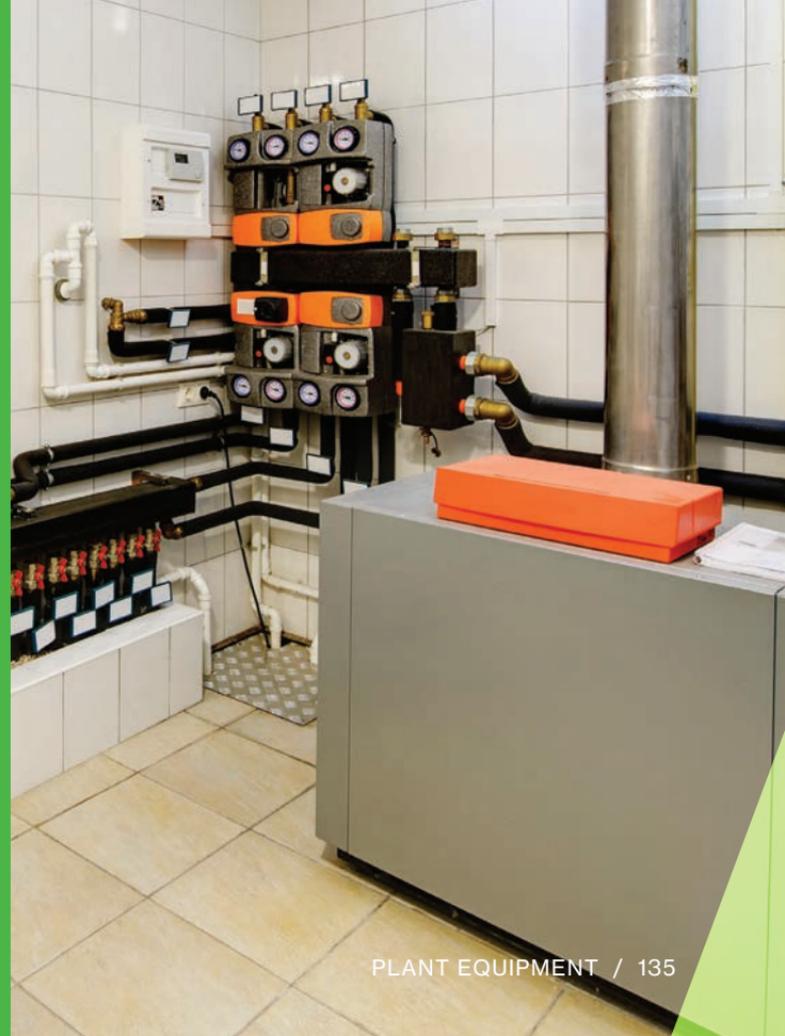
When is a good time of day to conduct trap-failure diagnosis?

What are some visual inspection techniques that can provide an indication of traps that have failed in an open position?

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QUESTION

What are three common ways that boiler types can differ?



ANSWER

Boiler types can differ in the following ways:

- Working fluid (e.g., hot water vs. steam)
- Fuel type (e.g., natural gas, oil, electric)
- Heat exchanger or burner type (e.g., condensing, fire tube, water tube, cast-iron sectional)



DISCUSSION

All three characteristics are important to consider when discussing and evaluating boilers. The working fluid differentiation is the most fundamental, followed by the fuel type differentiation. Note that not all types of heat exchangers are applicable to boilers of differing working fluids or fuels.

Today's most efficient boilers are condensing boilers. Condensing refers to the operating condition where exhaust gases are cooled below the dewpoint inside of the heat exchanger. This results in liquid condensate that is moderately acidic and requires draining. Most condensing boilers are gas-fired hot water boilers.

DISCUSSION QUESTIONS

Is it possible for a condensing boiler to generate steam?
Is it possible for a condensing boiler to fire on fuels other than natural gas?
What are the benefits and drawbacks of various heat exchanger types? Which is preferable?

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QUESTION

Why is it important to remove any residue, soot or scale that coats heat transfer surfaces?



ANSWER

Residue that coats heat transfer surfaces will reduce boiler efficiency and increase the likelihood of equipment failure.

DISCUSSION

Good boiler water chemical treatments are essential to maintaining efficient operation. Even a thin layer of scale interferes with heat transfer, thereby decreasing combustion efficiency. A layer of soot or scale only 0.03 inches thick can reduce heat transfer by 9.5%, while a layer of 0.18 inches can reduce heat transfer by up to 69%.

Consistent and frequent small-volume blowdowns are preferable to infrequent high-volume blowdowns because they conserve energy, water and chemicals. Large steam boilers with steady loads should have continuous blowdown, during which a small amount of water is drained continuously from the boiler while fresh make-up water is introduced.

Consider the following additional maintenance procedures to help ensure optimal boiler performance:

- Remove any buildup coating the tubes.
- Enact a water/chemical treatment plan.
- Calibrate instruments monthly.
- Examine water-side surfaces for any evidence of scaling or corrosion.
- Minimize boiler blowdown.
- Inspect and repair insulation.



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QUESTION

How much excess air is enough to ensure complete combustion?



ANSWER

Typically, 10% excess air will ensure complete combustion. However, this varies with the design and condition of the burner and boiler, as well as with varying rates of burner firing.



DISCUSSION

Complete combustion is critical to ensuring efficient boiler operation. Incomplete combustion of the fuel can reduce boiler efficiency by 10% or more. Conversely, increasing excess air by 10% may only impact boiler efficiency by about 1%.

Typically for a natural gas boiler, excess air of around 10% will ensure complete combustion and peak efficiency, which corresponds to excess air of around 2–3%. Operating with excess air beyond 10% is undesirable, as it can result in reduced efficiency and higher emissions. Therefore, it is preferable to maintain the optimum level of excess air across the entire firing range.

DISCUSSION QUESTIONS

- What are some signs of incomplete combustion?
- What types of burner controls are superior alternatives to mechanical jackshaft controls?
- How often should a boiler be tuned up to ensure an optimized combustion process?
- How often should the boiler be tuned up to ensure the combustion process is optimized?

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QUESTION

What energy losses can occur when a boiler is kept in standby?



ANSWER

When a boiler is kept in standby, it will cycle on and off, which wastes energy by losing heat to the surroundings through radiation losses.



DISCUSSION

At low firing rates, such as when a boiler is maintained in a standby condition, efficiency losses can be as much as 15% of the input energy. Keeping a boiler in standby will allow quick recovery if the lead boiler fails, but this must be weighed against this large energy penalty. If a standby boiler is not critical to your operation, or if the need for a standby boiler is seasonal, operators should consider shutting off any unnecessary boilers to prevent these energy losses.

For some operations, it is necessary to keep a standby boiler warm so that it can come up to temperature or pressure quickly if a lead boiler goes down unexpectedly. Typically, this is accomplished by idling the burner at low fire.

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QUESTION

What are some methods to improve boiler efficiency?



ANSWER

Boiler efficiency can be improved in the following ways:

- Installing an economizer.
- Reducing boiler pressure.
- Preheating combustion air.
- Using automatic boiler combustion controls.
- Properly treating boiler water.
- Ensuring boiler has lockouts based on outside-air temperature.



DISCUSSION

In addition to the aforementioned ways to improve boiler efficiency, there are also ways to reduce boiler efficiency and decrease equipment life. A prime example is frequent equipment cycling, which should be avoided whenever possible. Some potential indicators of frequent equipment cycling include:

- Flow switch is malfunctioning.
- Water-temperature high-limit switch is set too low.
- Deadband between on/off is too narrow.
- Boiler is overfiring, or the flue or turbulence-inducing inserts in fire tubes are clogged.
- Water-heating pump is cycling, causing boilers to cycle via the system flow switch.
- Natural gas pressure at the manifold is low.
- Flow of the induced-draft fan is inadequate.

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QUESTION

What is a boiler economizer?



ANSWER

A boiler economizer is a heat exchanger device that captures the lost heat (i.e., waste heat) from the boiler's hot stack gas.

DISCUSSION

Capturing waste heat reduces the overall fuel requirements for the boiler, which allows the boiler to operate at a higher efficiency to save money and reduce emissions.



Boiler economizers improve a boiler's efficiency by extracting heat from the discharged flue gases. Because the boiler feedwater or return water is preheated by the economizer, the boiler's main heating circuit doesn't need to provide as much heat to produce the output quantity of steam or hot water.

Note that a boiler economizer typically does not add efficiency to a condensing boiler because it already maximizes the heat extracted from the flue gas.

DISCUSSION QUESTIONS

What are the primary benefits of condensing economizers?

What are some other potential uses of recovered heat from stack economizers, besides pre-heating boiler feedwater?

What are some other heat recovery opportunities in boiler plants besides stack economizers?

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QUESTION

What percentage of a building's total energy use does central plant equipment (i.e., boilers and chillers) account for?



ANSWER

Generally, central plant energy use ranges from 20–70%, but the actual energy use percentage depends on a variety of factors including the building, climate and controls. For example, fossil fuel energy used at the boiler will often account for 75% of the total energy used by elementary schools in temperate climate zones.

DISCUSSION

Both boilers and chillers must be maintained properly to run at peak efficiency. In many cases, replacing an aging chiller with a new energy-efficient model can yield energy cost savings. Adding heat recovery can often provide additional, significant energy-saving opportunities.

Note that high plant equipment energy use is a result of not only the system loads imposed on the equipment by the building and its systems, but also the efficiency

of the plant equipment itself. Both energy loads and equipment efficiency must be addressed to make big reductions in the energy consumed in energy-intensive central plants.

Strategies for load reduction to reduce cooling loads on a chiller plant include:

- Making sure outside-air economizers on AHUs/ RTUs are functioning well.
- Increasing cooling space temperature setpoints.
- Adding shades to windows.
- Upgrading windows.

Strategies for load reduction to reduce cooling loads on a chiller plant include:

- Reducing excessive outside-air intake during extreme cold conditions.
- Implementing more aggressive temperature setbacks and schedules.
- Eliminating water-heating valve leaks.
- Upgrading building envelope to reduce heat loss.

PUMPS

COMMERCIAL ENERGY TALK CARDS

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QUESTION

What are the three primary factors in determining pump power requirements?



ANSWER

The three primary factors in determining pump power requirements are:

- Installing an economizer.
- Reducing boiler pressure.
- Preheating combustion air.



DISCUSSION

The relationship is defined as follows:

$$\text{Power (hp)} = \frac{\text{Flow (gpm)} \times \text{Pressure (feet of water)}}{\text{Mechanical efficiency} \times 3960}$$

Pump power can be reduced by manipulating any of these factors (i.e., reducing flow requirements, reducing pressure requirements, or increasing pump mechanical efficiency).

Mechanical efficiencies are indicated on pump curves along with flow and pressure performance. Typically, pumps should be selected to operate at or near the best operating point (BOP), which represents the maximum mechanical efficiency for a particular pump and impeller diameter.

DISCUSSION QUESTIONS

What other important information is contained on a pump curve?

How is the pump operation plotted on a pump curve?

betterbricks/

QUESTION

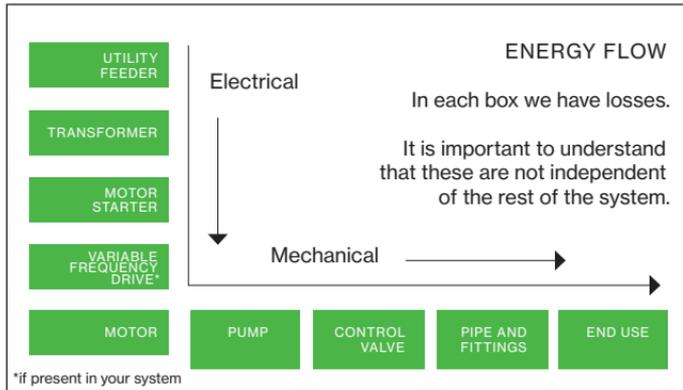
What are the elements of a pumping system?



ANSWER

The following are the elements of a pumping system:

- Motor
- Pump
- Piping
- Valves
- Gauges
- Controls
- Sensors



DISCUSSION

Always consider your pump system as a whole. Inefficiencies occur at each step, so matching supply to demand can have a multiplying effect on energy savings.

The motor system for a pump includes everything from the electricity entering the facility to the end-use application for the pumped fluid. Throughout the process, there are systems losses at each step.

DISCUSSION QUESTIONS

When was the last time your facility assessed the entire pump system?

Can an inspection of the entire pump system be incorporated in your usual equipment inspection cadence?

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QUESTION

What are the indicators of an unreliable and inefficient pump system?



ANSWER

Indicators of an unreliable and inefficient pump system may include:

- Throttled valves (more than 25% of design flow)
- Normally open bypass lines
- Pumps running continuously, counter to design or intention
- Pumps that are cavitating
- Over-cycling of pumps in batch operation
- Pumps with high maintenance costs



DISCUSSION

Inefficient pump systems often result in high maintenance costs and lower reliability. Unreliable and inefficient pump operation can also increase maintenance costs and lead to energy waste and poor productivity.

Be sure to check with your electric utility to see if they offer help evaluating alternatives to improve your system.

DISCUSSION QUESTIONS

Can you think of a particular system that has any of these indicators?

Who is the champion or owner of that system?

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QUESTION

What's a more efficient way to control flow than by throttling valves and bypass loops?



ANSWER

Efficient ways to control flow include putting in a smaller pump and motor, trimming the impeller, and/or installing a Variable Frequency Drive (VFD).



DISCUSSION

Bypass loops and throttling valves are the least efficient and most costly way to control flow, as they increase energy usage and maintenance costs, and decrease reliability. Throttled valves produce significant pressure drops and are a major contributor to pump efficiency loss. A VFD that reduces the speed by an average of 10% on a continuously running 100-horsepower pump can save about \$10,000 per year in energy costs alone.

VFDs can eliminate the need for valves, starters and bypass systems because they adjust pump speed automatically, according to demand. They also protect against pressure spikes, and some have soft-starting capabilities. A 20% reduction in speed can reduce power consumption by 50% (which is close to \$20,000 per year for the 100-horsepower pump example cited above). Be sure to contact your electric utility for potential energy efficiency incentives for VFDs.

DISCUSSION QUESTION

Are there any bypass loops and throttling valves in your facility?

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QUESTION

What are the typical pressure setpoints for chilled-water systems?



ANSWER

Typical pressure setpoints for chilled-water systems range from a low of 5 psig to a high of 20 psig.



DISCUSSION

To ensure flow through the farthest coil or terminal device on the system, differential pressure setpoints should be established just above the required pressure difference. This can be determined by reviewing the design pressure drops for coils and flow-control valves. Be sure to consider pressure drop through the fully open valve and coil in the series.

Higher-than-necessary setpoints will result in unnecessary pump energy use due to limited pump speed turndown. Implementing a reset control sequence is a good way to make sure pressure setpoints are optimized.

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QUESTION

Complete the following sentence: It is important to size and operate the motor and/or pump according to _____.



ANSWER

It is important to size and operate the motor and/or pump according to **system requirements**.



DISCUSSION

Improving the system can be as simple as turning a pump off or as complicated as re-sizing or re-piping the system based on current design conditions.

The following techniques can help ensure the system is matched to current production requirements. Before you begin, be sure to conduct a detailed analysis to determine which of these activities is most appropriate for your system.

- Trim pump impeller.
- Install a VFD (and contact your utility for potential incentives).
- Replace a single large pump with parallel pumps.
- Modify the fluid system (e.g., increase the pipe diameter, remove bends and valves, etc.)
- Turn off unneeded pumps.
- Examine the system to determine if function and requirements have changed over time.
- If the pump must be replaced, select one with a high efficiency rating. Look for pumps with Hydraulic Institute (HI) energy rating labels to help choose the most efficient replacement.

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QUESTION

What effect does pipe diameter have on water-pumping costs?



ANSWER

Large diameter piping is significantly more efficient.

- 6-inch pipe = \$1,750
- 8-inch pipe = \$500
- 10-inch pipe = \$200

DISCUSSION

Friction significantly increases pumping losses, which means larger pipes result in significantly less energy costs. For example, the following represents the annual energy costs for various sizes of a pump operating at 600 gpm:

- 6-inch pipe = \$1,750
- 8-inch pipe = \$500
- 10-inch pipe = \$200

Additional ways to reduce the frictional component of your pumping system include:

- Lower the flow rate.
- In systems dominated by friction head, evaluate pumping costs for at least two pipe sizes and try to accommodate pipe size with the lowest life-cycle cost.
- Look for ways to reduce the friction factor. If application permits, epoxy-coated steel or plastic pipes can reduce friction factor by more than 40%, which proportionately reduces pumping costs.

Best sure to compute the annual and life-cycle cost for systems before making an engineering design decision.

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QUESTION

What percentage of the life-cycle cost of a pumping system is devoted to energy and maintenance?



ANSWER

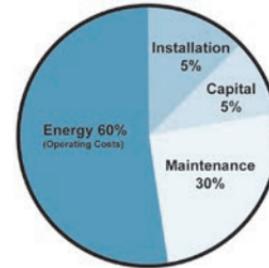
Energy and maintenance accounts for about 70-90% of the life-cycle cost of a pumping system.



DISCUSSION

The most significant life-cycle costs of pumping systems are the energy and maintenance/repair costs, followed by initial cost. There is a direct correlation between pump system operation and overall building maintenance costs.

LCC/TCO typical
75 hp pump
\$750,000 over
20 years



The two smallest slices in the pie chart above represent the initial purchase cost of the pump system and the installation costs. The second largest slice represents maintenance costs. The largest slice represents energy costs, which is more than 60% of the total cost of operation. This significant life-cycle cost is often overlooked when making purchasing decisions.

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QUESTION

What are the recommended methods for monitoring a pump system?



ANSWER

Use the following methods to monitor a pump system:

- Power monitoring
- Flow-rate or pressure monitoring
- Temperature monitoring
- Vibration monitoring



DISCUSSION

Pumping systems should be well-monitored to keep track of operational performance. In particular, tracking key performance indicators (KPIs) will help keep the system running in an optimal way, and potentially lead to significant electricity and maintenance savings. Note that wireless monitoring systems can be cheaper to install than wired systems.

DISCUSSION QUESTIONS

Do you employ any pump system monitoring methods in your facility?

Which parameters do you track? Is the information used to improve the operation of the system?

Can you easily measure power divided by flow?

Can you use wireless monitoring? Would it be cheaper?
Can we use wireless monitoring? Would it be cheaper?

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QUESTION

How often should the water-distribution system be inspected?



ANSWER

Water-distribution systems should be routinely inspected. The inspection frequency should be based on multiple factors, including system age, reliability and criticality. Systems with reliability issues or those serving critical applications (e.g., hospitals) should be inspected more often.

DISCUSSION

During inspections, building engineers should walk the entire system and check piping, valves and pumps for leaks and unusual noise. Noise often indicates hidden valve or pump problems. Sources of noise include turbulence, water hammer, cavitation and release of entrained air.

Locations for inspection may be unique to the pumping systems, but the following are typical locations to consider:

- Pump strainers or suction diffusers, especially on condenser water systems where debris can build up over time and cause excessive pressure drops.
- Suction and discharge pressure gauges. These can fail and should be replaced as needed to ensure accurate readings.
- Pump seals that can leak and cause loss of treatment chemicals and excessive use of make-up water.
- Air vents (both automatic and manual), which may occasionally require opening to prevent air binding in the system.

Add each of these components to your regular inspection checklists. Note that pumping systems with significant energy use should be checked daily. regular inspection checklists.

BUILDING AUTOMATION

COMMERCIAL ENERGY TALK CARDS

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QUESTION

How can Building Automation Systems (BAS), also known as a Building Management Systems (BMS), be used to enhance building performance?



ANSWER

- Live tracking of energy use
- Remote monitoring and trending
- Enables advanced control sequences
- Fault detection and alarming
- Improved occupant comfort
- Computerized maintenance scheduling
- Enables quick response to acute events



DISCUSSION

Typically, the first systems to be monitored (or automated) are the HVAC and lighting systems, which can save an estimated 5-30% on utility costs. Building Automation Systems (BAS) can also be integrated into plumbing systems to monitor and reduce water usage, and can allow third parties to collect and validate energy consumption data for benchmarking purposes.

The vast amount of information available in a BAS is another significant benefit. These systems provide all types of information including temperatures, pressures, speeds, equipment status, runtimes, etc. Many systems color code graphical elements to make interpretation of data easier and quicker for building operators.

Another benefit of a BAS is that it can enable quick response to acute events like pathogens or smoke. You can have specific control system settings that can be easily engaged/disengaged to accommodate such occurrences.

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QUESTION

Is it always better to use
BAS/BMS?



ANSWER

It is always better to use BAS/BMS, but only if it's properly configured.



DISCUSSION

BAS/BMS are most commonly implemented in large buildings with extensive HVAC, electrical and plumbing systems. When properly configured, they can be a critical element in managing and reducing energy usage.

However, improperly programmed controls or outdated technology can misleadingly suggest that a building is running efficiently when it is actually performing far below its potential. In fact, it is estimated that improperly configured systems account for approximately 8% of total energy use in the U.S.

It's important to take advantage of current controls technology to maximize the efficiency of all operating components of the building. Be sure to replace, upgrade, or reprogram (i.e., retro-commission) the energy management system and temperature controls to allow equipment to operate at peak efficiency.

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QUESTION

What sequence of operation and control is recommended as the current best practice for managing fan energy with BAS/BMS?



ANSWER

Duct static pressure reset is the recommended sequence when managing fan energy with BAS/BMS.

DISCUSSION

Supply fans controlled by variable frequency drives (VFDs) within variable air volume (VAV) systems are among the most common HVAC fan applications in medium- and large-sized buildings. Without static pressure reset, the fans operate at speeds that are sufficient to maintain duct pressure conditions at a fixed setpoint. With duct static pressure reset, BAS/BMS can vary duct static pressure by polling zone-load conditions. When load conditions are satisfied (i.e., when zones are receiving sufficient air), fan energy is saved by reducing the setpoint and fan speed. Note that implementing this sequence may qualify for energy management incentive from your local utility. Contact your utility representative to learn more.



Photo credit:
Marcela Gara, Resource Media

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QUESTION

When duct pressure reset is implemented, why must care be taken to avoid having the reset control sequence driven by one or two zones?



ANSWER

When duct pressure reset is implemented, care must be taken to avoid having the reset control sequence driven by one or two zones where it is particularly difficult to maintain load conditions. These zones are often referred to as “rogue” zones.



DISCUSSION

What are some root causes of rogue zones in VAV systems?

What are some remedies to allow a duct pressure reset to function effectively?

What is a practical minimum duct static pressure setpoint?

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QUESTION

What is the most commonly applied sequence of operation and control to minimize energy use associated with reheat and overcooling?



ANSWER

Supply air temperature reset is the most commonly applied sequence to minimize reheating and overcooling energy use.

DISCUSSION

In many multi-zone HVAC systems, centrally cooled air is reheated to avoid overcooling spaces. The energy management best practice is to limit reheating and other simultaneous heating and cooling conditions. Supply-air temperature reset is a control strategy in which the BAS/BMS polls zones to determine the sufficient supply-air temperature. The air temperature leaving the air-handling unit is then increased when possible. Warmer air limits the amount of reheating required throughout the system. Typical supply-air temperatures range from approximately 55–65 F.

HVAC systems rely on multiple interdependent components, so a change to one piece of an HVAC system may impact other pieces (e.g., implementing a supply-air temperature reset may result in increased supply-fan energy). Therefore, when implementing any change to an HVAC system, it is important to consider its impact on the entire system.

DISCUSSION QUESTIONS

Many BAS/BMS applications implement both duct static pressure reset and supply-air temperature reset. These two control sequences can fight each other. Why is this?

What are some ways that stable control interaction between these two reset controls can be achieved?

If you are inspecting an outside air temperature sensors installation, what are the issues to note and consider?

QUESTION

There are many different setpoints in VAV systems, including actual airflow setpoints at the VAV terminal units. What is an energy-saving opportunity for airflow setpoints in a VAV system?



ANSWER

Lowering minimum setpoints can achieve fan savings, heating savings and cooling savings. When minimum setpoints are lowered, total airflow is reduced during periods of minimum need for heating or cooling, which allows fan VFDs to slow. This reduces airflow past reheat coils and airflow past central cooling coils.

DISCUSSION

As with pressure and temperature, airflow setpoints can also be dynamically reset in BAS/BMS applications. Modern VAV terminal units have four airflow setpoints that establish zone control: maximum cooling airflow, minimum cooling airflow, maximum heating airflow and minimum heating airflow. Maximum cooling airflow is typically established by the cooling load in a zone, while the BAS/BMS resets the minimum airflow setpoints.

When a zone is occupied, the minimum airflow setpoint cannot be lower than the required fresh air ventilation rate for that zone. When the zone is not occupied (or partly occupied), the minimum airflow setpoints can be reset below the minimum ventilation requirements.

Sensing devices are typically required to implement airflow reset, although many systems also use time-of-day schedules.

DISCUSSION QUESTIONS

What type of sensing devices are commonly used?

It is reasonable to use occupancy sensors or carbon dioxide sensors for airflow setpoint reset?

Should a VAV box damper ever be reset to a fully closed position?

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QUESTION

How does BAS/BMS help avoid the need to condition too much outside air in a building's HVAC system?



ANSWER

A control sequence known as demand-controlled ventilation (DCV) can help avoid conditioning too much fresh air by matching the amount of fresh air to the needs of the occupants. Occupancy in a building can vary, so DCV drives the control using direct or indirect sensing of occupancy.



DISCUSSION

Carbon dioxide sensors are most commonly used to monitor occupancy. The BAS/BMS translates the carbon dioxide reading to estimate occupancy needs. The outside air damper in the air-handling unit is then adjusted to adjust fresh airflow to match needs. This approach can minimize excess heating or cooling loads while enhancing indoor air quality. Note that the carbon dioxide sensors are typically installed in either the return air duct or in the actual occupied spaces.

DCV based on direct occupancy sensing is also an option, though less common. An example of this is a movie theater where ticket sales are tracked and used to adjust outside air in the theater.

DISCUSSION QUESTIONS

What is a reasonable range of indoor carbon dioxide that corresponds to good air quality?

What is a maximum level above which control action should be taken?

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QUESTION

What is the recommended sequence of operation and control to manage pump energy with BAS/BMS?



ANSWER

The recommended sequence to manage pump energy with BAS/BMS is differential pressure control reset, typically based on valve position.

DISCUSSION

Differential pressure control reset is a sequence that applies to pumps in which pump speed is controlled by a variable frequency drive (VFD). In this sequence, pump speed is decreased or increased to maintain a differential pressure setpoint at an appropriate location in the pumping system, typically far downstream of the pumps. Lower setpoints translate to lower pump speeds, which reduces pump energy use. The lowest setpoints are possible with reset controls that are facilitated by the BAS/BMS.

What other control variables besides valve position can be used to drive pressure reset controls?

If outside air temperature is used as a reset control variable, how can accuracy of temperature readings be assured?

If you are inspecting the installation of an outside air temperature sensor, what are the issues to note and consider?

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QUESTION

What is the recommended sequence of operation and control to manage chiller energy use with BAS/BMS?



ANSWER

The recommended sequence to manage chiller energy use with BAS/BMS is:

1. Optimized chiller staging
2. Chilled water temperature reset
3. Condenser water temperature reset

DISCUSSION

Optimized chiller staging matches chillers to the load conditions in which they perform most efficiently. This can involve the sequential enabling or disabling of chillers, or the incremental staging of multiple chillers that operate together. To support development of these staging algorithms, it is important to have documented performance of each chiller in a plant over a full range of part-load conditions.

Chilled water reset refers to the dynamic reset (up or down) of the chilled water supply temperature setpoint. For every degree increase in temperature, chiller efficiency is improved 1–2%. Typical chilled water reset ranges are 42–54 F.

Condenser water reset is similar to chilled water reset, but it controls the leaving water temperature from a cooling tower (i.e., entering condenser water temperature into a water-cooled chiller). The BAS/BMS typically monitors ambient temperature and humidity conditions and resets the leaving tower water temperature setpoint to be as low as possible. Resetting the condenser water setpoint typically results in significant chiller savings. However, the cooling tower fans may use slightly more energy to achieve the lower condenser water temperature. In nearly all cases, the energy saved by the chillers will far exceed the increase in energy used by the cooling tower fans.

All of these strategies may qualify for energy management incentives. Be sure to contact your electric utility representative to learn more.

DISCUSSION QUESTIONS

Some chiller manufacturers are concerned about low temperatures of entering condenser water. What are some of the reasons for this concern? What are reasonable minimum temperatures of entering water?

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QUESTION

Is BAS/BMS time-consuming and difficult to operate?



ANSWER

No, operating BAS/BMS is not necessarily difficult or time-consuming.



DISCUSSION

While BAS/BMS can be initially daunting, most building automation technology is intuitive and user-friendly. Once you are familiar with the technology, it is likely that the BAS/BMS will save you time and make building operations easier.

Graphics screens make the BMS/BAS easy to use. However, operators should understand that graphics, just like actual controls, require commissioning. Some data reported on graphics screens may not be properly verified, and at times the images used in the graphics screens do not accurately reflect the actual system configuration.

DISCUSSION QUESTIONS

What are several common data inaccuracies present in graphics screens? How can these issues be rectified?

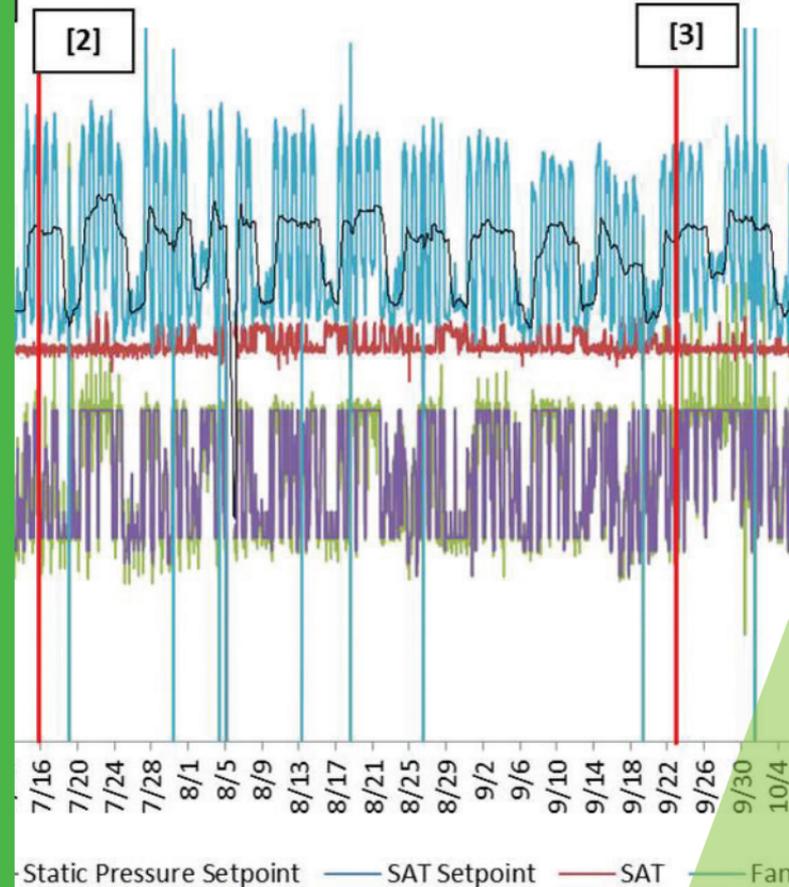
What additional performance data can be added to graphics screens to enhance usability?

betterbricks/

QUESTION

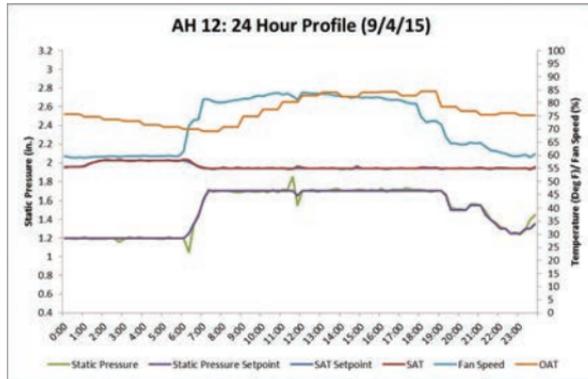
What are trend reports, and how can they be used to enhance the value provided by BAS/BMS?

AH 12: DSP and DAT Reset



ANSWER

Trend reports collect performance data about one or more monitored variables in the BAS/BMS. They report the data on a time-series basis.



DISCUSSION

Identifying deficiencies through a review of trend graphics is an exercise in pattern recognition and often requires practice before issues can be identified. However, graphic representations of trend reports are particularly useful in diagnosing minor and major HVAC system operating deficiencies. Trend graphs with multiple variables plotted on the same time scale can reveal deficiencies that are difficult to spot using other inspection and diagnostics techniques.

Often, graphical reports can be shared with other stakeholders within the facility to obtain buy-in on solutions to identified problems.

HVAC CONTROLS

COMMERCIAL ENERGY TALK CARDS

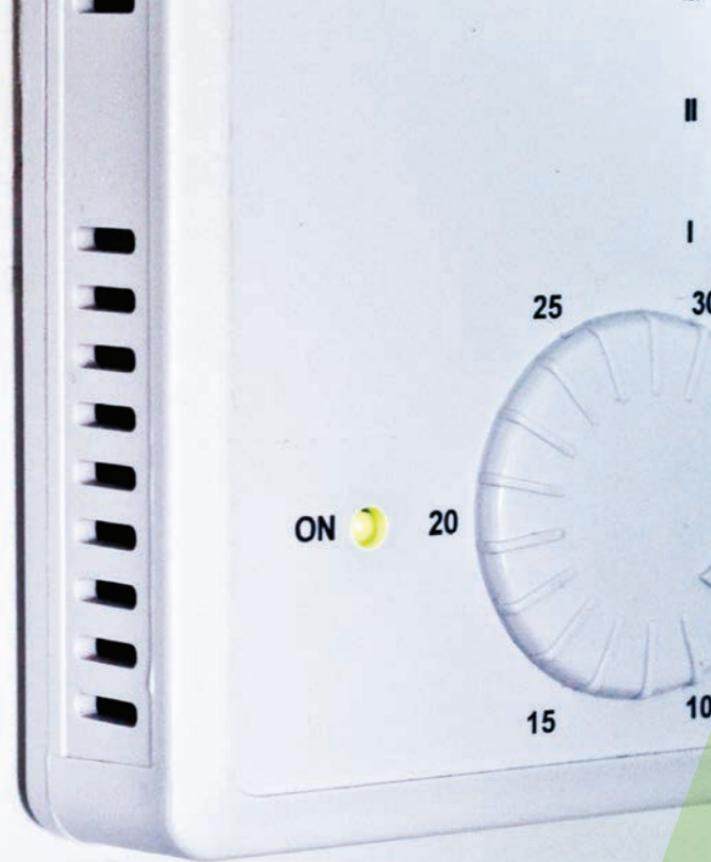
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QUESTION

Pneumatic control components, especially zone sensors and thermostats, can become uncalibrated and go unchecked for extended periods. For thermostats that have not been calibrated in more than two years, what percentage of them are likely to be out of calibration?

ENERGY TALK ON COMMERCIAL ENERGY EFFICIENCY



HVAC CONTROLS / 194

ANSWER

Up to 70% of thermostats that have not been calibrated for more than two years are likely to be out of calibration. Further, about half of these can be expected to be non-functional and require replacement.



DISCUSSION

In an older building with hundreds of zone sensors and thermostats, a trained technician or operator should be able to spend about 2–4 hours of systematic work taking a sampling of zone sensors and thermostats to determine the degree of the calibration problem. Often this work will uncover other related problems, such as improper thermostat location, brittle or failed pneumatic tubing, and low control pressures in part of the system.

Calibration of pneumatic sensors and thermostats is not particularly difficult, but it does require a basic set of calibration tools, some of which are uniquely suited to specific thermostat models and manufacturers. A calibrated and accurate thermometer or digital temperature gauge is always required. Note that thermostat calibration kits can be purchased at a reasonable cost from control manufacturers or parts distributors.

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QUESTION

What typically leads to energy waste in pneumatic control systems?



ANSWER

Air leaks and plugged orifices are common causes of energy waste in pneumatic control systems.

DISCUSSION

Pneumatic control systems are an older method of HVAC control. They accomplish numerous control functions mechanically instead of the digital control functionality of newer methods. Because pneumatic systems rely on mechanical action, they have several common issues that can lead to poor control and energy waste. The most common issue is caused by air leaks. As these systems rely on numerous fittings and tubes to distribute compressed air throughout the system, leaks in any of these components can result in control issues. Additionally, clogged tubing and orifices can also lead to improper control. Routine inspections of your pneumatic control system are recommended, in addition to inspections whenever specific issues are detected.

A conversion from pneumatic control to direct digital control (DDC) can result in significantly improved control function and reliability. However, this is typically a large and complex upgrade as it requires removal of the pneumatic system and the running of control wire to each piece of HVAC equipment. Wireless pneumatic DDC is a hybrid system that accomplishes the improved control functionality of a traditional DDC system without requiring the installation of control wire to each piece of HVAC equipment. Wireless pneumatic DDC significantly reduces the disruptions associated with a DDC upgrade while improving operations and achieving energy and maintenance cost savings.

DISCUSSION QUESTIONS

In what ways are direct digital control (DDC) systems and pneumatic systems similar? In what ways are they different?

What are some other advantages of DDC over pneumatics or electromechanical HVAC control systems?

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QUESTION

What is a good way to diagnose excessive leakage in a pneumatic control system?



ANSWER

Monitoring air compressor cycling is a good way to diagnose excessive leakage in a pneumatic control system.

DISCUSSION

Configured with an integral receiver, pneumatic control air compressors cycle to maintain a pressure setpoint in that receiver. When the control system is excessively leaky, compressors will cycle frequently and potentially

experience extended operating periods in which they never shut off. This can be observed in real time or identified through data logging.

Finding leaks in a pneumatic tubing system can be challenging. Many systems today are comprised of polyethylene tubing that can come loose from connections, be cut during remodels, or become brittle and fail over time. Systematic survey and calibration of pneumatic control devices (e.g., thermostats, receiver-controllers, transmitters, relays and switches) can uncover many leaks. Listen closely for the characteristic hiss associated with pneumatic air leaks – or better yet, schedule a leak test with a professional.

DISCUSSION QUESTION

What are some other maintenance considerations for pneumatic control systems?



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QUESTION

What are common issues that can cause programmable thermostats to operate in a suboptimal manner?



ANSWER

The following are common issues that can cause programmable thermostats to operate in a suboptimal manner:

- Schedules that do not match actual occupancy.
- Inappropriate temperature setpoints during unoccupied periods.
- Settings that result in continuous fan operation during unoccupied periods, or intermittent fan operation during occupied periods.
- Overrides that are not set to disengage and return to typical schedule or setpoints after a set time.

DISCUSSION

Programmable thermostats have a way of drifting away from intended programming. While most programming starts with the definition of occupied and unoccupied periods, sophisticated programmable thermostats can support multiple periods separately defined for

each day of the week. Each period should have defined cooling and heating setpoints, and most programmable thermostats (like many other thermostats) typically have fan and system settings.

Fan settings can either be programmed so that 1) the fan will cycle with the operation of the furnace or air-conditioning compressor, or 2) the fan will run continuously during the scheduled occupied period to provide ventilation. For most commercial buildings, fan settings should be programmed to support continuous operation during occupied periods to ensure adequate fresh air is always maintained when people are present. Additionally, the fan should be set to automatic during unoccupied periods to enable the fan to cycle off when the HVAC unit is not actively heating or cooling the space.

Typically, occupied schedules should start 1–2 hours before the first significant arrival of occupants, and it should end when most occupants leave the building. Occupancy schedules and corresponding setpoints should be reviewed seasonally to adjust for shifts in heating and cooling needs.

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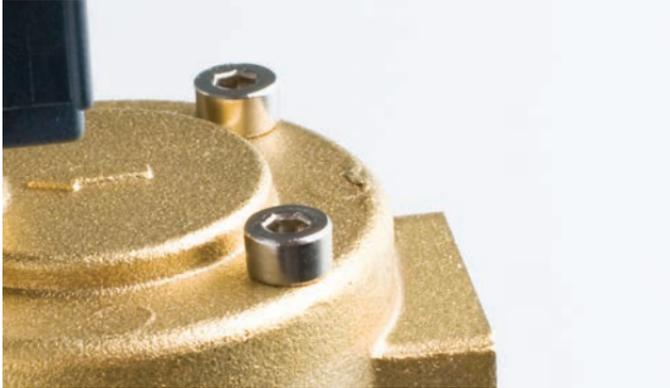
QUESTION

What are the primary drivers when sizing flow-control valves for both chilled and hot water HVAC systems?



ANSWER

For both chilled and hot water HVAC systems, flow-control valves should be sized to balance ideal flow-control characteristics. This will improve with pressure drop against excessive pump energy use, which deteriorates with pressure drop.



DISCUSSION

A good general rule is to size valves so that the pressure drop through a fully open valve is 10–25% of the entire system's pressure drop. Valve size is rated in Valve Flow Coefficient (Cv), which is the flowrate in gpm through a valve at a 1 psig pressure drop.

It rarely makes sense to have a flow-control valve sized at the same size as the piping in the system (i.e., a line-size valve). These valves are often oversized and can exhibit relatively poor flow-control characteristics.

DISCUSSION QUESTIONS

How much smaller than line size should valves be?

What are some circumstances where line-size valves make sense?

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QUESTION

Heating water valves that experience significant leak-by when fully closed are a common and expensive energy problem. What are three causes of valve leak-by?



ANSWER

Causes of valve leak-by include:

- Eroded or corroded valve seats.
- Inappropriate actuator signal.
- Loose or damaged actuator-valve connections.

DISCUSSION

Valve seats that have surface deterioration cannot seal completely when the valve is fully closed, causing water to leak through the poor internal seals. If the valve actuator is receiving an inappropriate signal, the internal valve components may not be properly positioned in conditions where the valve should be closed – even if they are in good operating condition. When this happens, the valve stays partly open, and water will continue to flow through the valve. Loose connections between actuator and valve stem can result in a similar problem in which the internal valve components are not positioned in accordance with the control signal to the actuator.

Leak-by in heating water valves can become a maintenance headache, reduce thermal comfort and waste energy. Leak-by commonly occurs in small distributed reheat coil valves, thousands of which are often located above the ceilings of occupied spaces. The problem is made worse when heating water systems are kept active throughout the entire year, including during the cooling season (this is typically done so that reheat coils can function).

Leak-by can also occur in central heating and pre-heat coil valves within air-handling units. Because these coils are typically located upstream of cooling coils, leaking central heating coil valves not only waste heat, but also increase cooling. This is because the cooling coil has to work harder to remove the heat added to the airstream by the leaking heating water coil valve.

QUESTION

Effective airside economizer control can significantly reduce mechanical-cooling energy use. What are some possible causes of poor economizer control?



ANSWER

Possible causes of poor economizer control include:

- Improper economizer high-limit setpoint.
- Damaged dampers, actuators or linkages.
- Poorly calibrated or poorly located sensors (e.g., mixed-air, return-air and outside-air temperature).

DISCUSSION

Using outside-air temperature is a common method of transitioning into and out of airside economizer operating mode. Typically, above a specific fixed temperature (usually 70–75 F), the outside air dampers will return to a fixed minimum ventilation position. This setpoint is referred to as the economizer high limit. If the high limit is set too low, the dampers will return to minimum position during conditions when cooling benefits can still be achieved with continued economizer operation.

Functioning outside and return-air dampers are essential for reliable economizer control. Damaged dampers or actuators can cause improper outside-air rates and can lead to excessive mechanical cooling and heating.

Mixed-air sensors can be challenging to install, and it can be difficult to receive accurate temperature readings from them. Many economizer and mixed-air control sequences rely on mixed-air temperature as a key control variable – if the control variable is not being measured correctly, then it is unlikely that the control sequence will be effective.

DISCUSSION QUESTIONS

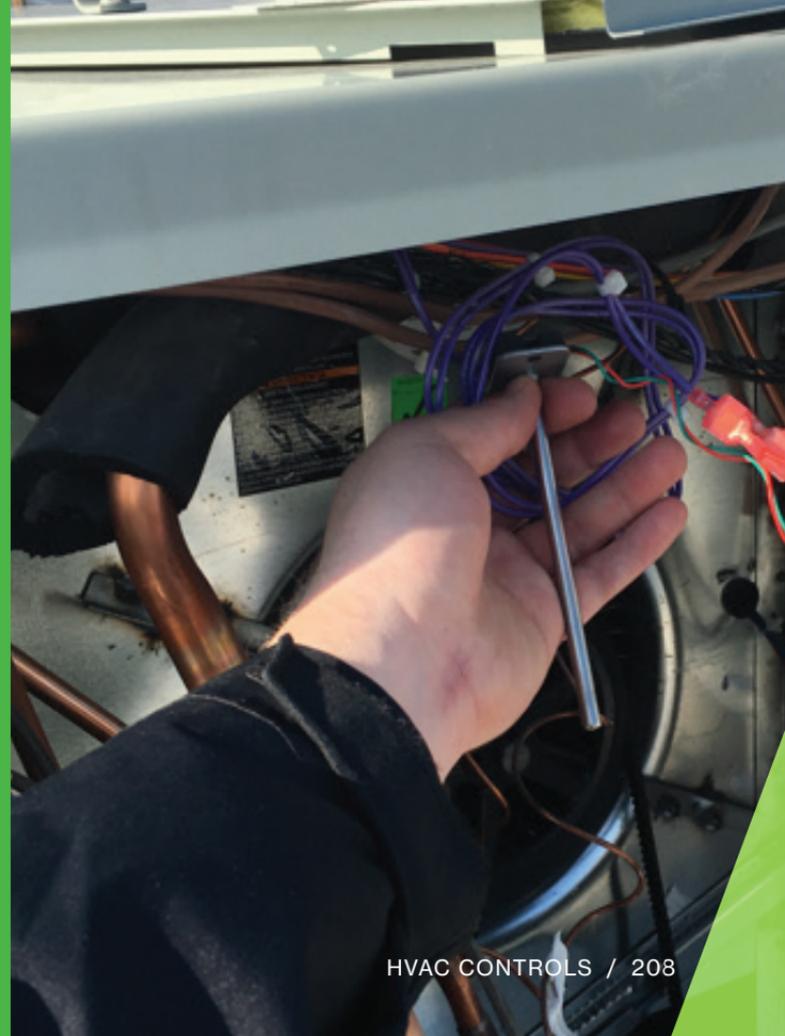
What are other methods of economizer control besides outside-air temperature? In what conditions do they make sense?

What are some solutions to this problem that would prevent inappropriate economizer operation and control?

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QUESTION

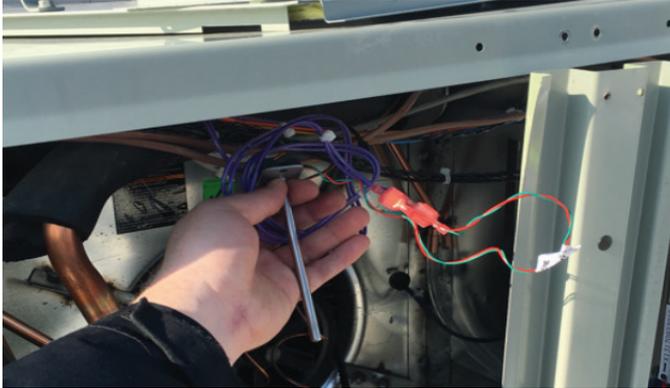
What are three important issues to consider when locating an outside-air temperature sensor?



ANSWER

Important issues to consider when locating an outside-air temperature sensor include:

- Avoiding direct solar radiation.
- Avoiding location near an exhaust-fan outlet or exhaust damper.
- Avoiding micro-climates created by proximity to black surfaces on walls or roofs.



DISCUSSION

Because outside-air temperature is used as a control variable in many control sequences, outside-air temperature sensors are often a critical sensor component within HVAC controls systems. It is important to have a reliable, accurate reading under all weather conditions at all times of the day and night.

Outside-air temperature sensors should be regularly checked and calibrated. Strange readings are often due to poor locations. Avoid these especially problematic locations for outside-air temperature sensors:

- Inside outside-air ducts.
- Locations where sun can directly shine on the sensor.
- Locations where the sensor will get wet when it rains.

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QUESTION

What are the primary causes of sensor error?



ANSWER

To help prevent sensor error, make sure to:

- Sensors out of calibration
- Incorrectly placed sensors
- Failed sensors
- Mistakes in control setup

DISCUSSION

Sensor error can increase energy use, compromise occupant comfort and cause equipment to operate when it shouldn't. While building systems use many sensors, critical control sensors are the most likely to cause severe energy penalties. For example, while space-temperature sensors cause energy waste and comfort problems, the effect on energy is usually minor and restricted to one zone. On the other hand, errors of a critical control sensor, such as the temperature of return air at the air handler, can cause large energy

penalties affecting many zones, yet may not cause comfort issues. Note that sensor error is hard to detect unless the sensors are calibrated and checked regularly.

Be sure to review sensor setpoints and locations to determine what changes might be necessary. For example, thermostats may have started out in optimal locations, but as the building's occupancy and use changes over time, potential new locations may merit consideration. When building occupancy or use changes, recalibrate building sensors to ensure their readings match actual building conditions.

To further prevent sensor error, make sure to:

- Calibrate sensors at least annually.
- Check controls systems for unusual sensors readings.
- Replace critical control sensors on a regular schedule as they approach the end of their service lives.

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QUESTION

How often should critical control sensors be checked and, when necessary, recalibrated?



ANSWER

Critical control sensors should be checked twice per year and recalibrated when necessary.



DISCUSSION

Critical control sensors are the sensors that drive a system's control sequences. Examples include outside-air-temperature or supply-air-temperature sensors. Even if a sensor is correctly calibrated, it may cause errors if it is not correctly placed. For example, when a static-pressure sensor is located too near the supply fan, or when an outside-air sensor is in direct sunlight.

Some indicators that sensors are not working optimally may include:

- Loads are not met.
- Economizer is not working.
- Equipment is on when it is not needed.
- Simultaneous heating and cooling is occurring.
- There is over- or under-ventilation of the occupied space.

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QUESTION

What are some considerations when it comes to damper functionality in small, packaged rooftop units (RTUs)?



ANSWER

Many RTUs are equipped with third-party damper controls that implement economizer functionality or demand-control ventilation control sequences. Note that these are not always uniform in installation, design or functionality.



DISCUSSION

Another key item to consider is whether the changeover setpoint is correctly established. For most RTUs, stage one of cooling is economizer cooling, while change-over to mechanical cooling involves restoring dampers to minimum ventilation position and enabling mechanical cooling. This is referred to as non-integrated economizer control. Note that optimized change-over setpoints are typically 63–68 F for non-integrated economizer controls.

Integrated economizers operate differently, as they enable both economizer and mechanical cooling operation simultaneously. This results in more hours each year when the economizer can operate, yielding improved energy performance relative to non-integrated economizers.

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QUESTION

What can be conducted to avoid chronic problems with mixed-air dampers and outside-air ventilation controls?



ANSWER

Functional performance tests can be conducted on a regular basis to identify deficiencies in damper control. It is recommended to document test results in writing. This documentation can be used to supplement visual observation and inspection, and help generate work orders for any necessary maintenance.

DISCUSSION

Consider the following simple functional test for dampers:

1. Override the damper control signal to position the damper to fully closed, 50% open, and fully open.
2. Once the signal has stabilized and the control action of the damper is documented, differences between signal intent and actual position can be noted.

3. Where outputs and inputs are significantly different, visually inspect the damper and any associated linkages or actuators to diagnose reasons for the difference.

4. Repeat the functional test as needed.

As dampers open and close, it is useful to observe the position of the damper blades through the entire actuator stroke. This can be difficult in many systems in which the dampers are internal to an air-handling unit or a duct. Often the air handler will need to be shut down. In some cases, access holes will need to be cut into ducts. And in both cases, damper testing can only occur when the fan unit is not operating.

For pneumatic actuators, the pressure signal usually ranges from 0–15 psig, and disconnecting the pneumatic motor is a quick way to achieve a zero signal. Note that there are many methods to manually apply a pressure signal independent of the pneumatic control system. For electric motors, the control signal will likely need to be manipulated via the digital control system using operator override functions.

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QUESTION

What is a good way to find out if you can adjust the thermostat to save on space heating and cooling costs?



ANSWER

A great way to find out if you can adjust the thermostat to save on space heating and cooling costs is to talk with the people who are commonly in the space being conditioned. Ask them if they're comfortable with current settings.

DISCUSSION

You may determine that you can adjust the thermostat by a few degrees and still maintain comfort. You can also ask when they're occupying the building to make sure the schedule is appropriate. This information may allow you to further relax system setpoints on evenings, weekends and holidays.

DISCUSSION QUESTIONS

Are there hours or days when temperature settings could be adjusted?

When is the last time you confirmed the accuracy of all critical digital/electronic thermostats and transmitters?



WATER HEATERS

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QUESTION

What are three ways to characterize water-heater types?



ANSWER

Ways to characterize water-heater types include:

- Fuel type (e.g., gas, electric or heat pump)
- Storage type (e.g., instantaneous or integral storage)
- Combustion type (e.g., condensing, atmospheric or forced draft)



DISCUSSION

The combustion-type characterization primarily pertains to gas-fired water heaters. Special attention should be paid to atmospheric or natural-draft water heaters, as they can exhibit excessive parasitic losses if they are not equipped with a vent damper that closes when the burner is not firing.

Condensing water heaters are ultra-efficient due to their ability to better utilize heat from exhaust gases to heat water. This ability helps condensing water heaters reach efficiencies as high as 99%.

Heat pump water heaters are an excellent option if they can be located in a space where waste heat from other equipment is always present, such as a mechanical room. Because heat pump water heaters extract heat from their surrounding environment, they effectively cool the space in which they are located. As a result, careful consideration should be given to their location. While heat pump water heaters are electric, it's worth noting that electric water heaters refer to those that heat using electric resistance.

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QUESTION

What are two common ways to control domestic water heater recirculation pumps?



ANSWER

Common ways to control recirculation pumps of domestic water heaters include:

- Time scheduling via timeclock or the central control system
- Aquastats



DISCUSSION

Timeclock scheduling typically limits recirculation pump operation to the occupied periods (i.e., when people are in the building and hot water is being used).

Aquastats are a special type of thermostat that sense return hot water temperature and de-energize the recirculation pump when the setpoint is satisfied. The aquastat setpoint should be set about 10–15 F lower than the domestic hot water supply temperature setpoint.

It's important to understand the primary reason for controlling recirculation pumps. These very small pumps have fractional horsepower motors, so shutting them off during unoccupied periods doesn't save a significant amount of electricity. However, when recirculation pumps are turned off, energy waste is greatly reduced throughout the rest of the hot water system. For example, when the pump runs unnecessarily, the entire domestic hot water piping system remains hot. This unnecessary heating maximizes heat loss from the piping distribution system, especially if the system is poorly insulated. This can also cause the water heater to cycle on for many hours when no one is in the building and no hot water is actually being used at plumbing fixtures.

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QUESTION

What are the primary drivers when establishing water heater setpoints?



ANSWER

With consideration to protect occupants from scalding and legionella, set the domestic water supply water temperature high enough to satisfy the hot water use with the highest temperature requirement.

DISCUSSION

For most commercial buildings, maximum use temperature dictates setpoints of 110–120 F. This temperature range is not sufficiently high to limit legionella growth within storage tanks, or to meet use-temperature needs for commercial kitchens equipped with temperature-based sanitizing dishwashers. These considerations typically drive setpoints to at least 140 F, which can cause scalding at conventional fixtures such as restroom lavatories. Appropriate setpoints require some judgment by operators, grounded in an understanding of how domestic hot water is being used in a building.

Legionella should always be a consideration in domestic water heater operations, but it doesn't always justify increasing temperature setpoints. There may be little risk for systems with no significant tank storage or systems with tank storage that includes tank-volume turnover of at least once per day. However, systems with tank storage in which the tank volume sits in the tank for multiple days may be at risk. Typical risk mitigation approaches for a system with high storage or low turnover include:

- Increase tank temperature to 140 F, and potentially install thermostatic mixing valves in the system to mitigate the scalding potential at plumbing fixtures.
- Limit or completely remove fixture aerators to avoid excessive aerosol zones at the discharge of hot water from fixtures.
- Remove tanks, or limit the effective storage by valving off selected tanks in a multiple tank line-up to increase water turnover cycle time.

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QUESTION

What are three control or maintenance actions that can increase water heater efficiency?



ANSWER

Ways to characterize water-heater types include:

- Reduce standby losses
- Reduce water heater setpoints
- Combustion tune-ups



DISCUSSION

Standby losses often result from suboptimal insulation, but they can also be magnified by other operating conditions. All heat transfer surfaces in a system (e.g., tank skin and piping) should be well-insulated. One way to reduce standby losses is to use point-of-use water heaters. There are many point-of-use water heater options available today, ranging from small two-gallon electric heaters that install directly under a sink or lavatory, to smaller centralized tank heaters that serve a bank of fixtures in a restroom cluster or small kitchen.

Water heater thermostatic setpoints should be set as low as possible while still satisfying all system operating requirements. To maximize energy efficiency, target setpoints should be at 110–115 F, assuming legionella concerns and system requirements have been addressed.

Note that combustion tune-ups can include the cleaning of the burner assembly, verification that combustion gases are venting properly, and an inspection of gas-valve operation. All of these approaches can keep water heaters at their factory-rated efficiency.

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QUESTION

Even without an energized recirculation pump, heated water can circulate through a piping system in a passive manner known as thermosiphoning. What is a common method to prevent thermosiphoning?



ANSWER

Common methods to prevent thermosiphoning include:

- Piping the water heater connections in a manner that creates a heat trap. Reduce water heater setpoints
- Adding a check valve so hot water can't passively circulate.

DISCUSSION

A heat trap is a simple piping arrangement in which the piping has a downward vertical component that prevents buoyant warm water from rising to the top of the system. This is typically done with a flexible connector installed with a loop.

1. Datalogging the water heater operation is a valuable overall diagnostics activity that can be set up to detect significant thermosiphoning. Consider the following data points with a portable datalogging installation:

- Water heater operation (e.g., burner amps, vent temperature, electric element amps)
- Leaving water temperature
- Return hot water temperature
- Entering cold water temperature (immediately upstream of the connection to the return water line in a recirculating system)
- Recirculation pump operation (i.e., motor amps)

2. Infrared imaging can also help identify warm piping systems. If executed as part of a night walk after the recirculation pump has been de-energized for several hours, it will be possible to help identify thermosiphoning by seeing how effectively the piping system is cooling off.

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QUESTION

insulation are appropriate in a potable hot water system?



ANSWER

Both piping and tanks in potable hot water systems should be well insulated along the following guidelines:

- Pipe insulation should be at least R-3, which can be achieved with 1-inch wall thickness in many insulation products.
- Tanks should have at least R-19 effective insulation, which may require an external insulation wrap in addition to the integral factory-installed insulation



DISCUSSION

It is relatively easy to visually inspect domestic water heater piping at or near the water heater location. Upon inspection, all piping should be insulated. Though it is often much more difficult and time-consuming to visually inspect the entire piping system throughout a building, all piping should also be inspected, and insulation levels and condition should be verified. These inspections will help you determine what improvements you can make to your tank and piping-insulation levels.

DISCUSSION QUESTIONS

Within the operations knowledge base, is the general condition of distributed domestic hot water piping known?

If not, what are some techniques and activities that can generate this information?

MOTORS

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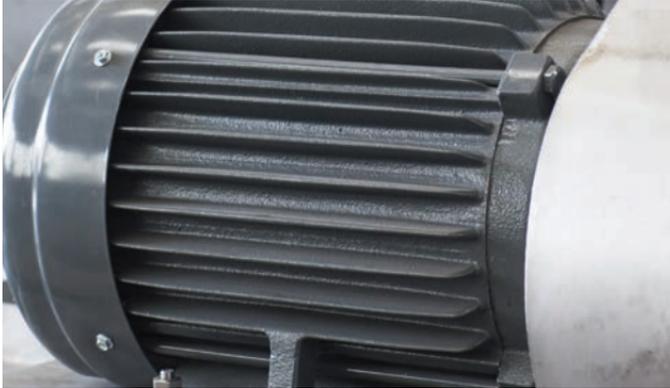
QUESTION

What is the most significant cost to consider when purchasing an electric motor?



ANSWER

Electricity is the most significant cost to consider when purchasing an electric motor. In fact, electricity accounts for 98% of the cost of owning a motor (which means the purchase price and maintenance costs only account for 2% of overall costs).



DISCUSSION

While first cost is often the determining factor when purchasing a motor, a motor's life-cycle costs (which are greatly impacted by application, run hours, motor efficiency and maintenance costs) are far greater than the purchase price.

DISCUSSION QUESTIONS

What are the typical cost considerations you use to purchase a new motor?

What are additional life-cycle costs to consider when making equipment-purchasing decisions?

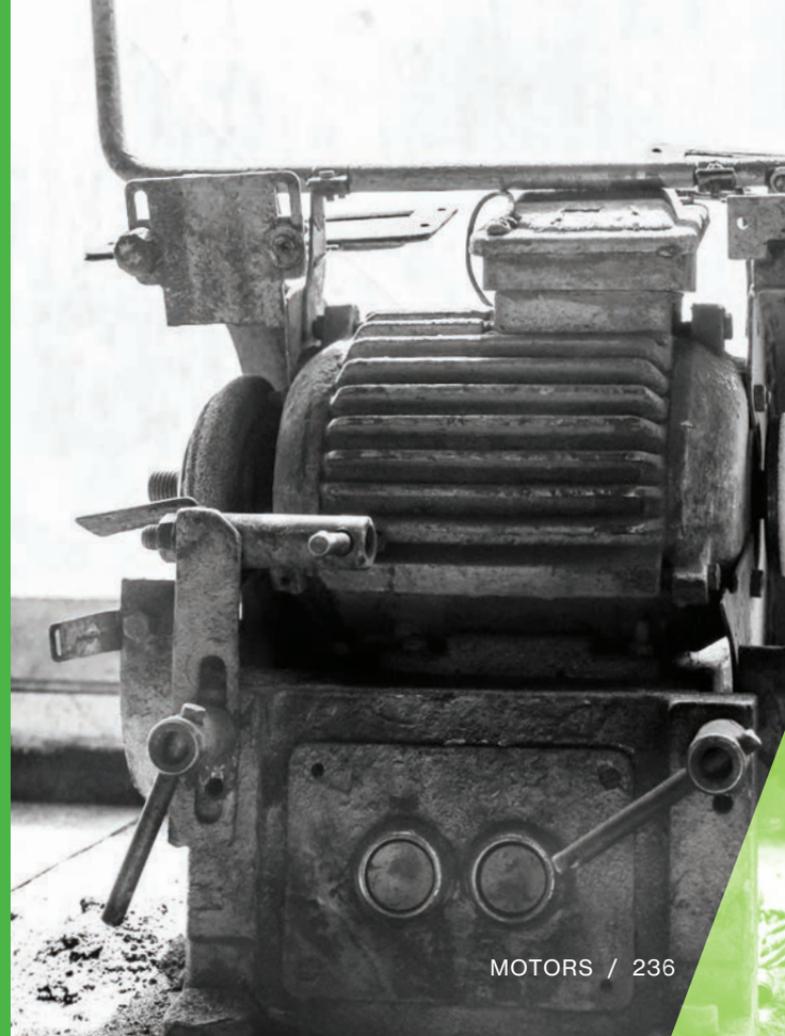
Are there any motors that can be scheduled to turn off using timers or an automation system?

Are there any motors that need to be replaced?

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QUESTION

How long does the average motor last?



ANSWER

Motor longevity can vary greatly based on load, environment and run hours. If properly applied and maintained, a smaller motor should last 10–15 years, while a larger motor should last 20–30 years or more.



DISCUSSION

While motor life can vary based on a multitude of factors, there are steps that can be taken to extend motor life and maintain efficiency regardless of motor size. These steps include:

- Regularly inspect bearings
- Check motor lubrication and apply as necessary
- Reduce or eliminate vibrations

Since all motors will eventually fail, it's smart to develop a motor-failure action plan to help prepare and plan upgrades to improve efficiency before failure occurs.

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QUESTION

What does “electric motor efficiency” mean?



ANSWER

Electric motor efficiency refers to the percentage of electrical power that is converted to mechanical power.

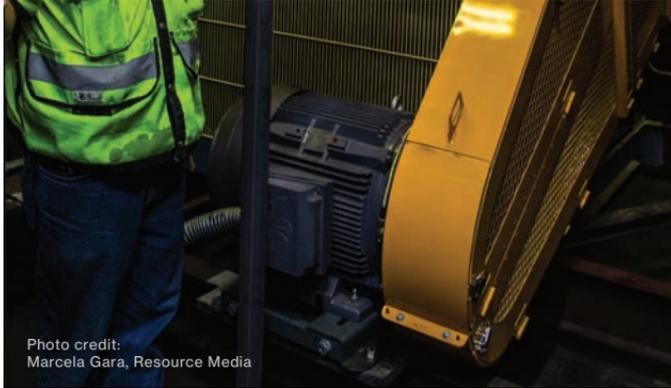


Photo credit:
Marcela Gara, Resource Media

DISCUSSION

For example, with a fully loaded, 85% efficient 5-horsepower electric motor, 100% of the electricity goes in, but only 85% is converted to mechanical power (4.25 horsepower) and made available at the motor's output shaft. The remaining 15% is lost due to electric resistance, stray currents, bearing friction and motor cooling. Most of the 15% motor inefficiency is manifested as heat and can directly contribute to a shorter motor life.

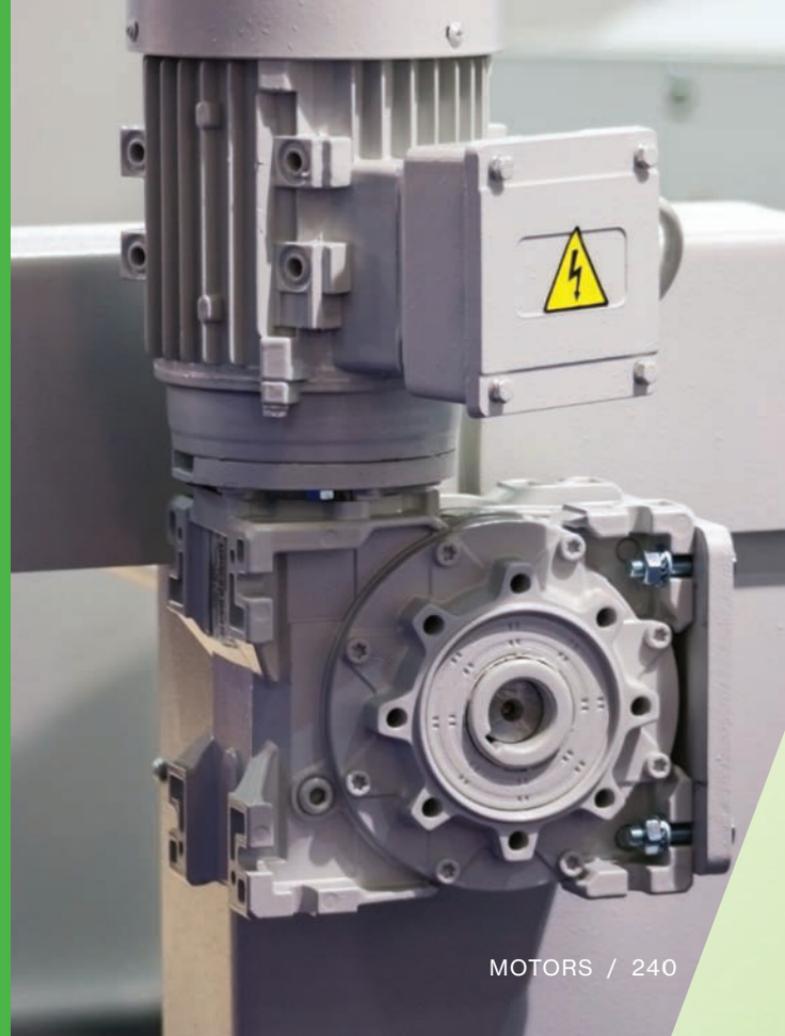
Benefits of efficient motors or motor-driven systems include:

- Less electricity used, which means lower operational costs
- Longer motor life due to higher build quality and components
- Increased reliability

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QUESTION

Do all electric motors have the same efficiency?



ANSWER

No, motor efficiencies and efficiency trends have varied for decades.



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DISCUSSION

Not all motors are created equal. For example, motors built in the 1950s can still be found in service due to their build quality. Quality manufacturing stands the test of time, so it's well worth the slightly higher cost to enjoy the greater reliability and efficiency offered by newer motors.

Using only general rules, a motor's quality can be difficult to define. However, there is a national standard called NEMA (National Electrical Manufacturers Association) Premium™ that qualifies motor efficiency. The NEMA Premium™ label indicates a high-performance motor that runs at a slightly faster RPM, is more tolerant to Variable Frequency Drive (VFD) application and meets or exceeds efficiency standards.

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QUESTION

Should a motor be turned off on holidays and when it is not being used?



ANSWER

Yes, for most situations, motors should be turned off on holidays and when they are not being used.



DISCUSSION

Turning off unneeded motors for extended periods can save considerable amounts of energy. And turning off unneeded motors for shorter periods is also typically the right choice. Motors have a maximum number of recommended starts per hour, based on the size and type of motor. Too many starts per hour can result in premature motor failure, a fact that should be considered whenever cycling an electric motor.

Additionally, it's important to consider the demand charge associated with motor inrush current during startup. In most cases, however, the energy saved from turning a motor off will be greater than the energy penalty associated with the elevated motor inrush current.

Generally speaking, the energy savings from turning off a motor for one hour each day is equivalent to upgrading from a standard efficient motor to a NEMA Premium™.

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QUESTION

If a motor is in storage, how often should the shaft be turned?



ANSWER

When in storage, a motor shaft should be turned every 30 days, or per the manufacturer's recommendation.

DISCUSSION

The motor shaft needs to be rotated to supply sufficient grease to the bearings' surfaces. Failing to do so can cause premature failure of the motor when it's put into operation. Approximately 52% of all motor failures are bearing related.

DISCUSSION QUESTIONS

Do you have motors that are not in service?

Are the shafts on those motors being turned regularly?



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QUESTION

Can motor over-lubrication
reduce efficiency?



ANSWER

Yes, over-lubricating motors can reduce efficiency.

DISCUSSION

Too much lubrication or the wrong lubrication is more likely to cause motor failure than under-lubrication. Improper application practices and over-lubrication can result in motor windings becoming packed with grease and unable to dissipate heat.

When grease comes in contact with motor magnetic-wire due to over-lubrication, resulting issues may include:

- Decay of insulation materials and premature electrical failure.
- Dust and fine particles can enter raceways and damage both rotating and static bearing surfaces.
- Additional friction.
- Collapsed bearing shields and seals (which cause a significant loss of efficiency and higher operational costs).

Proper lubrication and correct motor maintenance procedures are important, not only for maintaining efficiency, but also for extending motor life.

Many motor manufacturers have changed to a lubricant called Polyurea, which is incompatible with most grease. Improperly applying incompatible greases will almost certainly cause bearings to fail.

DISCUSSION QUESTIONS

Do you have a maintenance schedule for the motors in your facility? Does it follow manufacturer recommendations?

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QUESTION

Does a motor lose efficiency when it's rewound?



ANSWER

Motors don't necessarily lose efficiency when they're rewind. If the failure event that caused the need for a motor rewind didn't inflict catastrophic damage to the core, and the motor service center is EASA (Electrical Apparatus Service Association) accredited and follows Green Motors Practices' shop procedures, the motor should retain or slightly improve its efficiency.



DISCUSSION

Any service or upgrade involves a balance of time to complete, cost and quality of work. When it comes to rewinding a motor, quality should always be the top priority. Qualified motor service centers know that efficiency is just as important as reliability, and they'll be able to rewind motors in a way that sustains or improves efficiency.

Note that your utility may offer incentives and guidance on efficient motor rewinds. Contact your electric utility to learn more.

SERVER ROOMS

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QUESTION

What is a data center?



ANSWER

Data centers house the majority of an enterprise's application servers, network gear and storage. They are the place where this equipment is located, operated and managed, and they can range from a telecom closet to a 500,000 sq. ft. server farm.



DISCUSSION

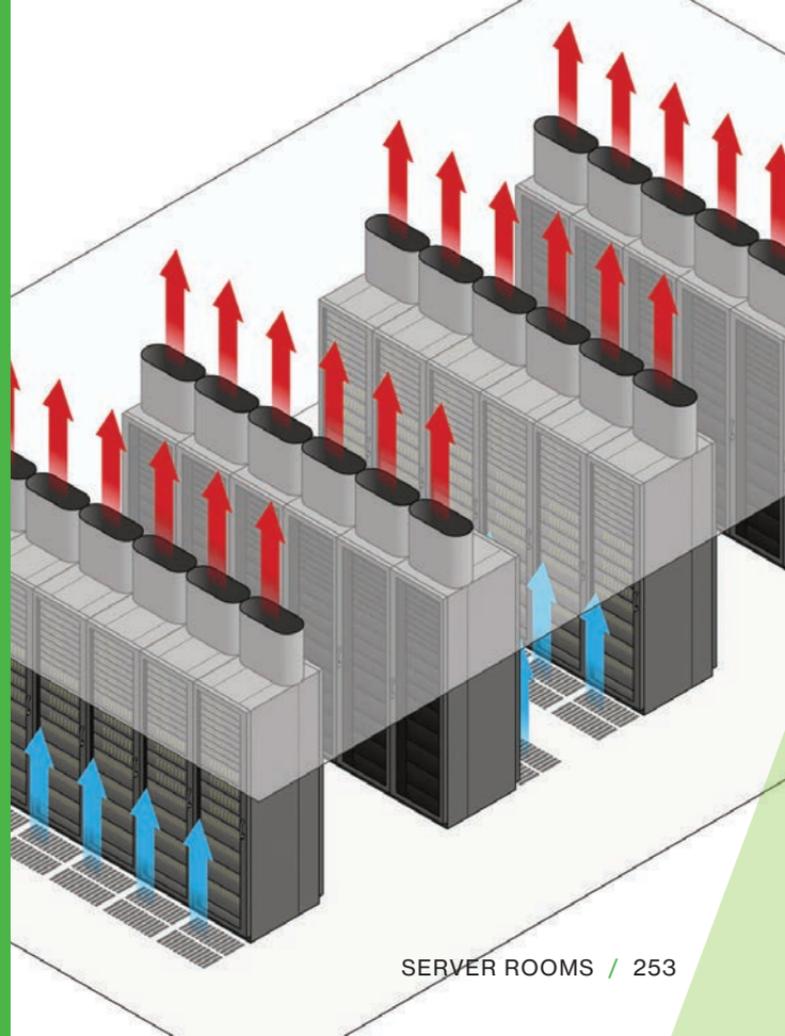
Data centers have four primary components:

- **Technical Space**
The usable floorspace for IT equipment installations, as measured in square feet.
- **Facility infrastructure**
The additional space and equipment required to support data center operations, including power transformers, an uninterruptible power source (UPS), generators, computer room air-conditioners (CRACs), chillers and air-distribution systems.
- **IT equipment**
The racks, cabling, servers, storage, management systems and network gear required to deliver computing services.
- **Operations**
The operations staff assures that the IT and infrastructure systems are properly operated, maintained, upgraded and repaired.

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QUESTION

What is a hot/cold aisle-rack configuration?



ANSWER

Hot/cold aisle-rack configurations are IT equipment aisles aligned to allow cold air to enter the IT equipment air inlet in one aisle (cold aisle), while exhausting air to a common aisle (hot aisle).

DISCUSSION

Orientation of rack lineups is crucial to efficient airflow management in the data center, and hot/Cold aisle-rack configuration is considered a pre-requisite for energy-efficient design. The following items are additional must-haves in a base data center design:

- Crucial to airflow management, blanking panels are rack-width plastic or metal barriers that install in the rack face to prevent the bypass of supply air into the hot aisle.
- When selecting and installing IT equipment, it is critical to ensure the equipment draws air into the face of the equipment, and exhausts from the rear of the chassis.

- Raised floors are often used in data centers to act as an air-supply plenum, allowing for the installation of perforated tiles to supply air where the IT equipment is installed. These environments must be maintained, and the plenum area should never be obstructed.
- The space housing sensitive equipment is considered the most critical area in the facility. It is often maintained at a positive pressure to ensure no air, dust or particulates infiltrate the IT equipment.
- If cables are not properly maintained, resulting issues can include hotspots, IT equipment overheating, lack of cable rack capacity, and other issues that prevent the most efficient use of the whitespace.

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QUESTION

What is the quickest and easiest way to reduce site mechanical-energy demands?



ANSWER

Relaxing the temperature and humidity setpoints is the quickest and easiest way to reduce site mechanical-energy demands.

The goal is to operate the systems as close to industry guidance (ASHRAE TC 9.9) limits as possible. That includes setpoints in the entire system: chiller setpoints, computer room air handler (CRAH) supply temperature setpoints, and room humidity limits.



DISCUSSION

The typical industry cold aisle setpoint is 75 F. This allows for some level of heat gain in the aisle while maintaining a setpoint lower than the recommended 80.6 F maximum. The higher CRAH air temperature setpoint allows for the chilled water setpoint to be adjusted up, which results in more efficient compressor operations and increases the number of available free-cooling hours. The typical chilled water setpoint is 55 F, with some approaching 60 F.

Prior to any chiller setpoint adjustment, a review with the original equipment manufacturer is recommended. This is because some deployments may not be able to operate at higher temperatures due to oil migration issues, or because the installed pump/valve seals are not designed to operate at elevated temperatures.

Note that humidity should always be controlled at its lowest threshold (a 41.9 F dew point) to ensure the greatest efficiency. Utilities may offer incentives for data center control optimizations – be sure to contact your electric utility to learn more.

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QUESTION

Why are variable frequency drives (VFDs) important for energy efficiency?



ANSWER

VFDs accurately vary equipment capacity to match load conditions. To enable this, install variable-speed motor drives in all system components that can accommodate them. This will allow every pump, fan and motor to operate at the appropriate speed to meet the system's load demands.



DISCUSSION

The affinity law describes the effect on power consumption when a motor operates at less than 100% speed. Mathematically, it is represented as $\text{Power} = \text{Speed}^3$. So, if a motor is operated at a speed of 80%, it would equate to a power consumption of $(.80 \times .80 \times .80)$, or 51.2%. Therefore, reducing the speed by 20% can reduce power consumption by 50%.

In data centers, where the amount of redundant equipment consumes large amounts of overhead electricity, the ability to operate these systems at lower speeds makes large impacts on the site's energy demands. When equipping VFDs or electronically commutated motors (ECs), it is possible to operate multiple pumps and fans more efficiently in parallel at lower speeds than by having any single unit operate at full speed alone.

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QUESTION

Why is system monitoring and reporting important for data center energy efficiency?



ANSWER

Because you can't optimize what you don't monitor, system monitoring and reporting is critical to data center energy efficiency. Without measuring, collecting, and analyzing trend data, you cannot affect changes in the systems that maximize efficiency. Note that utility-related rebates can help offset the capital costs any project.

DISCUSSION

ENERGY STAR® is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. This program offers a proven energy management strategy that helps measure current energy performance, set goals, track savings and reward improvements. To obtain an ENERGY STAR rating, applicable site data must be entered into an online portfolio with the following requirements: Total Building Energy (kWh) and IT Energy (kWh).

- The site must have energy consumption data for 12 consecutive months entered into the portfolio.
- The site must obtain a rating of 75 or higher to be considered a leading ENERGY STAR facility and receive the ENERGY STAR label.

ENERGY STAR is a valuable baseline tool used to compare properties using metered data from the data center. When analyzing and rating the property, the data center profile manager uses power usage effectiveness (PUE) as the dependent variable and the IT load as the independent variable. The metered data required to build a profile include Total Building Energy (kWh) and IT Energy (kWh).

DISCUSSION QUESTION

What kind of monitoring and control do you use in your data center?

UTILITY BILL ANALYSIS

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QUESTION

What types of charges typically show up on your utility bill?



Portland General Electric Cycle: 2108
Feeder Line Code: WW5

This month's charges

Meter	Schedule 83 Secondary
Energy Charges (431024 kWh)	41,161.28
Adjustments	10,853.23cr
	<hr/>
	30,308.05
Taxes and Fees	<hr/>
	1,051.48
Current Charges	<hr/>
	31,359.53

Thank you for your payment. It's a privilege to provide your electric service.

Point of Delivery Identification (PODID) number for meter number

Details of this month's charges

Meter	Schedule 83 Secondary
Energy Charges	
Basic Charge	25.00
System Usage Charge (431024 kWh)	2,090.51
Off-Peak Usage of 166344 kWh	11,580.87
On-Peak Usage of 264680 kWh	21,285.53
Demand Charge For 30 KW	16.80
Demand Charge For 1113 KW	2,103.57
Reactive Demand Charge for 442 Billed KVAR	221.00
(Reactive Demand of 899 Actual KVAR)	

ANSWER

The following charges typically show up on utility bills:

- Basic charge
- Energy charge (kWh)
- Demand charge (kW)
- Power factor charge (kVAR)
- Local taxes
- Franchise charges and adjustments

Details of this month's charges	
Meter	Schedule 83 Secondary
Energy Charges	
Basic Charge	25.00
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DISCUSSION

Basic charges allow utilities to recover costs associated with providing electric service to the customer. A utility bill reflects costs incurred by the utility for the following:

- Metering/billing
- Customer service
- Purchased and generated power
- Substations
- Transmission
- Distribution lines and poles
- Transformers
- System dispatch control

DISCUSSION QUESTION

Why do utilities break out the separate charges?

How much energy in kWh did your facility use last month?

How much demand in kW did your facility need last month?

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QUESTION

What information does a typical meter record?



ANSWER

Typical meters record the following:

- Energy (kWh)
- Demand (kW)
- Reactive power (kVAR)



DISCUSSION

Modern electronic meters record pulses, and each pulse is equal to an amount of energy (i.e., kWh). The meter is read by the meter reader in person or remotely, and the demand is reset. The information is then used to calculate your monthly bill. In some cases, your meter records on-peak and off-peak energy and demand. Typical on-peak times are 6 a.m. to 10 p.m., Monday through Saturday.

DISCUSSION QUESTION

How often are your meters read?

Where are your meters located?

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QUESTION

What variables are considered in the cost of electricity for your building?



ANSWER

The following variables are considered in the cost of your building's electricity:

- Energy used (kWh)
- Energy needed (kW)
- The power factor (kVAR)
- The local utility's rate schedule



DISCUSSION

There are many factors that go into determining what specific rate you pay for electricity, but a general range for the Northwest is 4–8 cents per kWh. Demand is usually \$4–5 per kW and may include a power factor charge.

DISCUSSION QUESTION

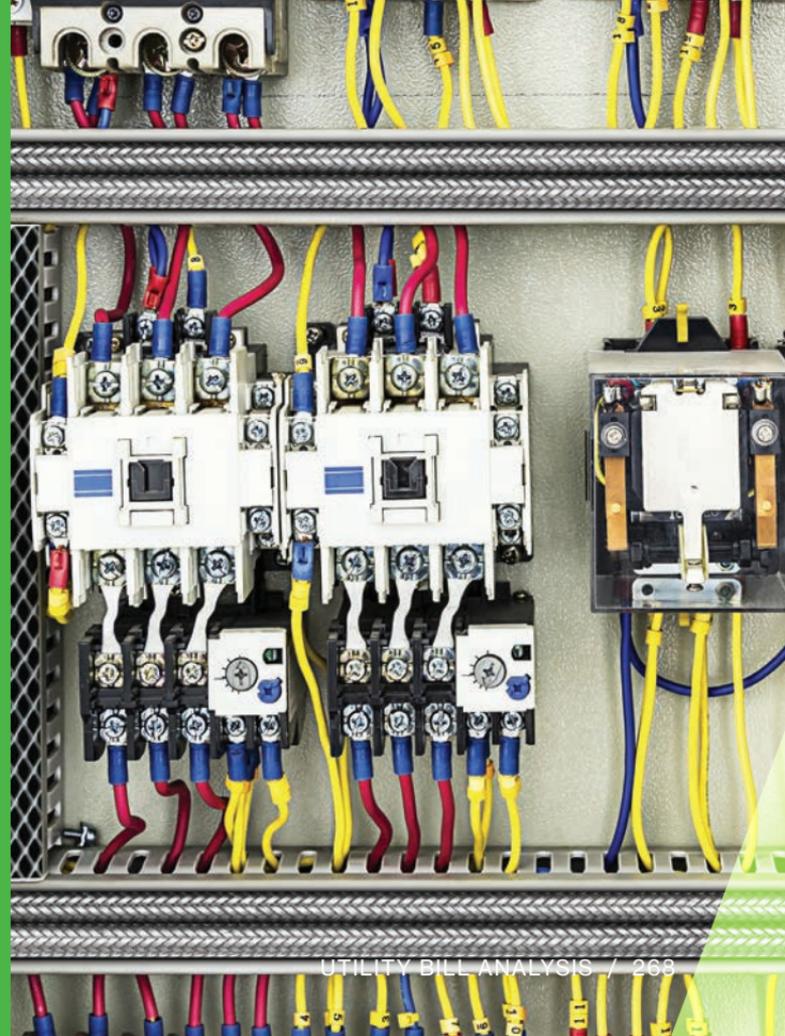
How much do you pay for energy each month? How does that change over the year?

How can you reduce utility costs through smart energy management, such as changing the times-of-use?

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QUESTION

What is power factor?



ANSWER

Power factor is the ratio between the real power (kW) and the reactive power (kVAR). More specifically, power factor is the ratio between the total amount of potential energy delivered to a plant and the power actually used by the plant.



DISCUSSION

Power factor is important to utilities and electricians because power lines and equipment are sized based on the potential power delivered. The primary culprits of a low power factor are large, unloaded motors. Typically, the best way to correct a low power factor is by using capacitors.

DISCUSSION QUESTION

How much does your utility charge for your facility's power factor, if at all?

What percentage of your entire bill is the power factor?

What is the largest motor in your facility that is unloaded at least part of the time?

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QUESTION

What costs the most on your monthly electric bill?



ANSWER

Energy use, measured in kilowatt hours (kWh), costs the most on electric bills in the Pacific Northwest.*

*In other regions, peak demand can be a more significant portion of the total cost.



DISCUSSION

Depending on your rate schedule and how you use energy, the typical monthly bill in the Northwest might look something like this:

- 77% energy (kWh)
- 19% demand (kW)
- 3% other
- 1% power factor (kVAR)

Note that the greatest opportunity to lower your monthly bill is to reduce your energy use through improved energy management and energy efficiency projects.

DISCUSSION QUESTION

What can you do to reduce energy consumption in this facility? Have you presented these ideas to a supervisor?

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QUESTION

Why do utilities have different rate schedules?



ANSWER

Utilities have different rate schedules because costs vary when serving different groups of customers.



DISCUSSION

Utilities attempt to allocate the costs among different customer groups. Non-residential rates are typically grouped by the voltage served: secondary, primary or transmission voltage (aka, sub-transmission).

DISCUSSION QUESTIONS

Under what conditions would it make sense for a customer to be served at a higher voltage?

What voltages does your facility use?

Are there transformers on site? Who owns them?

How many electric accounts do you have?

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QUESTION

How can you measure or calculate the energy that equipment is using?



ANSWER

For a precise understanding of the energy that equipment is using, the energy use must be directly measured or calculated. Energy use can also be determined by manufacturer's data, pump and fan performance curves, and industry databases, such as a lighting database.



DISCUSSION

Monitoring power (kW) is more than measuring amps with an ammeter. Energy consumption is power (kW) used over time (hr) producing kWh.

Calculating energy use can be done using the following formula for 3-phase power:

$$\text{kW} = (\text{volts}) \times (\text{amps}) \times (\text{power factor}) \times 1.732/1000$$

DISCUSSION QUESTION

Which piece of equipment in your facility uses the most energy?

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QUESTION

How can you get more details about a building's electricity use beyond what is provided by the numbers on the utility bill?



ANSWER

To offer a better understanding of your building's electricity use, some meters can provide the pulses gathered during each monitoring interval, as transmitted to a local data collector. Sometimes, utilities provide this service separately. This data, known as interval data, is often in 5- or 15-minute increments.



DISCUSSION

Electronic meters have the capability to store energy information for each monitoring interval programmed into the meter. Use this information to provide insight into how your facility is using energy. Energy used during unoccupied hours can help you make decisions about shutting down equipment that is unneeded. You might also use this information to discover equipment that is not starting or stopping as it should.

DISCUSSION QUESTIONS

Does your facility have access to interval data? If so, what can it tell you about how you use energy? Are there any surprises looking at the data?

Have you compared the energy used during unoccupied times with occupied times? What should it be? Can it be lowered?

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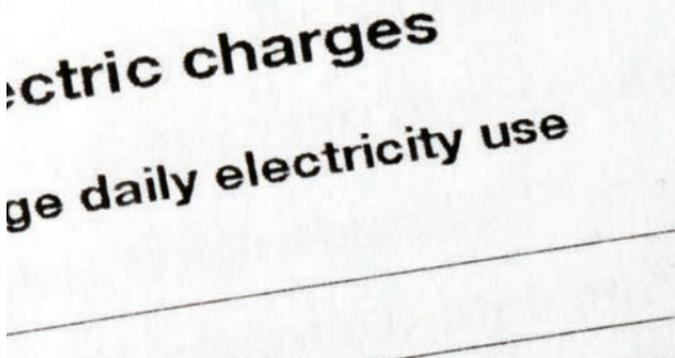
QUESTION

What information can be gathered from a monthly utility bill analysis?



ANSWER

- Seasonal trends
- Base-load consumption
- Electric-load factor (compare this with the occupancy factor)
- Estimate of heating and cooling consumption



Electric charges
Average daily electricity use

DISCUSSION

Generally, you would expect to see electricity use peak in the late summer and decrease in the shoulder months when free cooling is available. Winter usage will depend on what type of heating fuel is used. The base load (i.e., the lowest daily consumption for the year) for an all-electric building would be expected in the spring or fall. In buildings with only gas heat, the lowest daily electric consumption may occur in winter. Depending on the mix of fuel types for heating and cooling, you may be able to deduce the annual heating and cooling consumption by subtracting the base load from the total annual use.

A comparison of the Electric Load Factor (ELF) with the Occupancy Factor (OF) can give an indication of excess use during unoccupied hours.

DISCUSSION QUESTIONS

If a building only uses gas for heating, what does excess electricity use in the winter and shoulder months indicate?

What could it mean if a building that uses electric heating shows an excess of energy use in the typically milder autumn months?

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QUESTION

Why should you consider saving energy?



ANSWER

Saving energy will lower your energy costs.

DISCUSSION

There are often ways to meet your building's operational needs while using less power. For example, LEDs are the most efficient lighting source, and can easily replace legacy sources including fluorescent, HID and incandescent.

Other systems where energy savings can typically be found include:

- Electric motors
- Pumps
- Fans

The equipment being driven by a motor is usually the best place to look for energy improvements. Your local utility may even provide incentives to offset the costs of finding and upgrading them.

DISCUSSION QUESTIONS

What systems in your facility could be improved to save energy?

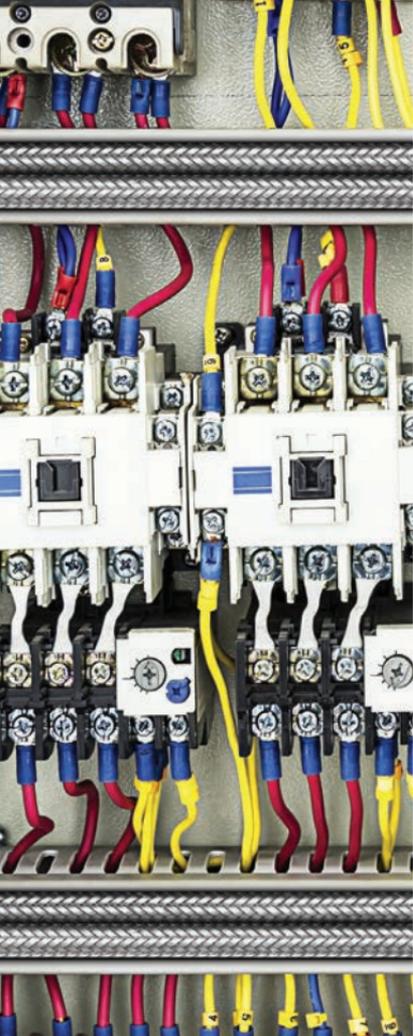
How can you determine the energy savings of these improvements?

What other procedures or technologies can you use to save energy?

INSPECTION CHECKLISTS

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EQUIPMENT SCHEDULING

- Equipment schedules are reasonable, accurate and match occupancy
- Optimum start/stop is utilized where available
- Space temperature setpoints and setbacks are reasonable
- Boilers and chillers are appropriately locked out
- Chilled and condenser water temperature setpoints are appropriate
- Chilled and condenser water pump operations are appropriate
- Domestic hot water circulation pumps are scheduled based on demand
- VFDs are in AUTO, and fan speed/static set points are appropriate
- Bathroom exhaust is scheduled
- Plug loads are scheduled (e.g., coffee, vending, etc.)

SENSOR CALIBRATION

- Routinely check and recalibrate, as necessary, key sensors used in your HVAC system using a NIST traceable calibration device. Sensors to consider include one or more of the following as applicable:
 - Outside air temperature
 - Outside air enthalpy
 - Mixed air temperature
 - Return air temperature
 - Return air enthalpy
 - Discharge air temperature
 - Humidity
 - Carbon Dioxide
- Outside air temperature sensor is properly located (away from exhaust sources and direct sunlight)





OUTSIDE AIR USE

- Minimum outside air percentage is appropriate for occupancy type and number of people
- Lobby is checked for any pressurization issues
- Stairwell and elevator pressurization fans are checked for damper positions (fire safety and others)
- Elevator machine rooms are checked for signs of exfiltration and infiltration
- Building perimeter is checked for signs of air leakage
- Economizer control setpoints – including high temperature lockout, minimum outside air position, low temperature lockout and control type – and operation are checked
- Outside air lockout is implemented during morning warm-up and after-hours where appropriate
- Demand Control Ventilation opportunities
- Dampers are operable
- CO2 levels are checked

HEATING AND COOLING

- The following setpoints are appropriate:
 - Discharge air temperature
 - Heating water
 - Chilled water
- Chilled and condenser water pump operations are appropriate
- Valve leakage at coils are checked
- Space temperature setpoints are reasonably consistent in adjacent zones
- VFDs are operating and fan speed is appropriate for demand
- Advanced VAV control sequences, if present, are functioning (e.g., duct static pressure reset and supply air temperature reset)
- Terminal unit dampers and reheat, if present, are operating appropriately





LIGHTING

- Control clock matches actual time and day
- Schedules match occupancy
- Interior lighting is off when building is not occupied (e.g., nights and weekends)
- Lights turn off as programmed
- Lighting control accounts for weekends and holidays
- Occupancy sensors are operational and setpoints are adjusted for each space
- Exterior lights are off during daylight hours
- Atrium lights, lobby areas and spaces with significant natural daylight are off during daylight hours

MAKE YOUR OWN CARDS

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QUESTION



ANSWER

DISCUSSION

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QUESTION



ANSWER

DISCUSSION

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QUESTION



ANSWER

DISCUSSION

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