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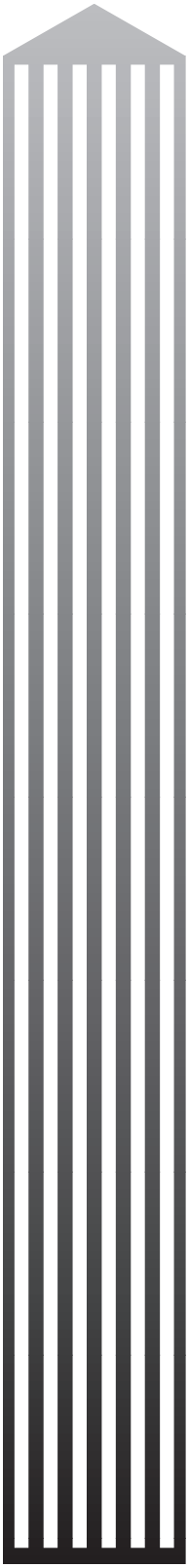

Fifteen O&M Best Practices

For Energy-Efficient Buildings

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September 1999

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For additional copies of this booklet, contact:

Portland Energy Conservation, Inc. (PECI)
921 SW Washington, Suite 312
Portland, OR 97205
(503) 248-4636
e-mail: peci@peci.org
Also available on-line at www.peci.org

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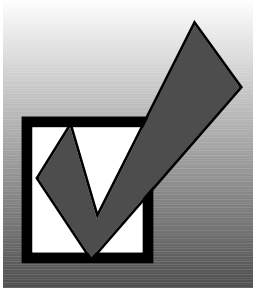


15 O&M BEST PRACTICES

The 15 Best Operation and Maintenance Practices for Energy-Efficient Buildings

INTRODUCTION

Building operation and maintenance programs specifically designed to enhance operating efficiency of HVAC and lighting systems can save 5 to 20 percent of the energy bills without significant capital investment. The U.S. EPA and U.S. DOE want to help commercial building owners capture these savings. The 15 Best Practices described in this booklet are strategies that facility managers, energy managers and property managers can use to integrate energy-efficient operation into their organizations' O&M programs and to obtain support from senior management.

This publication is part of the O&M Best Practices Series, which includes the following books:

- Fifteen O&M Best Practices for Energy-Efficient Buildings
- Operation and Maintenance Service Contracts: Guidelines for Obtaining Best-Practice Contracts for Commercial Buildings
- Portable Dataloggers - Diagnostic Monitoring Tools for Energy-Efficient Building Operation
- O&M Assessments: Enhancing Energy-Efficient Building Operation
- Energy Management Systems - A Practical Guide
- Putting the "O" Back in O&M: Best Practices in Preventive Operations,Tracking, and Scheduling

O&M Best Practices save energy while maintaining or enhancing indoor air quality and equipment reliability.

In line with the series' focus on energy, best practices are defined as those O&M activities, methods, and approaches that contribute to, or are directly responsible for, producing energy savings while maintaining or enhancing indoor environmental quality and equipment reliability. These overarching O&M practices lead to the *efficient operation* of commercial buildings rather than emphasizing energy-efficient capital improvements, (such as energy-efficient lighting and HVAC retrofits), or equipment-specific maintenance procedures, (such as cleaning indoor and outdoor coils, tightening fan belts and changing filters). Each of the best practices fall into one of the following four major categories:

These best practices focus on efficient operation — not capital improvements.

- **Management**—energy-efficient building operation and the "big picture."
- **Teamwork**—energy-efficient building operation is everybody's business.
- **Resources**—information saves time and money.
- **Energy-Efficient O&M**—expanding the preventive maintenance program.

Because there is very little information on building operation (the "O") compared to the volumes written on building maintenance (the "M"), this series emphasizes activities that support energy-efficient building operation, (such as optimizing schedules, control strategies, sequences of operation, etc.). Maintenance is not ignored but this discussion is limited to the maintenance activities that support efficient operation of equipment and systems.

MANAGEMENT

Energy-Efficient Building Operation and the "Big Picture"

BEST PRACTICE 1: GOALS

INCORPORATE GOALS FOR ENERGY-EFFICIENT BUILDING OPERATION INTO THE STRATEGIC BUSINESS PLAN

Today's business atmosphere of "downsizing" and reducing capital expenditures is fertile ground for energy-efficient building operation. Senior managers and building owners are focused on maximizing the return on investment (including assets such as facilities and O&M staff). This focus increases opportunities for energy managers, facility managers and property managers to demonstrate the relevance of energy-efficient building operation. Optimizing O&M strategies for keeping expensive building equipment and systems operating efficiently reduces the risk of early equipment failure, unscheduled down time, high utility costs, and tenant losses. Also, efficient building operation can increase a facility's net operating income (NOI), which in turn increases its value. Clearly defining O&M goals and objectives, and communicating to senior management how O&M fits into the "big picture," increases management's awareness and support for the O&M department's efforts.

Efficient building operation can increase capital value.

PURPOSE

- Gain the attention of senior management by increasing their understanding of efficient operation as part of asset management. Efficient building operation reduces operating costs and maintains comfort. This

translates into increased capital value. In addition, an income building with excellent comfort and low operating costs increases the owner's ability to attract and retain tenants.

- Obtain senior management support for the O&M department in general and for energy-efficient building operation in particular.
- Establish energy-efficient operation as a specific goal for the facilities department.

ACTION TIPS

- Thoroughly understand the organization's mission and strategic business plan.
- Clearly define and communicate to senior management how the O&M department fits into the overall organization by developing clear, written goals and objectives that are in harmony with the larger mission and strategic plan. Include an objective to achieve a level of measurable operating efficiency for the building or buildings.
- Keep senior management informed about the current level of operating efficiency, additional savings potential, and the resources needed to achieve it.

BEST PRACTICE 2: PLANNING

REQUIRE AN ENERGY MANAGEMENT PLAN WITH ENERGY-EFFICIENT OPERATION AS A PRIMARY COMPONENT

Energy-efficient operation means operating an energy-consuming device so that it uses only as much energy as necessary to fulfill its intended function. The primary objective of an effective energy management plan is to eliminate or minimize energy waste while maintaining a comfortable and safe environment. Effective energy management planning generally consists of three basic elements:

An energy management plan minimizes waste.

- Purchasing clean and reliable energy at the lowest cost
- Replacing old equipment and systems with new, efficient technologies
- Operating energy consuming equipment efficiently

The energy management plan should include and equally emphasize all three of these elements. Operating energy consuming equipment efficiently is the most under-rated and least understood element, yet it has high potential for savings with little or no capital outlay (Herzog 1997).

PURPOSE

- Create a written energy management plan that not only includes fuel purchasing and equipment replacement but equally emphasizes strategies for efficient building operation.
- Optimize energy cost savings by efficiently operating existing equipment and reducing inappropriate or premature capital outlay.

ACTION TIPS

- Include in the energy management plan a component clearly defining energy-efficient operation of energy consuming equipment. An example of a definition is: Operate energy consuming equipment to constantly maintain a match between the energy used and the energy required for the equipment or system to fulfill its intended function (Herzog 1997).
- As part of the plan, state the goals for energy-efficient operation, outline the steps to achieve the goals, and define methods of measuring and reporting whether goals have been met.
- When communicating with management, use language and terms they understand and emphasize benefits they value, which may differ from your own.

BEST PRACTICE 3: ENERGY ACCOUNTING

USE AN ENERGY ACCOUNTING SYSTEM TO LOCATE SAVINGS OPPORTUNITIES AND TO TRACK AND MEASURE THE SUCCESS OF ENERGY-EFFICIENT STRATEGIES

An energy accounting system is a critical part of the energy management plan. For an energy management plan to be successful it must include information on past and current energy use, demand (in the case of electricity) and cost. Without this information it is impossible to understand or communicate in any measurable way the progress of the overall energy management plan as well as the various energy-saving components. An energy accounting system can be used to better understand major drivers of a facility's energy use, such as weather, increased occupancy, additional equipment, operational deficiencies, etc. Tracking whole-building energy performance provides insight into of overall energy and O&M fitness of the building.

O&M staff need energy use information in order to implement energy-efficiency strategies.

Often those individuals that are most involved with operating and maintaining the building receive the least information on energy use. Sharing the energy accounting information with the building's O&M staff helps them to track the increases in demand and energy use that may indicate problems. It also may help them track the success of energy-efficient O&M strategies.

PURPOSE

- Provide a basic foundation for a successful energy management plan.
- Record and track the progress of energy saving strategies.
- Provide a basis for setting realistic energy savings goals.
- Indicate possible areas for improved O&M.

- Motivate O&M staff by continually giving them feedback through monthly reports.

- Provide owners and managers of multiple buildings the ability to benchmark and compare energy use among similar buildings. A building with a unusually high annual energy use intensity or energy use index (EUI, or energy consumption per square foot per year) compared to buildings of the same type and use, often indicates energy waste and opportunities for savings.

Energy accounting reports should be useful to both senior management and O&M staff.

ACTION TIPS

- Choose an energy accounting system or method that suits the size and complexity of the building or buildings involved. The accounting system may be manual or computerized.

- Fully understand various utility bills for each building, including rate schedules, consumption data and demand (electrical).

- Develop a reporting system for the data that is clear, concise and useful to both senior management and building O&M staff. This may include information in the form of charts and graphs that informs and educates the audience about energy use, demand, costs, savings and progress.

- Remember to normalize data for weather, changes in occupancy or use, and other relevant factors when developing the report.

- Distribute the report to both senior management and building O&M staff. Consider giving senior management a summary report and the building staff a more detailed report.

TEAMWORK

Energy-Efficient Building Operation is Everybody's Business

BEST PRACTICE 4: STAFFING

HIRE OR APPOINT AN ENERGY MANAGER

Assigning or hiring someone to take on the role of energy manager sends a message to the facility staff that the energy management process is important. A good energy manager engages the facility staff in the energy management process and supports and motivates staff efforts in energy-efficient operation. Often the cost savings generated by an experienced energy manager can easily cover his or her salary.

Often, the cost savings generated by an experienced energy manager can easily cover his or her salary.

As part of the facility staff, an energy manager has the primary responsibility for managing energy and promoting energy-efficient building operation. The energy manager must have the technical background such as an engineering degree, professional engineer's (PE) license, or certification as an energy manager (CEM). He or she should have the skill and the desire to develop and carry out all aspects of the energy management plan and should have a clear understanding of how indoor environmental quality (IEQ) issues relate to energy efficiency. A good energy manager also has good communication skills, the ability to make a business presentation to the organization's financial officers, and should act as a champion for the energy management plan.

PURPOSE

- Employ a skilled staff member whose primary focus is developing and implementing the organization's energy management plan with an equal emphasis on efficient building operation.

ACTION TIPS

- Depending on the building size, use, complexity of technologies, and potential energy savings, either hire a professional energy manager or assign the energy management function to a technically qualified staff person. Using an in-house staff person, (such as facility manager, property manager or building operator) is usually only appropriate for smaller (less than 300,000 sf) facilities.

- Provide adequate, up-to-date energy management training for the staff member assigned the energy management position. Training might include conferences, seminars, and university classes on the subject.

- Consider obtaining memberships in organizations that specifically support energy management such as the Association of Energy Engineers (AEE) and the Association of Professional Energy Managers (APEM).

- Clearly define the energy management job function along with reporting and authority guidelines. The energy manager should know who they report to and how much authority they have to carry out their goals.

- Assign a contracting representative "buddy" to work with the energy manager when he or she investigates the financing options of energy efficiency and O&M projects.

BEST PRACTICE 5: TRAINING

TRAIN BUILDING OPERATORS IN ENERGY-EFFICIENT O&M ACTIVITIES

Training helps staff to continually improve and sustain operating efficiency as a proactive O&M function. Today's building systems and controls are more sophisticated and complex than in the past. New technologies such as computerized energy management control systems (EMS) offer the ability to perform complicated energy-efficient control strategies but are often underutilized because of poor training. When staff understand the software control logic for the EMS, they can customize the control of equipment to account for a variety of internal and external conditions. However, without the proper training, the EMS often becomes a burden for the O&M staff. Some systems become scapegoats for comfort and control problems and staff may eventually disable them.

Training helps staff to utilize building systems efficiently.

Along with training staff on EMS control logic, train them in EMS-related maintenance activities that optimize energy-efficient operation. For example, certain sensors (such as the mixed air sensor and the supply air sensor) are more calibration-critical for preventing energy waste than others. Therefore, staff should clean and check the calibration of these sensors more frequently than other sensors.

Training for management-level facility staff should include contract and energy-related financing such as performance contracting, negotiating under utility deregulation, arranging service contracts, and equipment leasing.

PURPOSE

- Employ a confident, sophisticated, and motivated facility staff that has a clear understanding of how to operate the building's energy-consuming systems efficiently no matter how sophisticated the technology.

ACTION TIPS

- Develop an individual training plan and budget for each facility staff member using in-house resources as well as outside classes, conferences, and seminars that focus on energy-efficient building operation.
- If the building uses an EMS, obtain a complete training package specific to that system for the staff responsible for operating and maintaining the system. The training could payback in a matter of weeks from energy savings and reduced comfort complaints.

For information on operator training programs, visit the O&M Training Resource Directory at www.peci.org.

Best Practice 6: OUTSOURCING

REQUIRE SERVICE CONTRACTS THAT SUPPORT ENERGY-EFFICIENT BUILDING OPERATION

Building owners or managers may choose to hire outside service contractors to augment their own building O&M staff or they may outsource all of the O&M work, including the management. In either case it is important that service contracts require activities that address efficient building operation and include methods to track operating changes, improvements, and deficiencies over time. Unless requirements for attaining and sustaining efficient building operation are specifically addressed in the contract, contractors will traditionally focus their attention on maintenance issues only. The service contract should define requirements for both the "O" (operation) activities and the "M" (maintenance) activities.

Typical service contracts focus on maintenance activities. Make sure yours specifies operation activities as well.

Most outside service contractors are hired to do periodic preventive maintenance on large pieces of plant equipment (boilers, cooling towers, or chillers) or complex systems (fire, life and safety, security, and energy management systems). To detect and troubleshoot both maintenance and operational problems, include record keeping requirements in the service contract. Tracking the preventive maintenance (PM) work helps building staff locate recurring problems, understand when equipment performance is degrading, and ensure that the contractor is performing PM tasks outlined in the contract. The documentation generated by the service contractor provides building staff and management with critical information for comparing past and current conditions of equipment and system performance.

PURPOSE

- Increase the quality of the service provided by the service contractor.
- Increase service contractor accountability for both maintenance and efficient building operation.

- Instill confidence that the service contract works to efficiently operate and maintain building equipment.

- Obtain, sustain, and in some cases increase the energy savings and equipment life generated by the service contract.

ACTION TIPS

- Hire a contractor with expertise in efficient building operation as well as traditional maintenance tasks. Don't assume that all service contractors understand efficient building operation.

- As a building owner, manager or O&M staff member, get involved with the development of the service contract. The contract should clearly state which measurements and tasks are related to efficient operation.

- As part of the service contract, insist that the service technician who performs the work fills out the forms. The forms should clearly define the tasks along with blanks for recording the required measurements. Make sure the forms contain the expected performance data and nameplate data for each piece of equipment. Assign an O&M staff person to review the invoices and performance data forms after each PM servicing. Let the contractor know who is assigned to review and follow-up on the invoices

- Measured data is only as good as the measuring device. Include in the contract calibration requirements for the contractor's measuring instruments.

For more information on requiring service contracts that support energy-efficient building operation, see *Operation and Maintenance Service Contracts: Guidelines for Obtaining Best-Practice Contracts for Commercial Buildings*, a publication in the EPA O&M Best Practices Series.

BEST PRACTICE 7: PARTNERSHIPS

ACKNOWLEDGE ENERGY-EFFICIENT OPERATION AS A CROSS-FUNCTIONAL ACTIVITY

It is important to understand who directly operates the energy-consuming equipment in a building as well as who influences when and why equipment operates. Depending on how the building is managed and on how contracts are negotiated, tenants, custodians and security personnel may be primary operators of equipment such as lights, HVAC equipment, and office equipment (computers, printers, copiers). When building operators and managers are not primarily involved in the operation of energy consuming devices, providing easy-to-understand information on equipment operation, particularly in the case of new equipment and controls, is imperative. When new equipment and controls are installed, inform the users about proper operation. Otherwise, they often find ways to circumvent the technology, thus canceling the effects of energy-efficient operation.

Periodically remind equipment users to turn off equipment when it's not in use.

People often have misconceptions about how to operate energy consuming devices. For example many people feel they should always leave computers running and fluorescent lights on to extend equipment life and/or reduce energy costs. In fact, turning off idle computers and their monitors will not harm them. IBM has had a policy in place since 1973 encouraging their employees to turn off their computers when they aren't using them. IBM informed their employees that if they turned off their workstations and lights for an extra hour per day the company would save one million dollars per year (Stickney and Lovins, 1992.).

PURPOSE

- Increase energy savings and equipment life by educating equipment users on how to properly operate energy consuming devices.

- Reduce O&M problems and trouble calls for O&M staff.

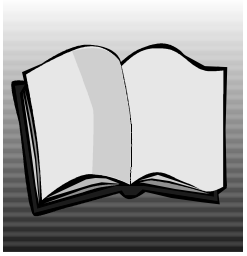
ACTION TIPS

- Make a list of who (other than the building's O&M staff) operates which energy consuming equipment and who *influences* when, why, and how the equipment is operated. Develop partnerships with these individuals regarding proper equipment operation.

- Involve these individuals in the energy management process through education. Instruct them in how to operate new equipment and give them fact sheets that put to rest misconceptions about operating equipment such as lights and office equipment.

- Periodically remind equipment users such as custodians, tenants, and employees to turn off equipment when it's not in use, especially when they leave the area for an extended period of time. Take advantage of meetings, company newsletter, e-mail, stickers, and other opportunities to issue these reminders.

- Perform periodic night and weekend audits to discover what equipment is operating that could be turned off.



RESOURCES

Information Saves Time and Money

BEST PRACTICE 8: DOCUMENTATION

MAINTAIN CONTINUITY AND REDUCE TROUBLESHOOTING COSTS

Many large commercial buildings start out with adequate mechanical and electrical drawings and O&M manuals. However, they seldom obtain operating documentation such as written sequences of operation or control strategies. Documenting the sequence of operation and energy-efficient control strategies for the energy using systems is essential to understanding building control. The control documentation is critical for maintaining energy-efficient operation and effectively troubleshooting operational problems.

Once accurate building documentation is obtained, keep it updated to maintain continuity. For example, sensor setpoint changes, sensor location changes, and control strategy changes should be documented whenever they occur. If the changes remain in the heads of only one or two staff members, when they leave the organization, the information is lost. Relying on memory can lead to mistakes that cost time and energy.

Control documentation is critical for maintaining energy-efficient operation and troubleshooting operational problems.

PURPOSE

- Increase troubleshooting ability to reduce the time spent defining and solving operational problems.

- Promote continuity of information in order to reduce training time for new staff and ensure that efficient operating strategies are maintained during staff turnovers or absences.

ACTION TIPS

- Obtain a clear, written set of sequences of operation and building control strategies. Two ways to accomplish this are:

  - Ask the current control contractor or hire a control expert to develop the operating documentation. Simultaneously have them review current operating strategies for energy-efficient improvements. The resulting savings could well pay for the time spent on developing documentation in a very short time.

  - Assign an appropriate in-house staff person to develop the current operating documentation. Make sure that other staff members are aware of the location of the documentation.

Videos and photographs can augment written documentation.

- As part of energy management policy require all changes to equipment, space, sequences of operation, set points, control strategies, schedules, etc. to be routinely recorded. Write this responsibility into the job descriptions of those responsible for making the changes.

- Record the operating schedule for all equipment that is not required to run continuously. This may include lighting, HVAC equipment, cooking equipment, and office equipment. Periodically review and update the schedules to reflect the current needs of building occupants.

- When specifying new control systems or equipment, include in the specification a requirement for the installer to provide at least two sets of complete documentation including a hard copy of the control strategies and sequences of operation.

- Use video and photographs to augment the written documentation.

- When taking over a new facility, request that the engineers provide the electronic files for the building's design intent and sequences of operation. Use a copy of the electronic files to document changes.

BEST PRACTICE 9: TOOLS

EQUIP O&M STAFF WITH STATE-OF-THE-ART DIAGNOSTIC TOOLS

Many of today's energy management control systems have trend logging capabilities and can be used to gather important data for troubleshooting and improving building operation. These capabilities can be used to detect energy waste. However, many energy management systems are limited in their ability to collect, store and present data. Also, EMS points are permanent, thus making it impossible to take a measurement other than where the point was originally installed.

For buildings lacking an EMS or for those having an EMS with limited data points, building staff can use portable electronic dataloggers to optimize equipment operation. Portable electronic dataloggers are battery-powered, small, light, and easily installed and removed without disrupting building occupants. Depending on complexity, they range in price from $50 to $1000. Loggers are able to take a variety of measurements such as temperature, humidity, pressure, electrical current, and light levels. The more sophisticated ones are capable of storing tens of thousands of readings and can be set up to gather data at almost any time frequency.

Building staff can use portable electronic data loggers to optimize equipment operation.

For analysis purposes, many loggers come with sophisticated software packages. Once the data are gathered, the information is downloaded into the computer software for analysis. The software is capable of presenting the data in line graphs, making troubleshooting, analysis, and presentation extremely "friendly." Numerous lines of data can be placed on one graph for analyzing multiple variables. Other useful tools include pressure gages and airflow hoods. Special software is now available to graph and analyze EMS data much faster than traditional spreadsheets. This software may be obtained as part of an EMS upgrade or as a stand alone product.

PURPOSE

- Provide O&M staff and managers with a state-of-the-art means of troubleshooting and detecting energy-wasting malfunctions as well as obtaining immediate feedback on comfort and operational changes.

- Provide a method of measuring the results of discrete changes in operating strategies.

ACTION TIPS

- Understand present EMS trending capability. Research the needs of the staff and facility for the number of dataloggers and types of compatible measuring instruments that would be most useful.

- Investigate the types of dataloggers available that would best fit the needs of the facility. Many vendors will be happy to demonstrate their products. Understand what innovations and upgrades they intend to introduce in the future. This could be important information for deciding which datalogger system to invest in.

- It may be useful to develop an analysis plan for the building prior to purchasing the datalogger package. This exercise could help determine which logger system is most appropriate.

- After deciding which product best fits the needs of the building, obtain sufficient training on the setup and use of the loggers for those staff members and managers responsible for collecting and analyzing the data.

- Once purchased, keep the dataloggers in use. They won't save any money sitting on the shelf and they will easily pay for themselves in a short time by increasing staff understanding of where and when energy waste is occurring.

Keep dataloggers in use. They won't save any money sitting on the shelf.

For more information on data loggers, see *Portable Dataloggers—Diagnostic Monitoring Tools for Energy-Efficient Building Operation*, a publication in the EPA O&M Best Practices Series.

BEST PRACTICE 10: ASSESSMENTS

PERFORM A COMPREHENSIVE O&M SITE ASSESSMENT

A rigorous O&M tune-up requires performing a thorough assessment of the current operation and maintenance practices. Understanding why building systems are operated and maintained the way they are, and where and what improvements are most beneficial and cost-effective is the first step in the O&M tune-up process.

The assessment systematically looks at all aspects of the current O&M program and practices as well as the management structures, policies, and user requirements that influence them. It may include interviews with management and O&M personnel, reviews of current O&M practices and service contracts, spot tests of equipment and controls, and trend or datalogging of pressures, temperatures, power, flows, and lighting use over time to reveal where improvements are needed. The assessment reviews schedules and control strategies to determine whether the building is being operated optimally and develops a list of recommended O&M improvements. It provides the starting point from which to measure the effectiveness of improvements and O&M activities. Depending on the scope of work, an assessment may also recommend where more extensive improvements may be needed (such as rebalancing the whole building or specific zones) and which capital improvements to consider for further investigation.

An O&M assessment is not an energy audit.

The O&M assessment differs from an energy audit in that its primary focus is identifying low-cost, low-risk changes in O&M practices that improve building operation rather than identifying expensive, technology-intensive capital improvements. The O&M assessment is often performed prior to or as part of an energy audit because it offers ways to optimize existing building systems and reduce the need for expensive technological solutions. Both the O&M assessment and the energy audit have the goals of reducing operating costs and energy waste and improving the building environment.

PURPOSE

- Identify the most immediate and cost-effective O&M tune-up activities that will lead to efficient building operation and meet management and user needs.
- Generate a master list of O&M improvements to assist management in budgeting and decision making.
- Document current O&M conditions as a baseline for comparing to future improvements.

ACTION TIPS

- Hire a qualified expert to perform the O&M assessment. Often an outside person who is not invested in or biased toward "the way things have always been done" can lend a new perspective and bring new experience to the facility's O&M program. The person or firm you hire should have a background in energy-efficient building operation. They should be able to provide a list of references and projects that demonstrate their ability to detect energy waste and provide low-cost O&M solutions. Engineering firms that provide building commissioning services are generally well qualified to perform O&M assessments. Your local utility may be able to recommend engineering firms that can perform this work.
- Often building staff members are capable of developing and performing O&M assessments. Assign a knowledgeable in-house staff person to perform the O&M assessment or assist the outside expert. Having in-house building staff assist with the assessment may be viewed as a training exercise. They can repeat the assessment themselves in the future.
- Require a final assessment report that includes a complete master list of improvements. This list should prioritize the improvements according to their estimated cost effectiveness. Most low-cost improvements should pay back in less than eighteen months.

For more information on O&M site assessments, see *Operation and Maintenance Assessments for Energy-Efficient Building Operation*, a publication in the EPA O&M Best Practices Series.

The O&M assessment identifies low-cost changes in O&M practices that improve building operation rather than identifying expensive, technology-intensive capital improvements.

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ENERGY-EFFICIENT OPERATION AND MAINTENANCE

Putting the "O" in O&M: Tune it Up, Turn it Off and Check it Out

BEST PRACTICE 11: TUNE UPS

PERFORM O&M TUNE-UP ACTIONS

Five to twenty percent of annual commercial building utility bills can be saved through low-cost O&M improvements—but only if they are implemented. Performing the O&M assessment and determining which improvements are most cost-effective is often the most time consuming and costly part of the O&M tune-up process. Once the improvements are selected and prioritized many of them may be implemented very quickly and inexpensively. For example, control strategy or schedule improvements, where the greatest savings often occur, may only take a few hours to implement.

Many operational improvements can be implemented quickly and inexpensively.

The O&M tune-up activities may be the first step in developing a sustainable finance mechanism for the organization. Once an organization funds the initial O&M assessment and tune-up improvements, future energy efficiency work can be funded from the savings generated by the low-cost O&M improvements. This kind of sustainable finance mechanism requires monitoring and tracking savings so that they can be dedicated to future improvements.

PURPOSE

- Implement the most cost-effective solutions that maximize building performance and minimize energy waste.

- Document the improvements and their effects in order to benchmark the performance of energy-using equipment and systems.

- Develop a sustainable finance mechanism for energy-efficiency measures for the organization.

ACTION TIPS

- Implement the improvements over a selected period of time such as six months to three years depending on budgets and paybacks. The savings from the initial O&M improvements may help offset the cost of other lower priority but important improvements as well as more expensive capital improvements leading to optimal building performance.

Savings from initial improvements can off-set the cost of more expensive capital improvements.

- Measure and document the effects of the improvements to create a baseline to track O&M activities against and ensure that improvements deliver the expected results.

To receive a set of case studies demonstrating the costs and benefits of tuning up five U.S. office and retail buildings, contact PECI at peci@peci.org or 503/248-4636.

BEST PRACTICE 12: AUTOMATIC CONTROLS

MAKE FULL USE OF AUTOMATIC CONTROLS TO OPTIMIZE EFFICIENT OPERATION

Although many facilities have sophisticated, computerized, energy management systems (EMS) in place, most do not take full advantage of the systems' capabilities. Staff often use these systems only to turn equipment on and off. These systems can be programmed to accomplish control strategies such as optimal start/stop, air- and water-side economizing, chilled and heating water resets, night setback and setup, night purge, morning warm-up, hot and cold deck optimization, and lighting sweeps. These strategies can save energy dollars beyond ordinary time-of-day control.

Save money by using automatic controls to do more than just turn equipment on and off.

Newer HVAC equipment may have sophisticated integral controls that can be programmed to accomplish energy-efficient strategies such as chilled water reset. Unless operators fully understand their capabilities, these controls may also be underutilized. The energy management control system may interface with these pieces of equipment but only to enable or disable them. Once enabled by the EMS, the integral controls take over the operation of the equipment. The integral controls should be programmed and adjusted to take full advantage of energy-efficient strategies.

PURPOSE

- Maximize the use of the control system to operate equipment and systems in the most energy-efficient manner possible while maintaining a comfortable and safe building environment.
- Reduce building staff time spent on comfort complaints from building occupants.

ACTION TIPS

- Take the time to fully understand the installed system's capabilities and which of these capabilities are programmed to function for your facility or piece of equipment. Take advantage of available training offered by the EMS vendor.

- For new systems, require the supplier/installer to turn over a full set of documentation on the installed system including *written* control strategies and sequences of operation so that O&M staff and managers know what is expected of the system.

- For both new and existing systems consider hiring a qualified third-party expert to evaluate and commission the installed system. This ensures that all the energy efficiency capabilities are being applied and the EMS interfaces correctly with the controlled equipment. The money spent for this service can often payback within one year.

- Train one or more of the building operating staff to program and oversee the control systems to ensure they are regularly updated, backed up, and the documentation remains current.

For more information on using building automation systems to optimize efficient operation, see *Energy Management Systems: A Practical Guide*, a publication in the EPA O&M Best Practices Series.

BEST PRACTICE 13: SCHEDULING

OPERATE EQUIPMENT ONLY WHEN NEEDED

The number-one way to waste energy is to leave equipment and lights on when they could be off. The payback for improved scheduling is almost immediate. Although individual pieces of equipment may be well maintained and perform efficiently, unless the control strategies and occupant needs are periodically reviewed, equipment may be operating more than necessary. Because many people often have access to lighting and HVAC controls, parameters and schedules may be changed to meet a special need or unusual condition and never get changed back to their original setting unless preventive maintenance procedures for addressing operational issues are in place. Equipment may operate very efficiently, but if it's "on" when "nobody's home," the only thing happening is energy waste.

Equipment may operate very efficiently, but if it's "on" when nobody's home, the only thing happening is energy waste.

PURPOSE

- Make sure that equipment is only "on" when actually necessary to meet occupant needs or fulfill its intended function.
- Reduce energy waste and costs by periodically reviewing schedules and operating strategies to ensure equipment runs only when needed.

ACTION TIPS

- As part of preventive O&M planning, develop procedures to periodically review and monitor EMS time-of-day schedules, optimum start/stop strategies, temperature setups and setback (these may be increased or decreased depending on outside conditions), lockouts, freeze protection, and other strategies and parameters that stage or turn equipment on and off.

- Also review and monitor any other on/off controls such as programmable and mechanical time clock settings, integral equipment controls, lighting photocells, sweeps, and occupancy sensors for proper operation.

- Ensure unused or unrented tenant/occupant spaces have HVAC equipment and lights turned off. Diffusers may be shut back or thermostats turned off in these spaces.

- Periodically perform an after-hours night or weekend walk-through to see if any equipment is on when it doesn't need to be. Pay attention to tenant plug loads such as computers, printers, and copiers. Small, inexpensive, "stick-on" dataloggers are available on the market that can assist in understanding when equipment is running more often than needed.

- Periodically interview tenants about their comfort and lighting needs to determine if any operating opportunities exist. Consider low-cost solutions such as occupancy sensors in areas of low or intermittent use like storerooms and employee lounges.

For more information on optimizing equipment schedules, see *Putting the "O" Back in O&M: Best Practices in Preventive Operations, Tracking and Scheduling*, a publication in the EPA O&M Best Practices Series.

BEST PRACTICE 14: TRACKING

TRACK ACTUAL PERFORMANCE AGAINST EXPECTED PERFORMANCE FOR MAJOR EQUIPMENT

It is important to track the overall energy use and demand of a facility as discussed in Best Practice 3: Energy Accounting, but it is also useful to track energy use and demand at the equipment level. When building O&M staff does not have adequate or correct information to assess day-to-day equipment performance, energy-saving opportunities may be lost. In order for O&M staff and managers to understand when major plant equipment is not operating as efficiently as it could be, they need to regularly track actual equipment performance data against expected performance data. Expected performance data or the "figure of merit" (FOM), such as kW per ton, may be a combination of manufacturer test data and the actual data obtained from field testing the equipment. The goal is to obtain benchmark performance criteria for comparisons against future data. When equipment does not meet the expected performance criteria, it may indicate a need for improved or more frequent maintenance procedures (cleaning, lubricating, etc.) or different operating parameters (setpoints, lockout strategies, capacity control strategies, etc.).

Building staff need up-to-date information to take advantage of savings apportunities.

PURPOSE

- Provide building O&M staff and managers with continuous feedback on the performance of major plant equipment such as chillers and boilers as a way to assess day-to-day operation.
- When O&M changes are made, regular performance tracking provides timely feedback on the effect and success of those changes on equipment efficiency.

ACTION TIPS

- Obtain the necessary manufacturer performance test data and "figures of merit"(FOM) for all major plant equipment, such as chillers, cooling towers, boilers, air handlers, and pumps. Or, establish benchmarks for the equipment using field measurements.

- When developing benchmark FOMs, the equipment and systems should be tested under full and part load conditions and only after they have gone through rigorous annual PM procedures to ensure that they are in best condition possible. Hire a test engineer to assist in developing the baseline performance data.

- Decide which temperatures, pressures, currents, voltages and flows should be measured to best analyze equipment performance over time. Keep in mind that only critical parameters need to be tracked regularly. These key parameters indicate when a problem exists and let operators know when more in-depth information needs to be gathered or when troubleshooting needs to occur.

Only critical parameters need to be tracked regularly.

- Remember to normalize data in terms of weather in order to accurately compare data from year to year. Software is available to help with benchmarking (www.lbselbse.org) and weather normalization.

- Decide how frequently to track equipment performance. Some equipment data should be looked at daily. Tracking methods may include manual logging of data from permanently installed gages, use of hand-held instruments and portable dataloggers, permanently installed monitoring/metering equipment, the EMS or a combination of these methods. The process can be automated by programming alarms in the EMS when temperatures, flows, pressures or combinations are outside appropriate levels.

For more information on tracking equipment performance, see *Putting the "O" Back in O&M: Best Practices in Preventive Operations, Tracking and Scheduling*, a publication in the EPA O&M Best Practices Series.

BEST PRACTICE 15: PREVENTIVE OPERATION & MAINTENANCE

REDEFINE PREVENTIVE MAINTENANCE TO INCLUDE ACTIVITIES CRITICAL TO ENERGY-EFFICIENT BUILDING OPERATION

Typically, the primary goal of the preventive maintenance (PM) plan is reliability and increased equipment life. Including procedures to check for efficient operation as part of the plan should enhance this primary goal as well as eliminate unnecessary energy waste. Buildings often have extensive maintenance-focused PM plans, which are rigorously carried out by the O&M staff. However, even if a piece of equipment or a system is meticulously maintained, if it is poorly operated using inadequate control strategies or improper scheduling, vast amounts of energy waste can occur. Also, poor equipment operation can lead to premature equipment failure (for example, short-cycling) and an increase in maintenance requirements. PM plans tend to focus on component-by-component care, missing the holistic view that sees the *operation* part of O&M as equal in importance to maintenance.

Develop a more holistic preventive maintenance plan. Give the operation side of O&M equal importance to maintenance.

PURPOSE

- Provide a comprehensive O&M plan for the facility by formally including PM procedures for periodically reviewing and monitoring the operating sequences, strategies, and schedules to ensure that the facility operates as efficiently as possible.

ACTION TIPS

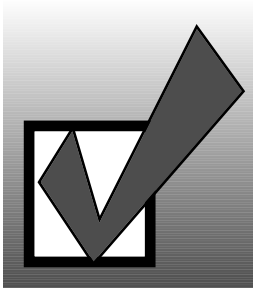
- As part of preventive O&M planning, perform periodic reviews of HVAC and lighting schedules, temperature setpoints, and occupant/tenant use requirements to ensure that equipment runs only when needed.

- Seasonally adjust control strategies. Just as certain maintenance tasks are performed to prepare equipment for heating or cooling season, control strategies should also be reviewed and adjusted. A good control strategy for cooling season is not necessarily optimal for "swing" season or heating season.

- Develop O&M procedures and forms for tracking actual equipment performance against expected performance. Forms may include the task description, checking method and frequency for each piece of equipment, reporting formats, procedures for addressing non-conformance issues and how to resolve performance deficiencies. In many cases the data gathering procedures on equipment performance dovetail nicely with other PM work adding very little staff time for accomplishing the task.

Review and adjust control strategies seasonally.

For more information on redefining preventive maintenance to include operation activities, see *Putting the "O" Back in O&M: Best Practices in Preventive Operations, Tracking and Scheduling*, a publication in the EPA O&M Best Practices Series.



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GLOSSARY OF TERMS

Baseline. The "before" data that is used in a "before & after" comparison. Baseline data may refer to energy consumption values, efficiency parameters, or other indications of building (or system) performance.

Commissioning. According to ASHRAE Guideline 1-1996, the process of ensuring that new systems and designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.

Control Strategy. An approach to controlling equipment. Usually this term refers to automated routines implemented through an energy management system that are designed to control equipment while providing maximum energy efficiency.

Datalogger. A stand-alone electronic data gathering device that utilizes sensors to collect equipment information over time. Data collected could include temperature, pressure, current, humidity, or other operational information.

Diagnostic Monitoring. The practice of collecting data on equipment operation over a period of time for the purpose of assessing the equipment performance. This data may be obtained through a **datalogger** or an **energy management system**. This data may consist of time-series or change-of-value (COV) data that can be collected for digital points such as temperature, pressure, or status.

Efficiency Curve. For some equipment, the efficiency varies with the load on the equipment. In those cases the efficiency is plotted against load. This efficiency curve illustrates the performance of the equipment over its range of operational conditions.

Energy Accounting. The process of tracking and analyzing energy use for the purpose of detecting problems, trends, or savings opportunities. Typically, energy accounting is performed for an entire building. In the analysis process, adjustments may be made for variations in weather, space use, or other variables from year to year.

Energy Assessment (audit). An investigation of systems in existing buildings with the goal of replacing or retrofitting equipment. This is a quick process that may include building simulation and results in a list of energy conservation measures that involve significant capital investment.

Energy Management System. The automatic system used for controlling equipment in a building. Most likely, this will be a computer-based system, including either pneumatic or digital components, or both.

Equipment Efficiency. A measure of the output of some piece of equipment as it relates to the energy input. Higher efficiency indicates that a machine can produce more heating, cooling, etc. for each unit of fuel (electricity, gas, etc.) consumed. For some equipment, the efficiency varies with the load on the equipment. In those cases the efficiency is plotted against load. This efficiency curve illustrates the performance of the equipment over its range of operational conditions.

Indoor Environmental Quality (IEQ). A term that refers to the total environment of a building and includes thermal comfort, proper illumination, adequate outside air ventilation, and control of indoor air pollutants.

O&M Assessment. A systematic method for identifying ways to optimize the performance of an existing building. This assessment involves gathering, analyzing, and presenting information based on the building owner or manager's requirements.

Performance Tracking. The ongoing procedure of obtaining data that gives an indication of a system's performance. This data could include information on energy efficiency, energy consumption, or run-time. As part of the process, performance data is often compared to the system's **baseline**.

Preventive Maintenance Program. A program that is implemented to address equipment maintenance issues proactively. The goal of such a program is to perform maintenance tasks on a regular schedule so as to maximize the operational efficiency and lifetime of the equipment.

Trend Log. A log of data that is collected through an **energy management system**. This data may consist of time-series or change-of-value (COV) data that can be collected for digital points such as temperature, pressure, or status.

LIST OF ACRONYMS

AEE Association of Energy Engineers

APEM Association of Professional Energy Managers

CEM Certified Energy Manager

COV Change of Value

DOE U.S. Department of Energy

EMS Energy Management System

EPA U.S. Environmental Protection Agency

EUI Energy Use Index

FOM Figure of Merit

HVAC Heating, Ventilating, and Air Conditioning

IEQ Indoor Environmental Quality

NOI Net Operating Income

O&M Operation & Maintenance

PE Professional Engineer

PM Preventive Maintenance

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