Leading by example, saving energy and taxpayer dollars in federal facilities

O&M First!

Actions You Can Take to Reduce Cooling Costs

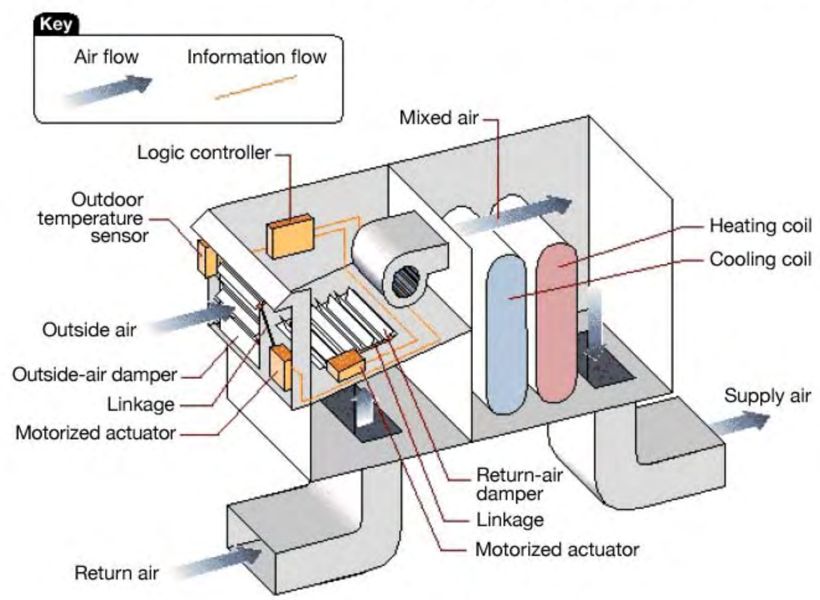
Cooling costs can be a substantial part of your facility's annual utility bill. A number of energy savings opportunities could be utilized to achieve demand and energy savings through development of a long-term approach to reducing building cooling loads. However, there are many operations and maintenance (O&M) opportunities that can also be implemented to make the existing air-conditioning systems operate more efficiently and effectively, thus lowering overall cooling costs. This FEMP O&M tutorial identifies some of the most likely opportunities for reducing cooling costs in your facilities. While most of these opportunities focus on packaged cooling systems, many also apply to larger systems. Actual opportunities and potential savings will vary by site.

Opportunity 1: Maintain Healthy Economizers

Air-side economizers are control devices designed to save cooling energy. When the outside air temperature is cooler than the return air, economizers bring in more outside air to cool the building, rather than using refrigeration equipment to cool the return air. A properly operating economizer

The components of an economizer

An economizer is simply a connection of dampers, sensors, actuators, and logic devices that together decide how much outside air to bring into a building to reduce the load on the cooling coil, thereby saving energy.



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How to Adjust the Damper to the Minimum Open Position:

Here is an example showing how to adjust the damper minimum open position to meet local codes or application requirements:

1. Measure return air temperature (RAT) (assume 75°F for example).
2. Measure outdoor air temperature (OAT) (assume 60°F for example).
3. Calculate the mixed air temperature (MAT) which will result from the desired combination of OAT and RAT. For example, if the designed outdoor air is 10 percent and the return air is 90 percent of the total supply airflow, respectively. Therefore:

   MAT = 0.1 OAT + 0.9 RAT or substituting example values: 0.1 (60°F) + 0.9 (75°F) = 73.5°F
4. Adjust the minimum position potentiometer knob until proper mixed air temperature as calculated above is reached. Care should be taken to ensure that the thermometer is sensing air that is well mixed.

can cut annual cooling costs by as much as 20 percent, depending on local climate and internal cooling loads. Unfortunately, economizers are notoriously unreliable and break down frequently. Early results from field studies suggest that about one-half of all newly installed economizers don't work properly. Some reasons for failed economizers, both new and old, include:

- Jammed outside-air damper
- Jammed, broken, and/or disconnected linkage
- Nonfunctioning actuator
- Inaccurate air temperature sensors.

To make things worse, a malfunctioning economizer may become a major energy waster. A significant amount of energy may be used to heat or cool excess outdoor air when an outside-air damper is stuck in an open position. *Solution*: Test economizers at least twice a year using the following procedure:

- Check to see if the economizer section is running at minimum outdoor air settings when the system is mechanically cooling.
- Cycle the minimum position potentiometer from 0 to full open and observe operation of damper to ensure that there is free, unobstructed operation through the entire angle of damper travel.
- Wait for a cool day when the economizer damper is wide-open; warm the outdoor air temperature sensor with your hands or an electric hair dryer; the outdoor air damper should move to its minimum position. If not, either the sensor needs the calibration or the economizer control is malfunctioning.

O&M TIP:

Air-side maintenance and repairs should be done BEFORE tackling the refrigeration system, because air-side problems are very common, and because most refrigeration problems cannot be fixed effectively until proper air flow is established. For example, refrigerant charge measurements will be erroneous if air flow is restricted by dirty filters.

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Opportunity 2: Clean and Replace Air Filters

Air filters play critical roles in maintaining indoor air quality, and protecting the downstream components of an air-handling system (e.g., the cooling coil and fan) from accumulating dirt that can reduce equipment efficiency. Dirty filters force air to go around filtration sections and the unfiltered bypass air deposits dirt on the cooling and heating coils rather than on the filter. It takes more effort and requires more skill to clean a dirty evaporator coil than to replace filters. *Solution*: Routinely change filters based on the pressure drop across the filter, calendar scheduling, or visual inspection. Scheduled intervals should be between 1 and 6 months, depending on the dirt loading from indoor and outdoor air. Measuring the pressure drop across the filter is the most reliable way to rate dirt loading on the filter. In facilities with regular and predictable dirt loading, measuring the pressure drop across the filter can be used to establish the proper filter-changing interval; thereafter, filter changes can be routinely scheduled. Refer to manufacturer's catalog for the recommendations of pressure drop across the filter.

Air Filter Pressure Kits

A complete air filter pressure kit costs about $70. Hardware for installing the pressure taps costs less than $10. Installation can be done by a service technician in just a few minutes.

Opportunity 3: Inspect and Clean Evaporator and Condenser Coils

A dirty evaporator coil or condenser coil will reduce cooling capacity and degrade equipment energy efficiency. A clogged evaporator coil reduces air flow through the coil, thus causing the compressor motor to consume more energy. Exposed to unfiltered outdoor air, condenser coils easily trap dust and debris, which raises the condensing temperature and reduces the cooling capacity. A Pacific Gas & Electric (PG&E) study showed that a dirty condenser coil can increase compressor energy consumption by 30 percent. *Solution*: Visually inspect the evaporator and condenser coils at least once a year for clean air-side passage. Replacing filters on a regular basis will keep the evaporator coil fairly clean. Remove the dirt from coils by washing and vacuuming them. To ensure that the coils are not damaged by the high-pressure spray wash, an experienced cleaning crew should be used. In a two-person crew, one person will spray clean the coil, while the second person continuously vacuums out the cleaning solution.

Filthy Cooling Coils Restricting Airflow and Cooling Effectiveness. Closer inspection revealed missing air filters.

Source: California Energy Commission—*Small HVAC System Design Guide*

Cooling Costs Impact of Dirty Condenser Coil

A dirty condenser coil that raises condensing temperature from 95°F to 105°F cuts cooling capacity by 7 percent and increases power consumption by 10 percent, with a net (compressor) efficiency reduction of 16 percent. In a 10-ton unit operating 2,000 hours a year, this wastes about $250 per year in operating costs. A technician can clean the condenser coil in about 1 hour, which typically costs about $50. In this example, the payback takes just over 2 months and delivers a net annual savings of $200.

Opportunity 4: Measure and Correct the Refrigerant Charge

Incorrect refrigerant charge can affect a direct expansion (DX) unit's energy efficiency significantly (Figure 1). A recent field study of 74 refrigeration systems reported that over 40 had incorrect refrigerant charges. Correcting the refrigerant charge can reduce cooling costs from 5 to 10 percent. Therefore, it is important to verify the correct refrigerant charge in your systems. Some signs indicating an undercharged system include frosting on the evaporator entrance, a warm suction line, a cool liquid line, warm supply air, and continuous compressor operation. In an overcharged system, on the other hand, excess liquid refrigerant backs up in the condenser and therefore increases the head pressure. *Solution*: Determine if refrigerant charge is acceptable, insufficient or excessive. Using the manufacturer's chart, look up the evaporating temperature that corresponds with the measured suction line pressure. Measure the actual suction line temperature. Determine the superheat as the difference between the measured suction line temperature and the evaporating temperature from the chart. For most direct expansion systems, a superheat temperature between 10°F and 20°F indicates an adequate refrigerant charge. For systems with thermal expansion valves, the degree of subcooling should also be checked and compared to manufacturer's recommendations to determine if the system has the proper refrigerant charge.

Don't have a refrigerant manifold gauge? Consider a digital refrigerant system analyzer. Automatic subcooling and superheat readings make it easier to determine the proper refrigerant charge.

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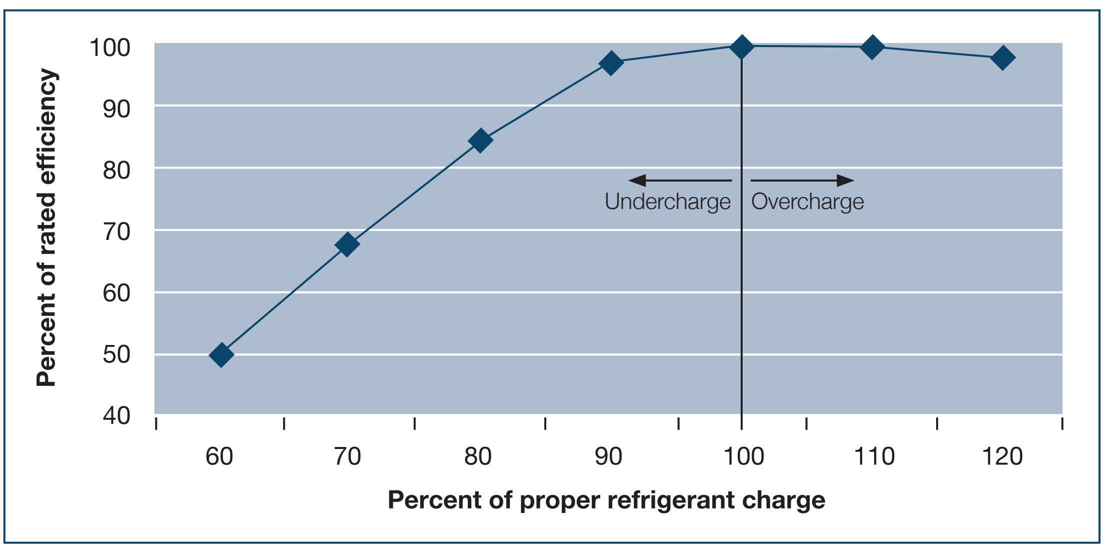

Figure 1. The effect of refrigerant charge on efficiency.[1]

1 R. Davis. 2001. *Influence of Expansion Device and Refrigerant Charge on the Performance of a Residential Split-System Air Conditioner using R-410a Refrigerant.* Report No: 491-01.7. San Francisco, Calif.: Pacific Gas and Electric.

O&M TIP:

Don't use duct tape to seal duct leaks because it tends to degrade over time. Specify sealing materials that meet UL Standard 118, such as mesh tape and mastic.

Opportunity 5: Fix Leaks in Cabinet and Supply Ducts

Pressurized air can easily find its way to leak through the unit cabinet and ductwork. Leaking air reduces the cooling capacity and wastes energy from the loss of the cooled air. Energy benefits from cabinet integrity and duct sealing are estimated to be about 20 percent of the annual cooling consumption, based on a recent study of 350 small commercial HVAC systems in Southern California. Comfort in buildings with tight HVAC systems is expected to improve because the system will be able to deliver sufficient cooled air (as designed) to serve the space loads. *Solution*: An easy task is to check the cabinets and correct air leakage. Some corrective actions include replacing screws or latches, patching or replacing gaskets, and replacing missing screws on loose access panels. Don't forget to recharge p-traps or U-bend water traps for condensate drain pans because the condensate drain pipe is another potential source of air leakage. Furthermore, duct leakage testing and sealing can be done, although this will take more resources and skills. Duct leakage testing should be conducted using the duct pressurization method described in the SMACNA[2] Air Duct Leakage Test Manual. Aeroseal is a new technique that combines duck leakage testing and sealing into one operation.

Opportunity 6: Reset Condenser Water Temperature

Most chillers reach their maximum operating efficiency at the designed peak load. However, chillers operate at the part-load condition most of the time. Resetting the condenser water temperature normally decreases the temperature lift between the evaporator and the condenser, thus increasing the chiller operating efficiency. *Solution*: Reset the condenser water temperature to the lowest possible temperature. Allow the cooling tower to generate cooler condenser water whenever possible. *Remember*: Although lowering the condenser water temperature will reduce chiller energy, it may increase cooling tower fan energy consumption because the tower fan may have to run longer to achieve the lower condenser water temperature. In addition, some older chillers have condensing water temperature limitations. Consult the chiller manufacturer to establish appropriate guidelines for lowering the condenser water temperature.

O&M TIP:

For centrifugal chillers, the compressor efficiency will increase 1.1% for every 1°F reduction in condenser water temperature.

The efficiency increase is lower for absorption chillers, delivering a 1.1% increase in efficiency for every 2°F reduction in condenser water temperature.

2 SMACNA stands for Sheet Metal and Air Conditioning Contractors' National Association.

Opportunity 7: Stage Multi-Chiller Operation to Improve Part-Load Performance

Electrical chillers often represent the single largest electrical load in facilities, accounting for between 35 and 50 percent of a building's annual electricity use. If you have a multiple-chiller system serving your facility, make sure each chiller operates at no less than 50 percent of rated load (if at all possible). This eliminates the potential that the chiller will operate at partial load, which causes the low efficiency of equipment, as well as the reduced equipment life resulting from unnecessary operation. *Solution*: Consider staging the multiple chillers; operate the fewest number of chillers required to meet the load and operate those chillers at their highest overall operating efficiency. This can be achieved by using an electronic control system to calculate the actual cooling load and matching the correct number of chillers to meet the load.

Additional Opportunities

There are many more opportunities that will cost-effectively improve cooling operations, save energy, and reduce summer electricity costs. Examples include:

- Raise thermostat settings for cooling, if appropriate
- Reduce the cooling system run hours to the extent possible
- Reset chilled water temperature
- Implement and improve the water treatment in cooling towers
- Clean the evaporator and condenser tubes to remove scale or buildup
- Clean fan blades, lubricate bearings and adjust belts
- Minimize the use of reheat to the extent possible
- Commission ventilating systems through testing, adjusting and balancing (TAB)
- Ensure control valves operate correctly
- Optimize multiple pumps controls to reduce pumping operating costs
- Don't cool unused space.

For Additional Information

EPA, "*Energy* EPA-430-B-98-004B—*Stage Two Building Tune-Up*," EPA-430-B-98-004B, U.S. Environmental Protection Agency, June 1998. http://www.cleanaircounts.org/Resource%20Package/A%20Book/EStar%20Buildings/buildings%20manual/stage2.pdf

DOE, O&M Best Practices: A Guide to Achieving Operational Efficiency, Release 2.0, Office of Federal Energy Management Programs, U.S. Department of Energy, July 2004. http://www.eere.energy.gov/femp/operations_maintenance/om_best_practices_guidebook.cfm

CEC, "*Small HVAC System Design Guide,*" 500-03-082-A12, California Energy Commission, October 2003. http://www.energy.ca.gov/reports/2003-11-17_500-03-082_A-12.pdf

PG&E, "*Energy-Efficient Operations and Maintenance Strategies for Packaged HVAC Systems,*" Application Note, Pacific Gas and Electric Company, April, 1997. http://www.pge.com/003_save_energy/003c_edu_train/pec/info_resource/pdf/ONM4HVAC.pdf

Pete Jacobs et al, "*Small Commercial Rooftops: Field Problems, Solutions and the Role of Manufacturers,*" Proceedings, National Conference on Building Commissioning, May 2003.

Turner, Wayne, Energy Management Handbook, Fifth Edition, Fairmont Press, Lilburn, GA, 2004.

Joan Gregerson et al, *Guide to Efficient Unitary Cooling Equipment*, E Source Tech Update, TU-95-5, June 1995. http://www.esource.com

David Houghton, *Operating and Maintaining Rooftop Air-Conditioning Units*, E Source Tech Update, TU-97-2, January 1997. http://www.esource.com

O&M First!—FEMP is pleased to present this series of fact sheets as a way to promote energy efficiency by first applying O&M best practices. It is our hope that the experiences shared will provide federal facility managers with strategies they can apply to their own facilities, as well as introduce the FEMP O&M program to federal site staff.

A copy of the FEMP O&M Best Practices Guide can be downloaded at www.eere.energy.gov/femp/operations_maintenance/om_best_practices_guidebook.cfm. This guide, which covers a full range of facilities O&M topics, provides the rationale for a proactive O&M program; identifies O&M management issues and their importance; explains the various O&M program approaches; introduces maintenance technologies; and explores O&M procedures for the predominant equipment found at most federal sites.

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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